Illinois Department of Transportation

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation

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Common Acronyms

AADB	Average Annual Daily Bicyclists
AASHTO	American Association of State Highway Transportation Officials
ACS	American Community Survey
ADT	Average Daily Traffic
ATA	Active Transportation Alliance
BBL	Buffered Bicycle Lane
BDE	Bureau of Design and Environment
BLRS	Bureau of Local Roads and Streets
CDOT	Chicago Department of Transportation
CMF	Crash Modification Factor
FHWA	Federal Highway Administration
HCM	Highway Capacity Manual
HSM	Highway Safety Manual
IDOT	Illinois Department of Transportation
IML	Illinois Municipal League
ITE	Institute of Transportation Engineers
LOS	Level of Service
MoE	Measure of Effectiveness
mph	miles per hour
MUTCD	Manual of Uniform Traffic Control Devices
NACTO	National Association of City Transportation Officials
PHB	Pedestrian Hybrid Beacon
RLC	Red Light Camera
RRFB	Rectangular Rapid Flashing Beacon
SBL	Separated Bicycle Lane
USDOT	United States Department of Transportation

Volumes

Volume 1

Overall Findings
Applications &
Impacts Matrices
Facility Summaries

Volume 2 - Bicycle Facility Reports

a. Bicycle Lanes
   1. Conventional
   2. Buffered
   3. Contra-Flow
   4. Left-Side
   5. Separated
b. Shared Roadway
   6. Bicycle Boulevards
   7. Widened Shoulders
   8. Road Diets
c. Markings
   9. Bicycle Intersection Markings
d. Signals
   10. Bicycle Signal Heads

Volume 3 - Pedestrian Facility Reports

a. Geometrics
   11. Median Refuge Islands
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b. Signals
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c. Other
   19. Red Light Cameras
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Overall Findings

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Overall Findings

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

1.0 Introduction

1.1 Purpose

The purpose of this study is to create, as a supplement to Bureau of Design & Environment (BDE) Policy, a guidance document for incorporation of bicycle and pedestrian accommodations along Illinois roadways. It is based on currently available research and national guidance and is primarily for use by planning and engineering staff at the Illinois Department of Transportation (IDOT). Its focus is on projects in urban and urban core areas but can apply to projects throughout Illinois. This document is intended to further encourage incorporation of safe and efficient bicycle and pedestrian facilities within roadway improvement projects. Tools and reports were developed and tailored to each Bureau within IDOT to provide that guidance. This guidance is not intended to alter nor contradict the IDOT design engineering and environmental policies that are contained in the BDE Manual, whether in Chapter 17 or other chapters. In any case where a conflict with the BDE Manual is found in this document the BDE Manual shall govern and not be compromised.

This report (Volumes 1 through 3) is one component of a robust and inclusive complete streets program. They supplement IDOT manuals and policies and highlight other local and national manuals to aid in achieving a complete streets network.

Figure 1 - Elements of complete streets in District One

1.2 Description of Study

Overall, this study evaluates, provides information on the performance of, and identifies opportunities to implement various 'innovative' bicycle and pedestrian accommodation strategies. IDOT is seeking a balanced approach to routinely accommodate pedestrians, bicyclists, and motorists as outlined in the State's Complete Street Policy (Sec. 4-220 of the Illinois Highway Code). That approach must take into consideration the varying roadway types and classifications as well as land uses and project contexts. Illinois is not alone in this regard. It is common practice in other states to fully consider bicyclists and pedestrians when improving roads as part of the federal complete streets guidelines. Complete streets policies consider streets that are designed for everyone. There were 31 complete streets policies in-place nationwide in 2006 (National Complete Streets Coalition 2014). By 2013, a total of 712 jurisdictions nationwide had complete streets policies in-place, including 30 states.[1] Smart Growth America maintains a list of all communities with policies on their website. According to the Active Transportation Alliance *Complete Streets, Complete Networks* guide, developed in partnership and with funding from Cook County, complete streets accommodate people of all ages and physical abilities, and uses transit, context and property value as important elements in street design. It includes other approaches known as context-sensitive solutions, living streets, or green streets.

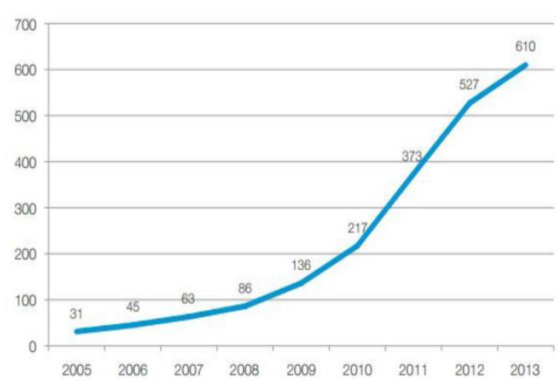


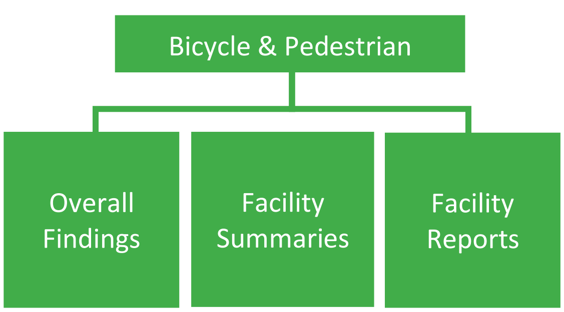
Figure 2 - Municipal complete streets policies that were in effect as of 2013. Source: Smart Growth America. Reprinted from the FHWA Separated Bicycle Lane Design Guide.

IDOT's mission is to provide safe, cost-effective transportation in ways that enhance quality of life, promote economic prosperity, and demonstrate respect for our environment. IDOT's guiding principles are Safety, Integrity, Responsiveness, Quality, and Innovation. In accordance with IDOT's mission and principles, this study provides the following recommendations and analyses:

1. Identify common issues and trends as highlighted by bicycle and pedestrian crashes.
2. Provide a toolbox of treatments.
3. Review implementation of bicycle and pedestrian facilities, including traditional and innovative treatments, around North America. Compile an inventory of those treatments, summarize existing research, and perform detailed analyses on the safety, operations, maintenance, and costs based on their integration of bicycle and pedestrian facilities into the transportation corridor.
4. Create a Geographic Information Systems (GIS) database to facilitate the identification of recommended improvement locations based on facility type and various roadway metrics. The GIS tool is expected to be used to identify locations where certain facilities would be appropriate for future consideration.
5. Enable Illinois practitioners to better facilitate the planning, design, analysis, operation, and maintenance of bicycle and pedestrian facilities within the transportation corridor.

1.3 How to use this report

The report is divided into three main components: the overall findings, facility summaries, and facility reports.



Overall Findings

The overall findings component is a high-level document that provides an overview of the study, overall safety, operations and maintenance information, matrix summaries, summary of outreach, a review of IDOT policy and guidelines, and a review of the study's data collection procedures and opportunities for future studies. Safety analysis includes the following topics: crashes, conflict points, user comfort, and signal/stopping compliance. Operations analysis includes: traffic volumes, delay, speed, and pedestrian wait times. Maintenance analysis includes: drainage, utilities, street sweeping, snow removal, and unique materials & equipment.

As a final note, neither sidewalks nor shared-use paths are directly discussed in this study and report. The requirements for those facilities, including design details and accessibility requirements, are covered in detail in the BDE Manual, primarily in Chapter 17. Off-road facilities such as these are common within urban and suburban areas and often work in concert with the improvements discussed as part of this study. Sidewalks are an important element of complete streets in most urban and suburban locations; shared-use side path facilities are often warranted and appropriate where there are certain traffic and land-use characteristics (e.g. higher volume, higher speed, more trucks, fewer driveways) make bicyclist separation from vehicle traffic more important and contextually appropriate.

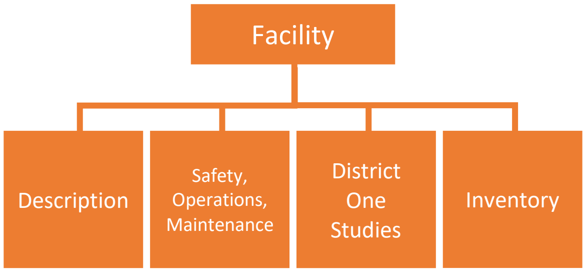
Facility Summaries

Facilities summaries are one-page compilations of important facts, benefits, and considerations for each facility. Each summary includes the following:

- Summary Paragraph
- Individual Application Matrix
- Benefits & Considerations Matrix

Each individual matrix includes the same information presented in the Application Matrix presented earlier. For more detailed information, refer to the complete facility reports in Volumes 2 and 3.

Facility Reports



The facility reports include a description of the facility with applications, features, warrants (if available), roadway characteristics and contexts, average costs, and a list of national & local design guidance. Example photos of a facility (typically within Northeast Illinois) will be included if the facility has already been installed within Illinois. Each report contains background information and national research pertaining to the safety, operations, and maintenance of the facility. Several facility reports contain the results of studies performed by IDOT District One on local facilities and may contain surveys, crash analyses, and behavioral or speed observations. Included at the end of each facility report are partial inventories of each facility in the United States and Canada. See Appendices A & B.

The facility reports can be read individually. The safety, operations or maintenance sections could be relevant to and read individually by specific bureaus. The facility reports are summarized in *Facility Summaries* and in the impacts and application matrices in Section 2.1, Matrix Summaries.

Warrants

"In January 1999, the USDOT FHWA task force members recommended against trying to create specific warrants for different facilities and determined that warrants leave little room for engineering judgement and have often been used to avoid providing facilities for bicycling and walking" (FHWA 1999). Instead of warrants, they issued a policy statement on Accommodating Bicyclists and Pedestrians in Transportation Projects as follows:

- An acknowledgement of the issues associated with balancing the competing interests of motorized and non-motorized users.
- A recommended policy approach to accommodating bicyclists and pedestrians (including people with disabilities) that can be adopted by an agency or organizations as a statement of policy to be implemented or a target to be reached in the future.
- A list of recommended actions that can be taken to implement the solutions and approaches described above.
- Further information and resources on the planning, design, operation, and maintenance of facilities for bicyclists and pedestrians.

Generally, each facility report does not contain warrants for these reasons. However, a few well-respected national resources do contain warrants for a few facilities. Some warrants are therefore included in the facility reports within the Description sections.

Headers and Links

Each facility header includes the report section name on the left and the facility name on the right. Additionally, look for a bicycle or pedestrian that denotes which facility type is being discussed.

Inserted throughout all reports are links to important external references, guides, and manuals, noted in the traditional blue hyperlink text. Links to other reports within the study are shown in orange and provide more details about the topic being discussed.

1.4 Disclaimer & Report Information

The accuracy of any results or outcomes made in this report partially depends on the accuracy of the data used. If inadequate data was available for analysis then data was collected by the project team for local facilities or found nationally for facilities outside of the region. Also see the limitations with studies performed by District One in Section 3.

This report and guidance are based on local and national research, notably the Federal Highway Administration (FHWA), American Association of State Highway Transportation Officials (AASHTO), Transportation Research Board (TRB), existing IDOT manuals, Institute of Transportation Engineers (ITE), and the National Association of City Transportation Officials (NACTO), among many other sources.

This study is not a design guide. Engineers should consult the IDOT Bureau of Design and Environment (BDE) and Bureau of Local Roads and Streets (BLRS) manuals as well as national guidance for bicycle and pedestrian standards and requirements. Each facility report contains links to the latest standards (at the time of report preparation) for convenience. This study also does not constitute a policy or requirement for IDOT. Federal and state guidelines do not prohibit the use of any facility mentioned in section 2.0. Where possible, information on the extent that a facility or component is allowed is provided.

'Bicycle' is typically used throughout this report although bike and bicycle are used interchangeably in some sections, depending on which word was used in surveys or in direct quotes from resources. 'Bicycle' was chosen to mimic the typical use in most FHWA documents.

1.5 Final Steps

Choosing a bicycle or pedestrian facility is only one component of the transportation planning, design, construction and maintenance process. This report can be used as a reference for all phases of the process from conception to implementation and maintenance.

Furthermore, additional facilities can be amended to this list, added to the application and impact matrices, and facility reports created for them if found to be appropriate in the future. Templates for the reports are available for use.

This study encompasses facilities or features that are traditional, innovative or relatively new in transportation engineering. As such, the efficacy of each facility or feature is at varying levels of safety, operations, or maintenance review. This study aims to fill in the gaps of those reviews by determining what research has been completed, where the research was performed, and how it applies to Illinois. Field tests were performed on facilities lacking robust or local research and depended on the availability of locations nearby for observations. Through examining the latest in bicycle and pedestrian research, coupled with a review of standard practices in transportation engineering studies, a series of measures of effectiveness were found or created to study these facilities as described in the data collection report.

The facilities were separated into bicycle and pedestrian uses, and then further organized by categories based on facility features. Some facilities allow both bicycle and pedestrian usage as noted in the respective facility descriptions.

2.0 Facilities Studied

Category	Facility	#
Bicycle		
Bicycle Lanes	Conventional	1
	Buffered	2
	Contra-Flow	3
	Left-Side	4
	Separated	5
Shared Roadway	Bicycle Boulevards	6
	Widened Shoulders	7
	Road Diets	8
Markings	Intersection Markings	9
Signals	Bicycle Signal Heads	10
Pedestrian		
Category	**Facility**	**#**
Geometrics	Median Refuge Islands	11
	Raised Crosswalks	12
	Curb Bump Outs	13
Signals	Pedestrian Hybrid Beacons	14
	Rectangular Rapid Flashing Beacons	15
	Lighted Crosswalks	16
	Signal Phasing	17
	Pedestrian Signal Heads	18
Other	Red Light Cameras	19
	Crosswalk Enhancements	20

2.1 Matrix Summaries

Each facility has varying applications and impacts within Illinois. A summary of the applications and impacts of each facility is provided in the Facility Summaries and Facility Reports. Additionally, the facilities are combined into a single matrix to aid with comparisons between facilities and better illustrate the various levels of applicability and benefits.

2.1.1 Applications

The Application Matrix is a quick reference that identifies the applicability of a facility based on various roadway characteristics. Included below is a combined matrix for each facility. Individual matrices are also placed in the upper right portion of each Facility Summary page.

Applications Legend:

Green cells indicate the facility is generally applicable for the listed condition

Yellow cells indicate the facility is applicable for the listed condition in limited contexts

Grey cells indicate the facility is generally not recommended for the listed condition

- 1W – One-Way
- 2W – Two-Way
- 2L – 2-Lane
- 3L – 3-Lane
- ML – Multilane (4 or more Lanes)
- INT – Intersection
- MBLK – Mid-Block
- SEG – Segment
- L – Local
- C – Collector
- A – Arterial
- R – Rural
- S – Suburban
- U – Urban
- <10K – Less than 10,000 ADT
- 10-25K – 10,000 to 25,000 ADT
- >25K – Greater than 25,000 ADT
- ≤30 – 30 MPH or less posted speed limit
- 35-45 – 35 to 45 MPH posted speed limit
- ≥50 – 50 MPH or greater posted speed limit

2.1.2 Impacts

All facilities, if applied in the correct context, improve safety to some degree with varying impacts on traffic operations and ease of maintenance. Some facilities have a greater impact to operations than others or are expensive to implement and contain unique maintenance requirements. Impacts are summarized in the Impacts Matrix as well as in the subsequent overall findings sections.

The Impacts Matrix is a reference that indicates the level and nature of the facility's impact on the three report categories: safety, operations and maintenance. Each category is broken down into the following subcategories: **safety** – crashes, perception, behavior; **operations** – motorists, bicyclists, pedestrians; and **maintenance** – street sweeping, snow removal. For each subcategory, a rating of positive or negative was assigned. If a facility has a positive impact on the subcategory, the level of that impact was indicated. The maintenance section also contains an additional section that indicates whether a facility includes any of the following materials or features: pavement markings, signals/beacons, signage or colored pavement.

The purpose of this matrix is to provide a comparison tool for engineers and planners. When used in conjunction with the Application Matrix, this Impacts Matrix can provide information on which facility provides the greatest positive impact for a targeted improvement. It shows the tradeoffs between safety and operations that occur with certain facilities as well as the level of maintenance involved. The matrix can be read horizontally from left to right for one facility type, or vertically for a specific subcategory across facility types in order to make a comparison.

Impacts Legend:

(green cell)	Green cells indicate the facility generally has a positive impact on the subcategory
(yellow cell)	Yellow cells indicate the facility requires additional scrutiny due to potential concerns with the subcategory
(grey cell)	Grey cells indicate the subcategory does not apply to the listed facility

Each positive green cell is further weighted by the level of impact as shown in the following key:

+	Slight benefit
++	Significant Benefit
+++	Highest Benefit

Combined green & yellow fill indicates mixed impacts depending on the level of facility implementation and/or context. See the individual facility reports for more information regarding these impacts.

+/-

Maintenance

Impacts on street sweeping and snow removal are also denoted with a plus (+) or minus (–), however these symbols denote a low or high impact. A plus (+) cell indicates the facility only requires inexpensive or simple street sweeping or snow removal operations. A minus (–) cell indicates the facility requires costly or complex street sweeping or snow removal operations. The other maintenance categories are simply marked with a checkmark (✓) to indicate whether that material or feature is present and will require upkeep.

Exceptions

Asterisks (*) indicate the impacts depend on the extent of features implemented. For example, Bicycle Boulevards can contain a minimal amount of pavement markings and signage with little impact to operations or can contain extensive use of diverters, bump outs, speed humps and other traffic calming features that can significantly impact traffic and maintenance operations. Checkmarks with asterisks indicate similar issues, with the inclusion of that material or feature dependent on the level of facility that is installed. See the respective facility reports for more information on items with asterisks. Note also that the ADTs listed for intersections are based on the higher-traffic route. Although Red Light Cameras are listed as a pedestrian facility, their use is highly restricted in Illinois and they are not a traffic control device.

Applications and Impacts Matrix
Bicycle Facilities

Applications

Category	Bicycle Facilities	Traffic Direction: One Way	Traffic Direction: Two Way	Location: Intersection	Location: Segment	Functional Classification: Local	Functional Classification: Collector	Functional Classification: Arterial	Area Population: Rural	Area Population: Suburban	Area Population: Urban	ADT: <10K	ADT: 10K-25K	ADT: >25K	Posted Speed Limit: ≤30 MPH	Posted Speed Limit: 35-45 MPH	Posted Speed Limit: ≥50 MPH
Bicycle Lanes	Conventional	1W	2W	INT	SEG	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Bicycle Lanes	Buffered	1W	2W	INT	SEG	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Bicycle Lanes	Contra-Flow	1W	2W	INT	SEG	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Bicycle Lanes	Left-Side	1W	2W	INT	SEG	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Bicycle Lanes	Separated	1W	2W	INT	SEG	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Shared Roadway	Bicycle Boulevards*	1W	2W	INT	SEG	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Shared Roadway	Widened Shoulders	1W	2W	INT	SEG	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Shared Roadway	Road Diets*	1W	2W	INT	SEG	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Bicycle Intersection Markings	Bicycle Boxes	1W	2W	INT	SEG (N/A)	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Bicycle Intersection Markings	Two-Stage Turn Boxes	1W	2W	INT	SEG (N/A)	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Bicycle Intersection Markings	Intersection Crossings*	1W	2W	INT	SEG (N/A)	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Bicycle Intersection Markings	Mixing Zones	1W	2W	INT	SEG (N/A)	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Bicycle Intersection Markings	Lateral Shifts	1W	2W	INT	SEG (N/A)	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH
Signals	Bicycle Signal Heads	1W	2W	INT	SEG (N/A)	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30MPH	35-45MPH	≥50MPH

Impacts

Bicycle Facilities	Safety: Crashes	Safety: Bicyclist Perception	Safety: Behaviors	Operations: Motorists	Operations: Bicyclists	Operations: Pedestrians	Maintenance: Street Sweeping	Maintenance: Snow Removal	Maintenance: Pavement Markings	Maintenance: Signals / Beacons	Maintenance: Signage	Maintenance: Green Pavement
Conventional	+	+	+	+	+	n/a	+	+	✓		✓	
Buffered	++	++	++	+	+	n/a	+	+	✓		✓	
Contra-Flow	+	++	++	+	++	n/a	+	+	✓		✓	
Left-Side	+	+	+	+	+	n/a	+	+	✓		✓	
Separated	+++	+++	+++	+/-	++	n/a	-	-	✓	✓*	✓	✓
Bicycle Boulevards*	++	+++	++	-	+	+	+	-	✓*		✓	✓
Widened Shoulders	+	+	+	+	+	+	+	+				
Road Diets*	++	++	++	+/-	+	+	+	+	✓		✓	
Bicycle Boxes	+	++	++	+	+	+	+	+	✓		✓	✓
Two-Stage Turn Boxes	+	+	+	+	+	n/a	+	+	✓			✓
Intersection Crossings*	++	++	++	+	+	n/a	+	+	✓			✓
Mixing Zones	+	++	+	+/-	+	n/a	+	+	✓		✓	
Lateral Shifts	+	+	+	+	+	n/a	+	+	✓		✓	✓
Bicycle Signal Heads	++	+++	++	-	+	n/a	n/a	n/a		✓	✓	

Applications and Impacts Matrix

Pedestrian Facilities

Applications

Category	Pedestrian Facilities	Lanes: 2-Lane	Lanes: 3-Lane	Lanes: Multilane	Location: Intersection	Location: Midblock	Functional Classification: Local	Functional Classification: Collector	Functional Classification: Arterial	Area Population: Rural	Area Population: Suburban	Area Population: Urban	Average Daily Traffic (ADT): <10K	Average Daily Traffic (ADT): 10K-25K	Average Daily Traffic (ADT): >25K	Posted Speed Limit: ≤30 MPH	Posted Speed Limit: 35-45 MPH	Posted Speed Limit: ≥50 MPH
Geometrics	Median Refuge Islands	2L	3L	ML	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH
	Raised Crosswalks	2L	3L	Multilane Roundabouts Only	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH
	Curb Bump Outs	2L	3L	ML	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH
Signals	Pedestrian Hybrid Beacons	2L	3L	ML	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH
	Rapid Flashing Beacons	2L	3L	ML	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH
	Lighted Crosswalks	2L	3L	ML	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH
	Signal Phasing	2L	3L	ML	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH
	Pedestrian Signal Heads	2L	3L	ML	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH
Other	Red Light Cameras	2L	3L	ML	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH
	Crosswalk Enhancements*	2L	3L	ML	INT	MBLK	L	C	A	R	S	U	<10K	10K-25K	>25K	≤30 MPH	35-45 MPH	≥50 MPH

Impacts

Category	Pedestrian Facilities	Safety: Crashes	Safety: Bicyclist Perception	Safety: Behaviors	Operations: Motorists	Operations: Bicyclists	Operations: Pedestrians	Maintenance: Street Sweeping	Maintenance: Snow Removal	Maintenance: Pavement Markings	Maintenance: Signals / Beacons	Maintenance: Signage	Maintenance: Colored Pavement
Geometrics	Median Refuge Islands	++	+++	+	-	n/a	++	-	-	✓		✓	
	Raised Crosswalks	++	++	++	-	-	+	+	-	✓		✓	
	Curb Bump Outs	++	+++	++	-	-	+	-	-				
Signals	Pedestrian Hybrid Beacons	+++	++	+++	+	+	++	n/a	n/a		✓	✓	
	Rapid Flashing Beacons	++	++	+++	+	n/a	++	n/a	n/a		✓	✓	
	Lighted Crosswalks	+	+	+	+	n/a	+	+	-		✓	✓	
	Signal Phasing	++	++	++	-	n/a	+++	n/a	n/a	✓*	✓	✓	
	Pedestrian Signal Heads	+	++	+	-	n/a	+	n/a	n/a		✓	✓	
Other	Red Light Cameras	++	+	++	n/a	n/a	n/a	n/a	n/a		✓	✓	
	Crosswalk Enhancements*	++	++	++	+/-	n/a	+	n/a	n/a	✓	✓	✓	✓

Legend

1W	One-Way	R	Rural
2W	Two-Way	S	Suburban
2L	2-Lane	U	Urban
3L	3-Lane	<10K	Less than 10,000 ADT
ML	Multi-Lane (4 or more)	10-25K	10,000 to 25,000 ADT
INT	Intersection	>25K	Greater than 25,000 ADT
MBLK	Mid-Block	≤30 MPH	Posted Speed Limits
SEG	Segment	35-45 MPH	Posted Speed Limits
L	Local	≥50 MPH	Posted Speed Limits
C	Collector		
A	Arterial		

Applications

Green cells indicate the facility is generally applicable for the listed condition.

Yellow cells indicate the facility is applicable for the listed condition in limited contexts.

Grey cells indicate the facility is generally not recommended for the listed condition.

Impacts

Green cells indicate the facility generally has a positive impact on the subcategory.

Yellow cells indicate the facility requires additional scrutiny due to potential concerns with the subcategory.

Grey cells indicate the subcategory does not apply to the facility.

+ Slight benefit

++ Significant benefit

+++ Highest benefit

+/- Combined green & yellow fill indicates mixed impacts depending on the level of facility implementation and/or existing conditions. See the individual facility reports for more information regarding these impacts.

Maintenance

A plus (+) cell indicates a low impact on maintenance and only requires inexpensive or simple sweeping and plowing operations.

A minus (–) cell indicates a high impact on maintenance and requires costly or complex sweeping and plowing operations. Checkmarks (✓) indicate whether that material or feature is present and will require upkeep.

Exceptions

* Asterisks on any application or impact signifies a result that is dependent on the extent of implemented features. Consult the facility report for more information.

3.0 Bicycle Facilities

3.1 General Safety Findings

All bicycle facilities improve safety of at least one mode. The extent of that improvement depends on the facility type and a combination of other factors such as enforcement, education, and volumes of bicyclists, pedestrians, and motorists. Consult the Impacts Matrix for an overview of the safety benefits, as well as the individual facility reports for a detailed review of national and local research.

Included in this section is information on topics such as crashes, conflicts, bicyclist comfort, signal/stopping compliance, bicyclist behaviors (e.g. wrong-way riding), surveys, health effects, speeding, and facility understanding. Some topics are applicable to pedestrians as well and may reference Pedestrian Facility Section 4.1, General Safety Findings.

Traffic safety is a top priority for IDOT. The Illinois Strategic Highway Safety Program (SHSP) instituted a goal of zero fatalities. Furthermore, bicyclists and pedestrians are considered vulnerable road users, and experience a higher crash rate compared to other modes. Therefore, safety is the main focus of this report.

Overall the safety findings are influenced by several trends, events, and availability of data. Information on Operations and Maintenance are provided to show the tradeoffs that may occur; however, safety is the overarching goal of this study.

Crashes

Crash analysis is a fundamental aspect of safety and measures roadway safety quantitatively and independently of the users.[2] However, crashes are a rare and random event. According to the Highway Safety Manual (HSM), the causes of crashes are also difficult to determine and are the result of a "convergence of a series of events that are influenced by a number of contributing factors."

Simple, descriptive crash analyses were performed on several bicycle facilities where data was available. Three crash analyses were performed: crash frequency, crashes by severity/type, and crash rates. Crashes were analyzed before and after a facility was installed to determine the impact of the facility on those crashes. There are numerous limitations to this simple analysis. One, the relationship between crashes and the effect of the facility is often not linear or direct. The crash rates may have been influenced by other factors. Two, depending on the variation in crashes and the length of observations, crashes fluctuate over time and may be due to natural fluctuations or too small of an observation period, known as regression-to-the-mean (RTM) bias. RTM bias was not accounted for in this high-level study and therefore, the reduction or increase in crash rates reported with some facilities may be due to natural regressions and not indicative of the facility's impact. Three, non-treatment sites were not included in the analysis, which accounts for general trends in crashes. Four, crash reporting varies across regions. Bicycle crashes in particular are an underreported crash event. "A meta-analysis of accident reporting across 13 countries, including the United States, found that single-vehicle bicycle accident reporting was the lowest of all categories – at less than 10%.[3] Another study found that fatal accident reporting systems underestimate crashes by 10%.[4] IDOT attempts to minimize these errors through robust crash reporting that includes many bicycle/pedestrian units. IDOT also places heavy importance on the quality of police reporting to ensure all bicycle and pedestrian crashes are recorded. Minor improvements can be made, however, to ensure that police report data is included in a unified IDOT crash database.

Descriptive, observational crash analyses were performed due to a lack of data such as the small sample sizes that bicycle crashes represent and sporadic bicycle volume counts. Some crash analyses were performed on facilities with only a few sites. Therefore, the results may not be accurate nor indicative of the facility's effectiveness. They are provided to show general trends and build a foundation for more robust crash analyses. However, several analyses included aggregating facilities together and analyzing the crashes as a group which will increase its accuracy. Error and bias in this study was further minimized by using data between 2008 and 2013 (the HSM recommends three to five years of crash data before and after installation of the facility). The crash analyses were performed on facilities installed over the normal course of efforts of local and state improvement programs.

The accuracy of crash rates was also compromised by the lack of in-depth and long term bicycle count data. Bicycle counts are further explained in section 3.2, General Operational Findings.

Further studies should be performed over the coming years to confirm the safety benefits of various bicycle and pedestrian facilities as more data is collected and made available.

According to the FHWA:

> "Culture and behavior… changes often occur over longer periods of time not covered in a typical safety evaluation. For example, separated bicycle facilities could be evaluated at a few trial locations in the U.S. and show no clear safety benefits in a typical one to two year safety evaluation. But in five to ten years, as more bicyclists use separated facilities and motorist and bicyclist behavior adapts, safety could improve dramatically. Unfortunately, this increase in safety would not be captured in typical safety evaluations because they do not capture long term behavior changes. It should also be noted that many… countries have undergone a culture change within the past 40 years that has placed increased emphasis on walking and bicycling safety and mobility. Changes of this sort can happen if fostered by a careful, evidence based approach."[5]

Grade Separation

See Pedestrian Facility Section 4.1 - General Safety Findings

Safety in Numbers

One potentially beneficial impact to the safety of bicyclists and pedestrians is the safety in numbers effect. Geyer and others have found that "the risk of collision for pedestrians decreases with increasing pedestrian flows."[6] "The likelihood that a given person walking or bicycling will be struck by a motorist varies inversely with the [total] amount of walking or bicycling. This pattern is consistent across communities of varying size, from specific intersections to cities and countries, and across time periods".[7] Using data from 68 cities in California, 47 in Denmark and 14 European countries, "it was found that across all data sets that motorists are less likely to hit bicyclists and pedestrians when there are more people bicycling or walking".[8] NYC also collected count and crash data at six locations around the city as shown in Figure 3. The graph shows bicycling risk decreasing between 2001 and 2013 with bicycle volumes rising over the same period, suggesting that a safety in numbers effect occurred in New York City. There is nothing that suggests these trends would not apply to Illinois.

Users that would otherwise forgo bicycling and walking will begin to convert to those modes and add to those volumes as safer and more comfortable facilities are installed. Additional safety benefits will then extend beyond the individual facility. These safety benefits will materialize over time and will be quantified through overall crash rates, something that is easy to calculate with existing region wide count and crash data. However, it may be difficult to verify the correlation between overall decreases in crash rate reduction and increases in volumes.

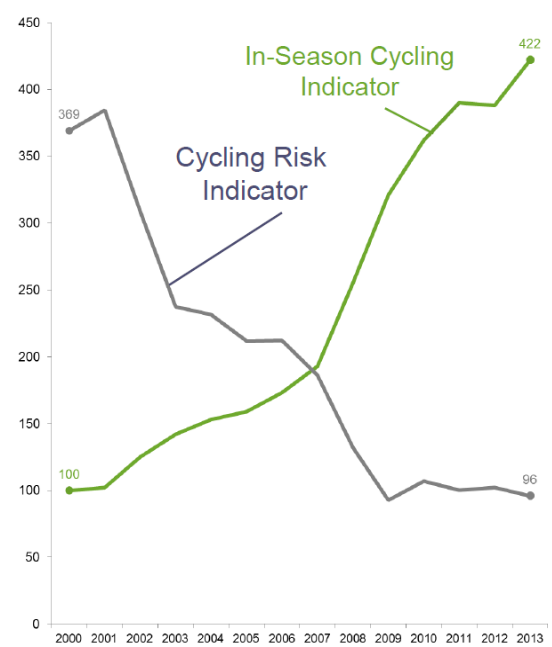


Figure 3 - NYC Bicycling Risk Indicator. Reprinted with permission from NYCDOT.

Surrogate Safety Measures

Throughout national research and the District One Studies, multiple surrogates for crash analysis were used to evaluate the effectiveness of the facilities. They include such studies as comfort, speeding, conflict analysis, video observations, behavioral analysis, compliance (signal or crosswalk stopping), and others. Surrogate measures allow evaluation when crash or volume data are lacking, or on newer facilities with less than 3-5 years of crash data. An extensive list of possible surrogate measures of effectiveness are provided in the Data Collection report located in Section 7.

Speeding

See Pedestrian Facility Section 4.1 – General Safety Findings

Comfort

Another surrogate measure pertains to user comfort or perceived safety. While actual safety with empirical data can be difficult to measure and depends on the availability of the data, perceived safety can be easily measured through the use of surveys. Nearly all surveys of users found bicycle facilities, to improve safety when compared to sites without any bicycle facilities.[9,10] The further separated the facility is from motorists, the safer the user perceives it to be. The same is true for residents and motorists who appreciate the guidance that bicycle facilities provide, especially when it is more separated from other modes. *Lessons from the Green Lane* found 75% of residents support building separated bicycle lanes elsewhere and "91% of surveyed residents agree with the statement, 'I support separating bicycles from cars.'"[10] District One's own surveys of users found generally positive results for all facilities, with the least separated facilities such as conventional bicycle lanes resulting in many requests for improved separation.

Increased comfort also leads to increased ridership. In the *Lessons from the Green Lane*, over 25% of bicyclists surveyed indicated they are "riding more in general because of the [separated bicycle lanes]."[10] A comfortable facility helps encourage the bicyclists that are labeled as "interested but concerned" to use a bicycle.[11] They are the proportion of bicyclists that comprise the majority of transportation bicyclists according to a commonly cited classification from the City of Portland. The more bicyclists using the road, the safer it becomes as mentioned earlier due to the safety in numbers effect.

Generally, the more separated the facility, the more comfortable it becomes for users.[12] Comfort is a significant surrogate measure of a facility's effectiveness at improving safety.

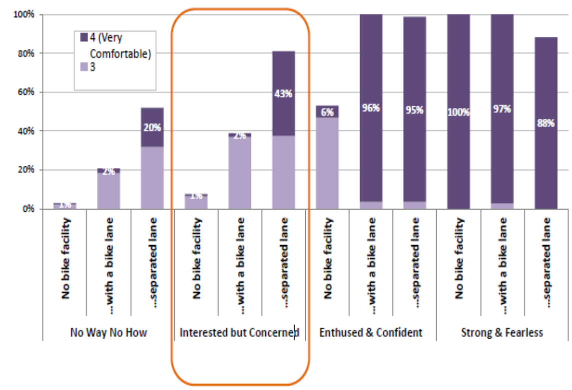


Figure 4 - Three levels of separation and their corresponding comfort level according to research by Jennifer Dill at Portland State University. The largest impact is with "interested but concerned" bicyclists. Reprinted with permission.

As shown in the Impacts Matrix earlier, perceived safety is sometimes different from actual safety (crashes). While a facility may not have been proven to reduce crashes significantly, the perceived level of safety may be high. That, in turn, encourages a larger mode shift and other benefits.

Enforcement

Enforcement of traffic regulations is crucial to maintaining a safe and operable facility. For example, the safety benefits described throughout the study are negated if a motorist is blocking or parking in the bicycle lane or using it illegally. In many cases, bicyclists are forced to merge with moving, higher speed traffic and in areas where motorists may not expect them. Enforcement needs to be maintained for any design to function properly and achieve the full benefits. Enforcement also provides operational benefits and helps ensure the lane is clear. For example, if a motorist is blocking the exit of a curb-separated bicycle lane then bicyclists may be required to dismount.

Some facilities help with enforcement through their inherent design. For example, buffered bicycle lanes encourage motorists to maintain at least 3' of distance when passing bicyclists as mandated by Illinois statute.

In New York, a group of students developed an online web platform which allows New York City bicyclists to record, photograph, and send in any information regarding bicycle lane violations by motorists. This website allows bicyclists to monitor bicycle lane violations as they happen and point out problematic areas where violations are occurring[13].

Crash Modification Factors

Crash modification factors were collected and presented in a separate report located in the appendix. The CMFs vary on the level of quality or confidence in the results. IDOT simple crash analyses performed during this study are also presented in CMF form and summarized in the appendix.

3.2 General Operations Findings

IDOT is focused on moving people and goods, not just motor vehicles. With that in mind, this feasibility report gives equal weight to the operations of motorists, bicyclists and pedestrians. Throughout each facility report, the impact of the facility on operations of traffic, travel delay, speed, and traffic volumes are presented. For motorists, the research focuses mostly on volumes, delay and speed. For bicyclists, the research focuses on volumes with some discussions on delay where applicable.

Bicyclist operations can be different from motorist operations; different in how it is measured, calculated, and presented. Generally, bicyclists are undercounted and more difficult to measure and collect data on. The smaller proportion of the travelling public utilizing a bicycle compared to motorists results in decreased concerns over bicyclist delay due to excess capacity (typically) for that mode. Therefore, the focus of most bicycle operations sections are on trends in increasing ridership.

When examining the effect of bicycle facilities on motorist operations, traditional metrics rise to the surface; mainly delay. Several facilities examined in this study reduce the capacity of the roadway, but as is the case in many installations around Illinois and the country, delay does not increase or increases minimally while providing the benefits of safety mentioned in the previous section. Therefore, operations of motorists must be considered within the context of the facility's increase on safety. The two are not mutually exclusive. The Active Transportation Alliance suggests an LOS of D as an "appropriate target for design of most multi-modal corridors, in most contexts", especially those occurring in much of District One.[14] Furthermore, when considering Level-of-Service (LOS), multi-modal LOS should be examined.

"Operations" was given its own independent section for ease of reading and quick reference for concerned bureaus within IDOT. Moreover, this general findings section, and the operations sections within each facility report, only discusses the operations of *traffic*, not how the facility operates. Information on how the facility operates may be found in the facility description of each facility report, if necessary. As this study is not a design guide, design guidance is available through the design references or referenced elsewhere.

Ridership Trends

Bicyclist volumes have been rising steadily. The longest, most reliable dataset is developed by the American Community Survey (ACS). In 2012, ACS found 1.57% of Chicagoans used a bicycle to commute to work as their predominant mode choice. Extrapolating that out, on any given day there could have been 42,625 Chicagoans using a bicycle. This number is most likely lower than actual. The ACS survey only asks "how did this person usually get to work last week".[15] Also, the margin of error is large since it uses a subset of the national dataset. However, it provides a general overview of bicycling trends and uses the longest dataset available in the region going back to 1980.

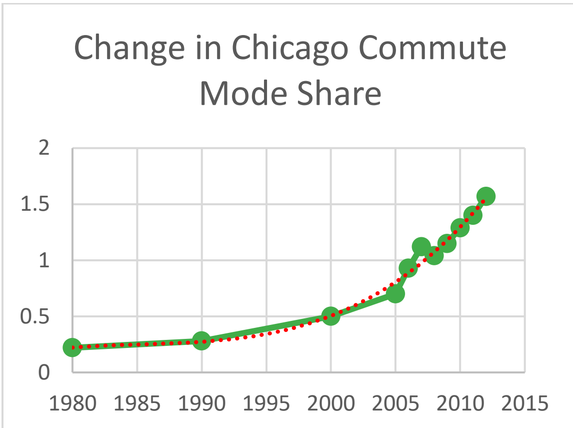


Figure 5 - Change in commute mode share based on American Community Survey U.S. Census data from 1980 to 2012

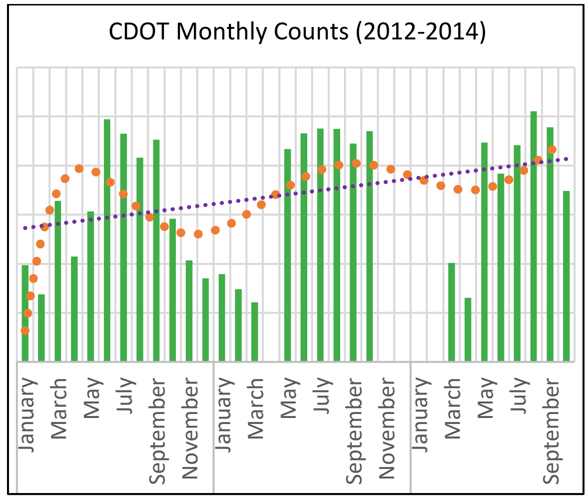


Figure 7 - Change in the number of bicyclists using specific streets measured consistently between 2012 and 2014. Streets were measured manually during peak hours. Some winter months were excluded due to incomplete data sets.

Bicycling trends were also analyzed using short term data collected by the Chicago Department of Transportation (CDOT) and plotted in Figure 5, Figure 6 and Figure 7. Volumes are purposely left off the charts as they are depicted here to only show general trends in bicycling growth, and not how many bicycles were travelling during the measurement day across the entire city. The method and timing of data collection lead to variations in counts over the seasons, but overall bicycling rates are increasing in Chicago.

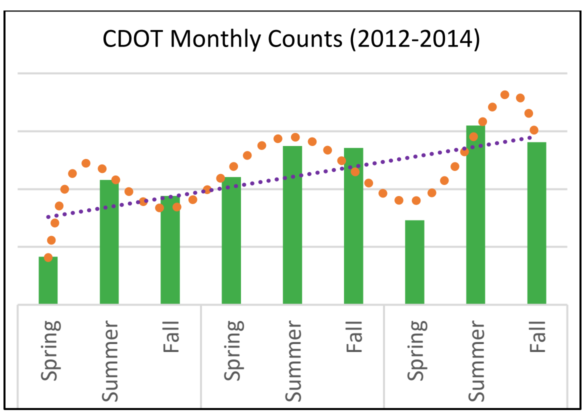


Figure 6 - Change in the number of bicyclists based on manual peak hour counts taken three times a year around Chicago's downtown area between 2012 and 2014.

Average Annual Daily Bicyclists

With the limitations of the bicyclist count data in mind, this study attempted to calculate factors to convert short-term bicyclist counts such as those collected during project analysis or during the evaluation phase of this study, to long term average annual daily bicyclist counts, or AADB. Similar to AADT numbers and conversion factors, these factors allowed the examination of crash rates, which is a more robust method of measuring a facility's impact on safety. AADB extrapolation factors have not been calculated before for the Chicago region.

The factors are based on numerous bicycle counts from the region taken by multiple agencies via pneumatic tubes, pavement pucks, and manual counts. These counts vary in length and consist of 2 hour counts, week-long counts or permanent data collectors that allowed for an analysis of yearly trends. Most data was provided by CDOT or collected during this study.. These factors were then used wherever bicycle crash rates were calculated in the facility reports.

Several problems exist with using the AADB factors to calculate the crash rates. For one, the data collection is only for one week and should only be extrapolated out for the year it was taken to minimize any changes in bike growth. Some count data was not available for the years prior to 2014, including before the installation of a facility. A growth rate was used in that case, based on ACS mode share trends to estimate bicycle volumes in past years.

Figure 8 - Pneumatic tubes counting bicyclists and measuring traffic speed on Clybourn Avenue in Chicago

AADB Alternative Methods

While researching the best way to analyze a facility's impact on crash rates, this study examined other methods of calculating bicycle volumes. One method involves using motorist ADT, of which there is abundant data, to determine a comparable bicyclist ADT growth rate. However, this is an inaccurate surrogate and will result in large errors. For example, bicycling rates are more affected by weather and seasonal patterns, and hourly adjustments are also skewed due to differing peak times.

Bicyclist volumes can also be calculated based on populations and surveys. Populations are adjusted for mode share according to numerous studies such as ACS by the U.S. Census, the National Personal Transportation Survey (NPTS) of 1995 to 1997, or the National Household Travel Surveys (NHTS) of 2001 and 2009. IDOT only looked at the ACS data since it included the largest data set.

Numerous inaccuracies may arise with using ACS commuting data. For one, over 80% of all transportation trips in Chicago are non-work related and comparison research has shown the census to undercount biking percentages.[16,17] Using mode share of workers or statistics based on the mode choice of all trips does not affect the isolated analysis of these studies. However, using mode share percentages of an areas total population will not result in crash rates that can be compared to studies on similar facilities in other regions. Instead it provides a crash rate before and after a certain facility is installed to show the effects that specific facility has on crashes only at the location being studied.

If ACS commuting data is used as the sole source of bicycle volumes in AADB calculations, a few issues arise. A specific street may experience a rise in crashes after installation of a bicycle facility, but when compared to overall city bicycle commuting rates, the crash rate may appear excessively high. This is because the crash rate does not take into account the shift of bicyclists from other routes onto the route with the new facility, or the new bicyclists that a comfortable facility may attract. Since the crash rates are based on citywide population numbers it will not show how much bicyclist traffic increased at the study site relative to the rest of the city, and thus the crash rates at the specific street will be skewed. Therefore, ACS commuting data should only be used to calculate general growth rates and overall crash rate trends.

While AADB factors were calculated and used for the purposes of crash analysis in this study, IDOT currently utilizes an alternative method when forecasting travel demand for proposed or future projects. In this case, IDOT calculates the AADB based on the ACS percentage of bicycle commuters and motorist ADT. For improvements where bicycle accommodations are not present, counting bicyclists as part of the data collection will not account for any future bicycle traffic that could utilize the roadway if a facility were to be provided. As such, IDOT will plan for a facility assuming that if a bicycle facility were to be provided, the percentage of bicycle commuters in the ACS would cease to drive and utilize the bicycle accommodation instead. In the absence of bicyclist volume projection data, this approach includes a measure of bicyclists into the traffic planning process in accordance with the State of Illinois requirements.

On the crash side of the equation, The State of Illinois collects and records all crash reports, including those with bicyclists and pedestrians. So, while it is difficult to collect bicyclist volumes at some sites, there *are* accurate and ubiquitous crash counts. For the purposes of this study, it was ultimately decided to use the bicycle counts provided by CDOT and collected by the IDOT study team, along with the developed AADB conversion factors, to determine crash rates at various locations. The crash rate results are presented in the facility reports.

Data Collection & Limitations

Data collection efforts need to increase in order to determine more detailed trends and draw more accurate conclusions about various facilities. Data collection faces various challenges not seen with traditional motorist data collection, such as varying paths that bicyclists can travel and not being confined to a specified lane that is easily measured with traditional equipment. However, data gaps can be closed through the latest advances in technology and utilizing partnerships with local agencies and advocacy groups. Refer to the data collection section in the appendix for research on the state of existing efforts in the region and solutions for implementing a healthy data collection plan.

Figure 9 – Bicyclists on the Dearborn Street two-way separated bicycle lane in Chicago

Furthermore, the previous count data only presents a snapshot of bicycling trends. The CDOT data is relatively new and only goes back to 2012. The ACS survey only collects data on the percent of residents who commute by bicycle as their primary means of transportation and may not represent the intricacies of many residents' commuting patterns that include multiple modes, especially in large urban areas. For instance, if a commuter takes the train into work, the ACS data may not record that user riding their bicycle to the train station during the first leg of their commute. The ACS data may underestimate bicycling trends, especially as different types of users start bicycling. In order to draw more accurate conclusions, especially in terms of the effects of particular facilities, more in-depth and long term bicycle counts must be collected.

District One utilized traffic tubes to reduce error but while accuracy rates in detecting bicyclists increased it came at the expense of equipment durability; the traffic tubes frequently broke while installed in the field resulting in incomplete data sets at a few locations. Coupled with very small crash sample sizes and short segments used in the analysis, some resulting crash rate comparisons are not significant enough to show any discernable patterns.

Motorist Delay

Motorist delay depends heavily on the type of facility being installed. Some bicycle facilities, especially those built mainly at intersections, do not affect motorist delay due to the nature of their design. Discussions of delay were therefore left out of those facility reports. Other facility's impacts depend on existing conditions such as excess capacity, roadway widths, and other physical characteristics. Another factor in motorist delay is whether building the bicycle facility encourages more roadway users to utilize a bicycle instead of a car. This causation is hard to prove, especially for specific projects and is not mentioned in the facility reports. Overall though, installing more bicycle facilities, especially those that are separated from traffic with a barrier and are more comfortable, should cause a shift, however minor, from other modes.

Figure 10 - Road diet on Wabash Avenue in Chicago- photo of the after design.

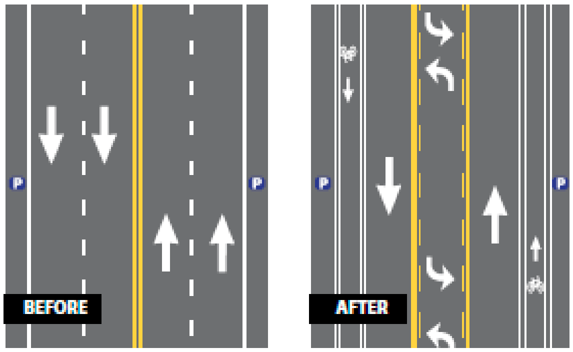


Figure 11- Road diet on Wabash Avenue in Chicago before and after marking designs (graphic from FHWA).

3.3 General Maintenance Findings

The third and final section of each facility evaluation pertains to the maintenance of the facility. Some advocacy groups argue that it is the main concern of bicyclists; the groups hear from their members that new innovative facilities are encouraging but additionally they need to be maintained and useable year-round. Maintenance means keeping the pavement in good condition, sweeping the facility of debris, plowing and salting, maintaining adequate drainage, ensuring signals and detection equipment are operating, restriping pavement markings, and ensuring signage is correct, up to date, and visible.

The maintenance section of each facility report has one or more of the following categories. The category discussed depends on the facility type, materials used and important concerns.

- Summary
- Typical Infrastructure to Maintain
- Street Sweeping & Snow Removal
- Utility Cuts and Construction Damage
- Drainage

Maintenance should not be an afterthought when designing and installing bicycle facilities. As the advocacy groups mentioned, users want a properly maintained facility and to be able to use it year round. Bicycling facilities in particular are sometimes a secondary priority for maintenance programs around Illinois. The reasons for this may be due to cost, lack of understanding of impacts to bicyclists, or other factors. Whatever the reason, bicycle facilities should be maintained with the same care and effort given to other roadway facilities.

Effect on Bicyclist Safety

Maintenance issues affect bicyclists differently than motorists. Bicyclists face many challenges when riding, such as:

- Snow or ice covered bicycle lanes that are difficult to ride on since balance is more important to a bicyclist than a four-wheeled motorist.
- Debris that pushes a bicyclist into moving traffic.
- Sewer grates with improper gaps or orientation.
- Tires that are easily punctured by glass or debris.
- Lack of maneuvering space, especially in barrier separated bicycle lanes.

Table 1 - Crash causes for single bicycle crashes in Sweden based on research by Anna Niska in the Proceedings of the International Cycling Safety Conference.

Cause	All Single Bicycle Crashes	Severe Single Bicycle Crashes
Road Maintenance	**47%**	**27%**
Road Design	17%	20%
Bicycle-cyclist Interaction	26%	27%
Bicyclist Behavior	10%	14%
Interaction with Road Users	1%	11%

According to research in Sweden, 47% of all single bicycle crashes (SBCs) and 27% of severe crashes were caused by road maintenance.[18] SBCs are crashes that only involved single bicyclists and do not include crashes with motorists; 70% of all bicycle crashes in Sweden are SBCs "The single largest contributory causal factor in SBCs was slippery surfaces or impaired grip. Uneven road surfaces were also stated as the cause of many [SBCs]." Left over debris from winter maintenance also leads to road grit causing slippery conditions after the winter months according to the researchers.

The largest cause of maintenance related SBC crashes was found to be ice and snow as shown in Table 2. Snow and ice are also of concern in winter. The same issue of grit that is left behind by melting snow is also a concern. Slippery conditions account for 34% (rounded up when combined in the study) of all SBCs. Therefore, street sweeping and snow removal should be a top priority.

Table 2 - Causes behind the maintenance related crashes in Sweden. Percentages add up to the total maintenance related crash cause in the previous table. Based on research by Anna Niska in the Proceedings of the International Cycling Safety Conference.

Maintenance Crashes	All Single Bicycle Crashes	Severe Single Bicycle Crashes
Ice/Snow	**18%**	**15%**
Grit – from winter	5%	6%
Wet/Leaves	9%	1%
Other Cause of Slipperiness	1%	2%
Uneven Surface	6%	5%
Temporary Objects	4%	3%
Road Edge	3%	2%

Furthermore, debris, snow, or worn-out markings decrease the effectiveness that markings provide. High conflict areas called out with green pavement marking become less effective when they are covered by snow or faded. The safety benefits mentioned in the impacts matrix are for clean, clear, and fully maintained bicycle facilities. An unusable facility that pushes a bicyclist into the motorist lane completely negates all safety benefits of the facility, and may even increase risk in instances where a motorist is not expecting a bicyclist to veer out into their lane.

Effect on Bicyclist Operations

Poor maintenance may contribute to crashes but they also decrease bicyclist comfort. Fixing frequent flat tires is tiresome and off-putting to bicycling. Navigating around debris or having to slow down on icy roadways increases travel time. An obstacle that pushes the bicyclist out into the motorist lane also decreases operations for motorists. During construction, the lane should be temporarily marked for shared operations with adequate pavement markings and signage. If an entire bicycle facility is blocked by construction or not ridable due to poor pavement, other facilities may not exist in the vicinity. Detours that are comfortable for motorists may be too distant for bicyclists.

Contractors should be encouraged to leave bicycle facility access open. In most cases, the work only uses a portion of the street and since bicycle facilities are narrower than motor vehicle facilities, a path can be maintained with adequate maintenance of traffic.

Figure 12 – Example maintenance of traffic that leaves an adjacent buffered bicycle lane open in Chicago

Some debris, blockage, or maintenance issues may prohibit use of a barrier separated bicycle lane, which may require a bicyclist to dismount to navigate around the obstacle. See the Separated Bicycle Lane report for more maintenance information.

Typical Infrastructure

The bicycle facilities vary between what materials, equipment, and restrictions are imposed on maintenance procedures. The impact matrix includes several columns on these items. Additionally, several common maintenance tasks are evident and apply to most of the bicycle facilities. They include pavement marking restriping, signage upkeep, and signalization maintenance. These form the basics of any bicycle facility and should be kept visible and working. Appropriate pavement marking material should be used, typically thermoplastic markings in Illinois. If green pavement is utilized, it should be maintained as well, especially since it is often placed in conflict areas. Certain green pavement materials exist with long lifetimes. Consult the maintenance section in the Bicycle Intersection Markings report for more detailed information on green pavement and the material options available.

Street Sweeping & Snow Removal

Debris, gravel, and broken glass discourage bicyclists from using the facility and decreases comfort. The debris should be collected within curbed sections or pushed off on shoulder sections as long as it does not collect on adjacent paths, shoulders, or sidewalks. AASHTO recommends street sweeping be instituted at the request of users that report deficiencies or as part of a regularly scheduled program. Extra sweeping may also be needed after the winter season due to the grit left over by melting snow. Other areas that require frequent sweeping include those prone to flooding, streets near large event areas, or areas that witness frequent vandalism and littering.

Figure 13 – Road grit and a broken bollard left from melting winter snow on the Vincennes buffered bicycle lane in Chicago

As mentioned in the section on the effects of maintenance on safety, snow and ice is one of the leading causes of single bicycle crashes and most likely contribute significantly to vehicle-bicycle crashes. Therefore, snow removal needs to be a priority for any maintenance agency. Many challenges exist with keeping bicycle facilities clear of snow. Since many bicycle facilities are placed along the edge of the roadway, plows may only exacerbate the problem by pushing snow onto the facility. In urban areas, many business owners often shovel snow into the street to clear the sidewalks. Snow removal should not be delegated or left with local agencies unless an agreement is developed to ensure year-round snow-removal.

Figure 14 - Many cities experience challenges with snow removal and storage, especially in urban areas. In the image above, a nearby construction crew used a front loader to clear a separated bicycle lane in Chicago. However, the snow was piled at the end blocking the bicyclist's exit.

Many facilities can be swept or plowed with traditional vehicles or plows. Some facilities, like separated bicycle lanes, require specialized equipment that fit within the width of the lane. One way to alleviate challenges with separated bike lanes (SBL) during winter months is to remove the bollards or separation and reinstall in the spring. Traditional street plows can then be used to plow the lane. If specialized equipment is required, the cost should decrease as a network of similar facilities are built. The network allows the vehicles to perform a more efficient cleaning route and reduce the need to circulate the vehicle around to various facilities. CDOT is utilizing a similar approach for their network building goals. Consult the separated bicycle lanes facility report for an example list with costs and specifications of several narrow-body vehicles.

Figure 15 - Plowed and salted two-way separated bicycle lane in Chicago

Utility Cuts

Utility cuts often degrade the surface for bicyclists. Repairs are sometimes inadequate or use rough concrete patches. Patches should be flush and level; AASHTO points out that asphalt bumps will not be smoothed by traffic. Compaction should be used. Avoid using cold-patch material. Utility contractors often do not consider the operations of bicyclists and may shut down the lane without providing adequate alternatives. Bicycle facilities should be treated with the same respect as the motor vehicle lanes and ensure they are operable during construction. Plates should cover pavement cuts, ideally with grip-textured plates and ramped edges. CDOT requires contractors to install ramps consisting of bituminous asphalt, cold patch material, or plate locking systems when plates are installed over the path of bicycle traffic.[19]

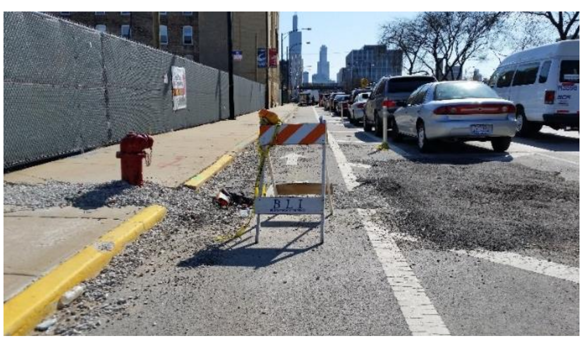


Figure 16 - Trench work completed for a fire hydrant. The bicycle lane pavement was left open with aggregate and the adjacent parking lane was patched with uneven asphalt.

Drainage

Drainage issues contribute to slipperiness, a major cause of single bicycle crashes. Drainage issues may also lead to icing. Furthermore, drainage facilities often degrade over time or bicycle facilities are installed as retrofits on existing roadways with deteriorating drainage. Therefore, extra attention should be made to ensure drainage is adequate before and after installation. Certain facilities elicit additional challenges especially if a physical barrier is used. Since many bicycle facilities are located adjacent to curbs or the edge of pavement, small drainage issues become large ones for bicyclists.

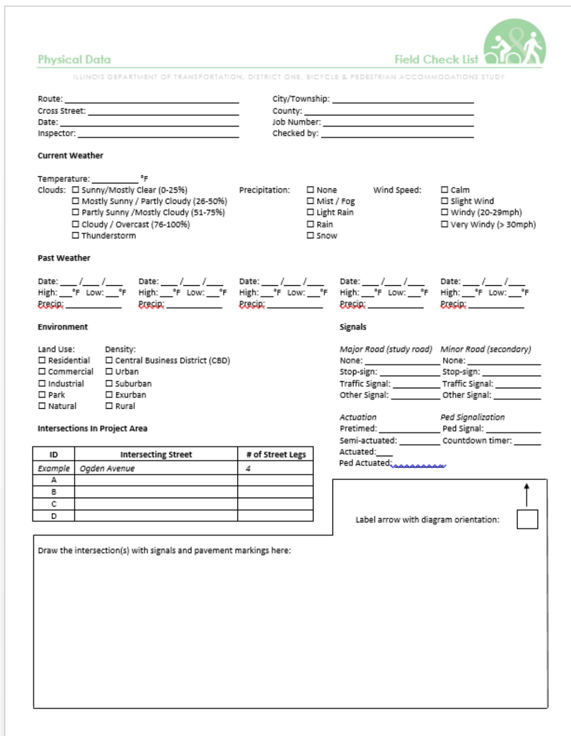
Figure 17 - Ponding on the Dearborn Street two-way separated bicycle lane in Chicago

Pavement

Pavement should be kept in good condition. AASHTO recommends numerous solutions such as small surface repairs, pavement overlays, and chip sealing. The AASHTO Guide to Bicycle Facilities also includes recommendations for patching, joints, and equipment. To reduce long term maintenance, high quality materials should be used. Numerous shared use paths in Illinois were built with inferior materials and are deteriorating faster than typical, rendering many paths unusable or uncomfortable. Ride Illinois suggests using a curb adjacent to asphalt shared used paths to increase durability.

Reporting & Tracking

AASHTO recommends spot-improvement programs that enable bicyclists to report maintenance issues. They suggest an online complaint/comment submission form for public input. All reports, inspections, and maintenance needs should be logged, prioritized, and conducted in a manner so that bicyclists' safety is not jeopardized. The user submitted reporting system can be tied into the sweeping and snow removal program for prompt responses. Other state DOTs have mentioned similar reporting systems.



Physical Data Field Check List

ILLINOIS DEPARTMENT OF TRANSPORTATION, DISTRICT ONE, BICYCLE & PEDESTRIAN ACCOMMODATIONS STUDY

Route: ______ City/Township: ______
Cross Street: ______ County: ______
Date: ______ Job Number: ______
Inspector: ______ Checked by: ______

Current Weather

Temperature: ______ °F
Clouds: ☐ Sunny/Mostly Clear (0-25%) ☐ Mostly Sunny / Partly Cloudy (26-50%) ☐ Partly Sunny /Mostly Cloudy (51-75%) ☐ Cloudy / Overcast (76-100%) ☐ Thunderstorm
Precipitation: ☐ None ☐ Mist / Fog ☐ Light Rain ☐ Rain ☐ Snow
Wind Speed: ☐ Calm ☐ Slight Wind ☐ Windy (20-29mph) ☐ Very Windy (> 30mph)

Past Weather

Date: ___/___/___ High: ___°F Low: ___°F Precip: ______ (×5)

Environment

Land Use: ☐ Residential ☐ Commercial ☐ Industrial ☐ Park ☐ Natural
Density: ☐ Central Business District (CBD) ☐ Urban ☐ Suburban ☐ Exurban ☐ Rural

Signals

Major Road (study road): None: ______ Stop-sign: ______ Traffic Signal: ______ Other Signal: ______
Minor Road (secondary): None: ______ Stop-sign: ______ Traffic Signal: ______ Other Signal: ______

Actuation: Pretimed: ______ Semi-actuated: ______ Actuated: ____ Ped Actuated: ______
Ped Signalization: Ped Signal: ______ Countdown timer: ______

Intersections In Project Area

ID	Intersecting Street	# of Street Legs
Example	*Ogden Avenue*	*4*
A		
B		
C		
D		

Label arrow with diagram orientation:

Draw the intersection(s) with signals and pavement markings here:

Figure 18 - Field checklist developed during this study to document maintenance issues and inventory facilities

IDOT will need to create a central maintenance database or amend current databases with bicycle facility maintenance needs. The database should be updated digitally, ideally with mobile software and devices. This study created and field tested a field checklist to collect data on maintenance deficiencies, among other physical roadway and contextual characteristics. Consult the study's data collection plan in the appendix for more information on IDOT's current database system and field check sheets including the study example.

Funding

Funding is a complex area of bicycle facility planning & design, not only for installation but also in terms of who is responsible for maintaining the facility after construction.

IDOT generally shares funding responsibility with local municipalities for the installation of bicycle and pedestrian facilities if included in an IDOT roadway improvement, depending on the scope and context of the roadway improvement as well as the impacts and costs associated with installation of the facilities. IDOT's policy has been successful at getting municipal participation in and funding of facilities that otherwise may not have been installed or would have been cost prohibitive for the municipality.

On the IDOT roadway system, IDOT generally maintains anything within the roadway whereas sidewalks and shared use paths outside of the roadway are maintained by the local municipalities. Crosswalks and bicycle lane markings are also maintained by the local agency. This maintenance policy is similar to other DOTs such as Minnesota, Washington, and Wisconsin. However, some states maintain everything from curb to curb and do not exclude striping for bicycle and pedestrian facilities. IDOT does reconstruct or restripe a facility if it is impacted by IDOT construction.

For IDOT's current funding and maintenance practices, please refer to the current version of Chapter 5 in the IDOT BDE Manual.

4.0 Pedestrian Facilities

The pedestrian facilities presented in this study focus on facilitating and improving the safety of pedestrian crossings in the roadway. Crossings are a risky part of the pedestrian experience being located where the most conflicts exist. The pedestrian facilities discussed in this report are located at **intersections** or **midblock** locations and are appropriate for varying contexts.

According to AASHTO*,* basic improvements should be considered on all projects such as curbs, speed management, lighting, using narrower lanes/medians, adequate sight distance at crossings, sidewalks on both sides of the street, buffers between the pedestrian and traffic or streetscapes.[21] Since this study only focuses on crossings, these other improvements are not discussed. Instead, visit the following helpful guides for more information:

- AASHTO Information Guide for Roadway Lighting
- AASHTO Roadside Design Guide
- ADA guidelines (PROWAG)
- NACTO Urban Streets Design Guide (Streetscapes)
- Active Transportation Alliance Complete Streets, Complete Networks Guide

Figure 19 - International style crosswalk markings

4.1 General Safety Findings

Similar to bicycle facilities, all of the pedestrian facilities studied in this report improve safety of at least one mode. The extent of that improvement depends on the facility and a combination of other factors such as enforcement, education, and volumes of pedestrians. Consult the Impacts Matrix for an overview of the safety benefits, as well as the individual facility summaries and facility reports for a detailed review of national and local research. Included in this section is information on topics such as intersection crossings, midblock crossings, levels of crosswalk development, grade separation, accessibility and speeding. Other general safety topics applicable to pedestrians and bicyclists may be covered and referenced in Section 3.1: General Bicycle Safety Findings.

Crashes

See the individual facility reports for information on pedestrian crashes within District One. Generally, local crash analyses were inconclusive on several facilities due to the lack of facilities in place to study and a small crash history. Crash rates were not calculated for pedestrian facilities due to the lack of pedestrian count volumes and average annual daily pedestrian conversion factors. As mentioned in the bicycle section, further studies should be performed over the coming years to confirm the safety benefits of various bicycle and pedestrian facilities as more data is collected and made available.

Intersections

At intersections, "turning vehicles and the speed at which they travel posed the greatest threat to pedestrians because the motorist's attention is focused primarily on other motorists."[20] AASHTO's *Guide for the Planning, Design, and Operation of Pedestrian Facilities* further states that all intersections should be "designed with the premise that there will be pedestrians present, that they should be able to cross the street, and that they need to do so safely."[21]

Besides the treatments studied in this report, AASHTO suggests using shorter curb radii, stop bar setbacks, intersection lighting, turn restrictions, and avoiding the use of skewed intersections. AASHTO and Ride Illinois (formerly League of Illinois Bicyclists) also mention the use of channelized right-turn slip lanes (pork chops). They shorten the pedestrian crossing distance and isolate the turning conflicts but increase the size of the intersection and adjacent property impacts. It directs the motorist attention to the pedestrian; however, overly large turning radii should be avoided to reduce impacts. Smaller radii encourage slower speeds, reduce property impacts and reduce risk associated with crashes.

Midblock

In general, IDOT encourages the pedestrian crossing to occur at an intersection in order to create a safer and more predictable crossing for the pedestrian-vehicle conflict. However, midblock crossings are sometimes easier for pedestrians because traffic is only flowing in two directions, versus the multiple directions and turning motorists at an intersection. Midblock crossings also have shorter crossing distances than intersections, especially those with double turn lanes and large turning radii. They are typically installed in areas with high pedestrian volumes around pedestrian generators or locations where pedestrians are crossing anyways. They can also be installed where a shared use path intersects a roadway, regardless of pedestrian volumes.

Motorists may not expect pedestrians to cross midblock therefore enhancements are required. Median refuge islands are one solution that allows for a two-stage crossing. Median islands allow for pedestrians to cross one direction of traffic at a time and provide a refuge to wait for a gap in the next direction. It promotes better visibility for pedestrians as well. See crosswalk development below for more options on enhancing midblock crossings. At a minimum signage should be used. Many enhancements can be used at both intersection and midblock crossings.

Figure 20 - Midblock crossing with median refuge island. Copyright Skyity.com. Reprinted with permission.

Midblock crosswalks require extra accommodations for persons with disabilities or visual impairments as they lack the traditional cues on when to cross safely. They may not know when there is an adequate gap in traffic to cross or when motorists have stopped. Besides tactile warning pads, accessible pedestrian actuated signals with locator tones can be installed to activate any signal device such as rectangular rapid flashing beacons or pedestrian hybrid beacons. Careful consideration should be given to locations were midblock crossings are recommended.

Crosswalk Development

According to the Illinois Vehicle Code, Section 1-113, a crosswalk is "That part of a roadway *at an intersection* included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or, in the absence of curbs, from the edges of the traversable roadway, and in the absence of a sidewalk on one side of the highway, that part of the highway included within the extension of the lateral line of the existing sidewalk to the side of the highway without the sidewalk, with such extension forming a right angle to the centerline of the highway."[22] Additionally, "any portion of a roadway *at an intersection or elsewhere* distinctly indicated for pedestrian crossing by lines or other markings on the surface placed in accordance with the provisions in the Manual adopted by the Department of Transportation as authorized in Section 11-301" (italics added for emphasis).

At an intersection, only one side of the street requires a sidewalk for it to be considered a crosswalk and markings may or may not be present. At a midblock location, striping is required for it to be considered a crosswalk. Crosswalks can take the form of several levels of treatment.

Crosswalk development is considered along the following levels of upgrade: unmarked, marked, and enhanced. Unmarked crosswalks are common throughout the transportation system. While not striped or marked, they are still considered legal crosswalks as mentioned earlier (except midblock as noted). The next phase of crosswalk development are marked crosswalks which includes marking the crosswalk with 6” white parallel lines.

Marking crosswalks require engineering judgment as some locations may actually result in an increase in crashes.[23] According to Zeeger et. al. on roadways of four or more lanes and ADT of 12,000 vehicles per day (vpd), marked crosswalks increase the pedestrian crash rate.[24] Therefore, they are typically only installed in urban areas and on local streets based on the location of nearby crossings, ADT, speed, pedestrian volumes and visibility requirements. For guidance on when and how to install a marked crosswalk refer to the IDOT Bureau of Operations Policy TRA-23. Further information is available in a study by the Virginia Department of Transportation: http://nacto.org/docs/usdg/guidelines_for_installation_marked_crosswalks_dougald.pdf.[25]

Crosswalks can be enhanced beyond simple parallel stripes. Enhancements can include signage, international style markings, and flashers. Enhancements are highly recommended or required for roadways. Several enhancements are discussed in this study. See the Crosswalks Enhancements facility report for a starting point for choosing an appropriate enhancement, especially at midblock crossings.

Figure 21 - Rectangular rapid flashing beacon lights

Crosswalk enhancements required for the following speeds and ADTs		
2 lanes	≥ 40 mph	≥ 12,000 ADT
3 lanes	≥ 40 mph OR 35 mph	≥ 12,000 ADT ≥ 15,000 ADT
4 lanes with median	≥ 40 mph OR all speeds	≥ 9,000 ADT ≥ 15,000 ADT
4 lanes without median	≥ 40 mph OR all speeds	any ADT ≥ 12,000 ADT

Figure 22 - For crosswalks installed in the above conditions, additional enhancements beyond striped lines must be used to achieve a safety benefit- Refer to Operations Policy TRA-23

Grade Separation

Beyond crossings at street level, grade-separated crossings can be used. Completely separating pedestrians from motorist traffic, through the use of underpasses or overpasses, removes all conflicts with motorists.

Therefore, it can be the safest crossing facility but generally requires the greatest cost to design and construct.

Percentage of pedestrians using grade separation if:	
Travel time is same as at-grade crossing	Underpass: 95% Overpass: 70%
Travel time is 50% greater than an at-grade crossing	Near 0%

Figure 23 - Pedestrian behavior study at overpasses and underpasses. The study compared how many people would utilize the grade-separation option when comparing travel times.

Grade separation must be comfortable and not create undue hardship on its users. Pedestrians generally follow the path of least resistance, that is, they walk or cross at areas that require the least effort. They "tend to weigh the perceived safety of using the [overpass/underpass] against the extra effort and time required" to use it.[21] Pedestrians may cross at non-crossing locations or avoid uphill ramps or dark underpasses. The facility must not result in an unnecessarily long path that could be circumvented by other routes, regardless whether the alternate routes are unsafe. Fences at grade crossings should not be used to obstruct pedestrian paths and instead an easier route should be provided that encourages pedestrians to use it with adequate lighting, the least amount of vertical difference, and located on the normal path of pedestrian movements. According to AASHTO, in some cases grade separation may actually decrease safety if not properly located or designed.

Figure 24 - Shared use path and overpass crossing Randall Road at Silver Glenn Road in South Elgin, Illinois

Safety in Numbers

See Bicycle Facility Section 3.1 - General Safety Findings

Surrogate Safety Measures

See Bicycle Facility Section 3.1 - General Safety Findings

Speeding

Speeding is a major influence on 'pre-event' and 'event' phases of a crash (HSM 2010). 'Pre-event' refers to the probability of a crash. With higher speeds, longer stopping distances are required and therefore should be involved in more crashes. However, research has shown a non-linear relationship although the reasons and causes for the relationship are unknown and hard to verify (see the HSM 2010 for more information). Additionally, one study found a greater risk of a crash where the speed of any one motorist exceeds the average speed of all motorists. AASHTO and the HSM still claim, however, that while the "observed data does not clearly support the theory that the probability of involvement in a crash increases with increasing speed, it is still reasonable to believe that higher speeds and longer stopping distances increase the probability of crash involvement and severity" (HSM 2010).

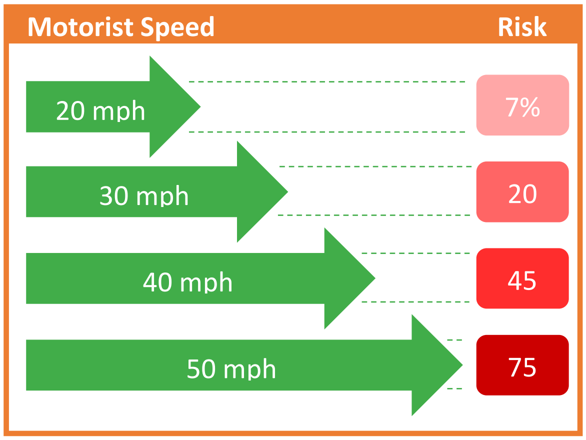


Figure 25 - The risk of death if a pedestrian is struck by a vehicle at varying speeds[26]

Speeds can be observed using a variety of low tech means or using specialized measuring equipment. Numerous studies over several decades have shown that injury severity and the risk of death between motorists and vulnerable road users increases with impact speeds. The latest study found a 45% chance of death if a pedestrian is impacted by a vehicle at 40mph.[26] Previous studies have shown that the chance of death was 85% at the same speed.[27] So while the risk of death and severe injury is decreasing with advances in medicine, safer vehicles, and faster emergency response times, speeding is still a major influence on the outcome of the crash.[28] Therefore, designs that calm traffic by controlling and reducing vehicle speeds are an essential aspect of many bicycle and pedestrian facilities.

The HSM further highlights several studies that have shown the "change in [crashes] is the ratio of the change in average operating speed to the power of 4. These studies refer to total fatal crashes caused by motorist-motorist and motorist-vulnerable road user crashes.

Comfort

See Bicycle Facility Section 3.1 - General Safety Findings

Enforcement

See Bicycle Facility Section 3.1 - General Safety Findings

4.2 General Operations Findings

IDOT is focused on moving *people* and *goods*, not just cars. With that in mind, this feasibility report gives equal weight to the operations of motorists, bicyclists and pedestrians. Throughout each facility report, the impact of the facility on operations of traffic, travel delay, speed, and volumes are presented.

Pedestrians operations are different from motorist operations; different in how it is measured, calculated, and presented. Like bicyclists, pedestrians are undercounted, difficult to measure, and collect data on. This study touches on some of those difficulties and includes steps to improve data collection methods, along with discussions about the delay and volumes of pedestrians. For motorists, the research focuses mostly on volumes, delay and speed.

Operations was given its own independent section for ease of reading and quick reference for concerned bureaus within IDOT. Moreover, this general findings section, and the operations sections within each facility report, only discusses the operations of *traffic*, not how the facility operates. Information on how the facility operates may be provided in the facility description of each facility report, if necessary. As this study is not a design guide, design guidance is omitted and available through the design references or referenced elsewhere.

Walking Trends

Pedestrian volumes are on the rise in the U.S. and Illinois. The longest, most reliable dataset was developed by the American Community Survey (ACS). In 2014, the ACS survey found 6.7% of Chicagoans walked to work as their predominate mode choice. This percentage only captures persons travelling to work and many other walking trips are made daily for recreation, errands or to and from school. The ACS data may also not record the resident's walking trip if they also take public transit into work. The ACS data may underestimate walking trends; however, it provides an overview of walking trends using data going back to 1980.

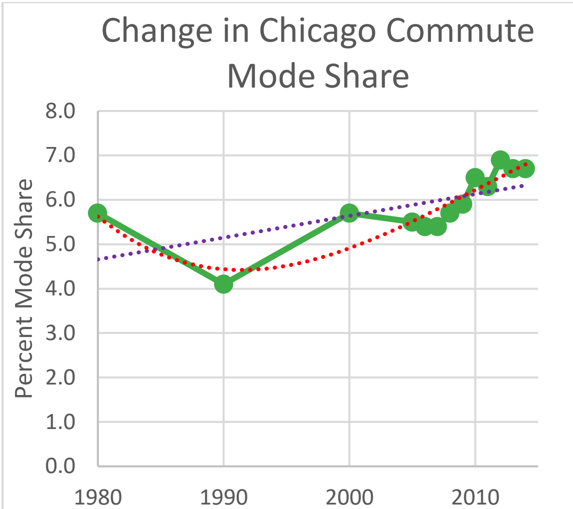


Figure 26 - Change in walking to work mode share based on American Community Survey U.S. Census data from 1980 to 2014

Data Collection & Limitations

Data collection efforts need to increase in order to determine more detailed trends and draw more accurate conclusions about various facilities. Data collection faces various challenges not seen with traditional motorist data collection. Similar to count bicyclists, pedestrians can travel on varying paths that is not conducive to measuring with traditional counting equipment. However, data gaps can be closed through the latest advances in technology and utilizing partnerships with local agencies and advocacy groups. See the data collection section for research on the state of existing efforts in Illinois and the region and solutions for implementing a robust data collection plan.

Figure 27 – Pedestrians at an enhanced crosswalk in Chicago

Motorist Delay

Most pedestrian facilities do not significantly impact motorist operations. Some facilities may increase intersection delay slightly but regardless whether a facility was installed or not, in Illinois, all motorists must come to a complete stop for pedestrians crossing in a marked crosswalk on the roadway and yield in all other encounters on the roadway. Some facilities that remove capacity are often installed in locations with excess capacity, such as the case with road diets.

4.3 General Maintenance Findings

The third and final section of each facility evaluation pertains to maintenance of the facility. Maintenance means keeping the pavement in good condition, sweeping the facility of debris, plowing and salting, maintaining adequate drainage, ensuring signals and detection equipment are operating, restriping pavement markings, and ensuring signage is up to date and correct.

The maintenance section of each facility report has one or more of the following categories. The category discussed depends on the facility type, materials used and important concerns.

- Summary
- Typical Infrastructure to Maintain
- Street Sweeping & Snow Removal
- Utility Cuts and Construction Damage
- Drainage

Similar to bicycle facilities, maintenance should not be an afterthought when designing and installing pedestrian facilities. As the advocacy groups mentioned, users want a properly maintained facility and to be able to use it year round.

Effect on Pedestrian Safety

Maintenance issues affect pedestrians differently than motorists. Pedestrians face many challenges when walking, such as:

- Snow or ice covered sidewalks or crossings that are difficult to walk on.
- Debris or construction that forces a pedestrian into moving traffic. Improper grades that force wheel-chair users into the street.

- Broken or damaged sidewalks.
- Lack of maneuvering space, especially in barrier separated bicycle lanes.
- Flooded curb ramps, or shoulders in areas of no sidewalks.
- Low visibility. Motorist may not see or expect pedestrians, especially at crossings or areas without sidewalks. Note, pedestrians are not required to wear reflective clothing or lights to compensate for this.

Debris, snow, or worn-out markings decrease the effectiveness that markings provide. The safety benefits mentioned in the Impacts Matrix are for clean, clear, and fully maintained facilities. An unusable facility that pushes a pedestrian into the motorist lane completely negates all safety benefits of the facility and may even increase risk in instances where a motorist is not expecting a pedestrian to walk. IDOT does not maintain pedestrian facilities but partners with the local agency in order to maintain these facilities and relies on the local agency enforcement to ensure maintenance is up to date.

Effect on Pedestrian Operations

General construction projects may negatively affect pedestrian operations. Where possible, detours that restrict pedestrians to one side of a roadway should be avoided. Pedestrians may use the side with construction anyways or put themselves in harm's way by walking in the roadway. Detours that seem negligible to a motorist may become cumbersome to a pedestrian. Detours onto the street should use traffic barriers and temporary ramps so persons with disabilities can utilize the detour.

Typical Infrastructure

Pedestrian facilities vary between what materials, equipment, and restrictions are imposed on maintenance procedures. The Impacts Matrix includes several columns on these items. Additionally, several common maintenance tasks are evident and apply to most facilities. They include pavement marking restriping, signage upkeep, and signalization maintenance. These form the basics of any facility and should be kept visible and working. Appropriate pavement marking material should be used, typically thermoplastic markings in Illinois.

Figure 28 - Example maintenance of traffic that provides a temporary handicap accessible ramp for the pedestrian detour

Street Sweeping & Snow Removal

Debris, gravel, and broken glass discourage pedestrians from using the facility and decreases comfortability. Extra sweeping may also be needed after the winter season due to the grit left over by melting snow. Other areas that require frequent sweeping include those prone to flooding, streets near large event areas, or areas that witness frequent vandalism and littering. Ice is hazardous to pedestrians, especially the elderly or persons with disabilities.

Sweeping and snow removal is a challenging issue for all transportation departments. IDOT typically requires local municipalities to maintain sidewalks, therefore sweeping and snow removal is the responsibility of the municipality. However, many do not have the funds to perform these actions. Some depend on local property owners to clear the snow. In Chicago, the city clears bridges with specialized sidewalk clearing vehicles, similar to one's used to plow separated bicycle lanes. Another challenge is clearing crosswalk entrances that are blocked by street plows. While property owners may clear snow in front of their property, the sidewalk may become blocked at the corner or crossing. Pedestrians with disabilities may not be able to cross, especially wheel-chair bound individuals. Crossings should be subsequently cleared of snow if blocked by plows.

Some facilities can be swept or plowed with specialized sidewalk sweepers or plows. Many areas include a network of sidewalks and crossings that allows a more efficient cleaning route and reduce the need to haul vehicle around to various facilities. Consult the separated bicycle lanes facility report for an example list with costs and specifications for several narrow-body vehicles which can often be used on sidewalks as well as separated bicycle lanes.

Figure 29 - Top: broken curb, brick, and road debris inside a median refuge island. Bottom: pedestrian push button and crosswalk ramp blocked by plowed snow.

Drainage

Drainage is important to sidewalks and shared use paths. Sidewalks and entrances to crosswalk facilities should be designed to properly drain. During major storms, concerns in some areas are flow restrictors which may cause storm water to overflow onto sidewalks. Sidewalks and shared use paths should also be installed adjacent to roadways in the suburbs to avoid forcing pedestrians to use ditches, worn out shoulders, or other areas that may become impassable during storm events.

Pavement

Sidewalk pavement should be kept in good condition. The latest ADA regulations should be followed to maintain a useable sidewalk surface.

Reporting & Tracking

See Bicycle Facility Section 3.3 - General Maintenance Findings

Funding

See Bicycle Facility Section 3.3 - General Maintenance Findings

Accessibility

All ADA guides, regulations and standards should be followed with each facility. ADA regulations do not preclude any facility in this study.

5.0 Outreach

As a part of this study, IDOT District One gathered data, guidance, and recommendations to assess the feasibility of the various bicycle and pedestrian infrastructure improvements. In addition to reviewing international research and internal policies and performing simple field observations, IDOT also sought feedback from users, advocacy groups, and other departments of transportation. IDOT interviewed five state departments of transportation, ten local advocacy groups, and collected over 326 surveys from bicyclists and pedestrians on various facilities. IDOT also surveyed municipal elected officials, engineers and planners. IDOT introduced the Bicycle and Pedestrian Accommodations study to each group and discussed several topics tailored to each state or organization.

5.1 State DOTs

The following state DOTs were interviewed over the phone by the study team: **Massachusetts, Minnesota, Oregon, Washington,** and **Wisconsin**. The **Chicago Department of Transportation** was also interviewed. These states were chosen based on several factors: the League of American Bicyclists rating[29], the number of bicycle friendly communities in the state, the Bicycling Magazine City Ranking[30], The FHWA Walking Friendly Community rating[31] and Governing's Walk to Work score for large cities.[32] Initial research was performed on what bicycle and pedestrian facilities types were present in the state and cross-checked against the IDOT study list. Districts similar to IDOT District One were identified, especially if it had a large metropolitan area. Finally, climate was another deciding factor; several states interviewed had climates similar to Northeastern Illinois or were located in the Midwest.

Figure 30 - Frequently mentioned words during the State DOT interviews

The calls lasted one to two hours and included at least two bicycle and pedestrian coordinators from each state (with the exception of Washington, who only had one coordinator on the call). Detailed minutes are included in the appendix.

Topics included:

- Policy (includes research endorsements)
- Funding
- Design guides
- Evaluation studies
- Count programs
- Maintenance
- Facility use, inventory, & GIS systems
- Public involvement
- Training
- Challenges

IDOT also gave a brief overview of Illinois' bicycle and pedestrian initiatives, policies and structure. IDOT fielded questions from the other states and encouraged a lasting relationship amongst both state's bicycle and pedestrian initiatives. It should be noted that since the outreach was limited to less than two hours, some discussions were heavily weighted toward certain topics depending on how the conversation progressed. This summary is not meant as a complete picture of each state's bicycle and pedestrian program. Due to time constraints, some topics were not covered. Please refer to Appendix C for meeting minutes.

State DOT Highlights

Overall, neighboring states (Oregon & Washington, Minnesota and Wisconsin), seemed to have similar policies and procedures. All states have initiatives that promote bicyclist and pedestrian projects. Specialized staff members are dedicated to various roles and bureaus, some integrated throughout the department and others with centralized staff. Connections and partnerships were an overarching theme throughout each topic, such as a partnership with a state advocacy group, or utilizing volunteers from the public for bicycle counts.

Many states are undergoing similar challenges on how to pay or who is responsible for maintenance of bicycle and pedestrian facilities, especially if they are off-street. Agreements are typically on a project by project basis and require the involvement and dedication of local jurisdictions.

Bicycle and pedestrian projects remain a small portion of the total state's budgets. Various mechanisms for fund disbursement are used, sometimes on a competitive grant basis. The public's opinion on projects is weighed heavily in many states.

Innovative facilities such as separated bicycle lanes are becoming more prominent in the states interviewed. A couple states have incorporated them in their design guides or created tailored guides for it. The states that do not have specific bicycle and pedestrian design guides typically adopt, endorse or refer to the NACTO Guide.

Policy

All states interviewed have complete streets policies: MassDOT, MnDOT (2014), ODOT (1974, similar to complete streets laws), WSDOT (2011), and WisDOT (2009). WisDOTs complete streets policy was repealed in 2015 with the following change from "ensure bikeways and pedestrian ways are established" to "shall give due consideration to establishing bikeways and pedestrian ways…" Originally, WisDOT had extensive clarification of the law throughout their design manuals and transportation administrative codes.

MassDOT has a checklist for minimum bicycle & pedestrian accommodations. MassDOT's goal is to triple the distance traveled by walking, bicycling, and transit by 2030. MassDOT also developed a complete streets certification program that requires communities to enact a complete streets policy, create an inventory, procedures and processes to incorporate bicycle and pedestrian projects, and a mode share goal. Once certified, the community is eligible for grants. **MnDOT** places their complete streets group within their engineering services and local government division. Their complete streets team is supported by a steering team comprised of local government representatives, environmental staff, and other MnDOT staff. **ODOT** includes bicycle and pedestrian facilities on all new roads, modernizations or reconstructions, however, 3R projects may or may not include facilities. ODOT partners with other large state partners on funds contributions.

WSDOT provided in depth information on their internal bicycle & pedestrian program structure. They recently created a new division called the Engineering Policy and Innovation Division. Created in 2014, it elevates bicycling and walking and interacts with the construction, design, and front offices. WSDOT is moving away from district level bicycle and pedestrian coordinators and will instead focus on bicycle and pedestrian teams in each region. WSDOT also has a 16 year program for bicycle and pedestrian projects, enacted in 2005. WSDOT noted the private sector has built several facilities, including some by Amazon and Google.

WisDOT's program includes statewide and regional bicycle and pedestrian coordinators. They also have a staff member in the standards unit developing design standards for their facility development manual. Exemptions are allowed if a local municipality refused to maintain the facility and passes an ordinance that they will not construct it.

CDOT, on the other hand, does not have a sole bicycle and pedestrian coordinator. These initiatives instead fall under two sections: Traffic Design and Citywide Services, both within the Division of Project Development. Outside of these sections, CDOT staff also collaborates on bicycle and pedestrian projects. For example, projects such as streetscapes will include bicycle and pedestrian facilities. CDOT has a robust ADA program which addresses accessibility barriers with various city improvements beyond just roadway or bicycle projects.

Funding

MassDOT funds the entire project construction cost, however sometimes the municipality will pay for the design. Municipalities also must pass a complete streets policy to receive funds from a new state transportation bond bill. **MnDOT** retains ownership and must maintain all facilities within their right-of-way, however, cost participation may vary on certain projects depending on the circumstances. **ODOT** pays for 100% of the facility cost unless it's a competitive grant process. **WSDOT's** complete street policy was mostly geared towards funding in the form of local grants. Washington also requires the department to spend a minimum of 0.3% of the total transportation budget on improving bicycling and walking conditions. Combined with other sources, their total budget is $30 million annually. WSDOT does not have a policy on cost sharing, they approach cities for partnerships on sidewalks. If a partnership cannot be agreed upon, WSDOT will build the sidewalk but not maintain it. **WisDOT** has an 80/20% funding split with local municipalities. However, they cover 100% of facilities on state highways. WisDOT pays 100% for sidewalks, with resurfacing completed at the 80/20% split.

CDOT pays for projects by incorporating them in streetscape or resurfacing projects, or using CMAQ, TIF, aldermanic menu funds, G.O. Bonds, or Divvy revenues. Each alderman receives approximately $1.3 million a year in menu funds which are used for infrastructure improvements in their wards, including bicycle lanes, bicycle boulevards, restriping old lanes, bicycle parking or corrals. Some wards do participatory budgeting and most of the time at least one bicycle project gets chosen.

CDOT also received $2.5 million in sponsorship funds from BlueCross BlueShield through their Divvy Bicycle Share arrangement. Some projects are also paid for through partnerships on storm water management initiatives, HSIP funds, Walk to Transit and Safe Routes to School sources. Also of note is CDOT and IDOT's use of jurisdictional transfers. CDOT has used them in the past; East-West Wacker Drive is one example.

Design Guides

Most states endorse, support, or recognize the NACTO Urban Bikeway Design Guide or the Urban Streets Design Guide (Figure 31). The wording varies between states with some hesitant to use the word endorse. However, all states utilize the NACTO guides in their design regardless of the level of endorsement. They either use the guide's outright or incorporate it

State DOTs and NACTO	
Massachusetts	Endorses
Minnesota	Supports
Oregon	Recognizes
Washington	Endorses
Wisconsin	Defers to FHWA

Figure 31 - State DOT language regarding the NACTO guides

into their own design manuals. WisDOT mentioned they refer to the FHWA memo in support of the NACTO guides.

MassDOT developed a Separated Bike Lane Design Guide that includes intersection designs, signal timings, pedestrian islands, and signal progression for bicycles and pedestrians among a basic separated bicycle lane guide. **MnDOT** developed a best practices guide with proven, tried and experimental categories. They also have a separate bikeway design guide separate from their traffic engineering manual. Their latest revision to the bikeway guide will reflect AASTHO and NACTO guides. **ODOT** also developed a Bicycle and Pedestrian Design Guide and is in the process of updating it. **WSDOT** provided a poster based on NACTO concepts that showcase various Washington facilities. **WisDOT** developed a Bicyclist Design Manual and a Pedestrian Best Practices Guide. WisDOT also originally had a 47 page chapter in their manual with check sheets on incorporating bicycle and pedestrian designs. On-street bicycle facilities have 15 levels of alternatives and contain different thresholds for urban and rural areas. It is unknown whether that chapter will stay with the recent modification to the complete streets policy. While not discussed during the interview, it's worth noting that **CDOT** developed a Complete Streets guideline. The guide includes insight on several facilities from our study.

Evaluation studies

Only two states reported performing evaluation studies on three facilities:

MassDOT mentioned a report due summer 2015 on before and after data for Road Diets. **WisDOT** performed studies on RRFBs and HAWK signals and found compliance rates to be lower than the national average. WisDOT believes a median refuge island would increase compliance rates with an increased focus on education, outreach and enforcement.

CDOT scales their data collection effort based on the impact of the project. They have collected data in the past regarding travel delay, speed, and signal compliance. CDOT does not have dedicated staff nor funding for before and after data collection.

Count Programs

In Massachusetts (**MassDOT**), the local MPO performed counts only on a shared use path. **MnDOT** has experience with temporary and permanent counting equipment including two permanent counters on a state suburban/exurban roadway and a trunk highway. MnDOT is also developing an equipment and standards training program for other jurisdictions that are inputting count data into the statewide database. MnDOT plans to install more permanent counters to reduce error and will incorporate the data into the vehicle traffic system. MnDOT also calculated AADB factors from a larger dataset.

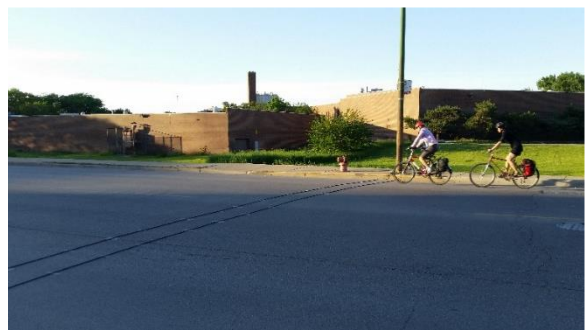


Figure 32 - Pneumatic tubes collecting short term bicycle counts on Clybourn Street in Chicago

ODOT performs manual counts with volunteers and has permanent counters on some routes. They utilize inductive loop detectors on multi-use paths. ODOT also created an adjustment factor to correct errors in the inductive loops. ODOT is working with Portland State University to develop a system that takes information from vehicle counters, push buttons, and loop detectors to feed into a central tracking system. **WSDOT** also performs manual counts through volunteers and has permanent inductive loop counters installed at six locations with a $300,000 grant. WSDOT's count data is managed by the WSDOT data office and is open and shareable.

CDOT has been performing manual counts on bicyclists as well. CDOT will install a permanent infrared detector shortly to count pedestrians. A few manufacturers have also installed test equipment with varying levels of success. CDOT and IDOT agree that CMAP is the best agency to standardize the myriad ongoing count programs in the region.

Maintenance

Maintenance discussions included varying advice, tools and equipment dependent on the level of facility installed in each state.

MassDOT maintains the roadway and municipalities maintain the sidewalk. Their Separated Bike Lane Design Guide includes a chapter on maintenance. Snow removal is MassDOT's largest concern. They have sidewalk plows and mentioned the City of Boston purchased specialized equipment for their SBLs. MassDOT mentioned the necessity for trash removal vehicles to include arms that extend over the barrier and pick up trash receptacles. They are also in discussions with utility companies for other requirements such as vacuum trucks that clean out catch basins over the barrier of separated lanes, like Figure 33.

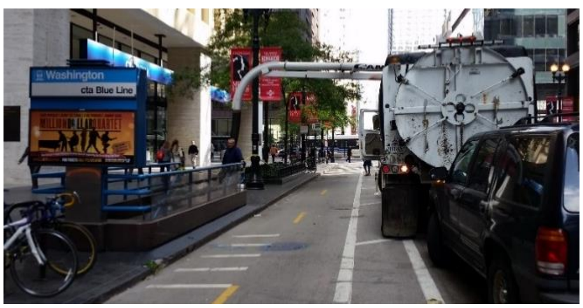


Figure 33 - Vacuum truck cleaning a subway station with boom extending over the two-way separated bicycle lane. Located on Dearborn Street in Chicago.

ODOT and **WSDOT** are only responsible for maintaining areas between the curbs with local jurisdictions responsible for areas outside the curbs. Although WSDOT mentioned bicycle facilities including shared use trails are a grey area. In Wisconsin, **WisDOT** installs the bicycle facility but the locals maintain the striping.

CDOT elaborated on maintenance of several facilities. With SBLs, they mentioned low points in the roadway require extra attention. Usually if additional inlets are required, or utilities require adjustment prior to installation or as a result of a deficiency noted after installation, then the city will compromise on the barrier and create cutouts instead to reduce cost. CDOT specifies a 7.5 feet minimum clear zone for their SBLs outside the loop due to maintenance requirements (SBLs inside the downtown area are 6' wide for passing reasons). Furthermore, CDOT has tested approximately 5-10 vehicles for street sweeping. They recently purchased an Elgin Broom Badger that fits their 7.5 feet wide SBLs. Downtown street sweeping is supplemented by manual hand sweeping. They utilize pick-up trucks for clearing snow as well as a Bombardier with a 4 feet shovel. Further from downtown, CDOT removes the bollards in the winter to allow conventional snow plows to clear the lanes. The CDOT interview minutes also include additional information on maintenance funds and material durability of various green pavements.

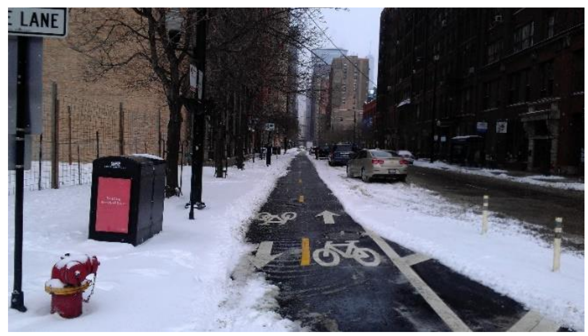


Figure 34 - Plowed and salted two-way separated bicycle lane on Dearborn Street in Chicago

Facility Use, Inventory, & GIS Systems

Each state's use of various bicycle and pedestrian facilities are included in the respective facility reports, typically in the inventory. All five states had some sort of inventory system, some utilizing a GIS based inventory. **MassDOT** allows queries on their system to provide statistics such as the number of miles of a certain facility. MassDOT is working to combine their inventory with their MPO's database and will make it publicly available. **MnDOT** has geocoded and added all pedestrian facilities into GIS and is in the process of adding their bicycling facilities as well. **ODOT** did not mention a GIS database but still had an inventory of all bicycle, pedestrian and ADA facilities. **WSDOT's** inventory has recently started including local data; they have 5 staff members assigned to collecting info. **CDOT** also maintains a GIS inventory; it includes bicycle facilities by type, installation date, and date of last maintenance or upgrade work. CDOT maintains an ADA inventory in a spreadsheet form.

Public involvement

All states have a public involvement process. In **Massachusetts**, the public is supportive of SBLs and have requested them from the DOT. **ODOT** relayed challenges they faced between groups with competing visions for bicycle facilities. One example was a conflict between a local bike club who wanted on-street facilities and a nearby school who wanted an off-road shared use path. **WisDOT** mentioned partnerships with the state advocacy group and education initiatives they developed for motorists, bicyclists, and pedestrians.

WSDOT developed an extensive public involvement initiative in 2008. They held six hearings and an open forum. The intent was to let the public voice their opinion in favor and against accommodations. WSDOT also collected information on unfunded facility needs from local agencies. They found over $1 billion in unfunded bicycle and pedestrian projects desired as part of that effort. They update that list periodically.

CDOT's public involvement process is more nuanced. They hold public meetings as required by IDOT, but for CDOT led projects they typically only hold the meeting with the support and approval of the local alderman. If the public meeting request is denied, it typically leads to termination of the project. CDOT will also go door-to-door for larger projects to solicit feedback and do targeted outreach on sensitive stakeholders that would be impacted the most. CDOT understands the concerns many people may have over various projects but has noticed that opposition decreases significantly anywhere from one to three months after installation. New designs may cause confusion at first before people grow accustomed and learn about the facility.

5.2 Advocacy Groups

The following advocacy groups were interviewed:

- **Active Transportation Alliance**
- **Association of Pedestrian & Bicycle Professionals**
- **Access Living**
- **Ride Illinois (League of Illinois Bicyclists)**
- **National Association of City Transportation Officials**
- **National Center for Biking & Walking**
- **National Complete Streets Coalition**
- **Safe Kids Illinois**
- **Trails for Illinois**
- **Chicago Metropolitan Agency for Planning**

The list includes statewide, suburban and urban groups, with various demographic constituencies. The groups represent member cities, engineers, planners, bicyclists, persons with disabilities, the public and public interest groups. A full-time employee at each group was contacted and interviewed for the study. Many calls included more than one employee from the group.

The groups were chosen based on how established the group was, memberships, location (national, state, local, suburban or urban), and gender representation. Six national groups, or their local chapter, and four local groups were chosen. Two groups did not respond to repeated requests for interviews: Chicago Cycling Club and Chicago Cycling Sisters. They were replaced by Trails for Illinois and CMAP. While CMAP is not considered an advocacy group, they are included here due to their local presence and voice for all the region's stakeholders.

Figure 35 - Frequently mentioned words during the advocacy group interviews

Advocacy Group Highlights

The groups had different goals and constituents; however, several common themes, challenges and requests emerged from the interviews. A frequent challenge reiterated by several groups includes difficulties with acquiring and using funds. The groups report that some communities are unable to provide the 20% local match on certain bicycle and pedestrian projects. If federal funding is available, the local agencies lack the staff or time to navigate the IDOT process for utilizing those funds. Many locals require assistance with the funding, project development, or review process or requested a more streamlined review procedure.

Generally, bicyclists, pedestrians and residents view the newest designs positively and are interested in seeing more advances. SBLs were a frequently mentioned topic. In the suburbs, however, numerous challenges still exist. One common issue was extra-wide multi-lane intersections with long crossing distances; frequently mentioned as being uncomfortable for users which may result in a turnaround point for many users.

Many groups stressed the importance of network connectivity. Infrastructure has been implemented around the region but creating connections should be a top priority. Maintenance is important as well. One group believes that while their members appreciate the newest bicycle designs, they now want to see it open and useable all year.

Several groups discussed design guidance nationally and locally. They understand need for AASHTO, but they highlighted other reputable guides such as the flexibility allowed in the MUTCD, the FHWA SBL, NACTO and ITE guides.

Many training opportunities exist for engineers and planners. A variety of training methods are used by the groups and more trainings are planned in the future. Many groups are eager and interested to team up with IDOT on a training

The calls lasted one to one and a half hours. Detailed minutes are included in Appendix C. Topics were tailored toward each group but generally included the following:

- Organization
- Campaigns
- Challenges
- Requests
- Data sharing
- Maintenance issues
- Partnerships
- State DOTs and governments
- Training
- Resources

The summary of advocacy group interviews are organized by each group since each call discussed various topics.

IDOT also gave a brief overview of Illinois' bicycle and pedestrian initiatives, policies and structure. IDOT fielded any questions. It should be noted that since the outreach was limited to less than two hours, some discussions were heavily weighted toward certain topics depending on how the conversation progressed. This summary is not meant as a complete picture of each advocacy group. Due to time constraints, some topics were not covered.

While guides and references from sources outside IDOT may be discussed, ultimately all IDOT guides and manuals must be adhered to. IDOT design policy is consistent with the AASHTO Guide to Bicycle Facilities and allows the application of many design treatments detailed in NACTO's Urban Bikeway Design Guide and ITE's Designing Walkable Urban Thoroughfares. For all applications the department requires that the requirements of the ILMUTCD be met.

Active Transportation Alliance

The Active Transportation Alliance (ATA) was created over 30 years ago as a bicycle advocacy group that evolved into a bicycle, pedestrian, and transit advocacy group. They host public meetings, perform public media relations work, and recently started a suburban campaign to catalyze bicycle infrastructure in the suburbs. They also develop bicycle and pedestrian plans for many local suburban governments. Safe Crossings, another

ATA campaign, is pedestrian focused and raises awareness about intersection safety. They created a list of the ten most dangerous intersections in Chicago and the suburbs.

ATA believes that bicyclists and pedestrians generally want more progressive facilities being installed, especially a connected network of low-stress facilities. Through their suburban connections, they found that most suburbs do not have the staff or time to navigate the IDOT process for bicycle and pedestrian facilities when using federal funds compared to CDOT which has larger staff.

ATA developed a manual with funding from Cook County, entitled Complete Streets, Complete Networks, it's a guide for engineers, planners, and decision makers tailored to the Cook County region. It involves solutions for various contexts, densities and land uses. ATA supports the use of bus rapid transit (BRT). ATA also mentioned some maintenance concerns with bicycle facilities, but overall, they are the result of a positive outlook on the facilities. For example, residents love riding on the bicycle facilities so now they want to see it maintained and open consistently. A guide tailored toward rural communities was also developed: Complete Streets, Rural Contexts.

Association of Pedestrian & Bicycle Professionals

The Association of Pedestrian & Bicycle Professionals (APBP) is a group of U.S. bicycling and pedestrian professionals, state coordinators, local coordinators, and consultants.

APBP discussed the organization of various state DOTs around the country. They advocated that states should ideally have bicycle and pedestrian coordinators in both the planning and engineering offices. APBP also believes instituting progressive bicycle and pedestrian policies before regulations are enacted allow agencies to save money in the long term such as the case with ADA upgrades in cities around the country.

APBP developed several guides including the *Bike Parking Design Guidelines* and *Designing Facilities for Accessibility* course. They host several webinars on their website on topics ranging from ADA transition plans to bicycle and pedestrian facility design. APBP recommends shorter, 15 minute videos for state DOTs, instead of day long training courses to teach bicycle and pedestrian design. APBP also believes engineers want designs that are clearly documented by AASHTO or IDOT guides; otherwise they feel liable for certain designs leading them to not consider progressive aspects. The last bicycle guide from AASHTO left out cycle tracks which hurt its acceptance, however, the 2017 MUTCD will include progressive advancements such as bicycle boxes, green paint and markings through intersections.

Access Living

Access Living is one of 23 Centers for Independent Living in Illinois. Access Living offers people with disabilities the tools for accessing opportunities. The center hosts programs on housing, education, healthcare, and other issues. They identify barriers to independence and allow people with disabilities to be fully included in their communities and live where they want to live.

One of their concerns includes certain bicycle facilities pushing out parking and creating potential conflicts with wheelchairs unloading. Impassable sidewalks and bus stops blocked by snow is also a challenge in the winter and persons with mobility devices may use the adjacent bicycle lane or motorist lane. Access Living requested larger sidewalks, safe and accessible intersection crossings, and crosswalk, ramps and sidewalks be kept in good condition. They are interested in audible pedestrian signals as well. Access Living mentioned the lack of sidewalks, especially at bus stops, as a concern in the suburbs.

Ride Illinois

Ride Illinois, formerly known as the League of Illinois Bicyclists, was formed in 1992 and is a statewide organization comprised of 1700 members. Their main interest is bicycle friendly road design. They focus on AASHTO guide advocacy, infrastructure advocacy at the policy and project level, and also the IDOT multi-year plan. They perform consultant work, host seminars and manage the state http://www.bikesafetyquiz.com/ website.

Ride Illinois discussed several challenges Illinois bicyclists face. Within the urban and grid-level street context, crossings of arterial roads are barriers at non-signalized streets. Signal detection should ensure bicyclists are recognized. Cycle tracks, also known as separated bicycle lanes (SBL), are a positive facility for a broad range of bicyclists. The suburban network, on the other hand, is the most difficult area for bicycle travel. It requires heavy reliance on arterial roadways and often has inadequate bicycle facilities. Sidepaths work well, especially on busy, high speed roads without crossings. However, getting the 20% local match can be difficult at times leading to delays and redesigns or even gaps in the network. Ride Illinois recommends policy flexibility by using paved shoulders in these instances. Ride Illinois also believes five foot sidewalks could be used where no bicycle accommodations are present but the 2010 IDOT policy did not address this. In the rural network, rumble strips are a concern. Ride Illinois recommends gaps in the rumble strips and a 4" separation from edge line to the strip. They also recommend a minimum three-foot clear area beyond the rumble strip, whereas the FHWA recommends a four-foot clear area. If the generous widened shoulder policy can't be met on certain roads, the pre-2010 policy should be considered at a minimum.

Intersections are a major concern for Ride Illinois. They believe motorist operations are taking priority with stop bars being pushed back and large turning radii being installed. This leads to long crossing distances and crosswalks further from the parallel route. Ride Illinois advocates the use of right-turn corner islands which isolate motorist turning motions and conflicts. Ride Illinois' anecdotal observations suggest higher yielding rates with corner islands. Many bicyclists also prefer midblock crossings because of the multiple conflicts associated with intersections; a midblock crossing with a median is preferable to wide multilane suburban intersections. Ride Illinois also mentioned a treatment for suburban contexts which they call a "combined bicycle/parking lane". The combined lane can be a parking lane that experiences only occasional use. If a vehicle is parked in the lane, the bicyclist can pass around it but generally uses the lane as a bicycle lane. The road can be signed as a MUTCD bike route without bicycle lane signs.

Ride Illinois advocates for increased flexibility in the BDE Chapter 17 design standards. They encouraged the use of a hierarchal structure of backup design options. Ride Illinois also mentioned many engineers and planners do not receive adequate bicycle and pedestrian training opportunities in college or continuing education; extra training programs should be made available. Ride Illinois is interested in teaming up with IDOT on a training program.

Ride Illinois followed up with several design documents and a review of the IDOT Bike Plan, attached with the minutes in Appendix A. Additional details on Ride Illinois' many recommendations are also included in the minutes.

National Association of City Transportation Officials

The National Association of City Transportation Officials (NACTO) is a non-profit association that represents large cities on transportation issues. NACTO develops guidance and helps cities achieve their urban transportation goals, especially bicycle and pedestrian goals. NACTO performs training, workshops, and conferences. They encourage communications amongst member cities.

NACTO developed the *Urban Bikeway Design Guide (UBDG)* and the *Urban Streets Design Guide (USDG)*. The UBDG received endorsement from 41 U.S. cities and eight states. The FHWA also supports the use of the NACTO guides. The guides are developed through a member peer group review process involving planners and engineers from various cities. Additional review is provided by consultants, city officials, and policy staff. Technical review is performed by a professional engineer. All facilities in the NACTO guides have been constructed and tested in member cities and/or exist in other U.S. guidance. NACTO is updating the UBDG shortly. The USDG was released in 2013. Additional comments on specific facilities within the guides are included in the NACTO minutes.

The guides include resources beyond design guidance such as performance measures, intersection LOS, maintenance topics, and links to innumerable research reports. Hard copies are not required, and the online versions are great resources for every engineer and planner.

NACTO discussed the challenges state DOTs face such as the requirement to accommodate large trucks. On the other hand, the biggest challenges facing cities are obtaining approval from the state and applying funding. As a result of state control in certain situations, some cities are afraid of supporting innovative bicycle and pedestrian facilities. NACTO believes the next area of focus for cities is expanding out their network of bicycle facilities, reconnecting their pedestrian networks, and improving transit street designs.

NACTO hosts full day workshops with presentations and design charrettes where participants critique each other's designs. NACTO also hosts the annual Designing Cities Conference. They are teaming up with ITE with FHWA support on a USDG training series and workshops. NACTO has teamed with APBP, ITE and other groups for webinars in the past.

National Center for Biking & Walking

The National Center for Biking and Walking (NCBW) was founded in 1977 as the Bike Federation of America. Similar to ATA, they also evolved into a pro-biking *and* walking group. They offer pro bono technical assistance, perform Safe Routes to School (SRTS) work (SRTS is a federal program that provides funding to state DOTs to address inadequacies with walking and bicycling to school), and collaborate with the League of American Bicyclists and Rails to Trails. Their primary role is hosting the ProWalkProBikeProPlace conference every two years and assembling the CenterLines newsletter.

NCBW discussed various topics. They mentioned how they worked with NJDOT to setup a program to oversee implementation and open up funding for SRTS. Locals were also having trouble navigating the competitive process. NJDOT now prequalifies some consultants that the locals can choose from to assist with their LTAP program. PennDOT provides funding for technical assistance to local governments to help with management.

For more information, NCBW suggested several contacts throughout the U.S. for specific issues. See the minutes for contact information and qualifications.

National Complete Streets Coalition

The National Complete Streets Coalition (NCSC), represents many professional organizations such as the American Planning Association and the American Society of Landscape Architects for example. NCSC's provides a forum for interested groups to collaborate and advance the complete streets movement. They create and share resources on policy implementation, offer workshops, and work with local groups or public agencies.

NCSC recommended the ITE Engineering Handbook (released in January 2016). It includes updated design standards such as using a ten foot or less lane width for urban areas with speeds of 45mph or less. NCSC develops various guides with performance measures available for free on its website (see here). NCSC agrees with CDOT's modal hierarchy change where the most vulnerable users are generally put first. NCSC agrees with the context sensitive nature of the hierarchy as well but understands adoption of CDOT's hierarchy is difficult in other municipalities or larger regions.

NCSC endorses and recommends the NACTO guides, the ITE/Congress for the New Urbanism Designing Walkable Urban Thoroughfares: A Context Sensitive Approach, and the FHWA SBL Guide. NCSC also recommended a joint guidebook developed by NJDOT and PennDOT called the Smart Transportation Guidebook. Additionally, the State Smart Transportation Institute (SSTI) published a report that summarizes the work state DOT's are doing overall entitled *Innovative DOT – A Handbook of Policy and Practice.* SSTI is comprised of researchers that publish technical guidance on sharing ideas and collaborating with various state DOTs. NCSC believes states should integrate the ideas coming out of cities into the

AASHTO guides although they understand cities and counties can move quicker with new designs because of the smaller bureaucracies.

Finally, NCSC stated that suburban land use patterns don't preclude suburbs from being friendly for walking, bicycling, or transit use. There is still a demand for multimodal access.

Safe Kids Illinois

Safe Kids is an organization dedicated to preventing injuries in children. They work with a network of over 500 coalitions in the U.S. with partners in 25 countries to reduce injuries from motor vehicles, sports, drownings, falls, burns, poisonings, and other causes. Safe Kids Illinois provides staff, operation support, and other resources to assist in achieving their goal. They implement evidence based programs such as car-seat checkups and safety workshops. One of their focuses is the perception of crossing streets safely. They have observed people engaging in unsafe behavior and understand that safety issues are often a result of poor user choices; therefore, education is an important element of their outreach.

Safe Kids has cooperated on several studies, including crash hot spot analysis in Chicago, a bump out study, and behavioral study. They highlighted the difficulty with collecting injury data on bicycling and walking due to the low crash rates associated with those modes. Safe Kids Illinois is actively engaged with education initiatives throughout the region, including cooperating with the CDOT Bicycling Ambassadors.

Trails for Illinois

Trails for Illinois (TFI) is a statewide advocacy group that promotes trail projects. Their projects include the recently opened Cal Sag Trail, Big Marsh Bicycle Park, and various other trails and projects. They work with the Chicago Park District, regional counties, and other groups.

TFI found that the majority of users are using trails such as the Great Western Trail or Illinois Prairie Path for recreation, health, and fitness. Some users also use the trails for riding to work. Connectivity is the dominant concern over the last 30 years. It's largely being solved in Northeast Illinois although some gaps and issues still exist. In one year, the regional trail system may become the most connected trail system in the U.S. with 500 miles of connected trails. In Illinois, the connectivity issue is solved by creating flexible routes that use multiple rights-of-way. Street crossings are another major concern according to TFI. Most crossings have basic pedestrian facilities that may not serve the trail user very well. For instance, many crossings require bicyclists to slow down, stop, then speed up, which can be irritating to bicyclists. Large intersections are difficult to navigate and uncomfortable. They become a turnaround point for many trail users.

TFI discussed several other topics include trail crowding, etiquette, potential widening, or user separation. TFI believes the ten foot wide trail standard should be revisited. TFI also supports the use of lighting along trails but understands installations can be controversial. Lighting is typically the local municipality's decision. Other best practices recommended by TFI include median refuge islands or right turn corner islands. Also recommended are mid-block crossings in some circumstances which may result in increased crossing comfort. Although, intersections are preferable to some users as well since they may be more comfortable crossing with a signal. TFI recommends RRFBs due to their low cost and ease of installation. Trail maintenance is an important concern. Some best practices include using a flush concrete curb along the asphalt path to increase pavement longevity, or using gravel which is a viable, low cost alternative to maintaining asphalt trails. Snow removal depends on what purpose the municipality want's the trail to serve during the winter such as for fat bikes/skiers or bicyclists.

TFI performs trail counts through their Making Trails Count initiative. They have many long term counts of combined bicyclists and pedestrians. They are interested in installing additional counters along the Cal-Sag Trail.

Chicago Metropolitan Agency for Planning

The Chicago Metropolitan Agency for Planning (CMAP) has a Bicycle & Pedestrian Task Force, an advisory body that coordinates all stakeholders around bicycle and pedestrian issues and opportunities. The Task Force is comprised of representatives for the region's counties, municipalities, Councils of Mayors, Forest Preserve Districts, federal and state transportation agencies (including IDOT), advocacy organizations, and other entities seeking improvement in bicycle and pedestrian accommodations and conditions in Northeastern Illinois.

CMAP coordinates with IDOT as required by federal law. It also engages with local agencies through the Local Technical Assistance program (LTA) and assists them with developing bicycle and pedestrian plans. CMAP developed and published criteria by which they fund bicycle and pedestrian projects through the Transportation Alternatives Program (TAP) and the Congestion, Mitigation and Air Quality (CMAQ) Improvement program. The methodologies and criteria used to review and evaluate proposals for TAP and CMAQ funds are available online on CMAP's website.

CMAP maintains a blog with regional bicycle and pedestrian news, and organizes workshops and training. CMAP believes opportunities exist for expanding IDOT's training programs to include local officials and agency staff in their training. CMAP developed the Local Ordinances and Toolkits program in order to showcase planning and policy resources for local agencies.

CMAP understands the need for a consistent, long term approach to collecting bicycle and pedestrian volumes. They are open to improving the count and database system (Bikeway Information System [BIS]) with IDOT and also have internal plans for updates. For more details on the current data collection system see the minutes.

Through CMAP's surveys, they found that residents generally want progressive bikeway facilities that will improve conditions for bicycling, bicycle safety, and network connectivity. The surveys also consistently indicate that local and subregional officials, transportation professionals, and residents perceive that one, if not the biggest, challenge to safe and convenient bicycling and walking in our region is the high speed, high volume arterial roadways – often under state jurisdiction – which were planned, designed, and built primarily to move automobiles at the highest possible speed.

In addition, survey respondents from municipal and county DOTs, public works and planning departments, and other agencies have consistently expressed the need to allow for and encourage flexibility in design. Roads which serve long-distance regional travel, but also serve more local and multimodal travel in certain segments, should have decreased speed limits and different designs, cross sections and goals as they enter and pass through an urbanized area (which is the majority of District One).

CMAP recommends IDOT include more up-to-date standards such as NACTO, ITE Guides, FHWA resources, and AASHTO's latest bikeway design guide. Overall, CMAP sees bicycle and pedestrian accommodations as part of the modernization of the transportation system called for in GO TO 2040 and many other plans, including IDOT's long range plans. Modernization means creating a transportation network that is up to date, contemporary, works for all users, and is sustainable in the future. It involves integrating land use and context into the transportation system. Other challenges identified by CMAP include local agency funding; the 20% match is sometimes difficult for municipalities to achieve.

5.3 Public Involvement

Public involvement also occurred with surveys. Over 300 bicyclists and pedestrians were interviewed as a part of the facility evaluation phase and described in each facility report. A summary of responses to opened-ended comments is provided below. Additionally, a total of 50 community representatives were surveyed during the 2013 Illinois Municipal League (IML) conference in Chicago. Most of the representatives were municipal government officials from the District One area. A summary of the IML survey is also included in this section.

Figure 36 - Bicyclist survey on Clybourn Street in Chicago. Handing out postcards with links to the online survey.

User Surveys

Survey data was collected both electronically and in-person for 13 distinct facilities throughout District One and Illinois. Most surveys were performed on a weekday from 7:00am to 9:00am and 4:00pm to 6:00pm. For every field visit, photos and other observational notes were recorded for each facility type with its location or nearest intersection including collection dates and times. The surveys targeted only those people walking or bicycling through the location. In addition to facility specific questions, each survey asked a set of basic questions such as age, gender, how often they biked or walked at the location, and how comfortable they felt using the facility or location.

Figure 37 - Frequently mentioned words submitted by bicyclists and pedestrians throughout District One.

Staff members collected handwritten surveys by those willing to participate onsite while an online survey was used to collect responses by those who wished to participate later. There were a total of **326 unique survey responses collected**. A total of 153 participants filled out the survey onsite while 173 opted for an electronic submittal.

User Survey Highlights

Over 300 surveys were collected from bicyclists and pedestrians in the field. Positive responses regarding innovative bicycle and pedestrian facility implementation outweighed negative input. Most of the comments were geared toward improving the facility in question or bicycling and walking in general which matches what some advocacy groups were saying during the IDOT interviews: bicyclists, pedestrian and residents view the newest designs positively and are interested in seeing more advanced designs continue developing. Installing separated bicycle lanes was the most common response received by bicyclists. Installing a signal or traffic control device was the most common request by pedestrians.

Summary of responses:

- Improve the facility, how do we make it better?
- Suggestions
- Requests
- Few negative remarks

The results of each survey are presented in the respective facility reports. The final question of each survey included a write-in question, typically asking the user if they had any suggestions or comments regarding the facility being studied. Similar open ended responses were grouped into several categories and aggregated together.

Disclaimer: since the question was open ended, and since some facilities may elicit particular responses, this survey has bias toward specific responses, perhaps eliciting more negative comments than may be warranted or specific comments that were only elicited because of the facility's presence. As Ride Illinois mentioned, people want better maintenance because they like the facility, and simply want it to be useable and seek to improve it. Only bicyclists and pedestrian were interviewed. Local residents and motorists were not interviewed due to study cost and time restraints and since the surveys were meant to collect bicyclist and pedestrian comfort level, a surrogate for the facility's effectiveness at improving safety.

Table 3- The number of user surveys completed per facility type online and in-person.

Facility Type	In-person	Online
All-Red Pedestrian Crossing	2	0
Barnes Dance	0	5
Buffered Bicycle Lane	5	0
Curb Bump Outs	0	38
Contra Flow Bicycle Lanes	30	15
Conventional Bicycle Lanes	5	18
HAWK Signals	13	0
Left-Side Bicycle Lanes	28	17
Lighted Crosswalks	11	1
Widened Shoulders	0	12
One-Way Cycle Track	7	65
Raised Ped Crossings	33	2
RRFB	19	0
Total	**153**	**173**

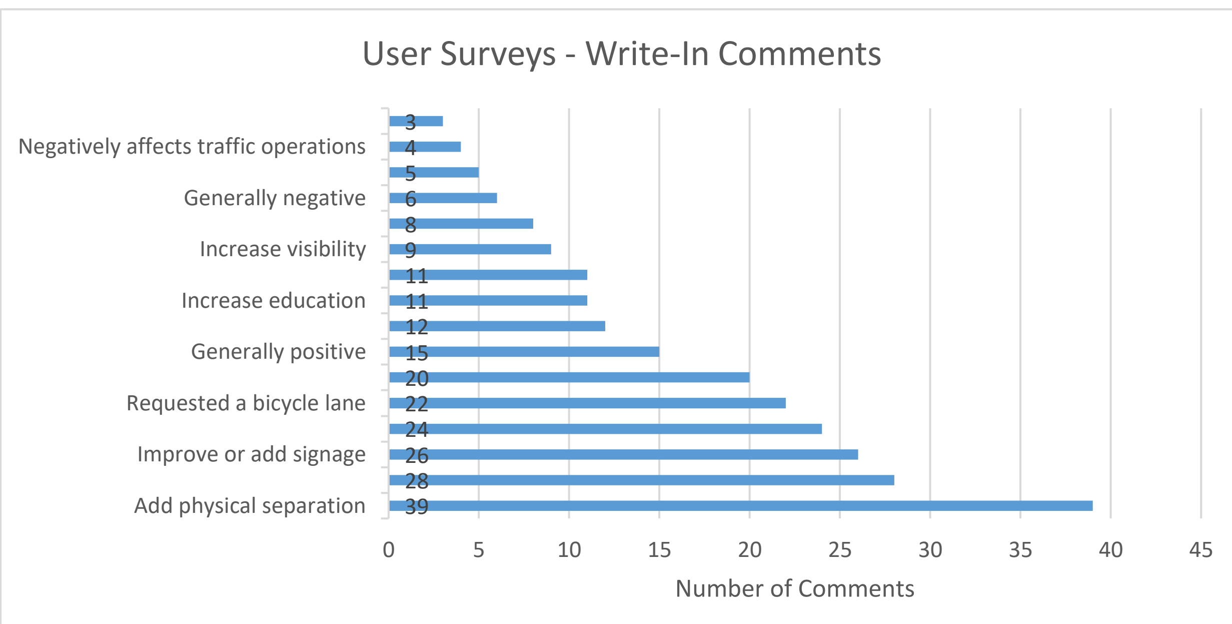


Figure 38- Aggregated responses to the final, open-ended question of the user survey

Illinois Municipal League

A survey was conducted at the Illinois Municipal League (IML) annual conference on October 17-19, 2013. IML gives local municipalities a voice in Illinois legislation and consists of Mayors and Village Presidents across the state of Illinois. The survey collected data regarding bicycle and pedestrian planning, design, usage, and education in their communities.

Survey participants were asked to rank the resources in Figure 39 in terms of how much the item could help the community add or increase bicycle and/or pedestrian facilities. The resource rankings were compiled, and a weighted ranking for each resource was calculated. A full summary of the survey is included in Appendix A.

Illinois Municipal League Survey Highlights

50 surveys were collected, of these 47% of the participants represented IDOT District One. The majority were government officials (89%). Nearly half (49%) of all surveyed participants have neither bicycle nor pedestrian plans in their communities.

The facility that garnered the most interest was the shoulder bikeway with 38% support, followed closely by a standard bicycle lane at 36%. Throughout the survey, the communities indicated that financial support and technical assistance is a major component of implementing bicycle and pedestrian infrastructure. The top three requested resources were found to be, beginning with most important: additional funding, design guidance, and additional resources for maintenance. Another question identified funding as the main hurdle or challenge for each community. 14 of the 25 responses to the open-ended question mentioned funding.

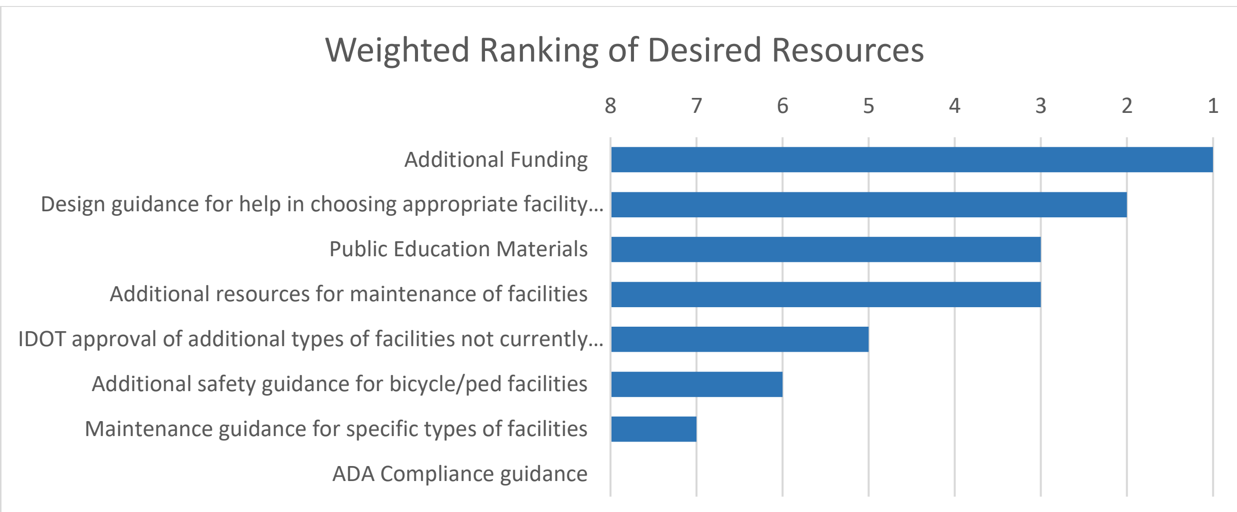


Figure 39 - Ranking of desired resources by respondents to the IML Survey

5.4 Training Recommendations

IDOT can incorporate additional bicycle and pedestrian information into its training programs. IDOT manages two training programs, one is the FHWA financed Technology Transfer (T2) program managed by IDOT's Technology Transfer Center. T2 focuses on training local agencies and consultants and is open to IDOT staff as well if room is available. One class already developed for T2 is the PROWAG training class to instruct locals and consultants on the latest ADA design guidelines. IDOT's other main training program is the professional development program which provides contract document, financing, phase one, land acquisition, and surveying training among other topics. This program is geared toward IDOT employees. In 2017 and 2018 IDOT offered many opportunities for training in the design of pedestrian and bicycle infrastructure with an emphasis on safety. This training was attended by IDOT staff from all districts as well as local agencies. Such training is expected continue on a regular basis.

Many other DOTs also have training programs for various topics. MassDOT developed complete streets training comprised of three to six hour long classes. MnDOT's complete streets staff trains their regional offices on the complete streets policy and cost participation. The bicycle and pedestrian group holds workshops at the community level to discuss ways the community can become more bicycle friendly. MnDOT also sets aside budget for sending staff to conferences and workshops as well. They hope to formalize a bicycle and pedestrian training program in the near future. ODOT also sends staff to training sessions, particularly NACTO trainings. WSDOT hosts a statewide meeting involving multiple DOT offices called Walkable Washington. They also host a statewide bicycle summit and workshops within each region

Audience

Training could be created for engineers and planners as well as policy makers within IDOT and state government. During IDOT's interview with CMAP, they suggested IDOT expand the training programs to include local officials and agency staff in their training. Non-traditional training should be considered. Online training classes can be created to reach a broader audience. APBP recommends shorter, 15 minute videos for state DOTs, instead of day long training courses to teach bicycle and pedestrian design. APBP also believes engineers want designs that are clearly documented by AASHTO or IDOT guides; otherwise they feel liable for certain designs leading them to not consider progressive aspects.

Themes

Many overarching themes in bicycle and pedestrian accommodation can be taught:

Policy	Illinois has a complete streets policy. What is it and what does it mean?
	What are IDOT's priorities? Moving cars or people? Safety or operations?
Guidance	IDOT, FHWA, AASHTO, ITE, NACTO
	Most facilities and treatment specifics are not prohibited by the FHWA MUTCD or the Illinois supplement
	AASHTO already recommends many facilities once considered "innovative"
Facilities	Facility Reports
	All facilities within this study have a proven track record of safety.
	Balancing safety and operations. What are the tradeoffs?

Figure 40 - Possible themes for an expanded IDOT bicycle and pedestrian training program

Format

Numerous training opportunities exist for IDOT. NACTO frequently provides training sessions. IDOT can purchase guidance shown in section 6, notably the AASHTO *Guide for the Development of Bicycle Facilities* and *Guide for the Planning, Design, and Operation of Pedestrian Facilities.* New guidance from AASHTO is expected in the coming years that consider more advanced features such as bicycle boxes, green paint, and markings through intersections. The bicycle guide is expected to be updated in 2020 after balloting by the individual states. AASHTO will also release an update to the pedestrian guide, very likely in 2019.

Figure 41 - Study team members touring a bicycle boulevard during a ride through of Chicago bicycle facilities. Divvy bicycles, part of Chicago's Bicycle Share program, can be used by IDOT staff or consultants that do not own their own bicycle. Vests should be worn during field reviews.

Below are a few training suggestions:

- IDOT bicycle rides and neighborhood walks. Put the engineers and planners in the user's shoes or 'pedals'. Advocacy groups such as the Active Transportation Alliance would likely team up with IDOT for such a program. Such rides as part of training programs were completed in both 2017 and 2018 in Chicago and Champaign. IDOT also previously sent an employee to Europe as part of the FHWA sponsored team to explore bicycle facilities there.
- Develop a training for consultants through T2 or a separate initiative, either within the District or Statewide.
- Update bicycle and pedestrian videos on the T2 video library. Update the library with current FHWA webinars and videos. Team with ITE to showcase their webinars.
- In the future IDOT may consider following a few other states by developing a complete streets certification program. This might require consultants to attend an approved program before submitting on bicycle and pedestrian contracts.

6.0 IDOT Policy and Guidelines

6.1 Path to Implementation

One of the goals of this study is to encourage incorporation of safe and efficient bicycle and pedestrian facilities within IDOT roadway improvement projects. Most of the bicycle and pedestrian facilities within this study are allowed under current FHWA, AASHTO and IDOT standards. In some instances and contexts, national standards even encourage the use of certain facilities. The primary standards that IDOT must comply with are the MUTCD (FHWA) and the department's internal manuals, which are based in large part on AASHTO policies and guides.

The MUTCD explicitly approves several of the facilities in this study. Many others have interim approval (IA) status. Only two features within the bicycle intersection markings facility are given experimental status. Other facilities not mentioned by the MUTCD are allowed if they do not conflict with other requirements. Some facilities are not traffic control devices and are therefore not controlled by the MUTCD.

IDOT manuals, such as the BDE and BLRS manuals, provide rules for installation of bicycle and pedestrian traffic controls, corridor facilities, and physical improvements. Current editions may not provide information on some of the facilities presented in this study.

The purpose of this section is twofold: 1) to collect and identify locations of design guides, and 2) to inform IDOT staff on what is allowed under current regulations and discuss possible obstacles to implementation. Included in the appendix is a design guidance matrix that lists 'mentions' of the facilities in this study within national and local design guides and standards. Any text outside of N/A indicates a mention of that facility within the document at the specified section.

The other guides in the matrix, such as the ITE and NACTO guides, do not preclude the use of the facilities. References to facilities should not be construed as standards but rather suggestions or guidance. This is not a complete list of all guides available to designers but simply a list of the most popular, widely used guides for bicycle and pedestrian infrastructure. The FHWA sponsored Pedestrian and Bicycling Information Center also developed their own matrix with additional design guides and features.

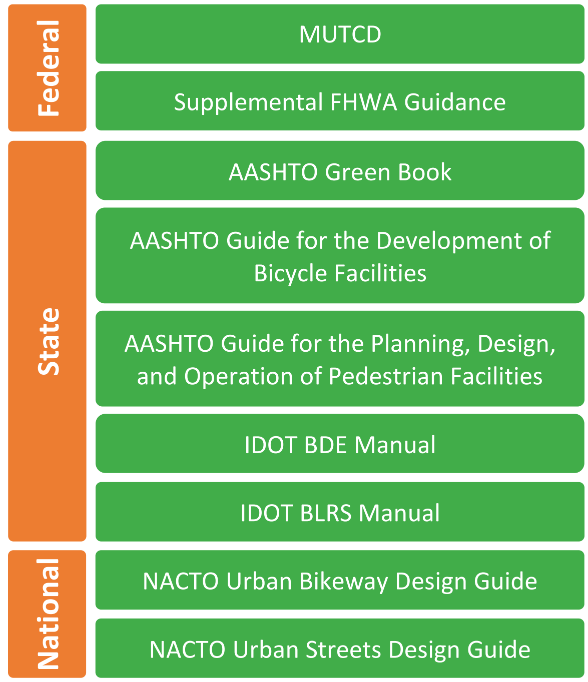


Figure 42 - Example guidance documents

6.2 Federal Guidance

MUTCD

The MUTCD specifically contains standards for installation of several bicycle and pedestrian facilities that are considered traffic control devices. A useful page for bicycle facilities covered under MUTCD is located at http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/index.cfm (A list of pedestrian facilities is not provided by MUTCD). Other facilities not mentioned by the MUTCD can be allowed if they do not conflict with other requirements. Therefore, most of the facilities within this study are allowed by the MUTCD except for a few exceptions as noted below. Additionally, several facilities are available through interim approval, or subject to experimentation. Facilities not included in the lists below are not traffic control devices and therefore not governed by the MUTCD.

The following facilities are approved for use by the MUTCD:

Bicycle

- Intersection markings
- Buffered bicycle lanes
- Left-side bicycle lanes
- Shared lane markings (used in some facilities)
- Contra-flow bicycle lanes

Pedestrian

- Pedestrian hybrid beacons (certain Illinois restrictions apply)
- Lighted crosswalks
- Crosswalk enhancements (certain features)
- Markings on raised crosswalks

The only two features **not** approved for use under the MUTCD as of April 2016 are:

- Combined bicycle lane/turn lanes with a dotted bicycle lane. However, combined turn lanes are allowed if shared-lane markings are used instead.
- Yield bar markings without standard, regulatory yield signs (used on some combined bicycle lane/turn lanes or on the approach to some crosswalks).

Available through Interim Approval

Facilities available through interim approval imply that the facility is pending official rulemaking and are based on FHWA's intention to include the facility in a future rulemaking process for MUTCD revisions. Ride Illinois (formerly the League of Illinois Bicyclists) recommends in comments to the Illinois State Bike Plan that the BDE and BLRS manuals include general statements accepting the design features from the MUTCD, including those available through interim approval.[33]

Interim approvals require less restrictions on their use compared to facilities subject to experimentation. To obtain permission to install a facility with interim approval IDOT must submit a written request to the FHWA and commit to tracking the safety performance of all locations. Blanket permissions for the state and all jurisdictions within the state can usually be granted. If a jurisdiction within the state wanted to install a facility that IDOT already requested a blanket approval for, then the jurisdiction does not need to request further permission from the FHWA. See the FHWA interim approval webpage for instruction on submitting a request (http://mutcd.fhwa.dot.gov/res-interim_approvals.htm) as well as Section 1A.10 – Interpretations, Experimentations, Changes, and Interim Approvals within the 2009 MUTCD.

The following facilities have interim approval:

Bicycle

- Green pavement
- Bicycle signals
- Bicycle boxes
- Two-stage turn boxes

Pedestrian

- Rectangular rapid flashing beacons

Subject to Experimentation

Facilities with experimental status require additional steps such as the ability to measure performance before and after installation. See the FHWA Experimentations page for more information (http://mutcd.fhwa.dot.gov/condexper.htm) as well as Section 1A.10 – Interpretations, Experimentations, Changes, and Interim Approvals within the 2009 MUTCD for requirements on the evaluation process. For suggested bicycle and pedestrian measures of effectiveness see the Data Collection report.

The following facilities have experimental approval:

Pedestrian

- Crosswalk Enhancements (certain features)

IDOT Supplement

The IDOT Supplement to the MUTCD contains guidance for a few facilities. The following sections in the Illinois Supplement contain conflicts with some facilities.

- Section 4D.04 requires changes to allow for contra-flow or two-way separated bicycle lanes on one-way streets. The current Illinois MUTCD standard and Illinois Vehicle Code (625 ILCS 5/11-306) allows for right or left turns from a one-way street on to another one-way street even if the turn lane has a red arrow. This will cause conflicts with through bicyclists.

- Section 4F.02 only allows Pedestrian Hybrid Beacons (PHB) at least 100 feet from side streets or driveways.[34]

6.3 State Guidance

AASHTO

Much of the IDOT BDE and BLRS manuals are based on guidance published by AASHTO. The main AASHTO guide, *A Policy on Geometric Design of Highway and Streets*, contains guidance based on established practices, some of which include bicycle and pedestrian specific guidance. Another AASHTO manual elaborates on bicycle design: *Guide for the Development of Bicycle Facilities.* It contains guidance on conventional on-road designs such as widened shoulders, marked shared lanes, conventional and buffered bicycle lanes, off-road shared use paths, midblock crossings and path geometry. The guide also contains more detailed features such as drainage grates, traffic signal detection, signage, and rumble strips. The AASHTO pedestrian specific guide is entitled: *Guide for the Planning, Design, and Operation of Pedestrian Facilities*.

While the guides may not provide explicit guidance on some facilities, built-in flexibility allows designers to utilize other state or nationally recognized guidance.

Green Book

Guidance for bicycle and pedestrian accommodations is generally referred to in either the AASHTO bicycle or pedestrian guides. Several items presented in the Green Book affect the bicycle and pedestrian realm such as curb radii, street widths (in terms of crossing distance), and speed. As it pertains to the facilities in this study, the Green Book does not restrict any of the facilities. An updated Green Book was issued in the Fall of 2018. The new guidance stresses the flexibility inherent in the guide and provides new guidance to state DOTs and other users based on peer-reviewed research. The guidance is needed on "how best to incorporate other modes of travel when designing safe and efficient roadways that serve all users."[35]

Guide for the Development of Bicycle Facilities

The AASHTO bicycle guide contains a few restrictions or challenges to implementing the facilities in this study. The chapters and sections of the current bicycle guide that conflict with other features in this study are documented below. An update to the AASHTO bicycle guide is expected in 2020 that will address many of these issues and will include guidance on separated bicycle lanes and complex intersections.

<u>Chapter 4 – Design of On-Road Facilities</u>

- Section 4.6.1 – General Considerations
  - AASHTO states that raised curbs and other raised devices can cause steering difficulties and should not be used to separate bicycle lanes from adjacent travel lanes. However, other national guidance suggests these separation options are adequate and safe.
- Section 4.6.5 – Bicycle Lanes and On-Street Parking
  - AASHTO recommends the bicycle lane be placed between the parking lane and the travel lane rather than between the curb and the parking lane, a common option in other guidance documents to separate the bicycle lane from the through traffic lane. AASHTO cites the reasons for this recommendation on reduced visibility, increased door conflicts, complicated maintenance, and preventing bicyclists from making convenient left turns. These issues are mitigated with proper separated bicycle lane designs as discussed in the separated bicycle lane report.
- Section 4.7.1 – Bicycle Lane Lines
  - AASHTO states curbs, posts, or barriers should not be used to separate bicycle lanes from adjacent travel lanes because of issues with traversing, prohibiting right turning traffic from merging into the bicycle lane prior to the turn, and maintenance. However, various options for accommodating separated bicycle lanes at intersections are discussed in the intersection markings report. Maintenance concerns can be mitigated through various low-budget means or specialized equipment. Restricting bicyclists to a set path is a concern but usually mitigated by frequent cross-roads and turn-boxes.

Guide for the Planning, Design, and Operation of Pedestrian Facilities

The AASHTO pedestrian guide does not contain any challenges or restrictions on the placement of the facilities within this study. Generally, the guide encourages using several of the facilities but simply lacks guidance on the more innovative ones such as lighted crosswalks, RRFBs, pedestrian hybrid beacons, or other crosswalk enhancements. Designers should rely on the flexibility built into the AASHTO guides to utilize the more innovative measures. An updated version of the AASHTO Pedestrian Guide is expected to be issued in 2019.

IDOT Manuals

This study is intended as a complement to the BDE and BLRS manuals for IDOT engineers. Chapter 17 within the BDE manual and Chapter 42 within the BLRS manual provide the main sources of guidance.

The IDOT BDE or BLRS manuals generally do not prohibit the installation of bicycle and pedestrian facilities on state or local routes. IDOT engineers and consultants may utilize the design guidance available in the facility reports and federal guidance as listed in Section 6.2 to design and implement those facilities within the bounds of existing IDOT policies and procedures. Note that the BDE manual Chapter 17 and BLRS manual Chapter 42 are currently undergoing updates as of June 2019. The revised chapters will incorporate new industry practices and guidance on additional facilities.

6.4 National Guidance

Supplemental Federal Guidance

The FHWA supports a flexible approach to bicycle and pedestrian facility design. They state the AASHTO bicycle and pedestrian guides are the primary source for guidance but also mention other national guides such as the ITE Designing Urban Walkable Thoroughfares or the NACTO Urban Bikeway Design Guide. FHWA states these supplemental guides build upon the flexibilities already provided in the AASHTO guides. The MUTCD states:

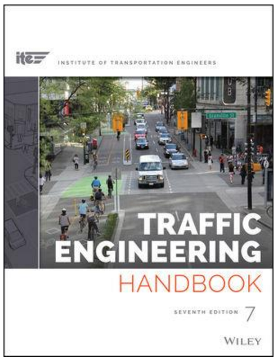
> "Under 23 U.S.C. 109(c), for projects on the National Highway System (NHS), FHWA and the States may consider guides from the American Association of State Highway and Transportation Officials (AASHTO) and other publications for design standards. Under 23 U.S.C. 109(o), States establish their own design standards for projects not on the NHS. FHWA supports a holistic approach to planning and design that will routinely incorporate bicycling and walking. FHWA also supports taking a flexible approach to bicycle and pedestrian facility design as described in the memo on Bicycle and Pedestrian Facility Design Flexibility."[36]

In addition to the AASHTO guides, the latest guidelines by the U.S. Access Board must be followed. The latest proposed public rights-of-way accessibility guidelines, also known as PROWAG, contain guidelines for sidewalks, pedestrian crossings, signals, and other pedestrian facilities. All facilities must be accessible to pedestrians with disabilities. See the guide for more information: https://www.access-board.gov/attachments/article/743/nprm.pdf. The PBIC design guide index also describes issues for the design of bicycle and pedestrian facilities.

Numerous other FHWA guidelines exist for various facilities and features. Examples include the *Road Diet Informational Guide*, the *Pedestrian Hybrid Beacon Guide* and the *Signalized Intersections Informational Guide*. These guidelines are highlighted and mentioned in each facility report. One recent federal report is the *Separated Bike Lane Planning and Design Guide* (SBL Guide). It provides direct guidance on designing and implementing on-road separated bicycle lanes. It was released in 2015 and goes above and beyond current guidance by AASHTO. The guide presents numerous bicycle features introduced by this IDOT study, regardless if it's used specifically for separated bicycle lanes or other facilities. For instance, all of the bicycle intersection markings are also discussed in the FHWA SBL Guide.

ITE

The Institute of Transportation Engineers produces and develops many comprehensive bicycle and pedestrian guides. The most recent update to their *Traffic Engineering Handbook* includes guidance for incorporating innovative bicycle and pedestrian facilities such as separated bicycle lanes, bicycle boulevards, and raised crosswalks. The handbook defines users of the road system, accommodates bicyclists and pedestrians at urban intersections, highlights numerous traffic calming options, and describes midblock crossings. The handbook heavily references MUTCD and NACTO guidance regarding specific bicycle and pedestrian facilities.

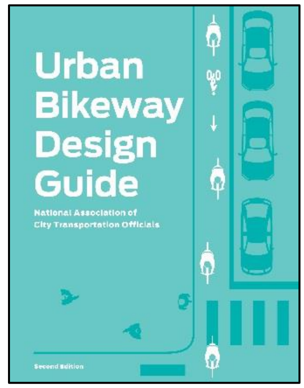


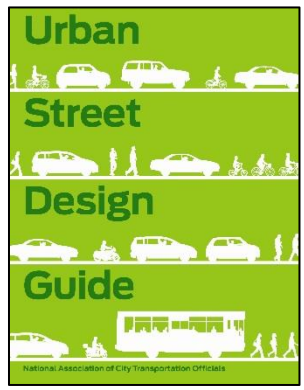
ITE also produced the informative guide entitled *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*. Published in 2010, prior to the latest Traffic Engineering Handbook, the *Designing Walkable Urban Thoroughfares* guide provided early guidance on context sensitive solutions. The guide includes additional design guidance and recommends practices for several facilities beyond what's in the Traffic Engineering Handbook; it's referenced in the design guidance section of many of the facilities in this study. The guide is available for free online. It does not restrict the use of any facility in this study.

ITE's *Separated Bikeways* report also provides an introduction to separated bicycle lanes but doesn't provide much actual design guidance. Other specific ITE guides are available at their complete streets webpage.

NACTO

The National Association of City Transportation Officials (NACTO) produces several guides geared toward urban areas. Formed in 1996, NACTO is a coalition of city transportation departments and focuses on promoting the interests and exchanging ideas within major cities. While NACTO is a relatively new organization compared to AASHTO and ITE, it's use is widely accepted around the country and supported by the FHWA as an option to encourage flexible designs. As of 2015, the Urban Bikeway Design Guide (UBDG) has received endorsements from 43 cities and eight states. Furthermore, the California Transportation Department Highway Division adopted the USDG which enabled local municipalities to apply the USDG to their own roads in addition to state roads. Washington State, Massachusetts, and Minnesota have also endorsed the guides. Additionally, CMAP recommended in a letter to the Illinois Bike Transportation Plan "that for urban areas (the majority of the CMAP region), IDOT accepts some of the newer, more innovative, treatments found in NACTO's Urban Bikeway Design Guide as potentially suitable and eligible for installation on local and county roads (BLR variance) and on state routes in IDOT's own designs."[37]





The majority of the facilities within this study can be found within the NACTO guides: *Urban Bikeway Design Guide* and *Urban Streets Design Guide*. The guides encourage and provide design guidance for implementing the facilities and do not provide any restrictions on their use. The guides are developed through a member peer group review process. NACTO members from various cities provided planners and engineers that work through a committee process to create the guidance. Cities that often provide leadership include Chicago, Portland, New York, San Francisco, Philadelphia, and Austin. City officials, several engineering consultants, and policy staff have coauthored the guides and provided additional peer review. Engineering technical review was performed by a professional engineer. All facilities in the NACTO guide have been constructed and tested in the member cities and/or exist in other U.S. guidance. District One also interviewed NACTO and discussed additional guidance not currently in the guides. See the interview minutes, located in Appendix C, for more information regarding new facilities, challenges with adoption on state roads, and other items.

6.5 Other State DOTs

District One interviewed five state departments of transportation and gathered input on facility inventories, design, policy, funding, and best practices. Several states discussed their design guidance procedures as well, including what national guidance they use or if they developed their own manuals. The full transcripts of those interviews are included in the appendix and a summary as it pertains to policy and guidelines is provided below. Additionally, other states with notable policies are included here as well, and were either gleaned from research or interviews with advocacy groups.

Table 4 lists facilities approved for use on state roads or already installed. Some facilities were approved on local roads but it's unclear if those facilities are also approved on state roads. Blank cells indicate no response by the DOT. Additional inventories of each facility around the country are available in the facility reports.

Other state departments standardize bicycle and pedestrian accommodations differently. Generally, neighboring states (Oregon & Washington, Minnesota & Wisconsin) have similar policies and procedures. Innovative facilities such as separated bicycle lanes are becoming more prominent in the states interviewed. Two states have incorporated them in their design guides or created tailored guides for it. The states that do not have specific bicycle and pedestrian design guides typically adopt, endorse or refer to NACTO's guides. See Section 5 - Outreach for more information on these state's design guides, NACTO endorsements, and other policy & procedure information.

Through these interviews, research, and other conversations, this study found several useful guides developed by state DOTs and the Chicago Department of Transportation:

- **California** created a *Separated Bikeways / Cycle Tracks* guide.
- **Massachusetts** developed a *Separated Bike Lane Planning & Design Guide* that includes intersection designs, signal timings, pedestrian islands, and signal progression for bicycles and pedestrians among a basic separated bicycle lane guide.
- **Minnesota** developed a *Best Practices for Pedestrian/Bicycle Safety* with proven, tried and experimental categories. They also have a bikeway design guide separate from their traffic engineering manual. Their latest revision to the bikeway guide will reflect AASHTO and NATCO guides.
- **Oregon** developed a *Bicycle and Pedestrian Design Guide* and is in the process of updating it.
- **Washington** produced a poster showcasing the various bicycle facility options.
- **Wisconsin** developed a Bicyclist Design Manual and a Pedestrian Best Practices Guide. WisDOT also originally had a 47 page chapter in their manual with check sheets on incorporating bicycle and pedestrian designs. On-street bicycle facilities have 15 levels of alternatives and contain different thresholds for urban and rural areas. It is unknown whether that chapter will stay with the recent modification to their complete streets policy in their state legislature.
- The **Chicago Department of Transportation** developed a Complete Streets guide. The guide includes insight on several facilities from our study with design guidance on intersections and segments, and policies on geometry and operations.

Most of the facilities in this IDOT study are allowed by these states when mentioned. A few notable exceptions are lighted crosswalks, pedestrian hybrid beacons, and pedestrian scrambles (a pedestrian signal phasing option). Lighted crosswalks were approved and considered by a few states in the past, but they have since moved away from using those with maintenance challenges often cited as a reason for the removal. Pedestrian hybrid beacons are approved by many states but extra attention is made by the DOTs on placement and warrants. Pedestrian scrambles are often only used on local road

Table 4 - List of approved study facilities by state as of 2016

Category	Facility	State Department of Transportation				
		Mass.	Minn.	Oregon	Wash.	Wis.
Bicycle						
Bicycle Lanes	Conventional	Allowed	Allowed	Allowed	Allowed	Allowed
	Buffered	Allowed		Allowed	Allowed	
	Contra-Flow			Allowed		
	Left-Side			Allowed		Allowed
	Separated	Allowed	Allowed	Allowed	Allowed	Local
Shared Roadway	Bicycle Boulevards			Local	Allowed	
	Widened Shoulders	Allowed	Allowed	Allowed		Allowed
	Road Diets	Allowed	Allowed	Allowed		Allowed
Intersection Markings	Bicycle Boxes			Local		
	Two-Stage Turn Boxes		Allowed	Allowed		
	Intersection Crossings	Allowed	Allowed	Allowed		
	Mixing Zones			Allowed		
	Lateral Shifts					
Signals	Bicycle Signal Heads			Allowed	Allowed	
Pedestrian						
Geometrics	Median Refuge Islands			Allowed		Allowed
	Raised Crosswalks			Local		
	Curb Bump Outs		Allowed	Allowed		Allowed
Signals	Pedestrian Hybrid Beacons	Local	Allowed	Allowed	Allowed	Allowed
	Rectangular Rapid Flashing Beacons	Allowed	Allowed	Allowed	Allowed	
	Lighted Crosswalks	Not used	Not used	Not used	Allowed	Allowed
	Signal Phasing	Local	Allowed	Local	Local	Allowed
	Pedestrian Signal Heads			Allowed		
Other	Red Light Cameras	Not used		Allowed		
	Crosswalk Enhancements		Allowed	Allowed		
Category	**Facility**	**Mass.**	**Minn.**	**Oregon**	**Wash.**	**Wis.**

6.6 Guidelines Matrix

*References to sections are current as of 2016.

				FEDERAL GUIDANCE		STATE GUIDANCE					NATIONAL GUIDANCE			
				FHWA	IDOT	AASHTO			IDOT		ITE	FHWA	NACTO	
	Category	ID	Bicycle Facility	MUTCD	Illinois Supplement to the MUTCD	Guide for the Development of Bicycle Facilities	Guide for the Planning, Design, and Operation of Pedestrian Facilities	Greenbook	BDE Manual	BLRS Manual	Miscellaneous	Misc. Memos, Guides	Urban Bikeway Design Guide (UBDG)	Urban Street Design Guide (USDG)
Bicycle	Bicycle Lanes	1	**Conventional**	Chapter 9C Interim Approval (IA-14)	N/A	Chapters 4.6-8	N/A	References AASHTO Bicycle Guide	Section 17-2	Section 39-3.04(d) Section 42-3.03(c)	Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - Chapter 9	http://www.pedbikeinfo.org/planning/facilities_bike_bikelanes.cfm	https://nacto.org/publication/urban-bikeway-design-guide/bike-lanes/conventional-bike-lanes/	N/A
		2	**Buffered**	Chapter 9C Interim Approval (IA-14)	N/A	Chapter 4.6.5	N/A	Page 2-79, also references AASHTO Bicyclee Guide	See Conventional Bicycle Lanes	Section 39-3.04(d) Section 42-3.03(c)	N/A	http://www.pedbikeinfo.org/planning/facilities_bike_bikelanes.cfm	http://nacto.org/publication/urban-bikeway-design-guide/bike-lanes/buffered-bike-lanes/	N/A
		3	**Contra-Flow**	Chapter 9C Interim Approval (IA-14)	N/A	Chapter 4.6.3	N/A	Page 2-79, also referencesAASHTO Bicyclee Guide	See Conventional Bicycle Lanes	N/A	N/A	N/A	http://nacto.org/publication/urban-bikeway-design-guide/bike-lanes/contra-flow-bike-lanes/	N/A
		4	**Left-Side**	Chapter 9C Interim Approval (IA-14)	N/A	Chapter 4.6.3	N/A	References AASHTO Bicycle Guide	Section 17-2.02(c)	N/A	N/A	http://www.pedbikeinfo.org/planning/facilities_bike_bikelanes.cfm	http://nacto.org/publication/urban-bikeway-design-guide/bike-lanes/left-side-bike-lanes/	N/A
		5	**Separated**	Chapter 9C Interim Approval (IA-14)	N/A	None	N/A	N/A	Requires changes to Section 17	N/A	Separated Bikeways Manual	https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm	http://nacto.org/publication/urban-bikeway-design-guide/cycle-tracks/	N/A
	Shared Roadway	6	**Bicycle Boulevards**	Chapter 9C Interim Approval (IA-14)	N/A	Chapter 4.10 Chapter 4.12.6-7	Chapter 2.6.1	References AASHTO Bicycle Guide	Section 17-2.02(b) Section 17-202(d) Section 17-2.02(i) Section 17-2.03	Section 42-3.03(c) Section 42-3.06	N/A	http://www.pedbikeinfo.org/planning/facilities_bike_bikeblvds.cfm	http://nacto.org/publication/urban-bikeway-design-guide/bicycle-boulevards/	http://nacto.org/publication/urban-street-design-guide/street-design-elements/
		7	**Widened Shoulders**	N/A	N/A	Chapter 4.5	N/A	Page 4-8 to 4-14	Section 17-2 Section 2.01 Section 2.02 Figure 17-2.A	Section 42-3.03(b) Section 42-3.05	N/A	http://www.pedbikeinfo.org/planning/facilities_bike_pavedshoulder.cfm	N/A	N/A
		8	**Road Diets**	Chapter 9C	N/A	Chapter 4.9.2	N/A	References AASHTO Bicycle Guide	Section 48-4.01	Section 42-3.03(d)	N/A	http://safety.fhwa.dot.gov/road_diets/info_guide/rdig.pdf	N/A	http://nacto.org/publication/urban-street-design-guide/streets/neighborhood-main-street/
	Bicycle Intersection Markings	9	**Bicycle Intersection Markings** Bicycle Boxes Two-Stage Turn Boxes Lateral Shifts Mixing Zones Intersection Crossing Markings	Part 9 Section 3B.16 Interim Approval (IA-14, IA-18). Two-Stage Boxes require experimental approval	N/A	Chapter 4.8	N/A	References AASHTO Bicycle Guide	Section 17-2.02(d)	N/A	Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - Chapter 10 Separated Bikeways Manual	https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm	http://nacto.org/publication/urban-bikeway-design-guide/intersection-treatments/	N/A
	Signals	10	**Bicycle Signal Heads**	Chapter 9D Interim Approval (IA-16)	Section 4D.04	Chapter 4.12.4-5 Chapter 7.2.5	N/A	References AASHTO Bicycle Guide	Section 17-2.02(j)	Section 42-3.06	N/A	http://www.pedbikeinfo.org/planning/facilities_crossings_bikesignals.cfm	http://nacto.org/publication/urban-bikeway-design-guide/bicycle-signals/	N/A

*References to sections are current as of 2016.

Pedestrian

Category	ID	Pedestrian Facility	FEDERAL GUIDANCE: FHWA MUTCD	FEDERAL GUIDANCE: IDOT Illinois Supplement to the MUTCD	STATE GUIDANCE: AASHTO Guide for the Development of Bicycle Facilities	STATE GUIDANCE: AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities	STATE GUIDANCE: AASHTO Greenbook	STATE GUIDANCE: IDOT BDE Manual	STATE GUIDANCE: IDOT BLRS Manual	NATIONAL GUIDANCE: ITE Miscellaneous	NATIONAL GUIDANCE: FHWA Misc. Memos, Guides	NATIONAL GUIDANCE: NACTO Urban Bikeway Design Guide (UBDG)	NATIONAL GUIDANCE: NACTO Urban Street Design Guide (USDG)
Geometrics	11	**Median Refuge Islands**	Section 3I.06	N/A	Chapter 5.3.5	Chapter 3.3.2 Chapter 3.4.1	Page 2-79 Section 2.1.2 Section 9.6.3 Islands	Section 34-2.0(c) Section 34-3.0(c) Section 36-1.09 Section 36-2.01(e) Section 36-2.02 Section 36-4 Section 36-9.04(n) Section 36-9.7 Section 48-3 Section 58-1.09(c) Section 58-2.01(b)	Section 34-2.01(d) Section 34-4 Section 41-5.03 Section 42-3.06	Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - Chapter 10 - Intersection Design Guidelines	http://www.pedbikeinfo.org/planning/facilities_crossings_islands.cfm	http://nacto.org/publication/urban-bikeway-design-guide/intersection-treatments/median-refuge-island/	http://nacto.org/publication/urban-street-design-guide/intersection-design-elements/crosswalks-and-crossings/pedestrian-safety-islands/
Geometrics	12	**Raised Crosswalks**	Section 3B.25-26	N/A	Chapter 4.12.6	Chapter 2.6.2 Chapter 3.4.2	Greenbook references AASHTO Bicycle Guide	N/A	Section 41-12.02	Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - Chapter 9	http://www.pedbikeinfo.org/planning/facilities_calming_speedhumps.cfm	N/A	http://nacto.org/publication/urban-street-design-guide/street-design-elements/vertical-speed-control-elements/
Geometrics	13	**Curb Bump Outs**	Section 3b.23	N/A	Chapter 4.12.6	Chapter 2.6.2 Chapter 3.3.2	Section 2,1 Section 3.3.6 Section 9.6.1	Section 36-2.01	Section 34-1.04 Section 34-2	Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - Chapter 10	http://www.pedbikeinfo.org/planning/facilities_crossings_curbextensions.cfm	N/A	https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/corner-radii/
Signals	14	**Pedestrian Hybrid Beacons**	Chapter 4F	Section 4F.01-02	Chapter 5.4.3	Chapter 3.4.3	Greenbook references AASHTO Bicycle and Pedestrian Guides	Section 36-9.07	Section 42-3.02(i)	Unsignalized Intersection Improvement Guide - Pedestrian Hybrid Beacon	http://www.pedbikeinfo.org/data/library/details.cfm?id=4851	http://nacto.org/publication/urban-bikeway-design-guide/bicycle-signals/hybrid-beacon-for-bike-route-crossing-of-major-street/	N/A
Signals	15	**Rectangular Rapid Flashing Beacons**	Interim Approval (IA-11)	N/A	N/A	N/A	N/A	Section 36-9.07	Section 42-3.02(i)	Unsignalized Intersection Improvement Guide - RRFB	http://www.pedbikeinfo.org/data/library/details.cfm?id=4766	Active Warning Beacon for Bike Route at Unsignalized Intersection	N/A
Signals	16	**Lighted Crosswalks**	Chapter 4N	Section 4N.02	N/A	N/A	N/A	N/A	Section 42-3.02(i)	Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - See photo on page Sec1:155	http://guide.saferoutesinfo.org/	N/A	N/A
Signals	17	**Signal Phasing**	Section 4E.06	N/A	N/A	Chapter 4.1.1	See AASHTO Pedestrian Guide for more detailed info.	Section 57-4.11	Section 41-5.03	Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - Chapter 10	Traffic Signal Timing Manual - Section 4.5 Signalized Intersections Guide - Section 9.1.5	N/A	http://nacto.org/publication/urban-street-design-guide/intersection-design-elements/traffic-signals/leading-pedestrian-interval/
Signals	18	**Pedestrian Signal Heads**	Section 2B.52 Section 4D.03 Chapter 4E	N/A	N/A	Chapter 4.1	See AASHTO Pedestrian Guide for more detailed info.	Section 57-4.06(e) Section 57-4.07€ Section 58-1.09(d)	Section 41-6.09	Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - Chapter 10	Traffic Signal Timing Manual - Section 5.3.3 Signalized Intersections Guide - Chapter 4.3.2 & 9.0	N/A	N/A
Other	19	**Red Light Cameras**	Section 2C.53 Interim Approval (IA-12)	Sign Illustrations - R10-I104	N/A	N/A	N/A	See SAFETY 2-13 Policy Memorandum - Red Light Running (RLR) Camera Enforcement Systems		N/A	Signalized Intersections Informational Guide - Section 2.2.2	N/A	N/A
Other	20	**Crosswalk Enhancements**	Section 3B.18 Section 4L.03	Section 2B.12 Section 2B.I70 Section 2C.I70 Sections 7B.09,11,12	N/A	Chapters 3 & 4	Page 2-79, also see AASHTO Bicycle Guide	Section 57-3.0(c) Section 58-1.10	Section 39-4.04 Section 39-30.03(b)	Unsignalized Intersection Improvement Guide ITE Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - Page 194	http://www.pedbikeinfo.org/planning/facilities_crossings_crosswalks.cfm	N/A	http://nacto.org/publication/urban-street-design-guide/intersection-design-elements/traffic-signals/leading-pedestrian-interval/

7.0 Data Collection

7.1 Overview

A lack of data on bicycle and pedestrian accommodations, usage, behaviors, and trends is commonly cited in research. The Transportation Research Board states that the "lack of system wide pedestrian and bicycle volume data limits the ability of transportation agencies to provide or improve pedestrian and bicycle facilities where the need is greatest and is an impediment to developing better predictive methods for pedestrian and bicycle crashes".[38] The FHWA and others have made repeated calls for increased data collection efforts at the state and city level. A robust data set is required for proper evaluation of the latest facility types and can aid in the project development process.[39,40,41] A standardized bicycle and pedestrian data collection program can inform policy and decision makers on general trends and the economic effects of increased bicycle and pedestrian accommodations. Data also allows for evaluating a department's goals and performance measures, whether required by policy or requested by advocacy groups.

- Phase I Studies
- Facility Evaluation
- Performance Measures
- Policy Making
- Inventory Systems

Figure 43 - Potential uses of bicycle and pedestrian data

There are three data collection areas examined and tested in this study: physical, behavioral and counts. The **physical** data collection method was developed to collect characteristics of Illinois' roadway network for use in project planning, design and construction as well as supplement the state's existing inventory system which collects similar physical features. The **behavioral** data collection method was developed to evaluate the performance of various bicycle and pedestrian accommodations. **Counts** based data collection is necessary for calculating crash analysis rates, and spatial and temporal trends.

Beyond these uses, the FHWA recommends collecting other information for use in facility analyses. "By evaluating a separated bike lane project using a wide range of criteria, planners will be better able to communicate the wide range of benefits that such facilities provide beyond improvements to cyclist safety."[39] Improvements on the local economy, environment, emissions reductions, and single occupancy vehicle commuting can also be measured. While the FHWA was specifically referring to separated bike lanes in this instance, criteria can be developed to review and study other pedestrian and bicycle facilities. Similar criteria can be used across multiple facility types and chosen from a list and tailored to a specific facility. This report provides a list of several criteria to include in any potential project evaluation.

7.2 Physical

Physical data collection allows for holistic evaluations of facilities and provides context for project development. A draft physical data collection sheet was created for the IDOT Bicycle and Pedestrian Accommodations Study. The sheet, or checklist, allows field crews to collect bicycle and pedestrian facility information along with street and environmental context. The checklist was field tested during the course of the IDOT study. An example sheet is included in Appendix E and explained below.

Instructions and a photo based description document were also created to assist the field reviewer in filling out the checklist. These checklists could be expanded into an official checklist for IDOT field crews or required to be completed during the Phase I process and then inputted into the IRIS database. While this example used a draft paper form, this study recommends automatic data collection using a laptop or tablet and ArcGIS online or a suitable replacement. This will allow for automatic data transferring and reduce overall costs and need for data entry.

There were numerous lessons learned from the initial checklist testing. The instruction sheet and description document was developed in response to initial confusion with data collection. Due to the complexity of some questions, a training session should be held with all field staff. Ideally all items could be linked together into a digital platform that would provide easy access to definitions, photos, and clarification on each item. For example, field reviewers could click on an item and a pop up window would explain more about the topic. Issues also arose with field reviewers filling out the checklist. More specific instructions should be developed. Having two field reviewers working at a time is ideal for safety and quality control purposes. Managers should also conduct periodic quality control reviews. The associated documents are also included in Appendix E.

In addition to the basic physical site characteristics requested in the draft IDOT data collection sheet, the FHWA recommends the following information be collected:[39]

- Number of nodes/intersections
- Refuge islands
- Street trees
- Medians
- Planters
- Parking availability
- Loading zones
- Plazas or public spaces
- Commercial rents/property values

An example check list was also developed by the Active Transportation Alliance in their recently released *Complete Streets, Complete Networks* guide. The ATA guide was reviewed and written with support from The Cook County Department of Transportation and Highways and local transportation consultants. It provides a framework and guidance for implementing complete streets designs. One component of the guide was a checklist of existing conditions, which can also be referenced when developing a data collection program within IDOT. The checklist is included in Appendix B.

7.3 Behavioral

In addition to the physical data collection sheet, numerous pedestrian, bicyclist and motorist behavioral elements can be measured. The information can be collected to measure the effectiveness of a facility or learn information about the target roadway for Phase I studies. Behavioral data can help identify safety deficiencies not found in crash analyses and inform planners and engineers on the proper facilities to install. The following is a sample of behavioral studies that can be performed:

- Yielding (stopping) rates
- Changes in pedestrian travel path
- Pedestrian hesitation or backup
- Pedestrian activation of device
- Pedestrian/bicyclist/motorist compliance with signals or markings
- Traffic speed
- Police citations
- Inadequate looking
- Lane positioning
- Stopping location
- Wrong way travelling

See a full list of potential behavioral studies in Appendix B. At a minimum the FHWA suggests collecting travel direction, wrong way riding, and location of riding for before and after studies of bicycle facilities.[39] This information and the items listed above allow for proper before and after studies of facilities to determine effectiveness.

Several behavioral studies were performed as part of the IDOT Bicycle and Pedestrian Accommodations Study. Each study requires a separate, and ideally tailored, data collection sheet that documents information about the study site such as intersecting streets, direction of travel, pavement markings, signalization, and instructions. The more information that is presented on the data collection sheets increases accuracy and reduces workload for field staff. Example behavioral study data collection sheets are included in Appendix B.

7.4 Counts

Why do we need it?

User counts are valuable for analyzing mode share trends, calculating crash rates, and can be a powerful education and public awareness tool. This report focuses on their use in calculating crash rates, which are an effective measure of safety for all of the innovative facilities being studied. Crash rates are taken by comparing the number of crashes to the volume of users on the facility. It is objective and relies on easily obtainable state recorded crashes which are generally recognized as being accurate and consistent when measuring the performance of a facility across several years. However, counts are usually more difficult to acquire, especially for pedestrians and bicyclists. Most states have count programs only for motorists, whom generally follow a consistent and easily measurable path whereas pedestrians or bicyclists are more erratic and sometimes unpredictable. Pedestrians and bicyclists can take numerous routes over variable terrain and streets. Counting these modes are a challenging but necessary component in determining crash rates. For the purposes of this study, only bicyclist count programs were examined due to the maturity and availability of counting equipment and ease of long term counting relative to pedestrians. Many of the suggestions and information regarding bicyclist counts can also be transferred to pedestrian counts as well with proper equipment.

Crash rates are generally calculated using annual data sets, such as crashes over an entire year and the average annual daily bicyclist counts (AADB). In order to calculate the AADB for a particular facility, short term counts are performed then the results are extrapolated out to annual counts. The problem lies in the variability of non-motorized traffic patterns which should be measured and accounted for.[42] This variability is adjusted for through the use of conversion factors which account for hourly, daily, monthly and weather effects on the number of cyclists using the facility within a certain geographic area. To accurately calculate these factors, 24 hour counts are required at multiple locations for an entire year. Ideally these conversion factors are recalculated every year. Permanent counts also have far reaching positive impacts that can benefit other facets of bikeway funding, planning, and engineering.

What is the history of long term counting in Illinois?

Extensive, continuous counts have not been performed in Illinois. IDOT does not have any long term bike count program. No information on biking is collected through surveys. IDOT sometimes performs short term, project-specific counts during the design phase.[43]

One of the longest bicycle count collections performed in Illinois was completed on the Illinois Prairie Path and various branches in cooperation with the DuPage County Division of Transportation and Trails for Illinois. The counts were for a period of 8-10 weeks, 24 hours a day. Trafx brand infrared trail counters were used. To calculate annual usage on the Prairie Path, the data was given to the Rails-to-Trails Conservancy who analyzed it “using a proprietary model that incorporates five million individual counts from 58 trails nationwide”.[44] However, the counts did not distinguish between bicyclists and pedestrians due to limitations with using infrared detectors. Trail counts also may contain errors due to the factor groups using the trail. That is, many users are using the trail for recreational purposes and may pass the counters numerous times within one visit, causing abnormally higher counts that can affect the accuracy of AADB conversion factors. DuPage County DOT may add permanent counting equipment to the Great Western Trail in the future similar to the Making Trails Count program but so far have continued with summer infrared detector counts.[45,46]

In Chicago, single 24 hour counts were conducted using EcoCounters in 2009 at various locations around the city. Originally proposed to continue every year, 2009 was the only year the City used the EcoCounter equipment. Since then the City has conducted quarterly “cordon” counts around Chicago’s Loop. The cordon counts are manual counts performed by volunteers during the Tuesday rush hour periods (7:00 to 9:00 AM and 4:00 to 6:00 PM). The streets being counted sometimes change between periods, however, and inaccurate counting may arise through the use of volunteers. Furthermore, the cordon counts do not take into account day of week, month, or weather variation and only capture the assumed periods of highest volumes. Chicago also conducts monthly counts at the same locations every year. They are one day, peak hour counts from 7:30 to 8:30 AM and from 4:30 to 5:30 PM and are generally more consistent.[47]

Additionally, Chicago installed 16 permanent micro-radar sensors on the Dearborn Avenue cycle track.[48] Although preliminary results show errors in measuring cyclists the data can be used to determine monthly and seasonal trends. The micro sensors are the closest system to a permanent bicycle count program in Illinois. CDOT should be consulted for further lessons learned regarding the system. One day counts are also performed on Chicago's Lake Front Trail by the Active Transportation Alliance.

Who has continuous on-street count programs in North America?

In the US, Boulder, CO and Minneapolis-St. Paul, MN have permanent bicycle counting programs. MnDOT and the University of Minnesota investigated the current state of counting in Minnesota and developed AADB conversion factors based on permanent counting equipment installed on 4 trails only. Either inductive loops or infrared detectors were used; 10% of the data collected was not utilized for various reasons.[49] Numerous assumptions were made to account for gaps in data or limitations with the counting equipment and locations. Vancouver, BC in Canada also conducts permanent counting programs.

Can we use conversion factors developed elsewhere?

The error rates of using conversion factors are already 23% according to a study analyzing estimation factors developed from Vancouver, BC, CA data.[50] Using conversion factors calculated for a different geographic area, with its own unique set of climate, cultural and economic conditions, further erodes the accuracy of the short term count extrapolation and may result in error rates greater than 23%. However, this 23% error rate can be also be reduced by using a full week of 24 hour short term counts for AADB extrapolation as recommend through research completed by Portland State University.

Can conversion factors developed during a certain year be applied to subsequent years?

Yes, but the error rate increases outside the factor development year. The error rates are relatively high for other years.[50]

Can conversion factors be developed from Divvy Bike Share data?

Divvy, Chicago's Bike Share system was launched on June 28, 2013. The data collected includes the time of day, week, month, start and stop time, and route. When analyzing Divvy data the following observations are made:

- Clear commuting patterns emerge from the data. Seasonal effects are pronounced.
- The publicly available data does not take into account station hopping, which means that the usage number may appear higher than the actual number of cyclists using Chicago's roadways. For example, a cyclist may rent out a bike and travel for 30 minutes, re-dock it to avoid fees, then immediately rent it out again to begin another 30 minute pay period, resulting into multiple counts for the same trip. Divvy may have additional internal data that accounts for this.
- No conversion factors have been created from bike share data.
- The first year of data includes a "ramp-up" of use as its popularity grew.
- Divvy bike share represents a small subset of the population, mostly Caucasian males (79% of Divvy member use in 2013 was male).[51]

Due to the limitations and inaccuracies built into the data collection and the fact that there is no way to confirm the validity of bike share calculated conversion factors, it is not recommended using the data for this purpose.

Can factors be derived from short term counts?

According to the FHWA Traffic Monitoring Guide, the short duration counts provide the geographic coverage to understand traffic characteristics on individual roads, streets, shared use paths, and pedestrian facilities, as well as on specific segments of those facilities. They provide site-specific data on the time of day variation, can provide data on day of week variation in non-motorized travel, but are mostly intended to provide general traffic volumes throughout the larger monitored network. However, short duration counts cannot be directly used to provide many of the required data items desired by users. Statistics such as annual average traffic cannot be accurately measured during a short duration count.

The FHWA recommends 24/7/365 days a year of permanent counts to derive conversion factors. Semipermanent counts may be used to develop some of the factors but they provide an incomplete dataset and increase inaccuracies. Partial permanent counts were used in calculated AADB factors for Chicago as explained in section 3.3.1.

How should the short term counts be conducted?

Short term counts should be conducted continuously over a seven day period for the best accuracy before converting to AADB. Counts should be conducted during normal workdays, Tuesday through Fridays, which is typical of any data collection plan. Esawey recommends either July or August to reduce error rates.[50]

What are the equipment requirements?

Each distinct factor group should include three to five count locations (commuter, recreational/utilitarian, and mixed).[42] In District One's case, three to five locations should therefore be included in Chicago and other urban centers and three to five locations should be included on suburban shared-use paths and trails such as the Prairie Path. Initially, six locations are recommended. Permanent count locations can be expanded annually as funds become available with eventual inclusion into the statewide data collection program. Opportunities exist to partner with existing counting programs such as the Trails for Illinois counts to ensure their data collection is at the same level of precision as IDOT's in order for their data to be added to the statewide database.

What equipment is suitable for permanent counts?

One suitable counting solution is a video/radar hybrid detector. Econolite and Iteris are two companies that sell such detectors. The hybrid radar addition helps with detection during inclement weather. Standalone video detectors may also be sufficient depending on if weather factors are desired. The video detection works through automatic detection algorithms that distinguish between bicyclists and motorists. Furthermore, video detectors mounted on traffic light poles are the only option for automatic on-street detection of bicyclists travelling on unconfined travel paths. Iteris claims a 99% accuracy rate for their Versicam product. They installed a camera on Dearborn at Adams Street as a demonstration unit for the City of Chicago. Iteris said CDOT was not interested in collecting permanent data on their bike facilities and the program was not continued or expanded. Miovision, another video detection brand, may not be used as it relies on manual post-processing of the video data and is not feasible for permanent counts. Their new Spectrum model, which relies on a video/radar hybrid detector, may work for permanent counts.

Embedded loop detectors or newer micro-radar pucks may also be used but are suitable only for confined bicycle routes such as curb separated bicycle lanes. Bicyclists should be confined to the area of the loop detector to allow for accurate data collection. Magnetic loops may not detect carbon fiber or other synthetic frame bicycles and micro-radar detectors are still in their infancy and exhibit their own detection errors.

For trails and shared-use paths infrared detectors may be suitable. Infrared detectors detect the heat signature of bicyclists and pedestrians but do not count users travelling side-by-side. The detectors cannot count traffic on roadways larger than 2 lanes and are not suitable in urban environments. They also do not distinguish between pedestrians and bicyclists unless coupled with embedded detector loops. They are mounted next to a trail or path and either locked in a box or hidden from view. The detectors are also susceptible to vandalism due to the proximity to the counting path. http://www.trafx.net/products.htm#Infrared%20Trail%20Counter.

What equipment is suitable for short-term counts?

For both on-street counts and shared used paths or trails, EcoCounter pneumatic tubes or Jamar Cycles Plus pneumatic tubes may be used. EcoCounter tubes are a cost-effective option, specially designed to detect bicycles, and have already been tested on Chicago streets. Product website: https://www.eco-compteur.com/en/produits/tubes-en/tubes-2/.

Jamar Trax CyclesPlus pneumatic tubes are capable of detecting both motorists and bikes. They are the latest in pneumatic tube technology and contain highly sensitive air switches to detect the light air pulses created by bikes. The equipment should be installed long enough to collect one week of continuous data, not including any days for calibration, malfunction or other issues. Equipment should be checked against manual peak hour counts between the hours of 7-9 AM and 4-6 PM.

What are the costs?

Trafx detectors cost $2245 for the initial self-contained package of 3 detectors and $500 for each additional detector. A rough cost estimate for measuring the trails and shared-use paths would be $4000 to conduct counts at 3 locations and includes three backup counters. Embedded detector loops are required as well but their costs are unknown. So the total cost for this option will be higher. Equipment utilized for the IDOT Bicycle and Pedestrian Accommodations study cost $5000 for two detection boxes, an initial set of six tubes, and the data reduction software.

Iteris Versicam video cameras with detection software cost $2500 for each unit, along with additional costs to tie into existing electrical boxes and surveillance networks. Versicam allows up to 8 definable fields of detection which only works for urban streets or smaller suburban routes. Large suburban thoroughfares (e.g. Golf Road in Schaumburg) will require Iteris's higher end unit which costs $4000 for each unit.

Where should the initial permanent count locations be located?

The permanent count locations should be placed to measure the same factor group as the one utilizing the facilities being studied. Since most of our study locations include Chicago facilities such as Clybourn or Dearborn, or Evanston's Church Street, then the permanent count locations should be placed within the commuter factor group. Eventually the permanent counts locations can be expanded to develop factors for all factor groups as budget and time become available.

What are the steps in developing a permanent counting program?

According to the FHWA Traffic Monitoring Guide (TMG):[42]

1. Review the existing continuous count program.
2. Develop an inventory of available continuous count locations and equipment.
3. Determine the traffic patterns to be monitored.
4. Establish pattern/factor groups.
5. Determine the appropriate number of continuous monitoring locations.
6. Select specific count locations.
7. Compute monthly, day of week, and hour-of-day (if applicable) factors to use in annualizing short-duration counts.

Suggested IDOT plan for steps 5-6:

1. Identify locations for permanent counts. FHWA TMG recommends more than three automated bicycle counters per factor group for a total minimum of 12 if all factor groups are counted.[52]
2. Determine best equipment for those counts.
3. Install equipment and visually calibrate with manual counts. Develop correction coefficient.
4. Begin counts for one year. Periodically check and test equipment for accuracy.
5. Institute program for continuous yearly monitoring to develop factors every year.

7.5 Inventories

IDOT's existing inventory was also reviewed and summarized followed by an overview of national research on creating and maintaining inventories.

Existing State Inventories

The state's inventory system is compiled under the Illinois Highway Information System (IHIS). IHIS accommodates the entry and retrieval of information contained in the following four databases: the Illinois Geographic Information System (IGIS), which allows a graphical display of various elements contained in IHIS; the Illinois Roadway Information System (IRIS), which contains information on all highways open to public travel; the Illinois Railroad Information System (IRRIS), which contains information on all public at grade and grade separation rail crossings; and the Illinois Structure Information System (ISIS), which contains information and inspection data for all structures open to public travel.[53]

IRIS contains basic roadway characteristics for state routes, local roads, and local municipal streets. The Office of Planning and Programming, Planning Services Section, maintains the IRIS database. The database only tracks information within the right-of-way lines of a highway that is open for public travel. This includes existing and proposed roads as well as dedicated right-of-way. IRIS provides the following information:

- AADT
- Political districts
- Functional class
- County
- Roadway jurisdiction
- Number of lanes
- Median type and width
- Maintenance responsibility
- Metropolitan planning organization
- Municipality
- Pavement type and thickness
- Pavement condition (condition rating survey)
- Shoulder type and width
- Speed
- Traffic control
- Truck route

The IGIS system provides various political, geographic, and natural boundaries including the following:

- Transit routes and stations
- Airports
- Schools
- Parks
- Historical sites
- Flood zones

ISIS follows Chapter Six of the IDOT Bureau of Local Roads and Streets (BLRS) manual which details the state's bridge inventory system. The inventory system follows the requirements in the National Bridge Inspection Standards (NBIS) and the National Bridge Inventory. Updates to ISIS must be made within 180 days after changes are made to the structure and the structure is opened or reopened to traffic, or if other additional events occur. ISIS contains the following items that may be useful when considering bicycle and pedestrian accommodations on or below bridges:

- AADT
- Bridge length
- Deck type
- Median type and width
- Curb type, height and width
- Truck percentage
- Expansion joint type
- Waterway info (e.g. Flood frequency)

IDOT District One created a self-evaluation pedestrian inventory utilizing ArcGIS Online to track existing and planned alterations on State roadways in an effort to move towards full accessibility compliance within the public ROW based on the upcoming Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG). The inventory contains the following items:

- Sidewalks (on State ROW)
- Curb ramps
- Crosswalks (Marked and Unmarked)
- Accessible Pedestrian Signals (APS)

Outside of IDOT, the local metropolitan planning organization (MPO), the Chicago Metropolitan Agency for Planning (CMAP), built an inventory of existing bikeway and pedestrian features. The inventory is based on local municipal plans that CMAP transcribed into a GIS database called the Bikeway Inventory System (BIS). The BIS is a database of existing and planned bikeway facilities from various jurisdictions throughout Northeastern Illinois. The Bike Plan and the CMAP database should only be regarded as transportation planning documents with approximate alignments. It includes the following items:

- Name of facility
- System designation
- Bike lanes
- Bike routes
- Side paths
- Trails
- Surface type & width
- Managing agency

Inventory Guidance

There are numerous elements to consider before creating and maintaining an inventory. "A successful inventory has a clearly stated purpose, provides useful and needed information, is easy to access and extract data from and can be kept current at a reasonable level of effort and cost."[54] Creating a bikeway inventory system or expanding the ADA inventory system will require significant effort in planning and execution as well as funds to maintain it. The initial effort and funds will be wasted unless these criteria are met and the inventory is properly maintained. Inventories should include a well-defined list of items and avoid becoming too cumbersome. An inventory system should not be at the same level of detail as a road audit; more detailed information can be obtained during the project development phase.
The following questions were adopted from the ITE inventory guide and should be addressed when creating inventories:

- How will the inventory be used?
- What specific information will serve the purpose of the inventory?
- Can those data be obtained more effectively by means other than an inventory?
- Does the information already exist in another form?
- How large is the study area?
- Who will collect, enter and analyze the data?

If a detailed bicycle and pedestrian inventory is desired, IDOT should amend the existing IDOT IRIS inventory as recommended by the Illinois Statewide Bike Plan. Additional items can be added relatively easily to the current database. A centralized statewide data collection plan should also be established. The plan would detail the data collection technique, who will perform the collection, how it will be collected, quality control guidelines, and how the data will be transferred to IRIS.

IDOT should create a plan for updating and maintaining the inventory system. One potential idea for maintaining the database would be to use public contributions. CMAP was examining options for one such inventory system. IDOT should collaborate with CMAP on developing an inventory maintenance plan.

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Facility Summaries: Bicycle

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Facility Summaries: Bicycle

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Direction: one-way or two way →	1W	2W	
Location: intersection or segment →	INT	SEG	
Functional Classification: local, collector or arterial →	L	C	A
Density: rural, suburban or urban →	R	S	U
Average Daily Traffic (ADT) →	<10K	10-25K	>25K
Posted Speed Limit →	≤30	35-45	≥50

Green cells indicate the facility is generally applicable for the listed condition

Yellow cells indicate the facility is applicable for the listed condition in limited contexts

Grey cells indicate the facility is generally not recommended for the listed condition

	Benefits	Considerations
SAFETY	•	•
OPERATIONS	•	•
MAINTENANCE	•	•

Conventional bicycle lanes are an on-road bicycle facility that runs alongside traffic. Bicyclists travel in the same direction as the adjacent motorist lane. Conventional bicycle lanes are marked for and used exclusively by bicyclists. They can be placed along the curb, shoulder or adjacent to parking and are delineated by pavement markings. Bicycle lanes can be augmented by regulatory and directional signage. According to Chicago's *Streets for Cycling Plan 2020*, Chicago built its first on-street bicycle lane in 1971.

<table>
<tr><td colspan="3">1W</td><td colspan="3">2W</td></tr>
<tr><td colspan="3">INT</td><td colspan="3">SEG</td></tr>
<tr><td colspan="2">L</td><td colspan="2">C</td><td colspan="2">A</td></tr>
<tr><td colspan="2">R</td><td colspan="2">S</td><td colspan="2">U</td></tr>
<tr><td colspan="2"><10K</td><td colspan="2">10-25K</td><td colspan="2">>25K</td></tr>
<tr><td colspan="2">≤30</td><td colspan="2">35-45</td><td colspan="2">≥50</td></tr>
</table>

Figure 1 - Example of a conventional bicycle lane. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Provides dedicated space for bicyclists • Motorists and bicyclists can expect more predictable behavior from one another • Increases bicyclists perceived safety	• Bicyclists can be "doored" if motorists open their door in the path of a bicyclist • Abrupt ends to bicycle lanes may put bicyclists in unsafe situations
OPERATIONS	• Provides motorists and bicyclists designated positions on the road, reducing conflicts	• The facility will be compromised if motorists or buses drive or park in the bicycle lane
MAINTENANCE	• Conventional bicycle lanes require minimal maintenance for pavement marking and signage	• Snow plowing may damage the pavement markings or may push snow into the bicycle lane

Buffered bicycle lanes are on-road lanes that are marked for and used exclusively by bicyclists, similar to conventional bicycle lanes, but with the addition of a designated buffer space between bicyclists and moving or parked vehicles, on one or both sides of the bicycle lane. Also similar to conventional lanes, buffered bicycle lanes can be placed along one or both sides of the roadway depending on available roadway width and travel lane requirements, allowing bicyclists to travel in the same direction as motorists. The buffer area is defined by two parallel, solid, white lines most often with diagonal crosshatching.

1W	2W	
INT	SEG	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Figure 1 - Example of a buffered bicycle lane. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Buffer along parking lane encourages bicyclists to ride outside of the vehicle door zone, reducing dooring collisions • Buffer along travel lane reduces rear end and sideswipe collisions between bicycles and moving vehicles • Provides guidance to both bicyclists and motorists	• Bicyclists riding improperly in the buffer zone • Bicyclists and motorists using the facility improperly due to lack of proper education on how to use the facility
OPERATIONS	• Provides a greater space between bicycle and motor vehicle travel while also providing positive guidance and positioning • Increases bicycle comfort and free travel while decreasing impedance to motoring travel • Buffer provides space for bicyclists to pass one another or avoid hazards without encroaching into motor vehicle lanes • Narrowed motor vehicle lanes produces traffic calming effect and can reduce speeds	• Buses driving in the bicycle lanes • Motorists parking or driving in the bicycle lanes • Loss of motor vehicle travel lanes or decreased lane width due to the addition of bicycle lanes
MAINTENANCE	• Street sweeping and snow removal can be performed at the same time as normal roadway maintenance	• Buffer marking requires additional maintenance compared to conventional bicycle lanes

Contra-flow bicycle lanes are on-road facilities designated exclusively for bicycles that are designed to allow bicyclists to ride in the opposite direction of motoring traffic on a one-way street. This converts a one-way street into a two-way street for bicyclists, with bicycle travel in the motoring direction typically accommodated by the provision of either a designated bicycle lane or shared lane markings. These facilities are usually placed in residential areas near existing bicycle lane facilities and are used to strategically connect bicycle routes to one another. The main purpose of a contra-flow bicycle lane is to create a safer and more direct route for bicyclists, while reducing instances of bicyclists riding on sidewalks or illegally against the flow of traffic. Contra-flow bicycle lanes reduce trip times, trip distances, conflict points, and improve bicyclists' travel.

1W	2W	
INT	SEG	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Figure 1 - Example of a contra-flow bicycle lane, separated from opposing motoring traffic by double yellow centerline marking. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Reduces dangerous wrong-way riding • Increases perceived level of comfort and safety • Provides dedicated space for bicyclists which reduces conflicts	• Decreases safety at intersections due to conflicts with turning motorists that are not looking for bicyclists riding in opposite direction of motoring travel • Debris or snow buildup can cause unsafe or unusable facilities if not maintained
OPERATIONS	• Provides a shorter, more direct route to high use destination points • Provides connectivity and access for bicyclists traveling in both directions • Decreases bicyclists' trip time and trip distance	• Motorists parking or driving in the bicycle lanes • Reduces width of roadway travel or parking lanes
MAINTENANCE	• Street sweeping and snow removal can be performed at the same time as normal roadway maintenance • Requires similar maintenance to conventional bicycle lanes	• Property owners may shovel snow off of sidewalks into bicycle lanes • Bicycle lane markings fade or disappear over time

Left-side bicycle lanes are on-road facilities designed exclusively for bicycles that are placed on the left-side of one-way streets or median-divided two-way streets and separated from motorists with white, solid pavement marking striping. Left-side bicycle lanes are placed on the left-side of the roadway to improve bicyclist visibility for motorists by having the bicyclist on the driver's side view, to reduce potential right-side bicycle lane conflicts from right-turning motorists, delivery stops, transit vehicles, and when parking is present.

1W		2W
INT		SEG
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Figure 1 - Example of a left-side bicycle lane. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Decreases potential right-side conflicts from right-turning motorists, delivery & transit vehicles, and parking motorists • Improves bicyclist visibility for motorists by having the bicyclist on the driver's side view • Reduces "dooring" incidents • Provides guidance to bicyclists and motorists.	• Bicyclists turning right may result in additional conflicts • Road users may not expect bicyclists on the left-side of the roadway since it is unconventional
OPERATIONS	• Reduces conflicts with motorists • A left-side bicycle lane's effect on motorist operations is dependent on the ratio of left-turning or right-turning motorists and is project specific	• Difficult to transition from a left-side bicycle lane to a bicycle lane on the right-side of the roadway • A left-side bicycle lane's effect on motorist operations is dependent on the ratio of left-turning or right-turning motorists and is project specific
MAINTENANCE	• Street sweeping and snow removal are unimpeded • Requires similar maintenance to conventional bicycle lanes	• Building owners shovel snow off of sidewalks into bicycle lanes • Striping becomes faint or disappears over time

A separated bicycle lane, also referred to as a protected bike lane or cycle track, is an on-road bikeway physically separated from motorist and pedestrian travel by a barrier or elevation change. Separated bicycle lanes can be installed flush with the roadway pavement, or can be raised to provide a vertical separation from motor vehicle lanes and/or sidewalk. Separated bicycle lanes can also be designed and marked for one-way or two-way operation, and placed along one side of the roadway, both sides of the roadway, or in the median.

1W		2W
INT		SEG
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

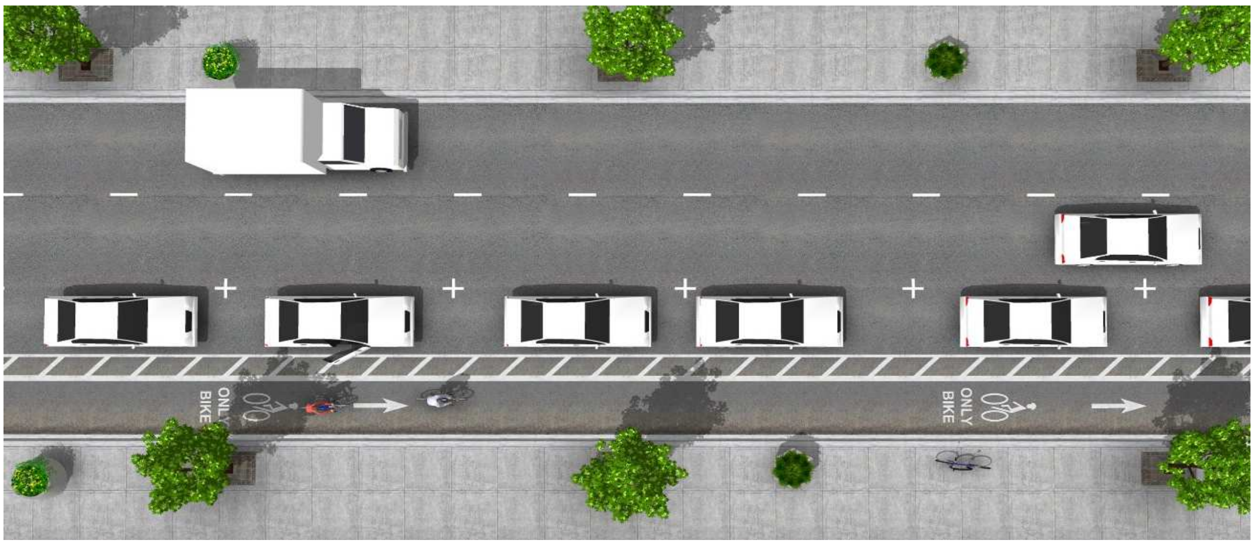

Figure 1 - Example of a one-way, parking separated bicycle lane. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Provides dedicated space for bicyclists • Eliminates risk and fear of over-taking vehicles mid-block • Reduces risk of doorings • May increase pedestrian and motorist safety as well • Increases perceived safety	• Decreased safety at intersections due to conflicts with turning vehicles • Debris or snow buildup can cause unsafe or unusable facilities if not maintained
OPERATIONS	• Helps prevent double-parking • More attractive for bicyclists of all ages and levels; increases ridership • Surveys have found motorists and bicyclists understood the intent of the cycle track design and were observed using them as intended	• Novelty of the facility in some areas may initially cause confusion • May require motorist lane reductions or turn restrictions depending on site constraints • May require parking reduction
MAINTENANCE	• Barriers may be used with commonly available materials such as bollards, barrier wall, or flexible delineators	• Creates challenges for snow and debris removal; some barriers may need to be removed in the winter • Certain barriers may increase drainage maintenance costs

Bicycle boulevards are shared roadways that incorporate and connect various bicycle facilities, encourage lower motorist volumes and speeds, and improve bicyclist priority, comfort, and accommodation. The purpose of bicycle boulevards is to provide a direct, safe route that is inviting to bicyclists of all ages and skill levels. This is accomplished by providing specific treatments on roadways intended to discourage motorist through travel while accommodating local travel. A combination of speed and volume management measures, signage and pavement markings, and minor and major street crossing elements are used to accomplish this objective.

1W		2W
INT		SEG
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

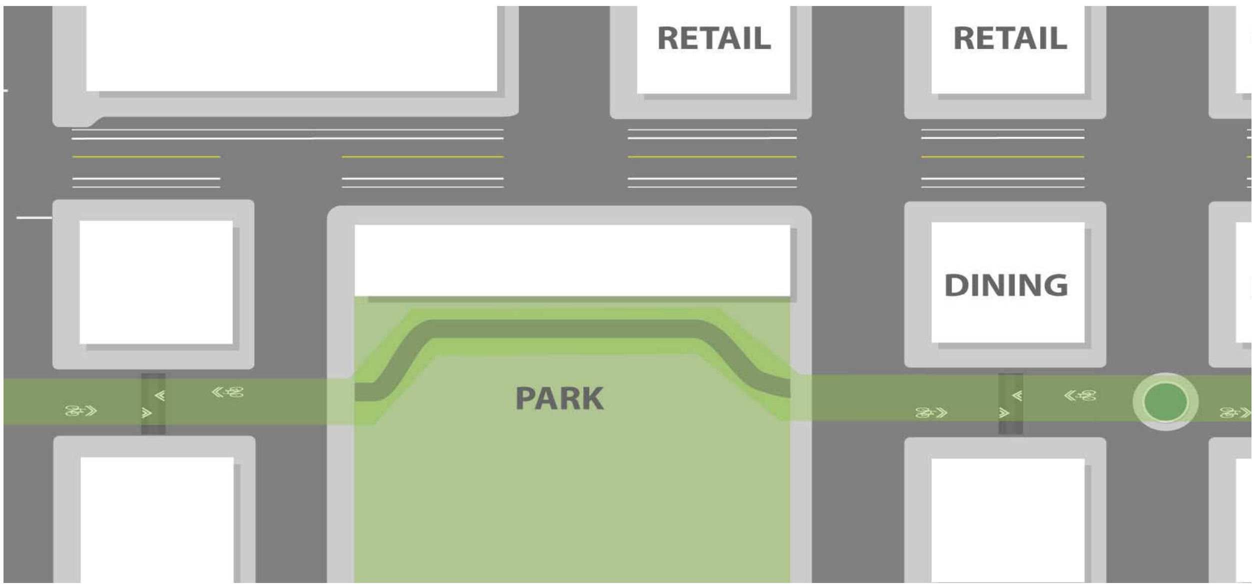

Figure 1 - Bicycle boulevard that includes speed bumps, marked shared lanes, a park connection, and a traffic circle. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press.

	Benefits	Considerations
SAFETY	• Lowers traffic speeds and volumes • Increases safety and awareness of bicyclists at intersections • Provides additional safety benefits for pedestrian and residents • Comfortable for bicyclists of all skill levels	• Typically constructed on residential streets, requiring additional public outreach to inform potential users of the facility
OPERATIONS	• Improves bicyclist travel time • Provides a direct and continuous route for bicyclists	• Certain features may impede emergency vehicles and increase response time. • May increase motorist delay
MAINTENANCE	• Pavement markings between intersections and signage are easy to maintain • Flexible design approach allows for features to be modified or excluded in areas with maintenance concerns	• Intersection markings may require frequent reapplication • Green infrastructure, if used, requires frequent cleaning • Diverters and other geometric features may cause difficulties for street sweeping and snow clearing

1W		2W
INT		SEG
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Paved, widened shoulders are becoming a common feature on rural highways and on highways in urban areas with rural cross sections. Paved, widened shoulders can increase a bicyclist's perception of comfort and safety by allowing a greater separation between bicyclists and motorists, by reducing conflicts between bicyclists and motorists, and by providing a stable riding surface. The widened shoulder width varies and is dependent on the posted speed and ADT. Widened shoulders help maintain traffic operations by providing additional space for motorists and bicyclists to share the roadway system. Widened shoulders are not typically marked or signed for bicycle use, but still provide a safer travel area for bicyclists. The addition of widened shoulders is a practical means of connecting communities while maintaining a safer facility for all users.

Figure 1 – Widened shoulders along County Highway 56 (Rochester Road) in Springfield, Illinois

	Benefits	Considerations
SAFETY	• Reduces passing conflicts and various crash types between bicyclists and motorists • Provides a stable riding surface outside of the motoring lane for bicyclist and pedestrian use • Increases bicyclist visibility • Provides emergency stopping space for inoperable vehicles • Provides an increased level of comfort and safety for bicyclists, and safer separation between from motorists	• Decreased safety at intersections due to conflicts with turning vehicles • Debris or snow buildup can cause unsafe or unusable facilities if not maintained
OPERATIONS	• Provides a greater space for bicyclists creating steady traffic flow for both bicyclists and motorists	• Routes not designated as bicycle routes and lack of proper facility signage • Inoperable vehicles moving out of the travel lane onto the widened shoulders • Used as a space for maintenance operations and snow storage
MAINTENANCE	• Street sweeping and snow removal can be performed at the same time as normal roadway maintenance	• Snow is plowed off of roadways onto shoulders • Rumble strips not maintained and become a hazard to bicyclists

A road diet is the removal of at least one vehicular travel lane and the reallocation of that space for other uses such as bicycling, pedestrian crossing refuge, parking, and transit. The most common configuration is the conversion of an undivided four-lane road to a three-lane road. This is achieved by the removal of one existing through traffic lane in each direction, and using the extra space for the addition of a center lane marked for left turning traffic and either a bicycle lane or on-street parking along the outside. The center lane can include markings for dedicated left turn lanes as well as a "two-way left turn lane" (TWLTL), where vehicles from both directions can make a left turn. Motorist ADT is often unchanged after installations of road diets yet bicycling and walking increases.

1W		2W
INT		SEG
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

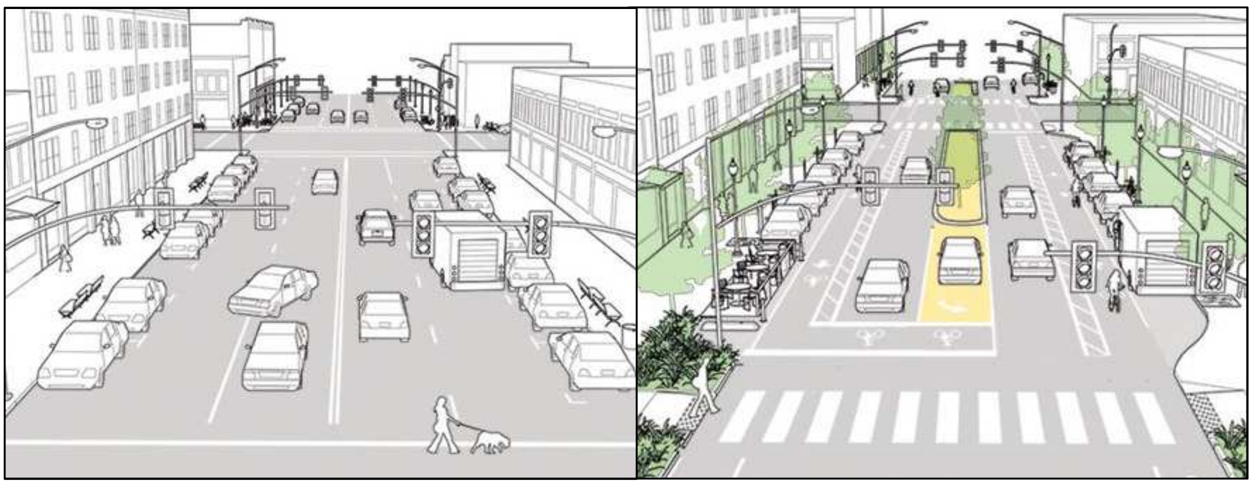

Figure 1 - A before and after road diet conversion. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Reduces likelihood of multiple threat crashes by minimizing vehicle passing and lane changes • Reduces conflict points • Reduces crash severity • Reduces vehicle speeds • Center lane provides shelter and increases visibility of oncoming traffic for left-turning traffic, reducing certain crashes • Increases the distance between moving traffic and the pedestrian realm	• May attract more bicyclists (if bicycle facilities are installed) and pedestrians, which may cause an increase in bicycle and pedestrian crashes without the addition of supplemental facilities
OPERATIONS	• Can make an area and surrounding businesses more accessible for pedestrians and bicyclists • Generally does not increase delay if roadway is already operating as a three lane road	• May increase delays for certain traffic movements during certain periods • May increase congestion based on existing conditions • May encourage traffic to divert to other neighborhood streets
MAINTENANCE	• Requires only basic striping maintenance • Street sweeping and snow plowing is uninhibited	• Additional maintenance may be required for supplemental bicycle and pedestrian facilities

A bicycle box, or advanced stop line, is a designated area for bicyclists at the head of a traffic lane at a signalized intersection (NACTO 2012). Motorists are required to stop behind the near stop line while bicyclists may stop at the far stop line. This provides bicyclists an opportunity to queue and proceed ahead of motoring traffic, providing various safety and comfort benefits.

1W		2W
INT		SEG (N/A)
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Figure 1 – Example of a bicycle box at an intersection. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Increases visibility of bicyclists • Reduces right-hook crashes • Increases motorist yielding rates • Increases feeling of safety for bicyclists • Reduces breathing of vehicle exhaust for bicyclists • Reduces vehicle encroachment on the crosswalk	• Use of colored pavement to enhance visibility of box, increase motorist compliance, and encourage bicyclist usage.
OPERATIONS	• Reduces signal delay for bicyclists • Groups bicyclists together so that intersections clear at a faster rate. • Reduces signal delay for right-turning motorists. • May assist left-turning cyclists	• Reduced storage for motorists.
MAINTENANCE	• A variety of material options exist for green pavement that can reduce maintenance needs.	• May require frequent reapplication if markings or green pavement are in the wheel-path of cross-traffic.

Two-stage turn boxes provide a designated area for bicyclists to make a safe, comfortable left turn from a right side bicycle lane or cycle track, or a right turn from a left side bicycle lane or cycle track, through a multi-lane signalized intersection (NACTO). The turning maneuver required is known as a Copenhagen Left or a Jug Handle turn. To use, bicyclists ride into the intersection, stop in the turn box, orientate their bicycle in the direction of cross traffic, and wait for the cross street signal to turn green before continuing. They are useful for bicyclists unaccustomed to making left turns through heavy traffic.

<table>
<tr><td colspan="3">1W</td><td colspan="3">2W</td></tr>
<tr><td colspan="3">INT</td><td colspan="3">SEG (N/A)</td></tr>
<tr><td colspan="2">L</td><td colspan="2">C</td><td colspan="2">A</td></tr>
<tr><td colspan="2">R</td><td colspan="2">S</td><td colspan="2">U</td></tr>
<tr><td colspan="2"><10K</td><td colspan="2">10-25K</td><td colspan="2">>25K</td></tr>
<tr><td colspan="2">≤30</td><td colspan="2">35-45</td><td colspan="2">≥50</td></tr>
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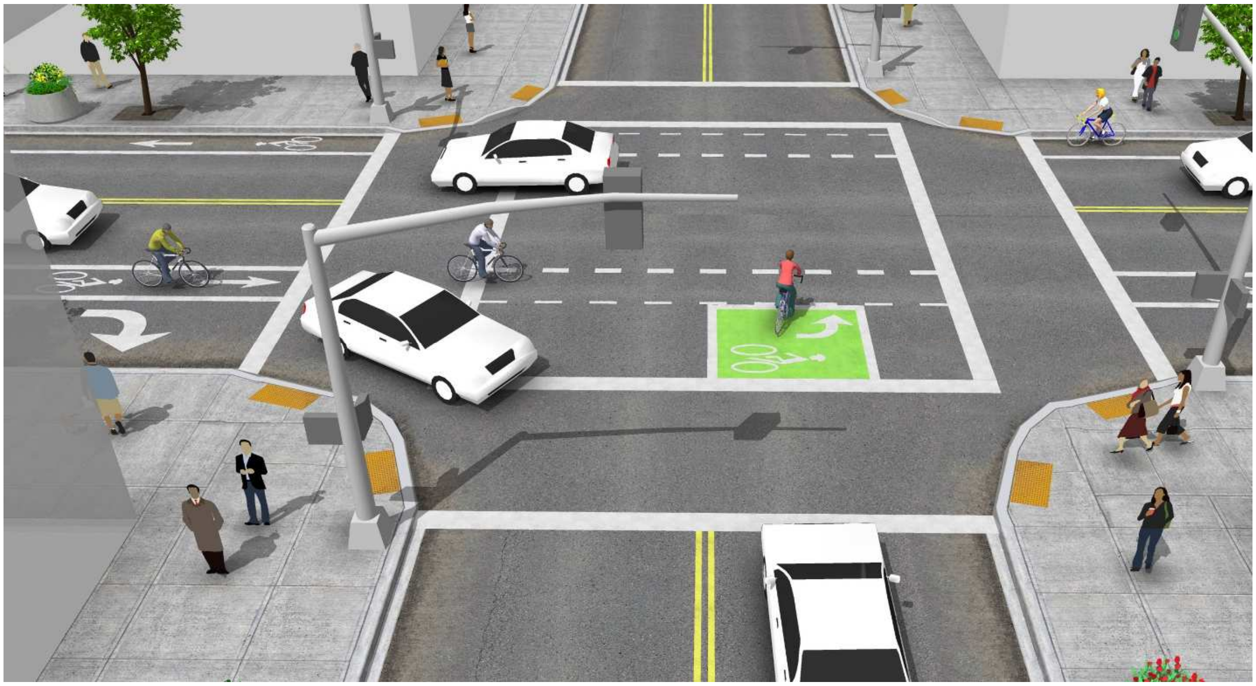


Figure 1: Example of a Two-Stage Turn Box at an intersection. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Reduces conflicts with motorists by separating turning bicyclists from opposing traffic • Increases bicyclist comfort for left turns	• May require education on proper usage • Typically involves colored pavement
OPERATIONS	• Prevents turning bicyclists from blocking through bicyclists • May be the only means of left turns for bicyclists on certain one-way streets	• Increases intersection delay for bicyclists since they must wait until the next signal cycle to complete their turn
MAINTENANCE	• A variety of material options exist for green pavement that can reduce maintenance needs	• May require frequent reapplication if markings are in the wheel-path of cross-traffic

Bicycle pavement markings crossing through an intersection define the intended path of bicyclists, and provide a boundary between bicyclists and motorists within the intersection. They help guide bicyclists through intersections and provide a continuation of a bicycle lane. Intersection crossing markings reinforce bicyclist right of way and alert turning motorists in either direction to expect and look for bicyclists travelling through the intersection. Furthermore, by defining a path, bicyclists are encouraged to travel in a more predictable manner.

1W	2W	
INT	SEG (N/A)	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

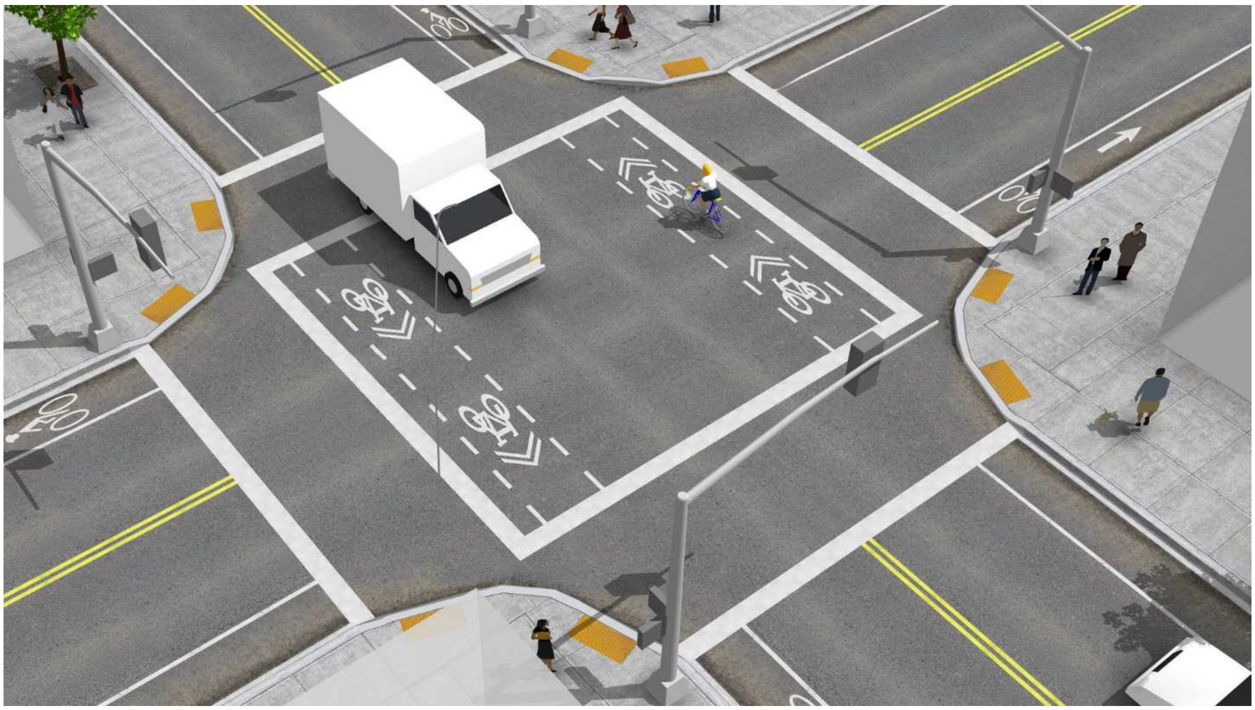


Figure 1 - Example of bicycle pavement markings that cross an intersection. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Decreases crashes • Increases motorist yielding • Increases bicyclist comfort • Encourages predictable bicyclist travel	• May instill a false sense of safety • Overuse of markings may cause confusion and lead to non-compliance
OPERATIONS	• Provides guidance on how to navigate intersections, especially complex or offset intersections	• Overuse of markings may cause confusion and lead to minor delays
MAINTENANCE	• A variety of material options exist for green pavement that can reduce maintenance needs.	• May require frequent reapplication if markings are in the wheel-path of cross-traffic.

A mixing zone, also known as a combined bicycle lane / turn lane, is a tool for creating a shared use space between bicyclists and turning motorists when approaching an intersection. The mixing zone is a dedicated turn lane with shared lane markings or a skip-dash lane line. The markings instruct through bicyclists on the best lane usage and positioning while alerting the motorist to expect and look for bicyclists in the lane. Proper lane positioning helps reduce right hooks where a right-turning motorist collides with a bicyclist who is passing on the right.

<table>
<tr><td colspan="3">1W</td><td colspan="3">2W</td></tr>
<tr><td colspan="3">INT</td><td colspan="3">SEG (N/A)</td></tr>
<tr><td colspan="2">L</td><td colspan="2">C</td><td colspan="2">A</td></tr>
<tr><td colspan="2">R</td><td colspan="2">S</td><td colspan="2">U</td></tr>
<tr><td colspan="2"><10K</td><td colspan="2">10-25K</td><td colspan="2">>25K</td></tr>
<tr><td colspan="2">≤30</td><td colspan="2">35-45</td><td colspan="2">≥50</td></tr>
</table>

Figure 1 - Mixing zone with "shark's teeth" yield markings and shared lane markings. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Decreases right-hook crashes • Increases motorist yielding • Increases bicyclist comfort • Encourages predicable bicyclist travel • Reduces motorist speeds	• May instill a false sense of safety • Excessive green pavement may cause some motorists to avoid the mixing area • Large vehicles may force bicyclists into the adjacent lane
OPERATIONS	• Allows for dedicated right-turn lanes on roads without adequate room for full channelization	• Overuse of markings may cause confusion and lead to minor delays • Through bicyclists may block right-turning motorists
MAINTENANCE	• A variety of material options exist for green pavement that can reduce maintenance needs	• May require frequent reapplication if markings are in the wheel-path of cross-traffic

Lateral shifts, also called through bicycle lanes, include the shifting of turning motorists across a conventional bicycle lane or buffered bicycle lane in advance of the intersection. The bicycle lane then continues in a dedicated through lane adjacent to the turn lane. Bicyclists can continue straight through the intersection or merge into the turn lane. There are a variety of options for marking the shift and weave area.

<table>
<tr><td colspan="2">1W</td><td>2W</td></tr>
<tr><td colspan="2">INT</td><td>SEG (N/A)</td></tr>
<tr><td>L</td><td>C</td><td>A</td></tr>
<tr><td>R</td><td>S</td><td>U</td></tr>
<tr><td><10K</td><td>10-25K</td><td>>25K</td></tr>
<tr><td>≤30</td><td>35-45</td><td>≥50</td></tr>
</table>

Figure 1 - Lateral shift with skip-dash marking and green pavement. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Decreases crashes • Increases motorist yielding • Increases bicyclist comfort • Encourages predicable bicyclist travel • Reduces motorist speed • Increases bicyclist visibility	• May instill a false sense of safety • Places bicyclists adjacent to faster moving through traffic
OPERATIONS	• Allows for a dedicated right-turn lane • Bicyclists do not block the right-turn lane.	
MAINTENANCE	• A variety of material options exist for green pavement that can reduce maintenance needs.	• Weave area may require frequent reapplication of markings due to repeated crossings

1W		2W
INT		SEG
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-40	≥50

A bicycle signal head is a facility put into place at an intersection to reduce conflicts between bicyclists and motorist and aid bicyclists in navigating through intersections. Bicycle signal heads are traffic control devices, most often installed at intersections with existing conventional traffic signals. They work in the same manner as conventional traffic signals, just for bicycles rather than cars. Bicycle signals can be used in conjunction with protected bicycle lanes, such as the two-way cycle track on Dearborn Avenue shown below. Typically, protected bicycle lanes offer increased safety along a road segment, but still leave bicyclists unprotected when going through intersections; bicycle signal heads can help with this issue by separating motorist and bicyclist movements in the intersection. Additionally, bicycle signal heads may improve both real and perceived safety for bicyclists by making motorists aware of their presence and enforcing the idea that bicyclists belong on the roadway.

Figure 1: Bicycle signals at Dearborn Street and Randolph Street in Chicago

	Benefits	Considerations
SAFETY	• Reduces potential conflicts between motorists and bicyclists at intersections • Can give bicyclists an appropriate clearance interval • Can provide a leading or lagging bicycle interval to increase the visibility of bicyclists at intersections • May Increase bicyclist compliance	• Motorists may confuse bicycle signals heads for conventional traffic signals • If bicyclist compliance is low the facility will not provide an safety benefits
OPERATIONS	• Makes bicyclists a priority at intersections • Streamlines bicyclists decision process which may increase flow	• Will reduce the turn arrow allowance time for motorists turning through the path of bicyclists
MAINTENANCE	• Maintained just like traffic signals so maintenance crews should be familiar with maintenance operations	• If not combined with an existing traffic signal, maintenance can be expensive

Facility Summaries: Pedestrian

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Facility Summaries: Pedestrian

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

# of Motor Vehicle Lanes: 2, 3, or 4 or more (ML) →	2L	3L	ML
Location: intersection or midblock →	INT		MBLK
Functional Classification: local, collector or arterial →	L	C	A
Density: rural, suburban or urban →	R	S	U
Average Daily Traffic (ADT) →	<10K	10-25K	>25K
Posted Speed Limit →	≤30	35-45	≥50

Green cells indicate the facility is generally applicable for the listed condition

Yellow cells indicate the facility is applicable for the listed condition in limited contexts

Grey cells indicate the facility is generally not recommended for the listed condition

	Benefits	Considerations
SAFETY	•	•
OPERATIONS	•	•
MAINTENANCE	•	•

Median refuge islands are intended to make street crossings safer and easier. They separate crossings into two phases so the pedestrian has only one direction of traffic to cross at a time. The island provides a safe and visible place to wait. Median refuge islands are ideal on roadways with high traffic volumes and wide street widths, and also higher speeds in certain situations. They can also be used at signalized intersections to allow pedestrians with disabilities, seniors, children, and other pedestrians who cannot cross the entire crosswalk in one phase to make a partial crossing then safely wait for the next cycle to complete their crossing. They can facilitate bicycle crossings as well, especially on bicycle boulevards, and shared use path or trail crossings.

2L	3L	ML
INT	MBLK	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

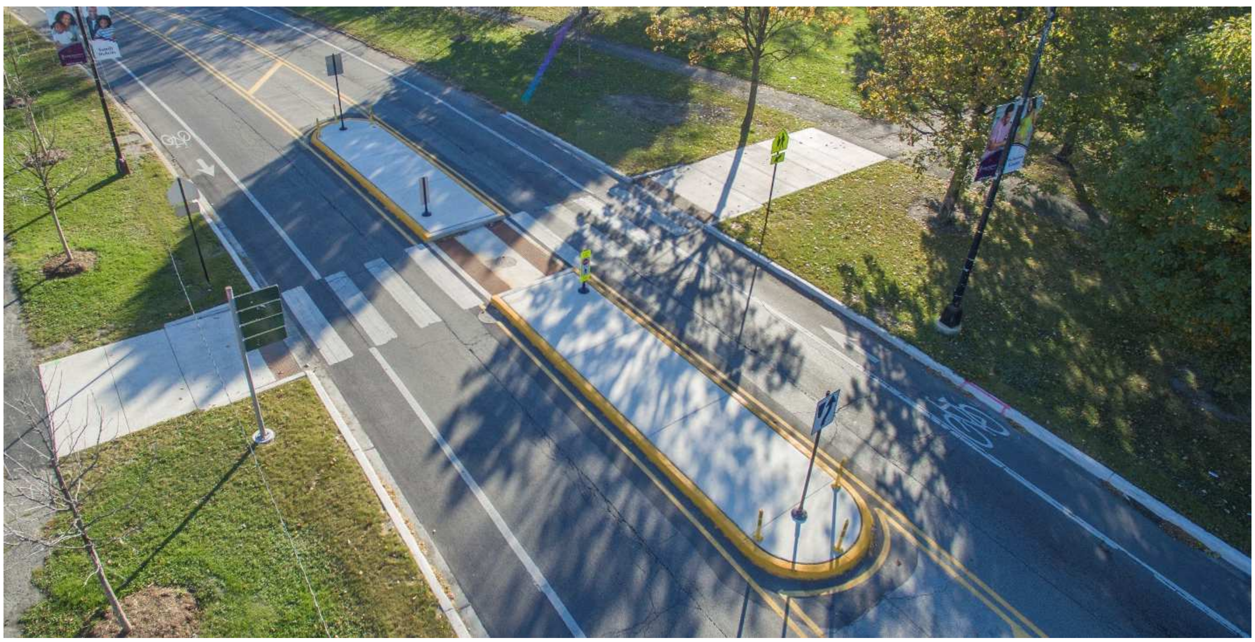


Figure 1 - Median refuge island on Sacramento Drive in Chicago. Copyright 2015, Skyity.com. Reprinted with permission.

	Benefits	Considerations
SAFETY	• Allows pedestrians to cross one direction of traffic at a time • Provides safe waiting area in median • Provides space to potentially improve lighting at pedestrian crossings. • Reduces pedestrian crashes	• Continuous medians may encourage higher vehicle speeds • May induce a false sense of security in crossing pedestrians
OPERATIONS	• Reduces the time a pedestrian has to wait to cross the road	• May interfere with truck and bus turns, depending on the road geometry • May replace/eliminate a turn lane for vehicles
MAINTENANCE		• May lead to increased maintenance costs for landscaping

A raised crosswalk is a pedestrian crossing at or near the same height as the adjacent sidewalks with sloped sides, a flat top, and crosswalk markings. A raised crosswalk is intended to provide a safer crossing for pedestrians via the elevated height. The elevated height facilitates pedestrian entrance to the crosswalk by reducing or flattening the sidewalk ramp grade, alerts roadway users to crossing activity by increasing pedestrian and crosswalk visibility, and limits vehicle speeds by providing a vertical deflection along the roadway.

2L	3L	Multilane Roundabouts Only
INT	MBLK	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

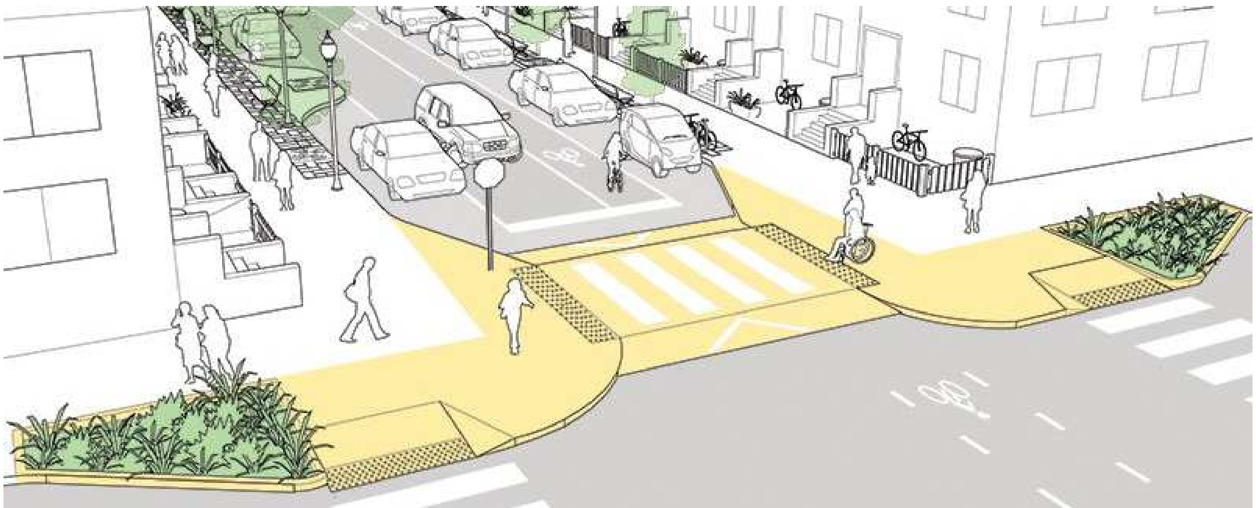


Figure 1 - A raised crosswalk with a curb bump out. Image from Urban Bikeway Design Guide*, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.*

	Benefits	Considerations
SAFETY	• Increases pedestrian/crosswalk visibility for road users • Increases pedestrian use by ~25% • Decreases 85th Percentile vehicle speeds by ~23% (traffic calming) • Slightly increases motorist compliance with state law that requires stopping for pedestrians within crosswalks	• May increase emergency vehicle response times
OPERATIONS	• Reduces/flattens sidewalk ramp grade facilitating pedestrian entrance to crosswalk • Improves accessibility, increases use of crosswalk, and reduces jaywalking • Smoother than speed bumps and traversable by larger vehicles	• May hinder travel for bicycles and emergency and transit vehicles. • May obstruct roadway surface drainage • Increase noise
MAINTENANCE	• Minimal maintenance • Routine crosswalk marking restriping which may include restriping of optional speed hump markings	• May impact street sweeping and snow removal operations • Increased maintenance costs

A curb bump out (also referred to as a curb extension or curb radius reduction) extends the curb line and sidewalk, typically into an existing parking lane, resulting in a visually and physically narrower roadway. Bump outs increase pedestrian visibility for approaching motorists, and decrease pedestrian crossing distance and roadway exposure time. By narrowing the perceived roadway, bump outs may also reduce motorist speeds. Bump outs also encourage slower turning speeds by tightening intersection curb radii that may be overdesigned.

2L	3L	ML
INT	MBLK	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

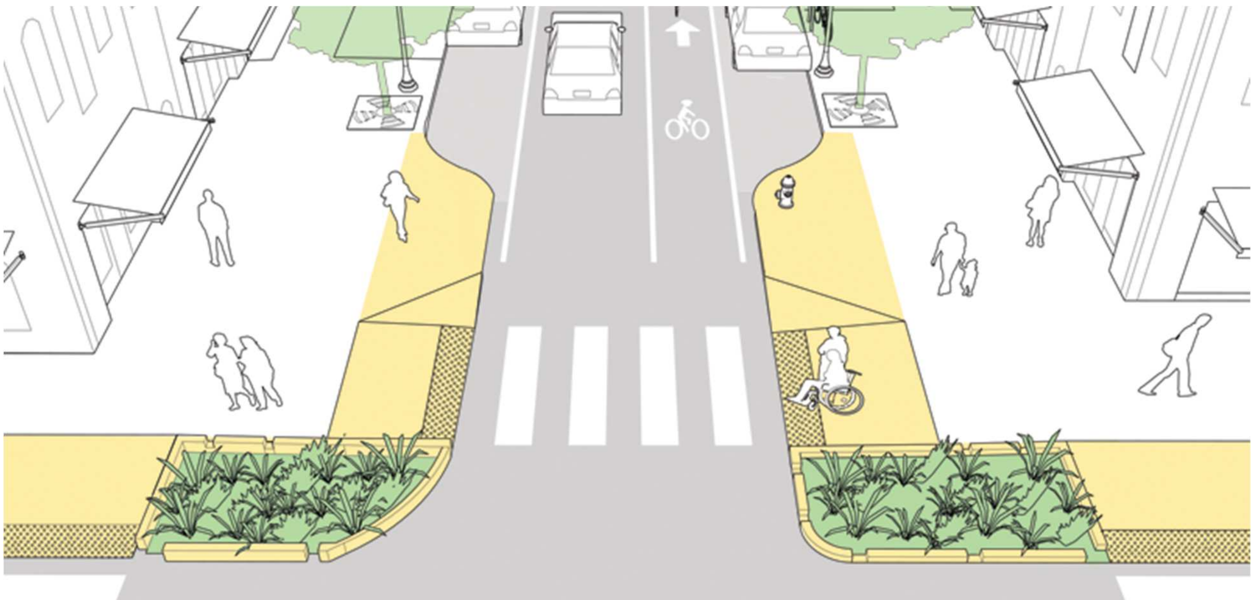


Figure 1 - Example of a curb bump out at an intersection. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

	Benefits	Considerations
SAFETY	• Increases pedestrian visibility • Decreases pedestrian crossing distance • Increases motorist compliance with state law requiring stopping for pedestrians within crosswalks	• May increase emergency vehicle response times • May force bicyclists into the motorist travelled way if bicycle lane width reduced
OPERATIONS	• Reduces traffic speeds • Encourages slower vehicle turning speeds at intersections • Discourages or prevents motorists from parking too close to an intersection/crosswalk and obstructing sight lines • Decreases the length of the pedestrian phase	• May cause traffic delays if number of lanes or lane widths are reduced • May hinder travel for bicycles and emergency and transit vehicles • May obstruct roadway surface drainage
MAINTENANCE	• Minimal maintenance • Can be used as a basin for storm water capture	• May impact street sweeping and snow removal operations • May prompt utility relocations

A pedestrian hybrid beacon (PHB), which includes the crossing device known as a High-Intensity Activated crosswalk (HAWK) signal, was designed by engineers in Arizona to aid pedestrians in crossing streets and raise motorist awareness. PHBs remain dormant until they are activated by a pedestrian. Once activated, the PHB has a sequence of five displays indicating what the motorist or pedestrian must do. Motorists are not obligated to stop unless the signal is activated by a pedestrian. PHBs are an FHWA approved device governed by Chapter 4F of the 2009 MUTCD. They can be installed midblock or at an intersection.

2L	3L	ML
INT		MBLK
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

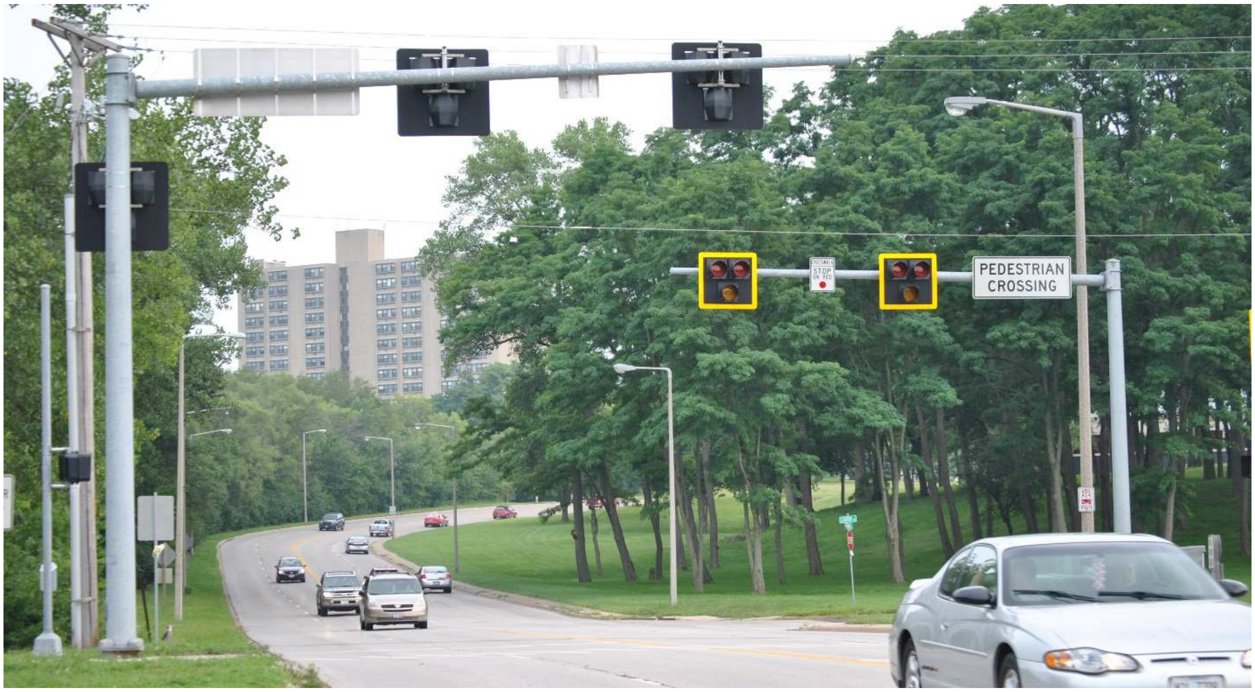


Figure 1 – PHB at a shared use path crossing in Pekin, Illinois

	Benefits	Considerations
SAFETY	• Increases pedestrian/crosswalk visibility for road users • Reduces vehicle/pedestrian crashes by 69% • Increases motorist yielding • Reduces jaywalking	• May increase certain crash types at roundabouts although current research is inconclusive
OPERATIONS	• Can reduce pedestrian wait times • Improves accessibility	• May increase queue lengths slightly at roundabouts and require extra storage
MAINTENANCE	• Almost identical maintenance needs as a conventional traffic signal	• Push button and adjacent sidewalk should be kept clear of debris and snow.

A rectangular rapid flashing beacon, or RRFB, is a pedestrian-activated warning beacon designed to aid pedestrians in crossing streets and is an innovative alternative to traditional flashing beacons. These beacons are installed in conjunction with and to supplement standard pedestrian or school crossing signs located at a marked crosswalk. They can be installed at midblock or uncontrolled intersections and at roundabouts, and in areas with heavy pedestrian and school traffic. When activated, the LED lights flash rapidly in an irregular, alternating pattern, alerting motorists to pedestrians attempting to cross the street. RRFBs have increased motorist yielding rates at every location studied.

2L	3L	ML
INT	MBLK	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Figure 1 – Midblock RRFB located on Madison Street between Millennium Park and the Art Institute in Chicago

	Benefits	Considerations
SAFETY	• Increases awareness of pedestrians • Can alert motorists to unsignalized crossings, midblock crossings, or crossings that are otherwise not expected • Improves motorist compliance rates	• Overuse may reduce effectiveness
OPERATIONS	• Can reduce pedestrian wait times through improved motorist stopping compliance • Does not increase motorist delay • Can be used at roundabouts with minimal delay changes	• Motorists may be unfamiliar with these beacons due to their relative newness in Illinois
MAINTENANCE	• Low cost • Minimal maintenance • Solar powered and independent of electrical grid	• Enhanced pedestrian detection systems may require additional upkeep

Lighted crosswalks are signed and marked crosswalks that include flashing yellow lights embedded into the pavement along both sides of the crosswalk. The MUTCD refers to the embedded lights as in-roadway warning lights (IRWLs), and allows their use only at uncontrolled crosswalks. IRWLs alert motorists to crossing pedestrians and to slow down and/or prepare to stop. They are especially effective at night and during fog, rain, or snow.

2L	3L	ML
INT		MBLK
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Figure 1 – A lighted crosswalk at night in Clovis, California. Image by James Sinclair, reprinted with permission.

	Benefits	Considerations
SAFETY	• Increases crosswalk visibility in darkness and during inclement weather • Increases driver compliance with Illinois state law which requires a full stop for pedestrians in a crosswalk	• Lights may only be visible to the vehicle nearest to the crossing • Lights may be difficult to see during the daytime • Headlights from oncoming traffic may obscure lights • Adverse weather conditions may decrease visibility of lights
OPERATIONS	• Encourages pedestrian use of crosswalk and reduces jaywalking • Decreases the amount of time a pedestrian waits to cross	• Minimal impact on vehicle speeds
MAINTENANCE	• IRWLs are made to resist damage from snow plows with improvements in materials and installation methods • Utilizes LED lights that last several years	• Additional work required to replace lights during pavement resurfacing or reconstruction • May require periodic cleaning of lights to maintain visibility • Adverse weather conditions and snow plows lead to premature deterioration of lights

2L	3L	ML
INT	MBLK	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Signal phasing is defined as the right-of-way, yellow change, and red clearance intervals in a cycle that are assigned to an independent traffic movement or combination of movements. Typical signal phasing for pedestrians is concurrent with one or more vehicle phases, resulting in potential conflicts between crossing pedestrians and turning motorists. Two phasing options that can reduce these conflicts by separating pedestrian and vehicle movements are exclusive pedestrian phases and leading pedestrian intervals (LPIs). An exclusive pedestrian phase stops traffic in all directions so that pedestrians may cross through the intersection in any direction, including diagonally in a variance referred to as a Barnes Dance or pedestrian scramble. Leading pedestrian intervals provide pedestrians a WALK signal before vehicle turning movements are allowed.



Figure 1 - Examples of exclusive pedestrian phase crossings and signage.

	Benefits	Considerations
SAFETY	• Reduces or eliminates pedestrian conflicts with motorists • Significantly reduces pedestrian-vehicle collisions • LPIs increase motorist compliance	• Increases vehicle rear end crashes • Faded pavement markings contribute to confusion at the intersection • May cause difficulties for visually impaired individuals
OPERATIONS	• Pedestrians can cross in all directions during the exclusive pedestrian phase • Allows intersections to operate more efficiently when large pedestrian volumes are present • Reduces total walking distance for certain directions • Reduces congestion, especially for right turning movements of motorists	• Increases motorist and transit delay • Increases pedestrian wait time • Increases pedestrian compliance violations
MAINTENANCE	• Requires minimal additional maintenance beyond work performed for traditional crosswalks such as pavement marking restriping, signage, and countdown timer maintenance	• User unfamiliarity with this facility makes well-defined pavement markings and signs essential • Striping fades over time without proper maintenance

2L	3L	ML
INT		MBLK
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Pedestrian signals are traffic control devices installed at signalized intersections and un-signalized marked crosswalks (which include pedestrian hybrid beacons) to provide positive guidance to pedestrians attempting to cross the street. Pedestrian signals prohibit crossing when conflicting traffic may impact the safety of the pedestrians. There are different types of pedestrian signal features and enhancements with varying functions and accessibility, including pedestrian signal head indications, countdown pedestrian signals, automated pedestrian detection, pushbutton detectors, accessible pedestrian signals and detectors (APS). Pedestrian signal heads and other signal enhancements are all dictated by the MUTCD. This report should be used in conjunction with other pedestrian crossing facilities discussed in the following reports: crosswalk enhancements, signal phasing, and pedestrian hybrid beacons.

Figure 1 - Examples of pedestrian signals in Chicago

	Benefits	Considerations
SAFETY	• Decreases conflicts between pedestrians and motorists when used in conjunction with countdown timers • Decreases number of pedestrian trapped in the intersection during the conflicting phase • Automated pedestrian detection can increase usage and compliance rates • Accessible pedestrian signals (APS) that are properly aligned with crosswalks achieve high usage rates with visually impaired individuals	• Pedestrian signals alone may not achieve significant safety benefits • Consider the use of additional enhancements such as countdown timers, automated detection, and APS • Ensure the latest APS standards are followed, as outdated APS equipment may lead to confusion by visually impaired individuals
OPERATIONS	• Provides continuous movement of pedestrian traffic and vehicular traffic • Countdown timers result in faster walking speeds • Automated detectors may advance the cycle once the pedestrian has crossed	• Low pushbutton activation rates may require pedestrians to wait for a subsequent cycle to cross legally • Pedestrian clearance interval and signal timing depends on walking speeds of slowest pedestrian
MAINTENANCE	• Improved use with common signal maintenance	• Snow and other debris may obstruct and hinder access to improperly placed detectors or push buttons

2L	3L	ML
INT	MBLK	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Red light running camera systems are typically installed at signalized intersections where a safety problem with red light running has been documented. The systems are designed to increase safety at intersections by decreasing the frequency of the most dangerous types of crashes, with the focus on angle crashes which are more likely to result in serious injury or death. The system tracks the status of the traffic signal, and typically utilizes video or laser technology to monitor the position and speed of vehicles approaching and passing the stop line. The system continuously monitors the traffic signal, and the red light cameras automatically photograph vehicles and their license plates as they fail to stop during the red signal phase. The cameras record the date, time of day, time elapsed since the beginning of the red signal, vehicle speed, and license plate number of the vehicle. Photographic evidence is reviewed and red light violators are mailed tickets.

Figure 1 - Red light cameras in Chicago

	Benefits	Considerations
SAFETY	• Reduces red light violations and associated crashes • Reduces dangerous right angle crashes, thus reducing fatalities and high severity crashes • May reduce the number of vehicles exceeding the speed limit • Community-wide increase in driver compliance with red lights	• May increase rear end collisions • Creates a distraction to drivers
OPERATIONS	• Does not directly impact traffic operations	• Red light running can be decreased with proper signal timing
MAINTENANCE	• An “early warning” system can be implemented that alerts when unusual enforcement activity is detected	• Continuous maintenance and monitoring of the system is required

Crosswalk enhancements are not a specific treatment, but rather a group of facilities or treatments. There are many treatments that when added to a traditional marked crosswalk can increase crosswalk and pedestrian visibility and usage. Several of these facilities are covered under separate facility reports within the IDOT District One Bicycle & Pedestrian Accommodations Study. In this report, a "crosswalk enhancement" refers to additional pavement markings, alternative materials or methods to pave, texture, and/or color the space between the crosswalk lines, optical illusion markings placed in advance of the crosswalk, and the addition and/or enhancement of standard pedestrian and school signs. These treatments are intended to focus motorist attention toward the crosswalk and the pedestrian.

2L	3L	ML
INT	MBLK	
L	C	A
R	S	U
<10K	10-25K	>25K
≤30	35-45	≥50

Figure 1 – Crosswalk enhancements utilizing alternative color and texture between crosswalk lines, at the intersection of Wabash and Roosevelt in Chicago, Illinois.

	Benefits	Considerations
SAFETY	• Improves crosswalk visibility for motorists and pedestrians • Improves crosswalk detection for pedestrians with visual or cognitive impairments • Decreases crashes • Increases motorist stopping rates	• Improper application by some governing agencies (using color or crosswalk line variations prohibited in the MUTCD), designing for aesthetics instead of safety • Potential improper usage by pedestrians • Increases dependency on maintenance (alternative materials must be properly maintained)
OPERATIONS	• Controls the flow of pedestrians and vehicles in a similar manner as a traditional crosswalk • Maintains the expected pedestrian travel pattern	• Potential improper usage by pedestrians • Potential motorist confusion with alternative markings • Slight decrease in motorist speeds
MAINTENANCE	• Potentially lowers maintenance costs if more durable materials are used	• Additional cost and effort to maintain alternative materials (color, texture, paving)

Facility Reports: Bicycle

Bicycle & Pedestrian Accommodations Study

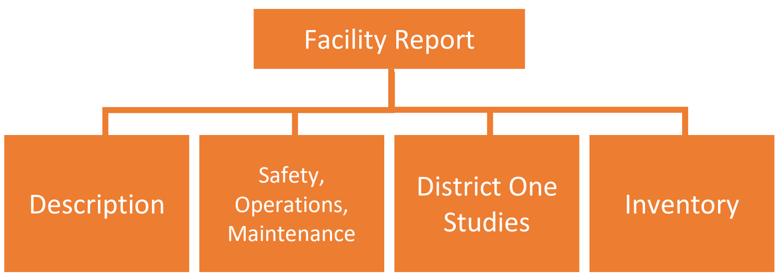
Illinois Department of Transportation, District One

VOLUME 2

Illinois Department of Transportation

Bicycle

Included in each Facility Report:



- Facility Description
  - Summary
  - Features
  - Warrants
  - Costs
  - Design Guidance
- Safety Analysis
- Operations Analysis
- Maintenance Analysis
- District One Studies
  - Summary
  - Field Survey
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Notes:
Safety analysis includes the following potential topics: *crashes, conflict points, user comfort, signal/stopping compliance, etc…*
Operations analysis includes: *traffic volumes, delay, speed, pedestrian wait times, etc...*
Maintenance analysis includes: *drainage, utilities, street sweeping, snow removal, unique materials & equipment, etc…*

Conventional Bicycle Lanes

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

Conventional bicycle lanes are on-road bicycle facilities that run alongside traffic. Bicyclists travel in the same direction as the adjacent motorist lane. Conventional bicycle lanes are marked for and used exclusively by bicyclists. They can be placed along the curb, shoulder or adjacent to parking and are delineated by pavement markings. Bicycle lanes can be augmented by regulatory and directional signage. According to Chicago's *Streets for Cycling Plan 2020*, Chicago built its first on-street bicycle lane in 1971.

Figure 1 - Conventional bicycle lane on Damen Avenue in Chicago

Features

According to the AASHTO Bike Guide, the recommended width of a bicycle lane is about 5 feet and has the following features:

- Solid white striping to outline the bicycle lane
    - One stripe between the bicyclists and adjacent traffic (required)
    - An additional/second stripe between the bicyclists and parking lane (optional).
    - Lane lines can be dotted at locations where motor vehicles are allowed to merge into or cross/turn through the bicycle lane such as intersections, bus stops, or right-turn lanes.
- A bicycle symbol and arrow to indicate direction and lane usage
- Regulatory signage to alert motorists of the bicycle lane (optional)[1]

Warrants

NACTO states conventional bicycle lanes are appropriate on streets with high potential for bicycle use and:

- Greater than or equal to 3,000 motor vehicle ADT
- A posted speed limit greater than or equal to 25 MPH
- High transit vehicle volumes

For streets with routine truck traffic, extremely high traffic volumes, high parking turnover, or on streets with posted speed limits over 35 MPH, NACTO suggests considered other treatments such as buffered bicycle lanes or separated bicycle lanes.

Costs

Standard bicycle lanes are comprised of two components: pavement markings (lane striping and bicycle symbol and arrow) and signage. The average cost of a conventional bicycle lane is $133,170 per installation, but may range between $5,360 and $536,680. The average cost of a pavement marking symbol is $180 per installation, but may range between $22 and $600 (2013 dollars). The cost varies due to the level of preparation and extent of features that are installed. Pavement may require patching before striping installation and medians may require reconstruction or removal. Signals and timings may also require adjustment. Many installations require changing the existing lane widths which may require restriping the center line and lane lines, addition of motorist turn lanes, crosshatching and parking restrictions at corners, and installation of parking restriction signs. Although optional, bicycle lane signage should be included in the project and installed at entrances and midblock locations along bicycle lanes, which further increases costs.[2]

Basic installations are near the low end of the range and can be installed for less than $133,170. For example, without signage or grinding and reinstalling existing striping, a conventional bicycle lane can be installed for approximately $27,000 per mile based on 2015 average pay item costs. Costs can also be reduced when coupling bicycle lane installations with street reconstruction or resurfacing projects.

Design Guidance

FHWA	Manual on Uniform Traffic Control Devices (MUTCD) – Sections 9B.04 and 9C.04 http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm
Illinois Department of Transportation	Bureau of Local Roads and Streets Manual – Chapter 42 http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Local-Roads-and-Streets/Local%20Roads%20and%20Streets%20Manual.pdf
Illinois Department of Transportation	Bureau of Design and Environment Manual – Chapter 17 http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Design-and-Environment/Illinois%20BDE%20Manual.pdf
AASHTO THE VOICE OF TRANSPORTATION	Guide for the Development of Bicycle Facilities – Section 4.6 to Section 4.8 https://store.transportation.org/Item/CollectionDetail?ID=116
NACTO	Urban Bikeway Design Guide http://nacto.org/cities-for-cycling/design-guide/bike-lanes/conventional-bike-lanes/

Figure 2 - List of design guidance manuals and documents

SAFETY

Bicycle lanes have distinguishing features that designate a specific area for bicyclists, resulting in more predictable behavior and reduced conflicts between bicyclists and motorists. Although conventional bicycle lanes have been shown to reduce conflict, there are safety issues that occur with conventional bicycle lanes. "Dooring" incidents (in which a bicyclist is hit by a vehicle occupant opening a door into the bicyclist's path) account for approximately 20% of bicycle accidents in the City of Chicago according to the Illinois Department of Transportation (IDOT).[3] Bicyclists using conventional bicycle lanes are often within the 45 inch door zone of parked cars, making them susceptible to "dooring".[4] Additionally, the lack of a physical barrier allows motorists to park or drive within the bicycle lane, especially when turning, which can cause conflict.

Studies have shown that 93% of United States bicyclists feel safer riding on streets with bicycle lanes than on streets without bicycle accommodations.[5] In 2012, a study done in Vancouver and Toronto, Canada looked at 690 crashes before and after the addition of bicycle lanes on major streets with and without parked cars. The study found that after the installation of bicycle lanes serious injury crashes were reduced by 31%, and 14%, respectively.[6]

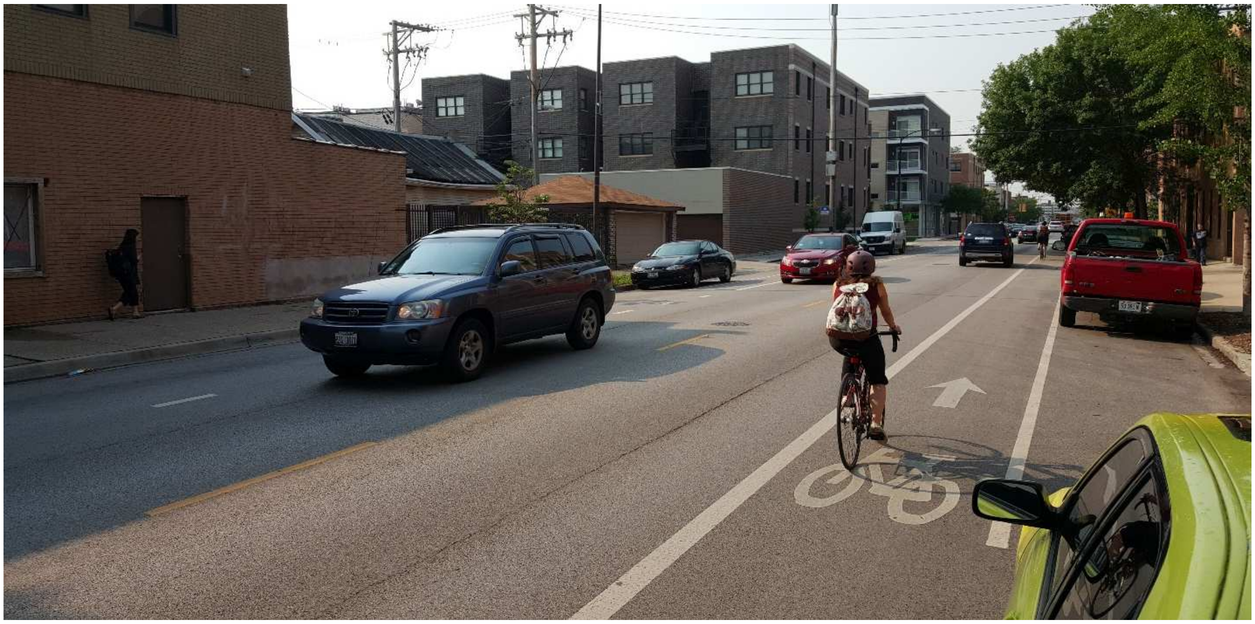


Figure 3 - A conventional bicycle lane on Damen Street in Chicago

A study titled, "Effects of Bike Lanes on Driver and Bicyclist Behavior" was published in ASCE's Journal of Transportation Engineering that looked at how conventional bicycle lanes affected the lateral positioning of bicycles and vehicles on a variety of urban streets both with and without bicycle lanes. The study's results show reduced variability in auto passing behavior on streets with conventional bicycle lane, meaning fewer wide swerves and close passes by autos overtaking bicycles. However, the average lateral separation between bicycles and overtaking cars was not affected by the provision of bicycle lanes.[7]

OPERATIONS

Conventional bicycle lanes are intended to improve bicyclists' and motorists' travel by providing a designated space for cyclists in the same corridor as motorists. This allows bicyclists to travel without impeding motorist traffic. Bicycle lanes also encourage bicycle travel in the direction of motorist traffic.

The installation of conventional bicycle lanes on existing roadways will reduce vehicular lane widths. As shown in a study posted in NACTO's urban street design guide, reducing vehicular widths shouldn't hinder traffic operations; the Florida Department of Transportation measured saturation flow rates of a street with lane widths reduced from 12 feet to 10 feet and found, "measured saturation flow rates are similar for lane widths between 10 feet and 12 feet...Thus, so long as all other geometric and traffic signalization conditions remain constant, there is no measurable decrease in urban street capacity when through lane widths are narrowed from 12 feet to 10 feet."[8] However, delay may increase if existing traffic lanes are removed to install the facility.

Bicycle lanes are often blocked by motorists parking in the lane, delivery trucks, and sometimes buses. This may require the bicyclist to wait behind the motorist until they clear, or pass by merging into the motorist travel lane, which increases conflicts. Snow or other obstacles may be present in the lane as well that would require bicyclists to ride outside the lane, which could slow down motorist traffic. Buffered bicycle lanes create additional visuals to reinforce the bicycle only nature of the lane. Further compliance is seen with separated bicycle lanes which moves the bicycle lane to the other side of the parking lane, making it difficult for motorists to block the lane. See the separated bicycle lane report for more information.

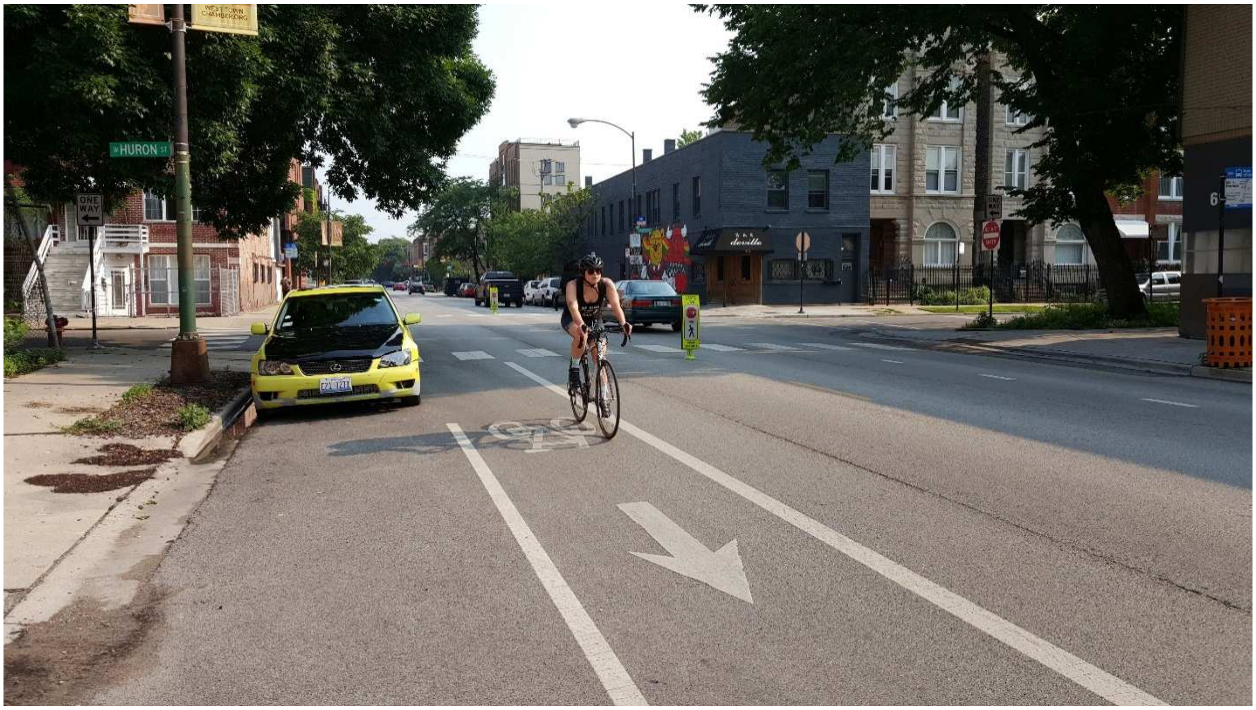


Figure 4- Conventional bicycle lane on Damen Street in Chicago

In order to ensure conventional bicycle lanes remain fully operational and reduce delays to bicyclist and motorists, law enforcement must be vigilant in issuing citations to motorists parking or standing in bicycle lanes. Between 2008 and 2011, 3,968 tickets were issued to motorists for parking in bicycle lanes in Chicago.[9]

MAINTENANCE

Conventional bicycle lanes require only basic maintenance such as restriping pavement markings, maintaining appropriate signage, and winter snow removal. Restriping of pavement marking lines, letters, and symbols should be performed in accordance with MUTCD standards. Snow and ice occupying the bicycle lane essentially render the facility useless. Therefore, it is important that winter maintenance of bicycle lanes is performed routinely in order to keep the bicycle lanes usable and clear of snow and ice. It is has been observed that the maintenance of bicycle lanes isn't always a high priority for local agencies and routine inspections of bicycle lanes aren't always performed consistently.

Figure 5 - Unplowed conventional bicycle lane in Chicago

Street Sweeping & Snow Removal

Snow removal from conventional bicycle lanes can be performed at the same time as roadway snow removal since conventional bicycle lanes do not effect a roadway's cross slope and there is no physical barrier between the motorist lane and bicycle lane. Snow removal can be performed with truck mounted plow blades or with smaller snow removal vehicles. Some street maintenance divisions have implemented "snow removal priority plans" which prioritize snow removal along routes with bicycle paths.

Drainage

Implementing conventional bicycle lanes on existing roadways would not influence roadway surface runoff because the existing grade of the roadway does not change. Those locations where a conventional bicycle lane is introduced for which widening of the roadway would be required, thereby increasing impervious area, should be analyzed to ensure roadway drainage systems account for the additional drainage runoff.

Utility Cuts and Construction Damage

Conventional bicycle lanes may be affected during utility repairs, but IDOT and most municipal utility policies require restoration to existing conditions upon utility repair completion by those performing the work. Utility companies may require guidance in the repair of the facility and their work should be inspected upon completion.

District One Studies

The following is a summary of findings from two studies performed in 2014 for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 1 - Local separated bicycle lane studies performed by District One

Study	Findings
Pedestrian Survey	The majority of the survey's participants felt comfortable riding in the conventional bicycle lanes; most did however suggest areas for improvement. The majority of participants mentioned conflicts with turning vehicles, pedestrians standing in the bicycle lane, and vehicles parking in the bicycle lane.
Behavior Study	There were a total of 106 bicyclists recorded during the bicycle compliance portion of the study. Of those bicyclists, 80% rode within the bicycle lane, 8% rode outside the bicycle lane on the street and 12% rode on the sidewalk or against traffic. Bicyclists riding outside the bicycle lane may have been due to various reasons such as parked cars or simply to allow a larger buffer between moving traffic.

Pedestrian Survey

Surveys were conducted at two locations to gauge bicyclists' opinions on conventional bicycles lanes. The first survey collected in-person and online surveys at West Fullerton Avenue and North Clifton Ave on August 6th, 2014 from 4-6PM. Fullerton Avenue is classified as a minor arterial by IDOT and has an ADT of 14,600 at this location. The weather conditions were 74 degrees and partly cloudy. The online survey was open for two weeks starting on August 6th. The second set of surveys were conducted on October 10th, 2014 on Illinois Street and Dearborn Street and also included in-person and online surveys. Illinois Street is classified as a principal arterial roadway by IDOT and has an ADT of 3,600 at this location. The temperature was 50 degrees and clear.

At the Fullerton location, a total of five paper surveys were completed and seven online submissions were received. At the Illinois location, a total of 16 paper surveys were completed and 27 online submissions were received.

Survey Method

Two spot studies were conducted on the conventional bicycle lanes on Fullerton Avenue at Clifton Avenue and on Illinois Street at Dearborn Street. One staff member was positioned on the north side sidewalk while another staff member was positioned on the south side sidewalk. Both members wore safety vests for safety purposes and to attract the attention of approaching bicyclists. The staff would approach oncoming bicyclists and ask them to take a survey either in person or online at their convenience. The IP addresses of online submissions were checked to prevent multiple submissions from the same person.

Survey Questions

Participants were asked questions 6 through 13 (Figures 6 through 13). The questions were based on the sites conventional bicycle lanes.

Table 2- Survey questions corresponding to the following figures

Figure #	Questions Asked
6	What is your gender?
7	Are you using a Divvy bike?
8	In what age group do you fall?
9	What best describes why you are out here today?
10	In the past month, about how often have you ridden here?
11	Why did you choose this route?
12	How comfortable are you cycling along Fullerton, between Racine and Halsted on a scale of 1-5?
13	Is there anything that could be improved to make you feel more comfortable?

Survey Results

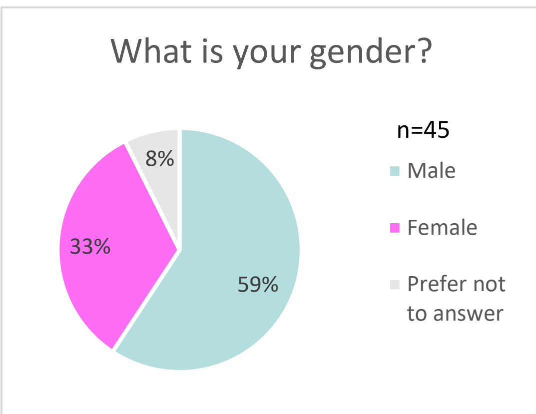


Figure 6- What is your gender?

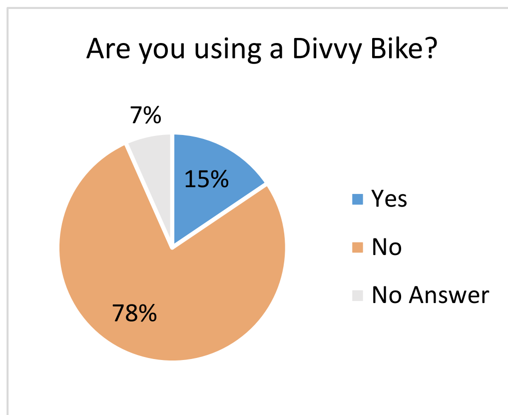


Figure 7- Are you using a Divvy bike?

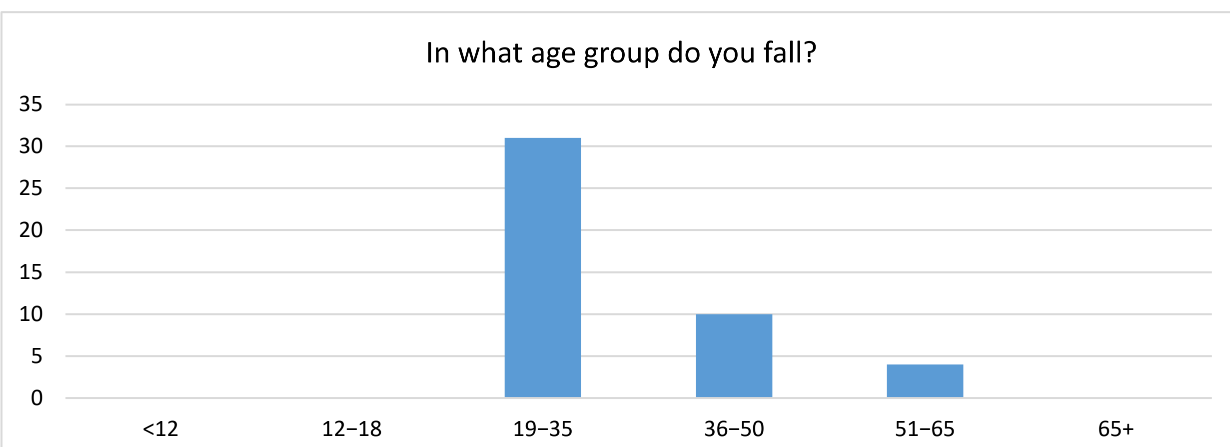


Figure 8- In what age group do you fall?

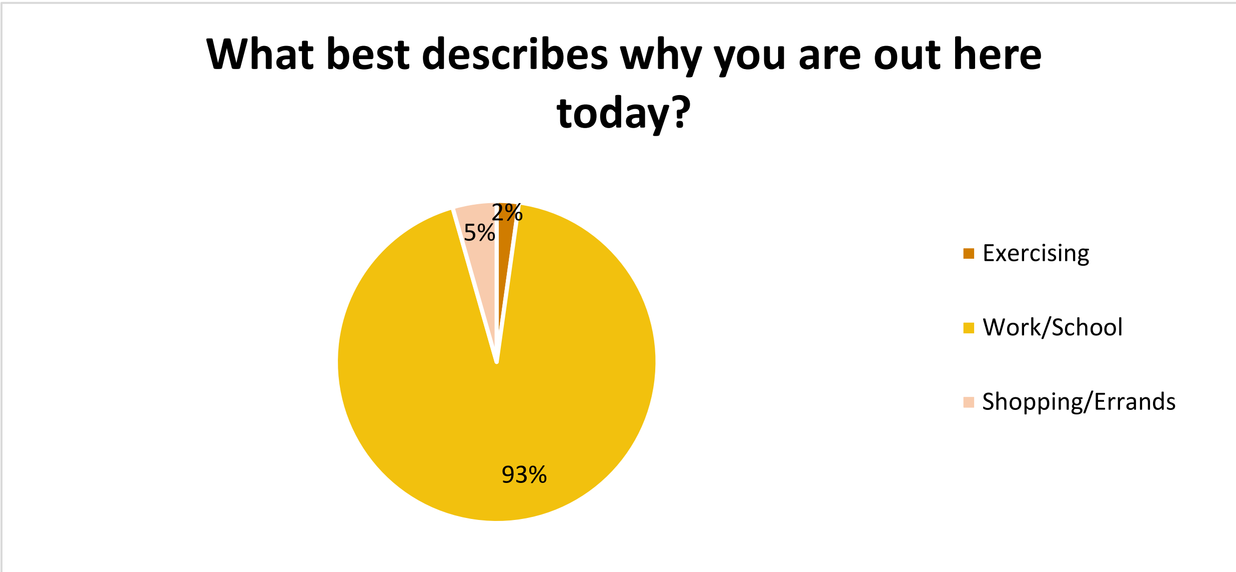


Figure 9 - What best describes why you are out here today?

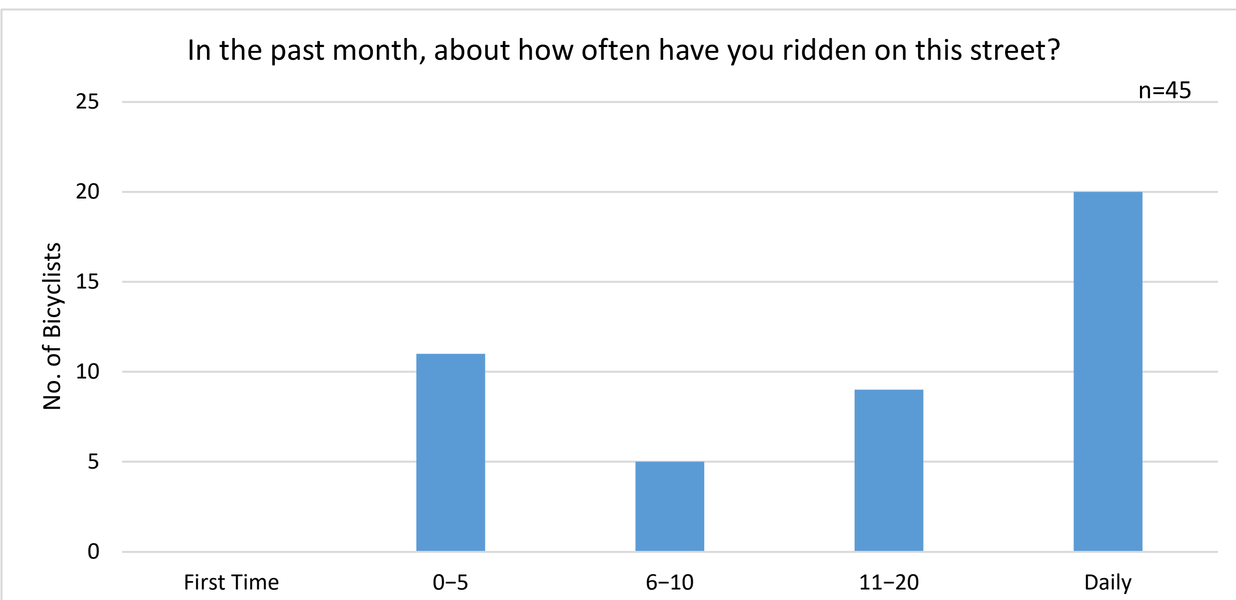


Figure 10 - In the past month, about how often have you ridden on this street?

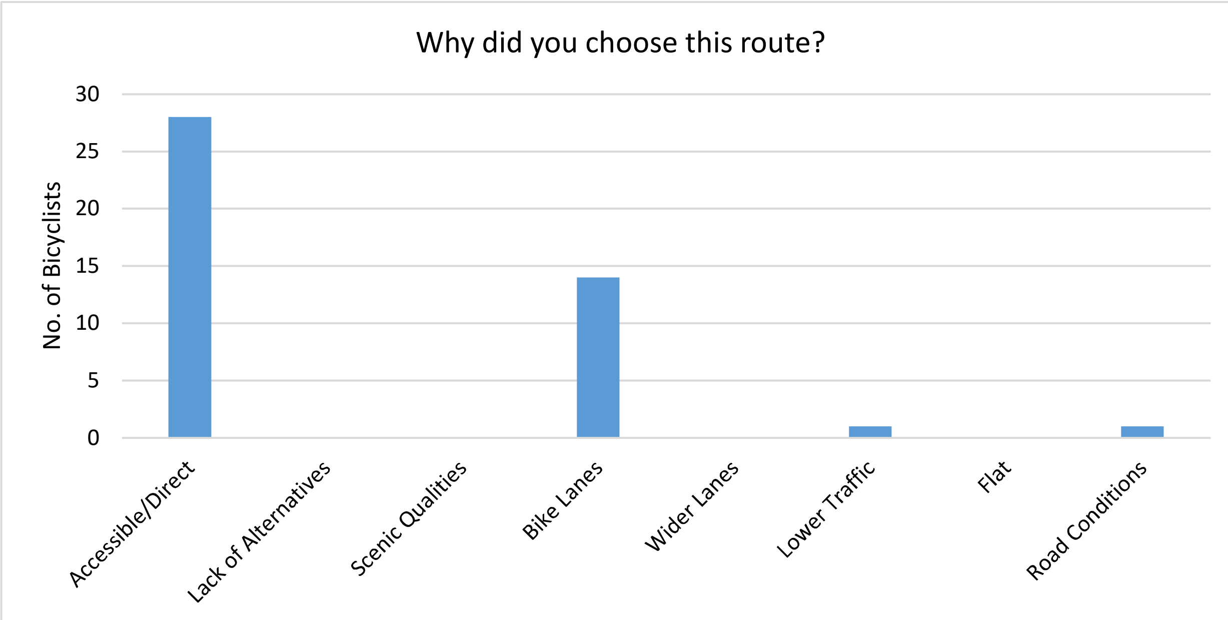


Figure 11 - Why did you choose this route?

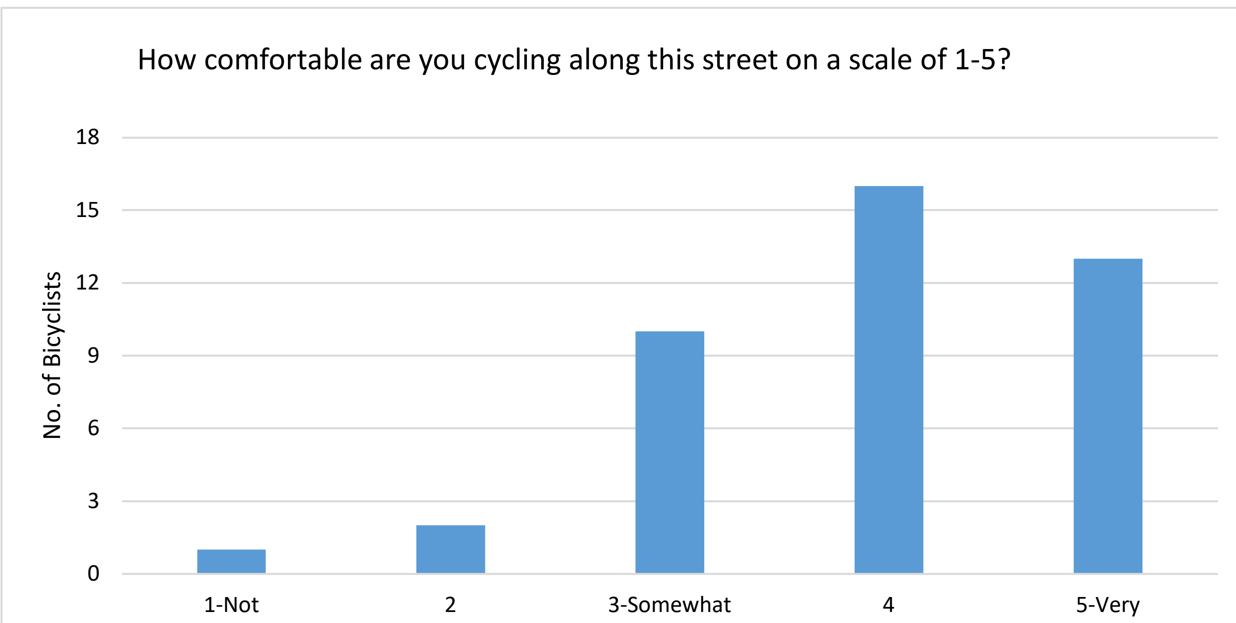


Figure 12 - How comfortable are you cycling along this street on a scale of 1-5?

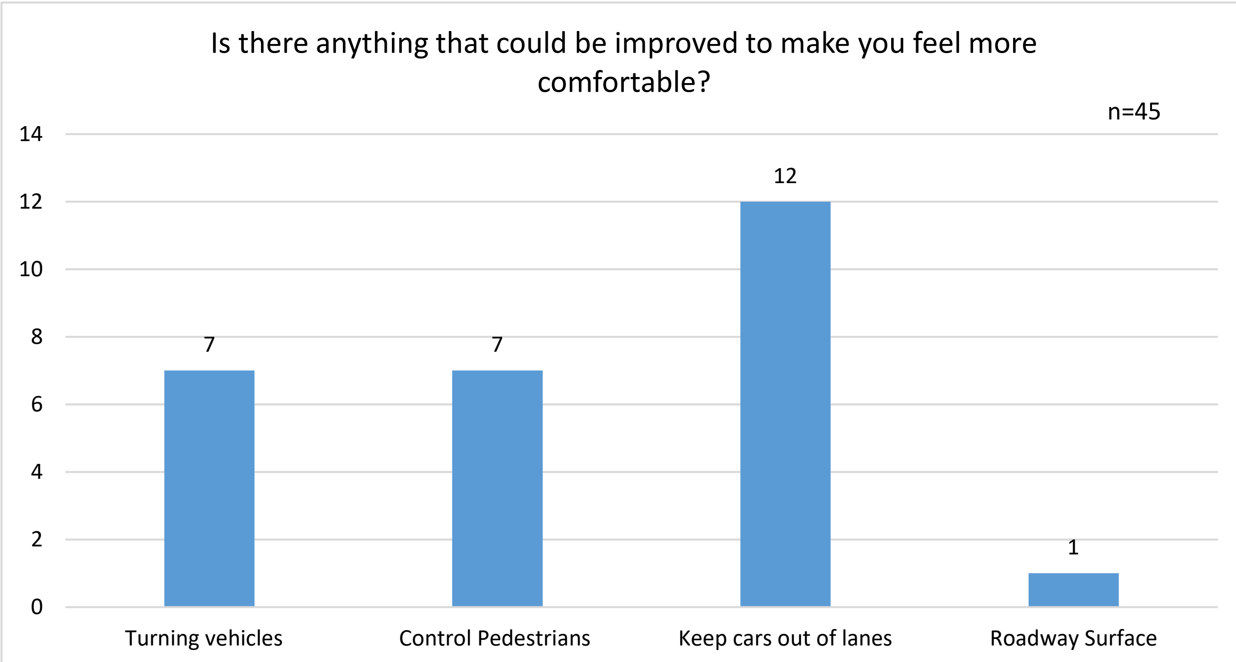


Figure 13 - Is there anything that could be improved to make you feel more comfortable?

Conclusion

The majority of the survey's participants felt comfortable riding in the conventional bicycle lanes; most, however, suggested areas for improvement. The majority of participants mentioned conflicts with turning vehicles, pedestrians standing in the bicycle lane, and vehicles parking in the bicycle lane. On Fullerton Avenue, most bicyclists voiced a want for protected bike lanes and repairs to the road surface.

Bicyclist and Motorist Behavior Study

A spot study on bicyclist and motorist behavior was conducted for the conventional bicycle lane on West Fullerton Avenue near North Clifton Avenue on August 5th, 2014 between the evening hours of 4:00 – 6:00 pm. This section of West Fullerton Avenue is located on a busy college campus in Chicago and has an ADT of 14,600 vpd with a minor arterial roadway classification by IDOT. The weather conditions were mid 70s and partly cloudy at the time of observation. The study intended to find the compliance rates of bicyclists and motorists along a conventional bicycle lane.

Study Method

Four staff members were positioned on the southeast corner of Fullerton Avenue and Clifton Avenue. The evaluators monitored whether motorists complied with the pavement markings and stayed in their own designated lane, or displayed noncompliant behavior by either driving or parking in the bicycle lane. They also monitored how bicyclists used the bicycle lane, noting whether they rode within the bicycle lane, rode the wrong direction within the bicycle lane, or rode on the sidewalk instead of the bicycle lane.

Bicyclist Behaviors

During the 2 hour period, 106 bicyclists were observed. Figure 14 shows the graphical comparison of their riding behaviors. The majority of bicyclists rode in the bicycle lane, 80%. Bicyclists who rode outside of the lane, in the wrong direction, or on the sidewalk, were relatively uncommon with incidences of 8%, 5%, and 7% respectively.

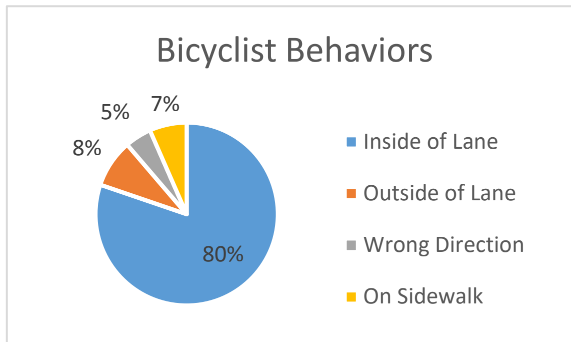


Figure 14 -Compliance of Bicyclists

Motorist Behaviors

Within the 2 hour period 2,197 cars were observed. Their various behaviors are summarized in Figure 15. Motorists stayed in their dedicated lane 99% of the time and were noncompliant only 1% of the time.

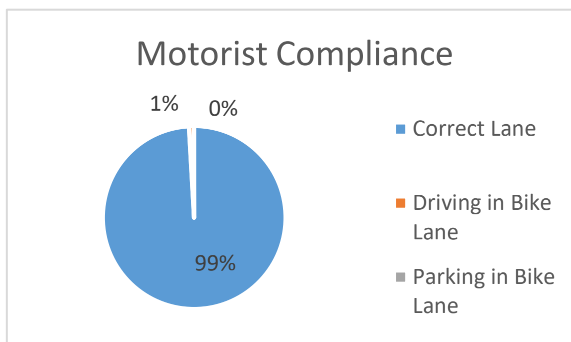


Figure 15 - Compliance of Motorists

Discussion

The high percentage of motorist compliance suggests that the motorists understood their designated position on road. The compliance of the motorists directly correlates to the ability for cyclists to use the bicycle lanes. Since motorists were consistently compliant with the bicycle lane, bicyclist behavior was not negatively affected by motorist behaviors.

The percentage of bicyclists not riding within the bicycle lane may have been due to various reasons such as parked cars in the bicycle lane, door openings from parked cars, or bicyclists waiting in the lane to make a left turn. There was no debris observed in the bicycle lane. Bicyclists who did not use the bicycle lane sometimes used the parking spaces to the right of the bicycle lanes when available. This could be the result of a preference to maximize distance between themselves and the motorists. Further studies should be performed exploring reasons why bicyclists rode outside the lane.

Conclusion

There were a total of 106 bicyclists recorded during the bicycle behavior portion of the study. Of those bicyclists, 80% rode within the bicycle lane, 8% rode outside the bicycle lane on the street and 12% rode on the sidewalk or against traffic. Bicyclists riding outside the bicycle lane may have been due to various reasons such as parked cars blocking the lane or simply to allow a larger buffer between moving traffic.

There were 2,197 motorists observed during the motorist compliance portion of the study. Of those, over 99% properly remained within their own lane and less than 1% encroached into the bicycle lane while either driving or parking.

As of December 22, 2014, all 50 states have at least one conventional bicycle lane, and one location from each state is listed in the table below. According to Chicago's Streets for Cycling Plan 2020, Chicago built its first on-street bicycle lane in 1971.

Country	State	City	Street
USA	AL	Mobile	Hillcrest Rd.
USA	AK	Anchorage	E 88th Ave.
USA	AZ	Phoenix	S. 7th St.
USA	AR	Little Rock	Arkansas River Trail
USA	CA	Sacramento	Riverside Blvd.
USA	CO	Denver	Martin Luther King Jr. Blvd.
USA	CT	New Haven	Howard Ave.
USA	DE	Rehoboth Beach	Coastal Hwy.
USA	FL	Pensacola	N Davis Hwy.
USA	GA	Atlanta	Ivan Allen Jr. Blvd.
USA	HI	Honolulu	Ala Wai Blvd.
USA	ID	Rexburg	S. 2nd W.
USA	**IL**	**Chicago**	**S. South Chicago Ave. from Marquette Rd. to 79th St.**
USA	IN	Indianapolis	N. Illinois St.
USA	IA	Des Moines	Beaver Ave.
USA	KS	Olathe	E. Sheridan St.
USA	KY	Louisville	Camp Ground Rd.
USA	LA	New Orleans	St. Charles Ave.
USA	ME	Lewiston	Ash St.
USA	MD	Baltimore	W. University Pkwy.
USA	MA	Boston	Massachusetts Ave.
USA	MI	Detroit	Michigan Ave.
USA	MN	Minneapolis	Park Ave. S.
USA	MS	Hattiesburg	W. Pine St.
USA	MO	St. Louis	S. McKnight Rd.
USA	MT	Bozeman	Durston Rd.
USA	NE	Lincoln	S. 14th St.
USA	NV	Las Vegas	E. Harmon Ave.
USA	NH	Keene	Washington St.
USA	NJ	Teaneck	Palisade Ave.
USA	NM	Albuquerque	Broadway Blvd. SE
USA	NY	Syracuse	E. Genesee St.
USA	NC	Raleigh	Reedy Creek Rd.
USA	ND	Fargo	4th St. N.
USA	OH	Columbus	Norton Rd.
USA	OK	Norman	McGee Dr.
USA	OR	Salem	Commercial St. SE
USA	PA	State College	S. Sparks St.
USA	RI	Cranston	Narragansett Blvd.
USA	SC	Lexington	N. Lake Dr.
USA	SD	Sioux Falls	E. 41st St.
USA	TN	Knoxville	E. Magnolia Ave.
USA	TX	Houston	Lyons Ave.
USA	UT	Provo	E. 700 N.
USA	VT	Norwich	W. Wheelock St.
USA	VA	Charlottesville	Jefferson Park Ave.
USA	WA	Olympia	State Ave. NE
USA	WV	Parkersburg	2nd St.
USA	WI	Madison	Odana Rd.
USA	WY	Cheyenne	Vandehei St.

1 American Association of State Highway and Transportation Officials. 2012. *Guide for the Development of Bicycle Facilities.* 4th ed. Washington, DC: American Association of State Highway and Transportation Officials.

2 Bushell, Max, Bryan Poole, Daniel Rodriguez, and Charles Zegeer. July 2013. *Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners and the General Public*. University of North Carolina Highway Safety research center. Accessed August 28, 2014. http://www.pedbikeinfo.org/cms/downloads/Countermeasure%20Costs_Report_Nov2013.pdf

3 Jenkins, Jason. May 15, 2014. "Don't Become a Dooring Statistic," The Weblog of the Active Transportation Alliance. Accessed July 21, 2014. https://activetrans.org/blog/dont-become-a-dooring-statistic

4 Torbic, Darren J., Karin M. Bauer, Chris A. Fees, Douglas W. Harwood, Ron Van Houten, John LaPlante, and Nathan Roseberry. 2014. *Recommended Bicycle Lane Widths for Various Roadway Characteristics.* Transportation Research Board. National Cooperative Highway Research Program. NCHRP Report 766 (Washington, D.C.)

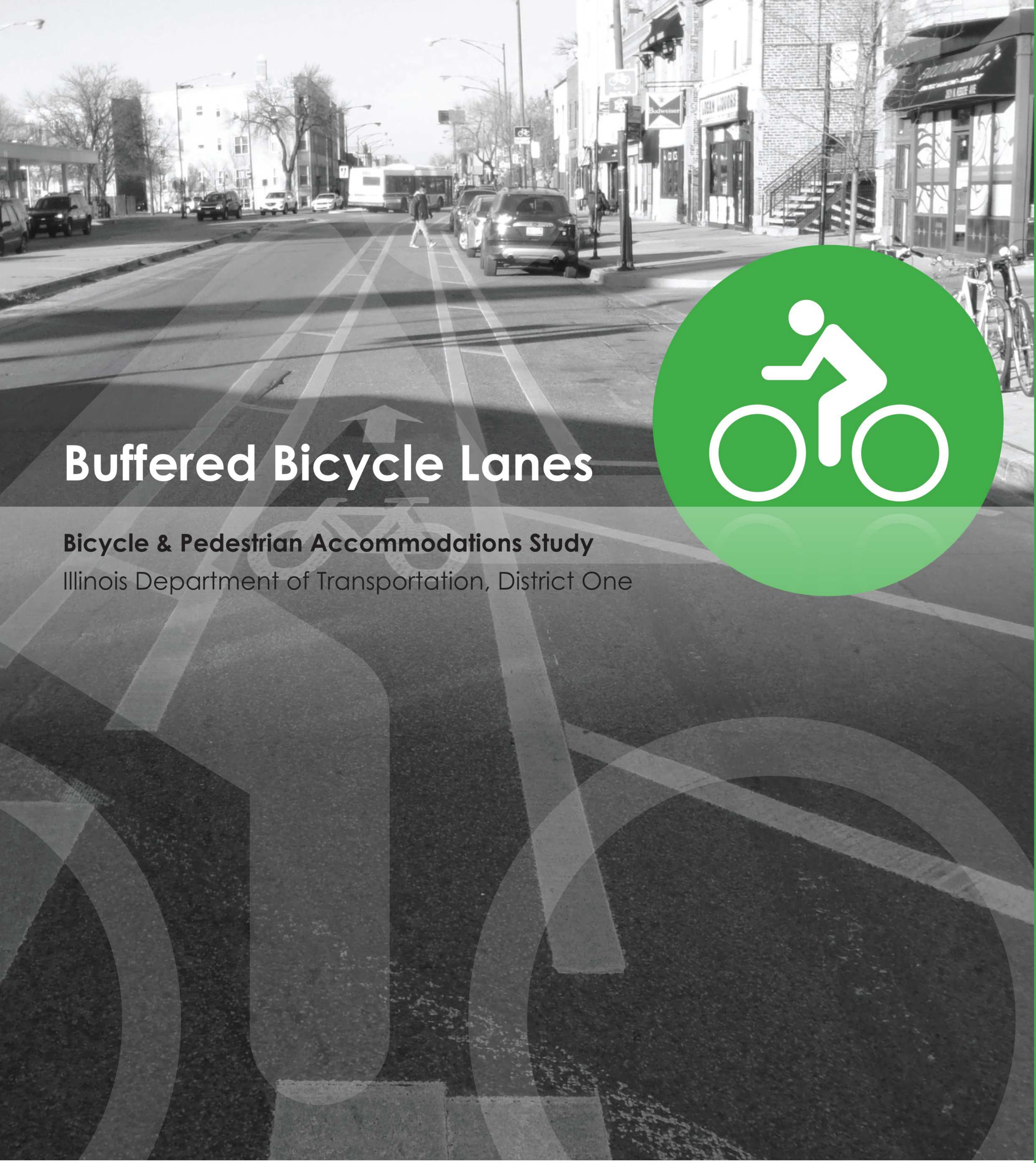
5 Federal Highway Administration. *Bicycle Lanes versus Wide Curb Lanes: Operational and Safety Findings and Countermeasure Recommendations, 1995-1998,* by William W. Hunter, J. Richard Stewart, Jane C. Stutts, Herman H. Huang, and Wayne E. Pein. Accessed August 21, 2014. https://www.fhwa.dot.gov/publications/research/safety/pedbike/99035/index.cfm

6 Techke, Kay, Anne Harris, Conor Reynolds, Meghan Winters, Shelina Babul, Mary Chipman, Michael Cusimano, Jeff Brubacher, Garth Hunte, Steven Friedman, Melody Monro, Hui Shen, Lee Vernich, and Peter Cripton. 2012. "Route Infrastructure and the Risk of Injuries to Bicyclists: A Case-Crossover Study." *American Journal of Public Health* 102, no. 12 (December): 2336-2343.

7 Kroll, Bonnie J., and Melvin R. Ramey. "Effects of Bike Lanes on Driver and Bicyclist Behavior." *Journal of Transportation Engineering* 103.2 (1977): 243-56. Web. Oct. 2015. http://cedb.asce.org/cgi/WWWdisplay.cgi?7229

8 State of Florida Department of Transportation. *CONSERVE BY BICYCLE PROGRAM STUDY - PHASE I REPORT*. Rep. N.p.: n.p., 2007. Web. Oct. 2015. http://nacto.org/docs/usdg/conserve_by_bicycle_fl_dot.pdf

9 Grid Chicago. 2014. *Traffic Citations – A Look at Traffic Enforcement in Chicago*. Accessed September 2, 2014. http://gridchicago.com/citations/ (link inactive)



Buffered Bicycle Lanes

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation


Budweiser

Buffered bicycle lanes are on-road lanes that are marked for and used exclusively by bicyclists, similar to conventional bicycle lanes, but with the addition of a designated buffer space between bicyclists and moving or parked vehicles, on one or both sides of the bicycle lane. Also similar to conventional lanes, buffered bicycle lanes can be placed along one or both sides of the roadway depending on available roadway width, thus allowing bicyclists to travel in the same direction as motorists. According to the Illinois Department of Transportation and research by the Active Transportation Alliance, approximately 20% of bicycle crashes in the City of Chicago were a result of a "dooring" accident.[1] The addition of designated buffer spaces, within the bicycle lanes, reduces "dooring" accidents by indicating lateral positioning and increases the feeling of safety for bicyclists.

Figure 1 – Buffered bicycle lanes on Kedzie Avenue in Chicago

Features

Two solid white pavement marking lines can be used at a minimum operating width to designate the location of the bicycle lane.[2,3] The buffer space is then defined by two solid white lines spaced 18-24 inches apart, typically with a diagonal hatching, to further separate adjacent traffic and/or parked vehicles and the bicycle lanes (as shown in Figure 1).[2,3,4] A chevron style marking should be used when the width of the buffer exceeds 3 feet, similar to that used for a gore area. Additionally, bicycle lane pavement markings, such as "BIKE LANE" text and bicycle symbols with arrows, are used to denote a designated bicycle area.

At intersections without a dedicated right-turn only lane, a buffer marking transition to conventional dashed lines or crossing pavement markings are used. Bicycle boxes can also be implemented at these locations. At intersections with a dedicated right-turn only lane, a dedicated through bicycle lane transitioned to the left of the right-turn only lane is used when available road space is available. At intersections where available road space is not adequate to provide a dedicated bicycle lane, a mixing zone is used. See the bicycle intersection markings report for more information on transitions and crossings. When space is limited to provide a buffer zone on both sides of the bike lane, CDOT chooses to place the buffer zone on the side adjacent to parking.

Warrants

Typical Applications include the following:[4]

- Anywhere a standard bike lane is being considered.
- On streets with high travel speeds, high travel volumes, and/or high amounts of truck traffic.
- On streets with extra lanes or extra lane width.
- Special consideration should be given at transit stops to manage bicycle and pedestrian interactions.

Costs

The average cost of a conventional bicycle lane is $133,170 per mile but may range between $5,360 and $536,680.[5] Costs will be higher for buffered bicycle lanes due to the additional striping. The average cost of a pavement marking symbol is $180 per installation, but may range between $22 and $600.

$ | $133,170/mile
Average cost

Design Guidance:

FHWA	Manual on Uniform Traffic Control Devices (MUTCD) Chapter 3D. Markings for Preferential Lanes Chapter 9C. Markings. 2009 Edition, Revisions 1 & 2, May 2012 http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm
FHWA	Bicycle and Pedestrian Facility Design Flexibility Memorandum Date: August 20, 2013, Updated 9/24/2015 https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_flexibility.cfm
AASHTO	Guide for the Development of Bicycle Facilities 2012 – Fourth Edition https://store.transportation.org/Item/CollectionDetail?ID=116
NACTO	Urban Bikeway Design Guide 2012 – Second Edition http://nacto.org/publication/urban-bikeway-design-guide/bike-lanes/buffered-bike-lanes/

Figure 2 - List of design guidance manuals and documents

SAFETY

Studies have found that buffered bicycle lanes provide safety benefits for both bicyclists and motorists. These studies show that the buffered bicycle lanes will provide the following:

- Potential reduction in "dooring" collisions between parked vehicles and bicyclists.
- Roadway positioning guidance to both bicyclists and motorists.
- A space for bicyclists to pass one another without encroaching into adjacent vehicle travel lanes.[6]
- Additional space for bicyclists to maneuver more safely when avoiding potholes or obstructions within the bike lane.

Figure 3 – Buffered bicycle lanes on Wabash Street in Chicago

Studies in Portland, Oregon, conducted by their Bureau of Transportation, found that bicyclists' perception of safety increased with the addition of buffered bicycle lanes.[7]

- Nearly 65% of the bicyclists surveyed chose a route with buffered bicycle lanes versus a route without.
- Video counts at two study locations showed a 77% increase and a 271% increase in bicyclist volumes after installation of buffered bicycle lanes.
- Most bicyclists (90%) preferred using buffered bicycle lanes over conventional bicycle lanes.
- Bicyclists felt a lower risk of being "doored" in the buffered lanes.

The Transportation Research Board, National Cooperative Highway Research Program, conducted a study in 2014 with findings and recommendations for bicycle lane widths based on various roadway characteristics for urban and suburban travel lane widths (both bicycle lanes and wide curb lanes) and parking lane widths for existing roadways with low speed limits.[8] Variables studied included bicycle lane widths from 3.5 feet to 6 feet, parking lane widths from 7 feet to 9 feet, and travel lane widths from 10 feet to 14 feet when bicycle lanes are present. Behavioral studies were conducted at the different test sites with the use of video camera monitoring. Several behavioral impacts were examined for both bicycle lanes and wide curb lanes, with the results concluding that the addition of bicycle lanes is indeed a safer type of facility over widened curb lanes. Since "dooring" incidents are significant, the study also examined parking lane widths, wide curb lane widths, and the distance cars park from the curb in order to control the open door zone. The results from this study concluded that wide curb lanes are ineffective because they cause bicyclists to ride in the door zone. The study also concluded that by adding a buffer zone between bicyclists and parked cars, bicycle "dooring" incidents decreased, which means that this layout is very effective. Because of the findings of the study, the Transportation Research Board recommended utilizing a buffered bicycle lane over a wider conventional lane.

Approximately 20% of bicycle accidents in the City of Chicago were a result of a "dooring", according to the Illinois Department of Transportation[1]. Currently, in the City of Chicago, adequate long-term accident data is not available to determine the effects that buffered bicycle lanes would have on both motorists and bicyclists. For additional crash analysis data, see District One Studies section of this facility report. IDOT did not begin incorporating "dooring accidents" into their records until 2010.[9] This "dooring" accident data is now available on IDOT'S Data Safety Mart website and shows that there have been 1,098 recorded "dooring incidents" in the City of Chicago since 2010. A significant number of these doorings occurred between the evening rush hours of 4:00 P.M. to 6:00 P.M.[10]

OPERATIONS

Buffered bicycle lanes improve travel operations by providing increased separation between bicyclists and motorists or parked vehicles. The additional bike lane width may reduce friction and potential for conflicts between the two modes while also having a traffic calming effect. The Road Diet Informational Guide, states the addition of buffer space or converting a conventional bicycle lane to a buffered bicycle lane accomplishes vehicle speed reduction.[11] Some of the factors that can compromise the operations of this facility are:

- Motorists or buses parking or driving in the buffered bicycle lanes.
- Bicyclists riding within the buffer zone.
- Snow and other obstacles not being removed from the bicycle lane.

Figure 4 – Snow and vehicles parked in buffered bicycle lane on Kedzie Avenue

In 2010, the Bureau of Transportation in the city of Portland, Oregon, conducted an “after study” which evaluated both separated and buffered bicycle lane facilities and how each facility functioned one year after placement. In this study, video data was used to collect bicycle counts and intercept surveys were completed choosing a random representative sample of motorists, bicyclists, and businesses. The findings concluded that bicyclists’ perception of safety increased with the addition of the buffered bicycle lanes, and more bicyclists were already using the route and would still use the route instead of using conventional bicycle lanes. The findings also concluded that motorists were frustrated with the addition of the buffered bicycle lanes because they felt that parking was more challenging, thus delaying their travel time. However, the study also found that motorists appreciated the buffer zone which provides separation between bicyclists and vehicular traffic. The Portland Bureau of Transportation concluded that buffered bicycle lanes are a great addition to roadway facilities and provide many benefits to all users.[12]

MAINTENANCE

Buffered bicycle lanes require minimal routine maintenance aside from restriping pavement markings and signage maintenance but may require additional striping upkeep compared to conventional bicycle lanes due to the additional striping required.

Street Sweeping & Snow Removal

Buffered bicycle lanes should be kept free of structural deterioration, damage, and other debris. On-site inspections, street sweeping, and snow removal should occur on a regular basis to ensure bicyclists safety in all weather conditions. Local ordinances may dictate that property owners remove snow from their sidewalks which can often end up in bicycle lanes. Therefore, it is important to educate the public on striking a balance between clear paths for both walkways and bikeways. Snow removal from buffered bicycle lanes can be done with traditional snow plows.

Figure 5 – Partially plowed and salted buffered bicycle lane on Warren Boulevard in Chicago.

Drainage

Buffered bicycle lanes do not obstruct roadway surface runoff since they do change the existing grade of the road.

District One Studies

The following is a summary of findings from two studies performed by IDOT in 2014, for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 1 - Summary of IDOT District One Studies, 2014

Study	Summary of Findings
Pedestrian Survey	Overall, the majority of participants had positive responses for both the buffered bicycle lane and conventional bicycle lane. The buffered bicycle lane had a slightly higher average perception of safety rating, 4.5/5, than the conventional bicycle lane, 3.7/5, although survey sites had slightly different contexts in the immediate vicinity.
Crash Analysis	Between 2005 and 2013, 223 crashes were recorded at 12 sites. There were 4.3 crashes per roadway mile per year before installation and 3.8 crashes per roadway mile per year after installation of the buffered bicycle lanes. The percentage of intersection crashes decreased slightly from 55.1% before installation to 48.7% after installation. Of the injuries recorded along the facility before installation and after installation, type "A" injuries decreased significantly (from 12% to 2.9%), type "B" injuries increased some (from 54.2% to 65.7%), type "C" injuries decreased slightly (26.8% to 20.0%), no fatal accidents, and property damage increased (from 7.0% to 11.4%). The majority of the accidents occurred in daylight but decreased from 65.3% to 57.9% after the installation of buffered bicycle lanes. The average crash rate from the five sites with volume data drops slightly after the installation of the buffered bicycle lanes. This method factors in changes in bicyclist volumes over time and the increase in ridership usually experienced when BBLs are installed. The average crash rate dropped by nearly 5 crashes per million bicycle miles ridden after installation (7%).

Pedestrian Survey

Two surveys were conducted, one at a buffered bicycle lane along Kedzie Avenue and one at a conventional bicycle lane along Fullerton Avenue, to compare and contrast bicyclists opinions on the respective facilities. The corridor along Kedzie Avenue from Milwaukee Avenue to Belmont Avenue is a two-lane, two-way street through a neighborhood and commercial area, ending at a busy intersection near the interstate to the north. The in-person survey regarding the buffered bicycle lanes was conducted along Kedzie Avenue at Avondale Avenue on November 5, 2014 from 4:00 p.m. to 6:00 p.m. During the survey, the weather condition was overcast with a drizzle and the temperature was 55 degrees. The corridor along Fullerton Avenue from Racine Avenue to Halsted Street is a two-lane, two-way street through a neighborhood and commercial area, ending near the campus of DePaul University to the east. The in-person surveys for the conventional bike lanes along Fullerton Avenue were conducted on August 6, 2014 from 4:00 p.m. to 6:00 p.m. near the intersection of Clifton Avenue. The weather condition was partly cloudy with a temperature of 74 degrees. For both locations, online surveys were also available for a two week period. Additionally, the survey at Kedzie Avenue was performed at the nearest stoplight intersection to reach bicyclists stopped at the light. The intersection widens as it passes under the expressway and includes green pavement during the lateral shift merge for right turning motorists. While, the survey at Fullerton Avenue was also near an intersection it does not widen as much as Kedzie. Therefore, caution should be made with comparing both sides since the context of the immediate vicinity of each survey site is different. However, the overall corridors that the bicyclists were riding in are similar: two-lane, two-way streets with on-street parking with mixed residential and commercial buildings.

Figure 6 - Left: Fullerton Avenue conventional bicycle lane survey approach. Right: Kedzie Avenue buffered bicycle lane survey approach.

Survey Method

A cross sectional study was conducted to compare bicyclists' opinions of riding on an already in-place buffered bicycle lane versus riding on a similar corridor with conventional bicycle lane. The facility and control questions were kept as similar as possible in order to facilitate response comparison.

For the surveys two staff members stood along Kedzie Avenue at the intersection of Avondale Avenue and along Fullerton Avenue at Clifton Avenue. Both members were wearing safety vests, for safety purposes and to attract the attention of bicyclists. The staff would approach bicyclists asking them if they would like to take a survey. They were given the option of taking the survey in person or online at their convenience. The online survey was open for two weeks, and the online submissions were analyzed to avoid multiple submissions from the same person.

The buffered bicycle lane received 6 survey responses overall, with all of these responses in-person. The conventional bicycle lane received 12 responses, with 5 in-person and 7 online.

Survey Questions

Participants from the buffered bicycle lanes and the conventional bicycle lane location were asked the questions in Table 2. The participants at the buffered bicycle lanes were only asked questions regarding the buffered bicycle lanes and participants at the control location were asked similar questions in regards to the control location. The results were aggregated for comparison purposes.

Table 2 - Survey questions corresponding to the following figures

Figure #	Questions Asked
7	What is your gender?
8	Were you riding a Divvy bike at the time of the survey?
9	In what age group do you fall?
10	What best describes why you are out here today?
11	In the past month, about how often have you ridden on Kedzie Avenue from Milwaukee Avenue to Belmont Avenue (buffered bicycle lane) or Fullerton Avenue from Racine Avenue to Halsted Street (conventional bicycle lane) in Chicago?
12	Why did you choose this route?
13	Have you ever had any problems bicycling on this street, such as near misses or conflicts with drivers? (buffered bicycle lane)
14	How safe and comfortable do you feel when bicycling along Kedzie Avenue from Milwaukee Avenue to Belmont Street (buffered bicycle lane) or Fullerton Avenue from Racine Avenue to Halsted Street (conventional bicycle lane) in Chicago on a scale of 1 to 5?
15	Is there anything that can be improved to make you feel more comfortable?

Survey Results

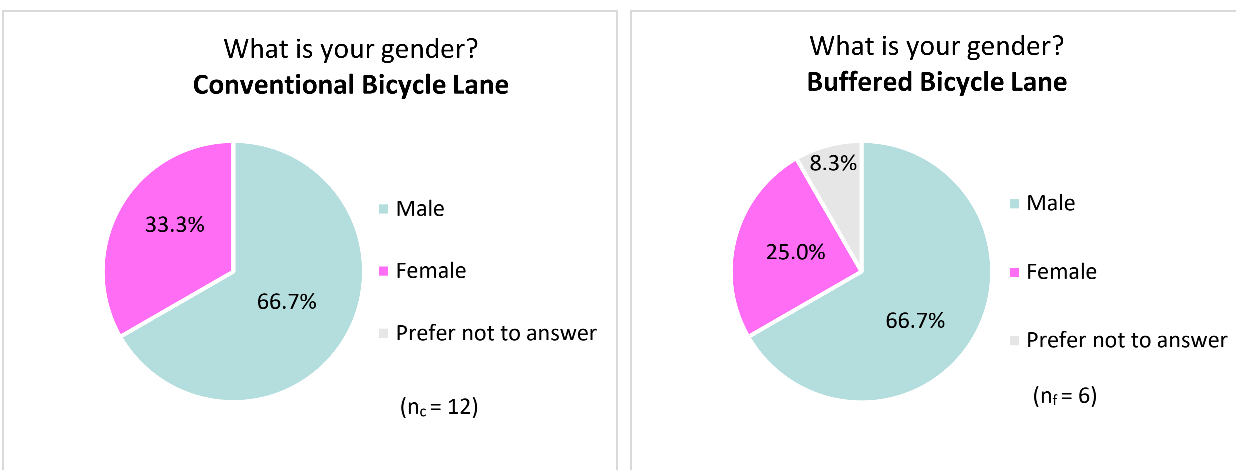
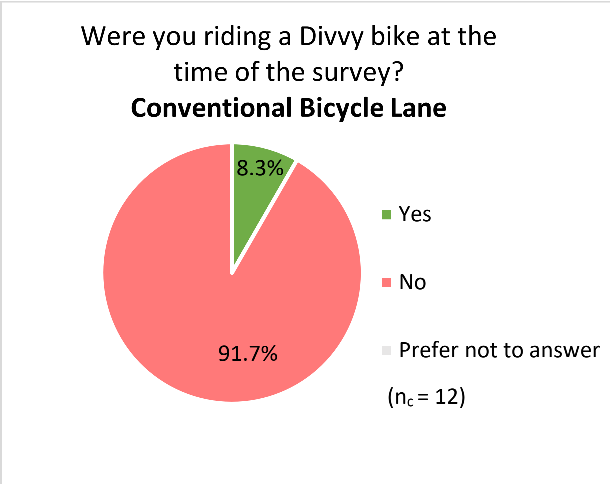


Figure 7 - What is your gender? Results from conventional bicycle lane (left) and buffered bicycle lane (right).



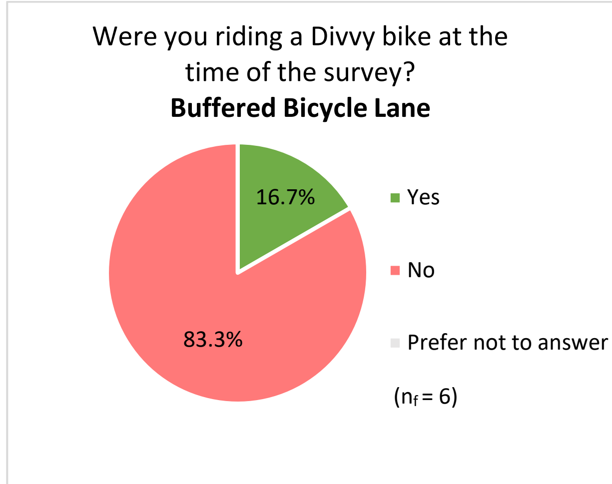


Figure 8 - Were you riding a divvy bike at the time of the survey? Results from conventional bicycle lane (left) and buffered bicycle lane (right).

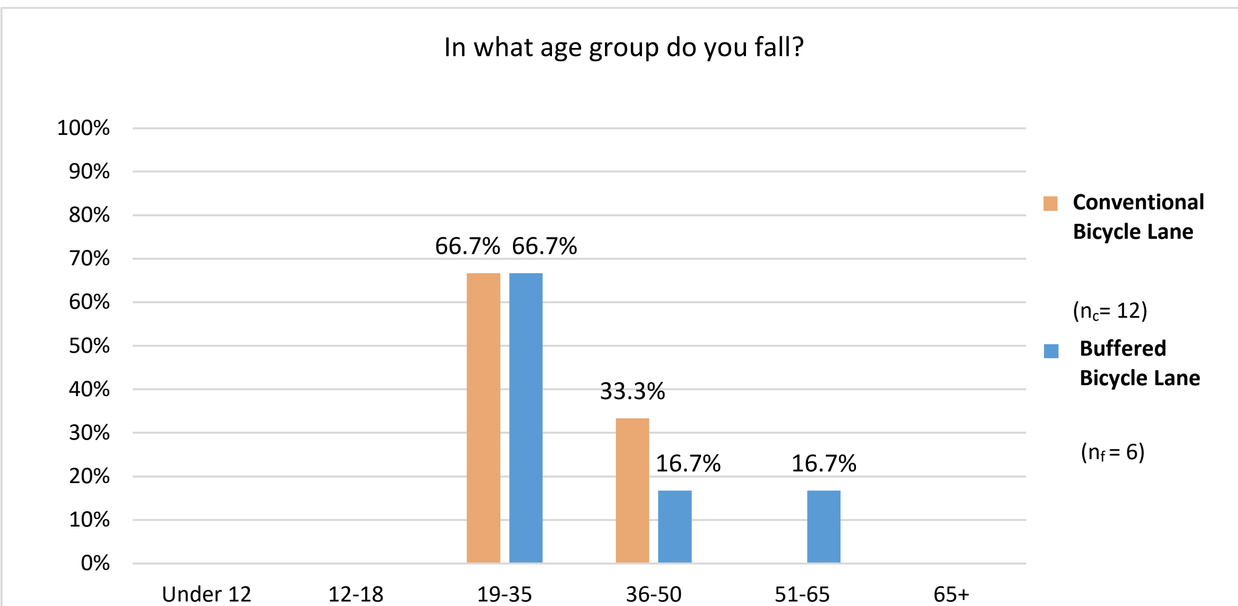
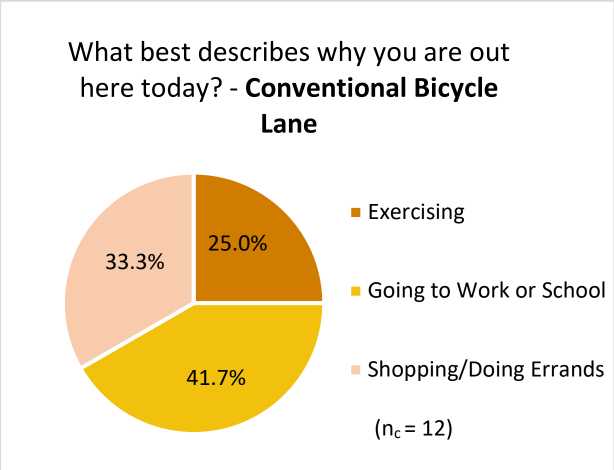


Figure 9 – In what age group do you fall? Results from conventional bicycle lane (left) and buffered bicycle lane (right).



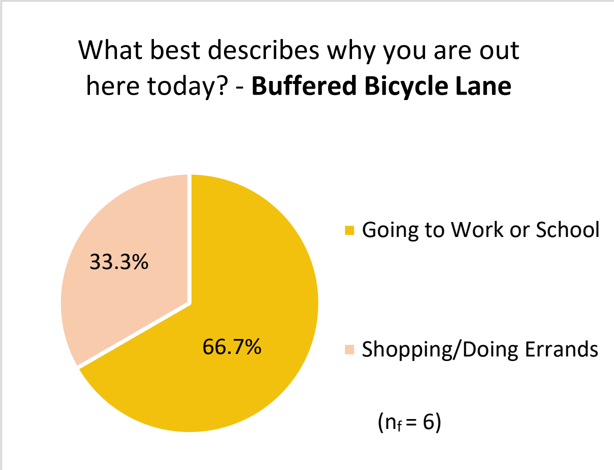


Figure 10 - What best describes why you are out here today? Results from conventional bicycle lane (left) and buffered bicycle lane (right).

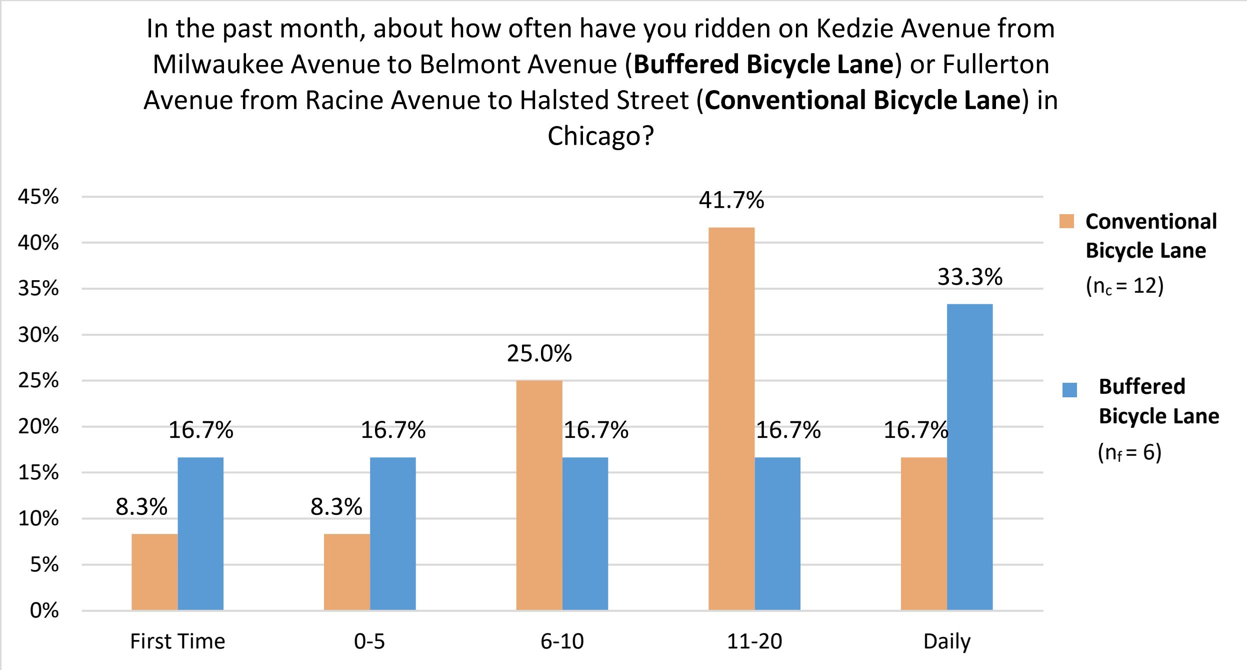


Figure 11 - In the past month, about how often have you ridden on Kedzie Avenue from Milwaukee Avenue to Belmont Avenue (buffered bicycle lane) or Fullerton Avenue from Racine Avenue to Halsted Street (conventional bicycle lane) in Chicago?

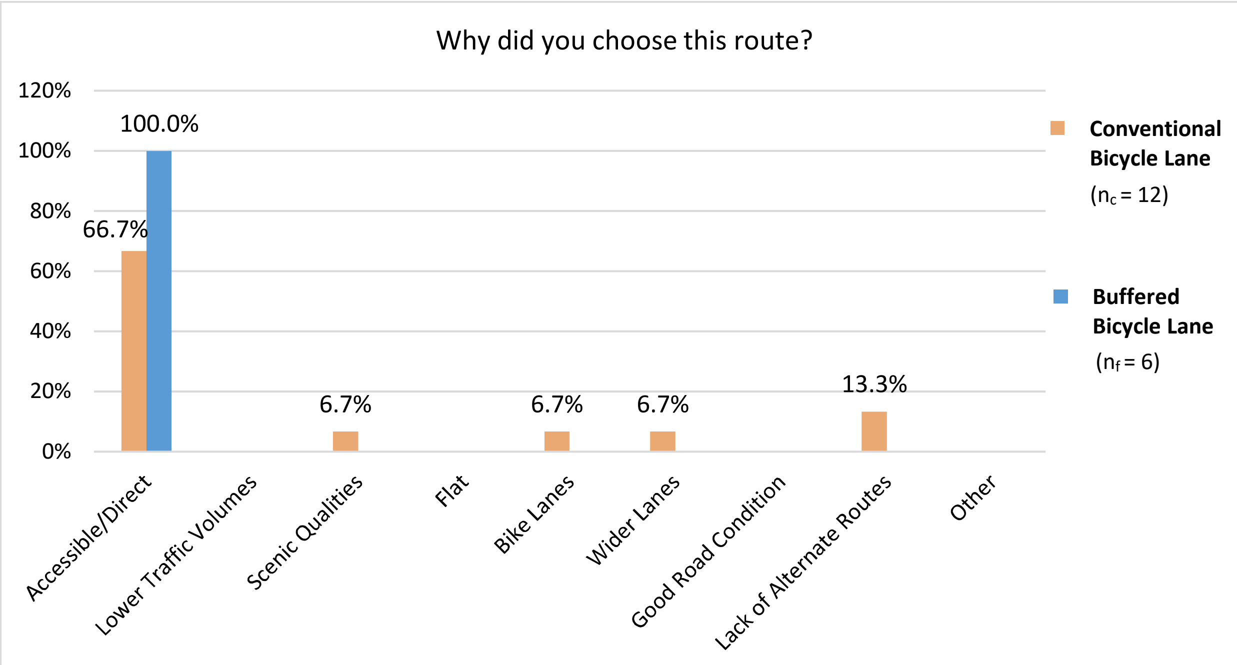


Figure 12- Why did you choose this route? Results from conventional bicycle lane (left) and buffered bicycle lane (right).

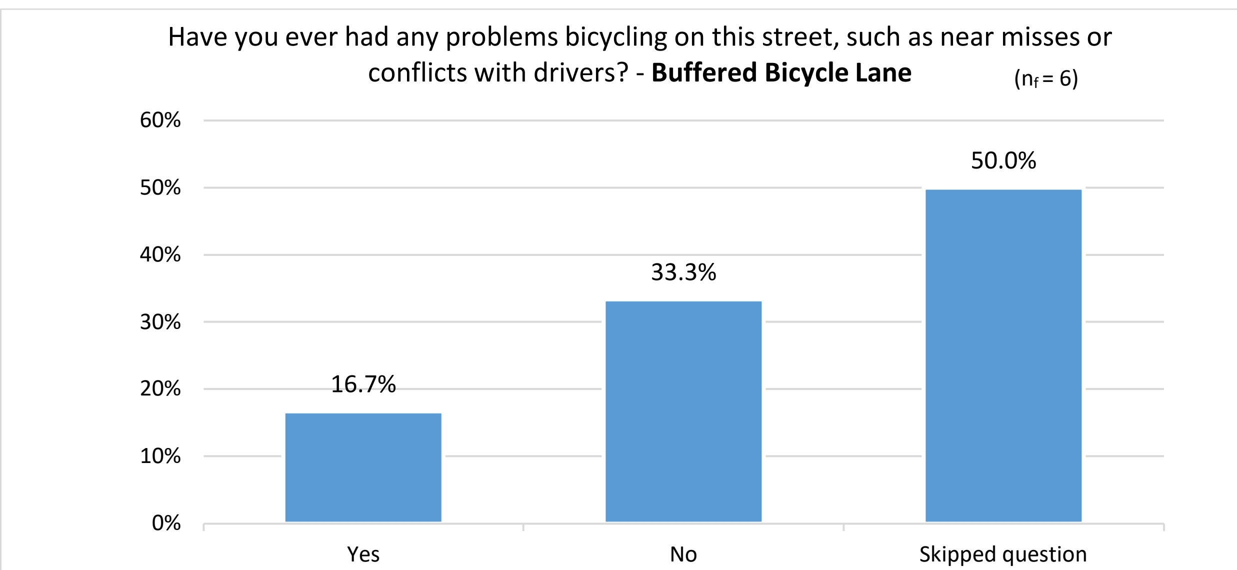


Figure 13 - Have you ever had any problems bicycling on this street, such as near misses or conflicts with drivers? Results from buffered bicycle lane.

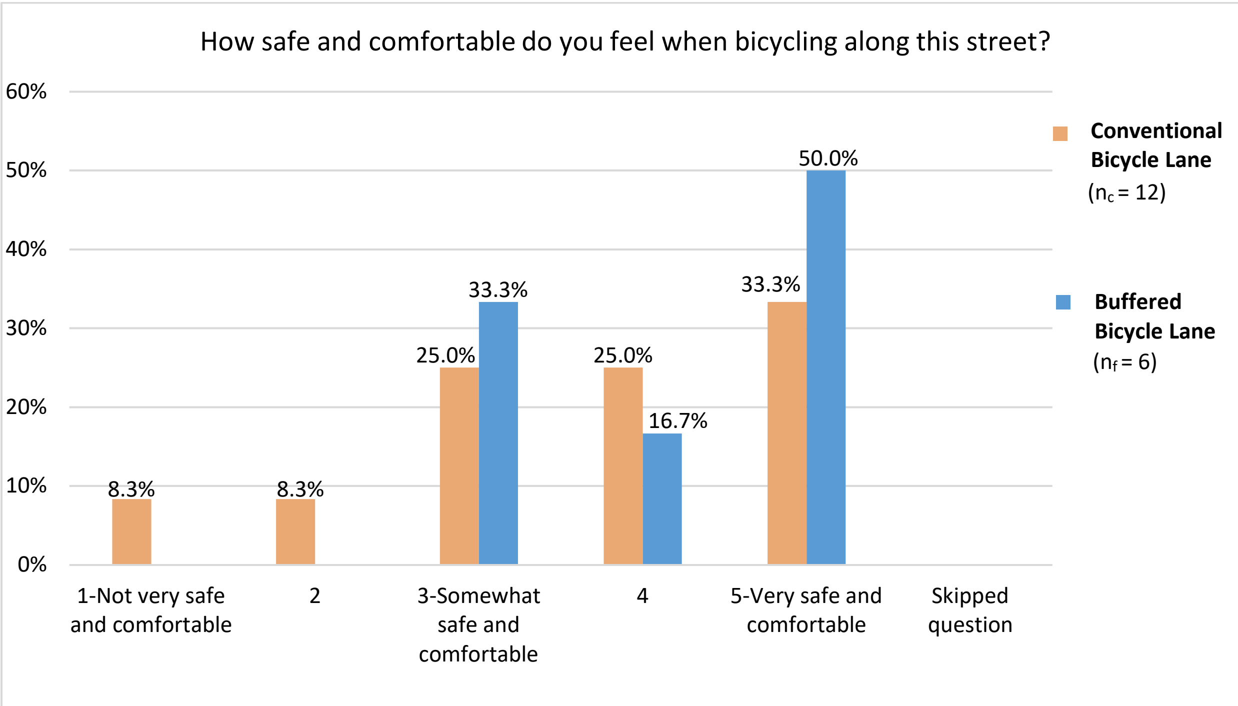


Figure 14 - How safe and comfortable do you feel when bicycling along Kedzie Avenue from Milwaukee Avenue to Belmont Avenue (buffered bicycle lane) or along Fullerton Avenue from Racine Avenue to Halsted Street (conventional bicycle lane) in Chicago?

Figure 155 shows the open-ended comments. Participants were given the opportunity to voice their opinions about the buffered bicycle lanes and the conventional bicycle lanes. Their opinions were categorized and shown below.

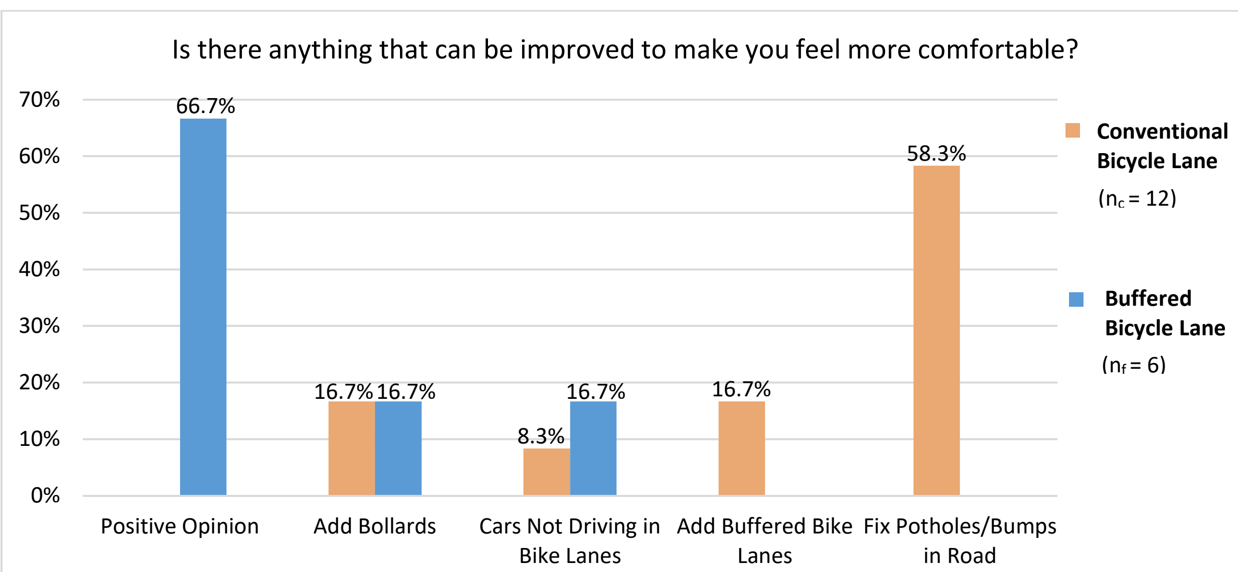


Figure 15 - Is there anything that can be improved to make you feel more comfortable?

Discussion

For the buffered bicycle lane facility, six paper surveys were completed, while zero online surveys were completed. As shown in the survey, there was a mix of survey participant familiarity with the facility. The majority of participants gave this facility a safety rating between a 4 and a 5 which indicates they feel very safe. Two thirds of their open responses were also positive comments towards the buffered bicycle lanes. One person said they would like to see bollards added between the bicyclists and motorists to provide a better sense of safety, and another would like cars to be more aware of the surroundings and look for bicyclists more.

For the control facility on Fullerton Avenue, five paper surveys were completed and seven online surveys were completed. The majority of participants were males in the 19-35 age group. The users' rating on safety was mainly positive and comparable with the responses from the buffered bicycle lane, with buffered bicycle lanes receiving a slightly higher overall safety rating, 4.5 versus 3.7. In the open responses, seven participants would like to see the potholes and bumpy road fixed, two participants would like buffered bicycle lanes added along the facility, two participants would like to see bollards added between the bicyclists and motorists, and two participants would like to prevent cars from driving in the bicycle lanes.

Conclusion

Overall, the majority of participants had positive responses for both the buffered bicycle lane and conventional bicycle lane. The buffered bicycle lane had a slightly higher average safety rating, 4.5, than the conventional bicycle lane, 3.7. Note that the survey received a minimal amount of survey responses at both study locations. In order to obtain a more reliable conclusion, another study in a higher trafficked area should be conducted under a longer period of time.

Crash Analysis

One quantitative measure of a bicycle facility's effectiveness is a comparison of the crashes before and after the facility was installed. Below are three different types of crash analyses for buffered bicycle lanes: crashes by total number, crashes by severity/type, and crash rates. Our study analyzed 12 buffered bicycle lanes in Chicago. Crash data was provided by IDOT for the years 2008 to 2013.

Total Crashes

The Federal Highway and Safety Administration uses the following method to analyze crash data when no traffic volume data is available. For this method the number of crashes are totaled then divided by the number of years of data collection and the length of segment to find the overall crashes per mile of buffered bicycle lane per year. Only crashes on the street with the buffered bicycle lane were counted, including both segmental and intersection crashes.

Table 3 – Crashes before and after installation

Segment	Length (mi.)	Bicycle Crashes Before Installation			Bicycle Crashes After Installation		
		# of Crashes	Years of Data	Crashes/mi /Year	# of Crashes	After Years	Crashes/mi /Year
18th (State to Clark)	0.2	2	3	3.3	1	2	2.5
Clark (Diversey to Addison)	1.2	44	4	9.2	16	1	13.3
Clark (Oak to North)	0.7	16	4	5.7	5	1	7.1
Division (California Ave to Western)	0.5	14	4	7.0	1	1	2.0
Franklin (Van Buren to Wacker)	0.7	11	4	3.9	0	1	0.0
Halsted (75th to 69th)	0.8	5	4	1.6	1	1	1.3
Halsted (Wellington to Diversey)	0.3	6	4	5.0	3	1	10.0
Jackson (Ogden to Morgan)	1	8	4	2.0	0	1	0.0
Jackson (Western to Damen)	0.5	4	3	2.7	0	2	0.0
Roscoe (Campbell and Damen)	0.6	5	4	2.1	2	1	3.3
Wabash Ave (Cermak to Harrison)	1.5	9	4	1.5	3	1	2.0
Wells (Wacker and Chicago)	0.7	22	4	7.9	3	1	4.3
Average of All Sites	-	-	-	**4.3**	-	-	**3.8**

When aggregating buffered bicycle lane data across Chicago, the results show the total number of crashes per mile of buffered bicycle lane per year decreased post-installation.

Crashes by Severity/Type

Included in the crash data were various characteristics of the crashes such as injury types, lighting, road conditions, turning movements, etc. The crash analysis showed a decrease in the percentages of intersection and rear-end crashes.

Table 4 - Crashes by severity

Crashes by Severity	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
K-Fatal	0.0%	0.0%
A-Injury	12.0%	2.9%
B-Injury	54.2%	65.7%
C-Injury	26.8%	20.0%
PD-Property Damage Only	7.0%	11.4%

Table 5 - Intersection crashes

Intersection Crashes	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
% of Total Crashes	55.1%	48.7%

Table 6 - Rear end crashes

Rear End Crashes	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
% of Total Crashes	15.7%	12.8%

Table 7 - Crashes by lighting conditions

Lighting Conditions	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
Darkness	5.7%	5.3%
Darkness, Lighted Road	22.2%	23.7%
Dawn	0.6%	0.0%
Daylight	65.3%	57.9%
Dusk	6.3%	13.2%

Table 8 - Crash severity code descriptions. Source: NSC (2001).

Code	Severity	Injury Description
K	Fatal	Any injury that results in death within 30 days of crash occurrence
A	Incapacitating	Any injury other than a fatal injury which prevents the injured person from walking, driving, or normally continuing the activities the person was capable of performing before the injury occurred
B	Injury Evident	Any injury other than a fatal injury or an incapacitating injury that is evident to observers at the scene of the crash in which the injury occurred
C	Injury Possible	Any injury reported that is not a fatal, incapacitating, or non-incapacitating evident
O	Property Damage	Damage to property that reduces the monetary value of that property

Crash Rates

The following crash rates were calculated based on the FHWA's crash rate formula, which takes into account the number of crashes along a segment, the length of the segment, and the Average Annual Daily Bicycle Volumes (AADB). Three sites with known bicycle volumes were studied for this portion of the report. The other sites did not have bicycle count data so they were excluded from this section:

Table 9 - Wells Street crashes

Wells Street (Wacker to Chicago)	2008	2009	2010	2011	2012 Before Installation	2012 After Installation	2013
Segment AADB	510	533	557	582	607	647	676
Number of Crashes	7	1	9	2	3	1	2
Crash Rate (bicycle crashes/million bikes miles)	53.69	7.34	63.22	13.44	46.48	14.34	11.58

Table 10 - Clark Street crashes

Clark Street (Oak to North)	2008	2009	2010	2011	2012 Before Installation	2012 After Installation	2013
Segment AADB	162	169	177	185	193	259	271
Number of Crashes	5	4	3	3	3	N/A	5
Crash Rate (crashes/million bikes in a year)	120.80	92.49	66.38	63.53	81.43	N/A	72.33

Table 11 – Wabash Avenue crashes

Wabash Avenue (Cermak to Harrison)	2008	2009	2010	2011	2012 Before Installation	2012 After Installation	2013
Number of Crashes	2	4	0	3	3	2	3
Segment AADB	45	47	49	51	53	53	55
Crash Rate (crashes/million bikes in a year)	81.67	156.31	0.00	107.37	205.88	164.96	99.46

Table 12 - Average crash rate from three sites

Average of 5 Sites	Before Installation	After Installation	Percent Change
Crash Rate (bicycle crashes/million bicycle miles)	**77.33**	**72.50**	**-7%**

Conclusion

Between 2005 and 2013, 223 crashes were recorded at twelve sites. There were 4.3 crashes per roadway mile per year before installation and 3.8 crashes per roadway mile per year after installation of the buffered bicycle lanes. The percentage of intersection crashes decreased by 6.4% after installation. Type "A" injuries decreased (from 12% to 2.9%), type "B" injuries increased (from 54.2% to 65.7%), type "C" injuries decreased slightly (26.8% to 20.0%), no fatal accidents occurred, and property damage increased (from 7.0% to 11.4%). The majority of the accidents occurred in daylight but decreased from 65.3% to 57.9% after the installation of buffered bicycle lanes.

The average crash rate from the three sites analyzed dropped slightly after the installation of the buffered bicycle lanes. This method factors in changes in bicyclist volumes over time and the increase in ridership usually experienced when buffered bicycle lanes are installed. The average crash rate dropped by nearly 5 crashes per million bicycle miles ridden after installation.

Figure 16 - Buffered bicycle lanes on Wabash Street in Chicago

There were two assumptions that were made to determine these crash rates. The AADB's were extrapolated from two hour bicycle counts provided by CDOT and a 4.3% yearly growth rate calculated from existing American Community Survey data on commuter's mode split in Chicago. There were two hour bicycle counts from before installation and after installation at all five sites, which were used to calculate AADBs. The brief length of the counts, along with the assumptions made to find the extrapolation factors may have compromised the accuracy of the AADBs. This is especially true at sites with lower rider volumes. Numerous inaccuracies can result when extrapolating out such a small count to average annual daily counts. Additional local data should be collected in order to make more accurate conclusions on the safety impacts of BBLs in Illinois.

Buffered bicycle lanes are located in many cities throughout the United States and have become a very popular bicycle facility. On June 20, 2011, the Chicago DOT installed their first buffered bicycle lanes[13]. Another milestone occurred in 2013 when CDOT installed 15 miles of federally funded buffered bicycle lanes[14]. By October 2015, the City of Chicago had constructed approximately 83 total miles of buffered bicycle lanes.[15] There are many additional buffered bicycle lane corridors being planned for future construction throughout the United States.

Table 13 – Buffered bicycle lane inventory

Country	City/County	State	Location	Install Year
USA	Phoenix	AZ	Central Ave. from Camelback Rd. to Bethany Rd.	2012
USA	Fairfax	CA	Sir Francis Blvd. (safe routes to school) from June Ct. to Olema Blvd.	Unknown
USA	San Francisco	CA	Alemany Blvd. from Folsom St. to north of Ellsworth St.	2011
USA	San Francisco	CA	Bayshore Blvd. from Silver Ave. to Paul Ave.	2014
USA	Boynton Beach	FL	U.S. 1 from Martin Luther King Jr. Blvd. to Hypoluxo Rd.	Unknown
USA	Cape Coral	FL	Eldorado Pkwy. West from Bayside Ct. to Del Prado Blvd.	2012
USA	**Chicago**	**IL**	**S. Archer Ave. from S. State St. to W. Cermak Rd.**	**2012**
USA	**Chicago**	**IL**	**N. Clark St. from W. Oak St. to North Ave.**	**2013**
USA	**Chicago**	**IL**	**N. Clybourn Ave. from N. Southport Ave. to W. Belmont Ave.**	**2012**
USA	**Chicago**	**IL**	**W. Douglas Blvd. from S. Ridgeway Ave. to S. Albany Ave.**	**2012**
USA	**Chicago**	**IL**	**Dr. Martin Luther King Jr. Dr. from E. 26th St. to E. 51st St.**	**2012**
USA	**Chicago**	**IL**	**S. Ellsworth Dr. from E. Garfield Blvd. to E. 51st St.**	**2012**
USA	**Chicago**	**IL**	**N. Elston Ave. from N. Milwaukee Ave. to W. Chestnut St.**	**2012**
USA	**Chicago**	**IL**	**N. Franklin St. from W. Madison St. to W. Wacker Dr.**	**2012**
USA	**Chicago**	**IL**	**N. Halsted St. from W. Diversey Pkwy. to W. Wellington Ave.**	**2012**
USA	**Chicago**	**IL**	**S. Hamlin Blvd. from W. Harrison St. to W. Washington Blvd.**	**2012**
USA	**Chicago**	**IL**	**S. Independence Blvd. from S. Ridgeway Ave. to W. Harrison St.**	**2012**
USA	**Chicago**	**IL**	**W. Jackson Blvd. from S. Western Ave. to S. Oakley Blvd.**	**2011**
USA	**Chicago**	**IL**	**N. Kedzie Ave. from W. North Ave. to W. Palmer Square**	**2013**
USA	**Chicago**	**IL**	**W. Madison St. from S. Central Ave. to S. Pulaski Rd.**	**2013**
USA	**Chicago**	**IL**	**N. Milwaukee Ave. from W. Hubbard St. to W. Ohio St.**	**1996**
USA	**Chicago**	**IL**	**S. State St. from W. Cullerton St. to W 18th St.**	**2013**
USA	**Chicago**	**IL**	**S. South Shore Dr. from E. 79th St. to E. 71st St.**	**2013**
USA	**Chicago**	**IL**	**W. 18th St. from S. State St. to S. Clark St.**	**2011**
USA	**Chicago**	**IL**	**E. 55th Pl. from S. Dorchester Ave. to E. 55th St.**	**2012**
USA	**Chicago**	**IL**	**S. Vincennes Ave. from W. 89th St. to W. 84th St.**	**2013**
USA	**Chicago**	**IL**	**S. Wabash Ave. from E. Cermak Rd. to E. 18th St.**	**2012**
USA	**Chicago**	**IL**	**N. Wells St. from W. Chicago Ave. to W. North Ave.**	**2013**

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Contra-Flow Bicycle Lanes

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation


NO
TURN
ON RED

Contra-flow bicycle lanes are on-road facilities designated exclusively for bicycles that are designed to allow bicyclists to ride in the opposite direction of motoring traffic on a one-way street. This converts a one-way street into a two-way street for bicyclists, with bicycle travel in the motoring direction typically accommodated using either a designated bicycle lane or shared lane markings. These facilities are usually placed in residential areas near existing bicycle lane facilities and are used to strategically connect bicycle routes to one another.[1] The main purpose of a contra-flow bicycle lane is to create a safer and more direct route for bicyclists, while reducing instances of bicyclists riding on sidewalks or riding illegally against the flow of traffic. Contra-flow bicycle lanes reduce trip times, trip distances, conflict points, and improve bicyclists' travel.

Figure 1 - Contra-flow bicycle lane along West Ardmore Avenue from Kenmore Avenue to Sheridan Road in Chicago. The bicycle lane is in the contra-flow direction separated from the opposing marked shared lane with a dashed double yellow line.

Features

According to the NACTO Urban Bikeway Design Guide, contra-flow bicycle lanes include the following features: [2]

- A solid white pavement marking line used at the outside edge of the bicycle lane.
- A double yellow centerline pavement marking, solid or dashed, used to delineate the separation between the contra-flow bicycle lane and the opposing motoring lane.
- A dashed, double yellow centerline separating the motoring lane and the contra-flow bicycle lane, allowing motorists to park on both sides of the street when parking is allowed adjacent to the contra-flow bicycle lane.
- A solid double yellow centerline separating the motoring lane and the contra-flow lane when parking is not allowed adjacent to the contra-flow bicycle lane.

- At intersections, motorist and bicycle traffic signals or stop signs (oriented towards bicyclists in contra-flow bicycle lanes), and the dashed, double yellow centerline extended through the intersection.
- Bicycle lane word and/or symbol and arrow marking used to delineate the bicycle lane's direction and preferential use, in accordance with MUTCD.[3]
- Restriping of pavement marking lines, letters, and symbols done in compliance with the MUTCD standards.[3]
- Recommended use of bicycle lane signage, including posting a ONE WAY" sign with "EXCEPT BIKES" plaque posted along the facility and at intersecting streets, alleys, and driveways, a "NO TURN ON RED" sign posted at signalized cross streets, and a "DO NOT ENTER" sign with "EXCEPT BIKES" posted along the bicycle facility
- Recommended use of marking transition to conventional dashed lines and/or crossing pavement markings and bicycle boxes at intersections with no dedicated right-turn only lane.
- Recommended use of a dedicated through bicycle lane transitioned to the left of the right-turn only lane at intersections with a dedicated right-turn only lane, when roadway width allows.
- Recommended use of a dedicated right-turn only lane, combined bicycle lane and/or motorist turn lane, if inadequate space is available for a dedicated bicycle lane.

Costs

$ $5,000/mile - $50,000/mile cost

According to the Fundamentals of Bicycle Boulevard Planning and Design Guide for the city of Portland, Oregon, the cost of a contra-flow bicycle lane ranges from $5,000 to $50,000 per mile.[4] The average cost of a conventional bicycle lane is $133,170 per installation but may range between $5,360 and $536,680.[4] The average cost of a pavement marking symbol is $180 per installation but may range between $22 and $600.[5] See the Conventional Bicycle Lanes for a more detailed cost breakdown.

Design Guidance

FHWA	MUTCD - Chapter 3D. Markings for Preferential Lanes Chapter 9C. Markings. http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm
Illinois Department of Transportation	BDE Manual Chapter 17-2 http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Design-and-Environment/Illinois%20BDE%20Manual.pdf
AASHTO	Guide for the Development of Bicycle Facilities Chapter 4.6.3 https://store.transportation.org/Item/CollectionDetail?ID=116
NACTO	Urban Bikeway Design Guide Contra-Flow Bicycle Lanes http://nacto.org/publication/urban-bikeway-design-guide/bike-lanes/contra-flow-bike-lanes/

Figure 2 - List of design guidance manuals and documents

SAFETY

Studies have found that contra-flow bicycle lanes:

- Reduce dangerous wrong-way riding for bicyclists in the motorist lane
- Decrease conflict points when placed on streets with fewer driveways, alleys, or streets intersecting the contra-flow bicycle lane
- Improve bicyclist comfort
- Reduce conflicts between bicyclists and motorists by providing bicyclists with a dedicated space to ride against traffic

Figure 4- Bicyclist riding in contra-flow bicycle lane on West Ardmore Avenue in Chicago

Wrong-Way Riding - Chicago	17%
Wrong-Way Riding – Glenwood	+50%

The most common bicyclist error resulting in a crash on bicycle lanes occurs due to bicyclists riding against traffic.[6] Bicyclists riding against traffic or crossing the intersection the wrong-way resulted in approximately 17% of the bicycle accidents in Chicago.[7] CDOT is currently proposing a greenway with a marked contra-flow bicycle lane on the Glenwood Avenue Neighborhood Route in Chicago since a substantial number of bicyclists are already using the one-way street incorrectly and riding against traffic on Glenwood Avenue.[8] Mike Amsden of CDOT and 48th Chicago Ward Alderman Harry Osterman gave a presentation on the Glenwood Avenue Neighborhood Route at a community meeting in the Edgewater Baptist Church on June 10, 2015.[8] Additionally, residents shared stories on their bicycling experiences and the majority of community members present confirmed their support for a safer bicycling option.[8]

A study was conducted in Cambridge, Massachusetts in order to provide practitioners with the latest information available for improving the safety and mobility of bicyclists. City of Cambridge staff members analyzed different criteria at several potential project locations to determine the feasibility of constructing contra-flow bicycle lanes. Evaluation criteria used for determining placement of contra-flow bicycle lane facilities in this study was developed in another study conducted in Eugene, Oregon. This evaluation criteria included:

- decreasing conflicts
- increasing safety
- ensuring that facility entry and exit points were safe for bicyclists
- providing short and direct access to destination points
- analyzing whether a significant amount of bicyclists were already using the facility
- improving bicyclists' travel experience
- low-volume facility placement
- contra-flow suitable roadway geometry

Four contra-flow bicycle lane corridors were constructed in Cambridge, Massachusetts, based on the evaluation criteria. "Before" and "after" bicycle counts were conducted on two of the four facilities, and survey comments were collected from facility users. The study found that contra-flow bicycle lanes were successful in accommodating bicyclists on one-way streets.[9]

In May 2013, Taverner Research and Roads and Maritime Services completed a research study in Australia. Taverner Research is an independent Australian company that has been conducting high quality market and social research for more than 20 years. Roads and Maritime Services is an agency of the New South Wales Government that builds major roads, promotes road safety, manages traffic, and manages day-to-day compliance. The study was conducted to determine if safety risks existed for bicyclists when parallel parking was allowed on the left-side of contra-flow bicycle lanes. A bicyclist intercept survey was conducted and a total of 193 interviews were completed, with 81 responses from the study sites and 112 responses from the control sites. Results concluded that more bicyclists used the sites with designated contra-flow bicycle lanes compared to sites with no dedicated bicycle lanes. Bicyclists felt a little safer riding in contra-flow bicycle lanes, although inadequate motorist awareness was still a problem.[10]

OPERATIONS

Contra-flow bicycle lanes improve travel operations for both bicyclists and motorists by allowing bicyclists to travel in both directions on a street that only allows one-way travel for motorists. The contra-flow bicycle lane facility is the only type of facility that allows bicyclists to ride in the opposite direction of motoring traffic on a one-way street. Some of the factors that can compromise the operations of this facility are:

- Motorists parking or driving in the dedicated contra-flow bicycle lane.
- Bicyclists continuing to ride in the motoring lane in the wrong direction or outside of dedicated contra-flow bicycle lane.
- Potential added conflict points due to unfamiliarity with bicyclists riding on the opposite side of the roadway against traffic.
- Reduced roadway travel width or parking lanes.
- Snow and other obstacles not being removed from the bicycle lane.

Figure 5 –Vehicle parked in contra-flow bicycle lane along West Ardmore Avenue in Chicago

In September 1998, a traffic advisory leaflet (applicable to England, Wales, and Scotland) advising when the implementation of contra-flow bicycle lanes on one-way streets was appropriate was released by the Department for Transport, United Kingdom. The use of other facilities such as mandatory contra-flow bicycle lanes, advisory contra-flow lanes, and no cycle lanes was also discussed. The choice of facility type was dependent on whether the roadway being studied had adequate space available to provide protected space for bicyclists. This document stated that a 5 foot minimum width should be provided for contra-flow bicycle lanes, but should be dependent on volume of traffic, speed of traffic, and amount of truck traffic. A dedicated space for bicycle traffic should be provided at the entry and exit points of the contra-flow bicycle lane facility since the majority of accidents occur at these locations. The leaflet also discussed a study regarding six different contra-flow schemes that were monitored. The study confirmed that a large number of bicyclists using the contra-flow bicycle lanes were already using the facility and traveling illegally against traffic. The study also found that vehicle speeds decreased and most bicyclists felt safer when dedicated contra-flow bicycle lanes were present.[11]

Figure 6 - Bicyclists riding opposite motoring traffic in a contra-flow bicycle lane and with traffic in a marked shared lane

Figure 7 - Cross-traffic blocking contra-flow bicycle lanes at the intersection of West Ardmore Avenue and Sheridan Road in Chicago

MAINTENANCE

Contra-flow bicycle lanes require minimal routine maintenance aside from restriping pavement markings and signage maintenance. Because this facility may be unsafe without adequate striping, contra-flow bicycle lanes may require more consistent striping reapplication compared to conventional bicycle lanes. Restriping of pavement marking lines, letters, and symbols should be done in compliance with the MUTCD standards.[3] The contra-flow bike lane on West Ardmore Avenue from Kenmore Avenue to Sheridan Avenue was restriped and enhanced in 2011.[12]

Street Sweeping & Snow Removal

Contra-flow bicycle lanes should be kept free of structural deterioration, damage, and other debris. On-site inspections, street sweeping, and snow removal should occur on a regular basis to ensure bicyclists safety in all weather conditions. Local ordinances may dictate that property owners remove snow from their sidewalks which can often end up in bicycle lanes. Therefore, it is important to educate the public on striking a balance between clear paths for both walkways and bikeways. Snow removal from contra-flow bicycle lanes can be done with traditional snow plows. Since contra-flow bicycle lanes are on the same slope as the roadway, snow plows can continue routine operations without lifting plows. Some street maintenance divisions, such as Madison, Wisconsin's Public Works Agency, have implemented a "snow removal priority plan" which prioritizes snow removal on routes with bicycle facilities.[13]

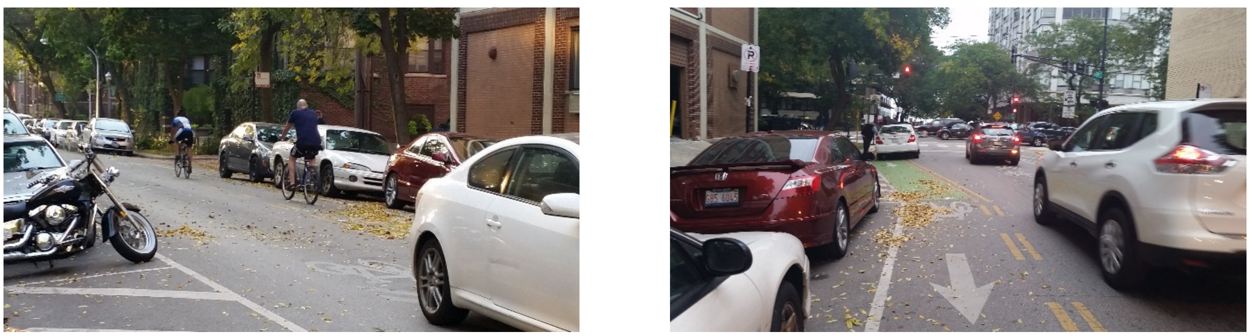

Figure 8 - Debris in contra-flow bicycle lanes along West Ardmore Avenue in Chicago

Drainage

Contra-flow bicycle lanes do not obstruct roadway surface runoff since they do not change the existing grade of the road.

District One Studies

The following is a summary of findings from studies performed by IDOT in 2014, for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 1 - Summary of IDOT District One Studies, 2014

	Summary of Findings
Bicyclist Survey	Overall, the responses from the surveys indicate 60% of the bicyclists felt safe and comfortable when riding in contra-flow bicycle lanes and had a positive opinion regarding the contra-flow bicycle lanes.
Motorist Compliance and Bicyclist Behavior	100% of motorists were compliant and did not drive or park in the contra-flow bicycle lane. 87% of bicyclists were compliant at the contra-flow bicycle location, while 41% of bicyclists were compliant at the control location. The percentage of sidewalk riders was higher at the control location (8%) than at the contra-flow bicycle lane facility location (1%).
Crash Analysis	Due to the low number of crashes after the installation of the facility chosen, no crash trends could be determined. Therefore, the crash analysis was indeterminate.

Bicyclist Survey

Two surveys were conducted, one at a contra-flow bicycle lane facility and one at a facility with no dedicated bicycle lanes, to compare and contrast bicyclists opinions on the respective facilities. West Ardmore Avenue, from Kenmore Avenue to Sheridan Road, is a one-way west to east local road in an urban residential area with an ADT of 900 and a speed limit of 30 mph. Berwyn Avenue, from Kenmore Avenue to Sheridan Road, is a one-way west to east local road in an urban residential area with an ADT of 1,100 and a speed limit of 30 mph. An in-person survey regarding the contra-flow bicycle lanes was conducted along West Ardmore Avenue at the intersection of Sheridan Road on September 29, 2014 from 4:00 p.m. to 6:00 p.m. During the survey, the weather condition was sunny with a temperature of 75 degrees. For the control location, on Berwyn Avenue, no in-person surveys were conducted due to a lack of bicyclists present at the time of the survey. For both the facility location and the control location, online surveys were also open and available for a two week period.

Survey Method

A cross sectional study was conducted to compare bicyclists' opinions of riding on an already in-place contra-flow bicycle lane versus riding on a facility with no dedicated bicycle lanes. The facility and control questions were kept as similar as possible in order to facilitate response comparison.

For the West Ardmore Avenue contra-flow bicycle lane, one staff member stood on the southeast corner along West Ardmore Avenue at the intersection of Kenmore Avenue. Another staff member stood along West Ardmore Avenue at the intersection of Sheridan Road. Both members were wearing safety vests, for both safety purposes and to attract the attention of bicyclists. The staff would approach bicyclists asking them if they would like to take a survey. They were given the option of taking the survey in-person or online at their convenience. The online survey was open for 2 weeks, and the online submissions were analyzed to avoid multiple submissions from the same person.
At the control location on Berwyn Avenue, one staff member was positioned at the southeast corner along Berwyn Avenue at the intersection of Kenmore Avenue. The staff member was wearing a safety vest, for both safety

purposes and to attract the attention of bicyclists using the facility. No in-person surveys were conducted due to a lack of bicyclists present at the time of the survey.

Survey Questions

Participants from the contra-flow bicycle lanes were asked the questions listed below in Table 2.

Table 2 - Survey questions corresponding to the following figures (facility only)

Figure #	Questions Asked
8	What is your gender?
9	Were you riding a Divvy bicycle at the time of the survey?
10	In what age group do you fall?
11	What best describes why you are out here today?
12	In the past month, about how often have you ridden on West Ardmore Avenue from Kenmore Avenue to Sheridan Road?
13	Why did you choose this route?
14	Have you ever had any problems bicycling on this street, such as near misses or conflicts with drivers or buses?
15	How safe and comfortable do you feel when bicycling along West Ardmore Avenue from Kenmore Avenue to Sheridan Road in Chicago?
16	Do you have any suggestions or comments regarding contra-flow bicycle lanes like the ones on West Ardmore Avenue in Chicago?

Survey Results

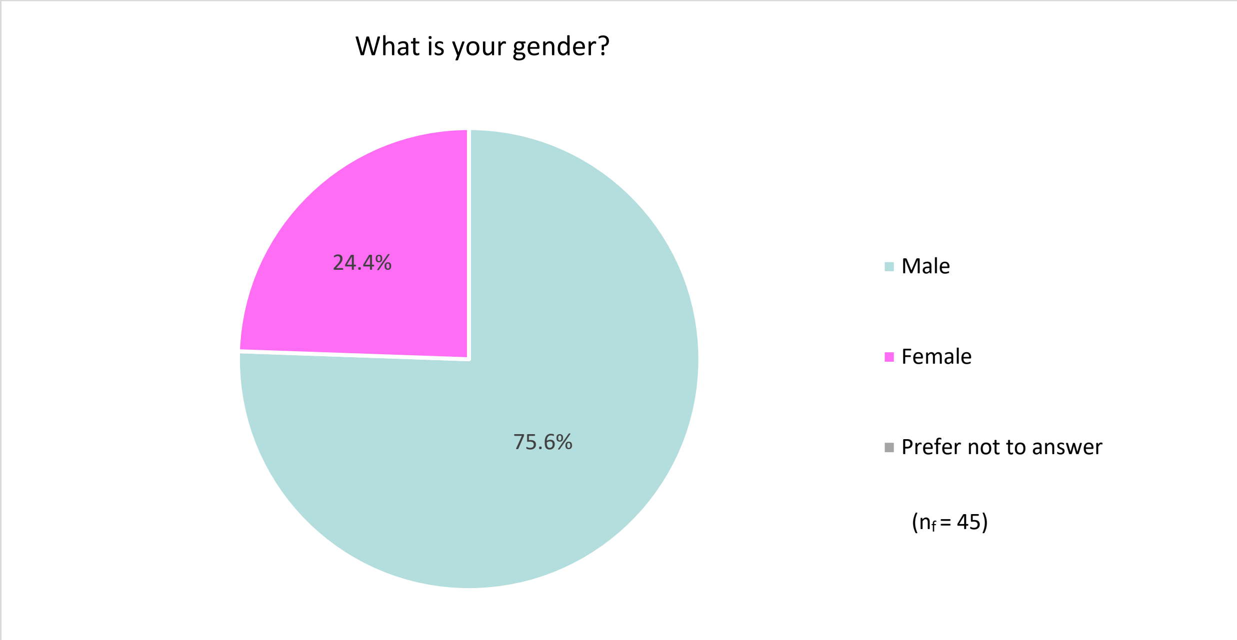

Figure 9 - What is your gender? Results from contra-flow bicycle lanes.

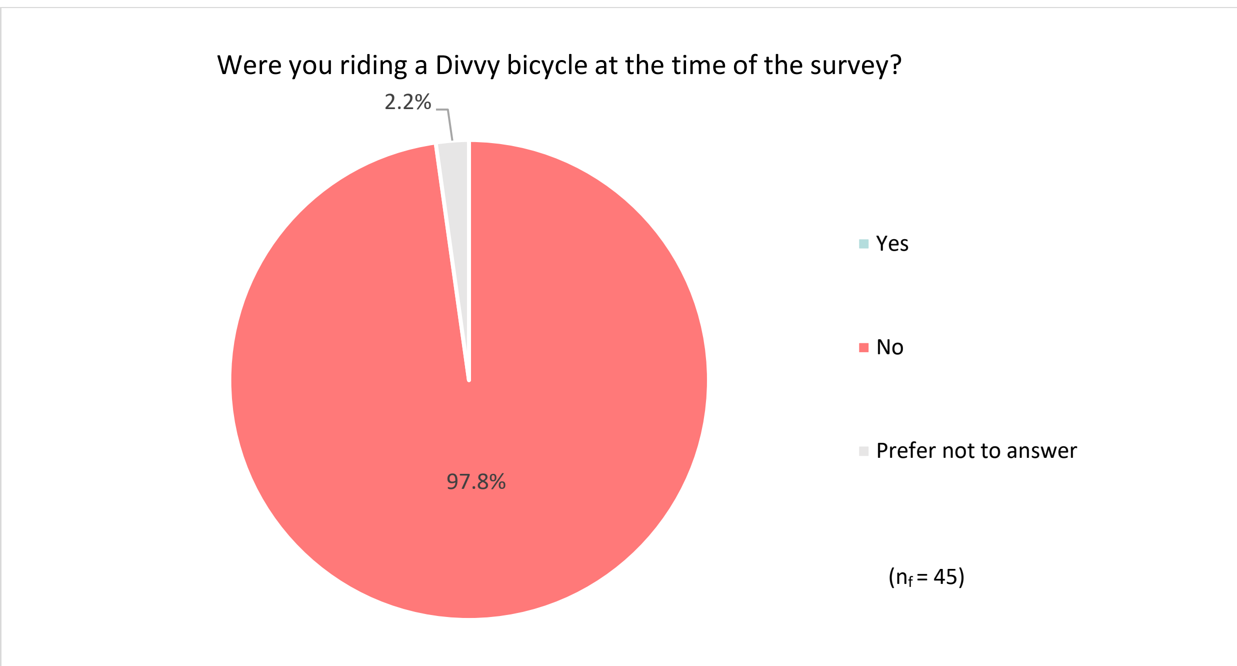

Figure 10 - Were you riding a Divvy bicycle at the time of the survey? Results from contra-flow bicycle lanes.

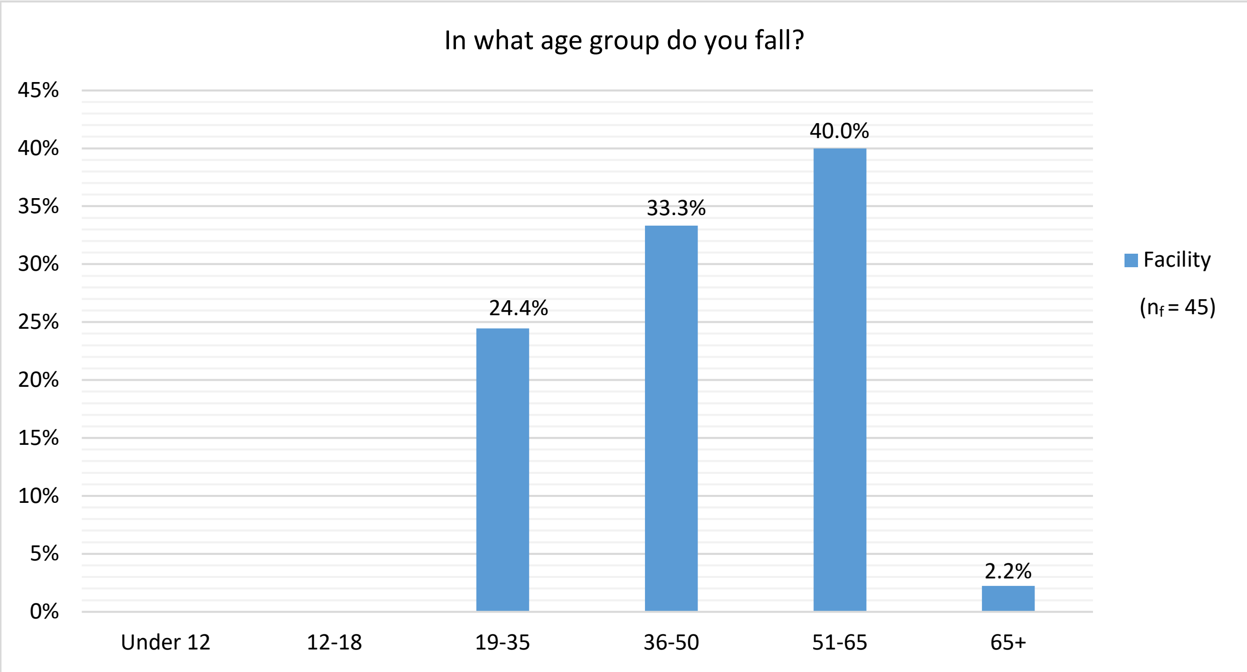

Figure 11 - In what age group do you fall? Results from contra-flow bicycle lanes.

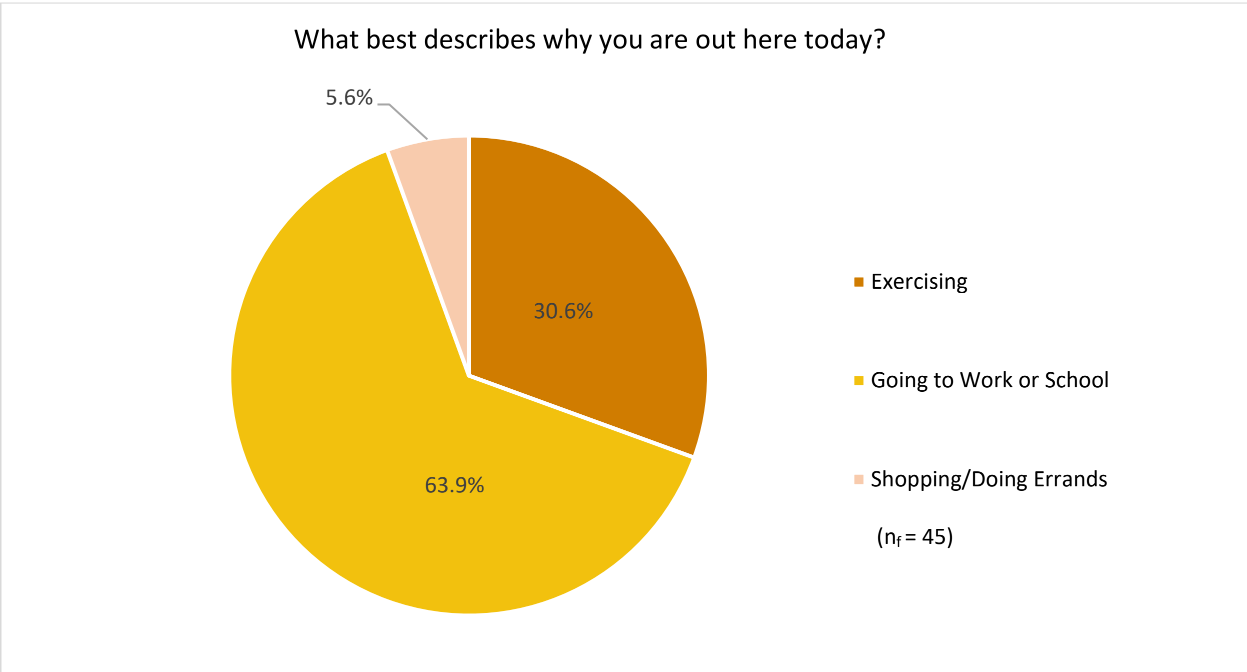

Figure 12 - What best describes why you are out here today? Results from contra-flow bicycle lanes.

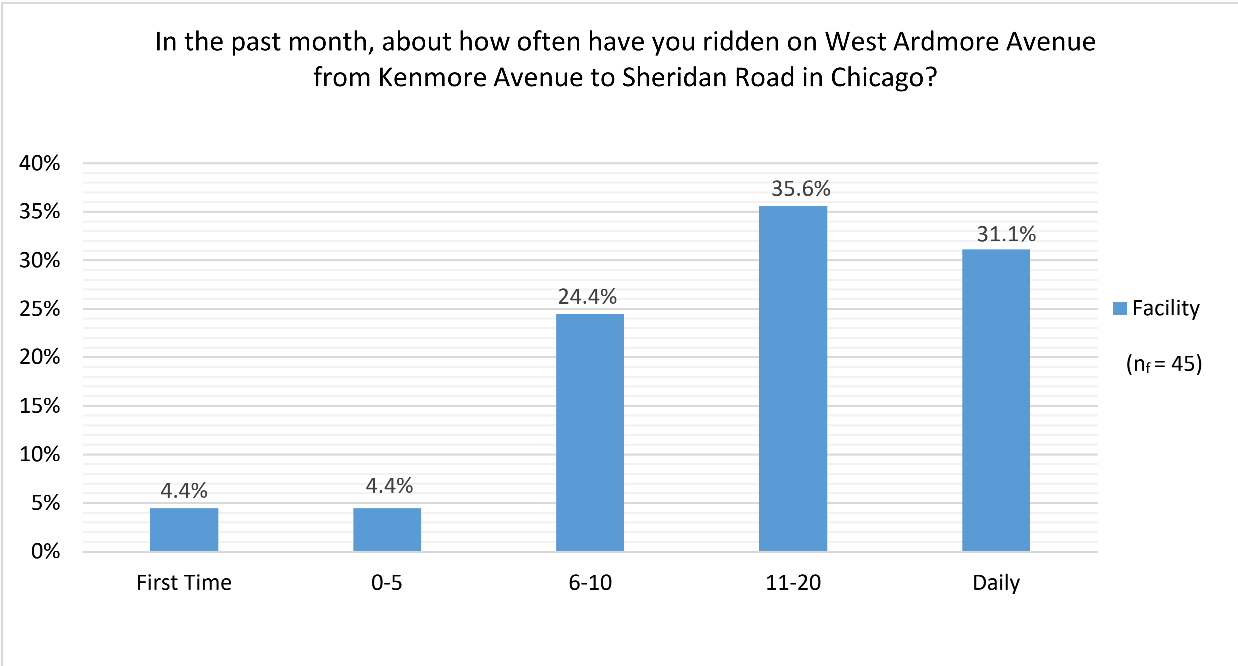

Figure 13 - In the past month, about how often have you ridden on West Ardmore Avenue from Kenmore Avenue to Sheridan Road in Chicago? Results from contra-flow bicycle lanes.

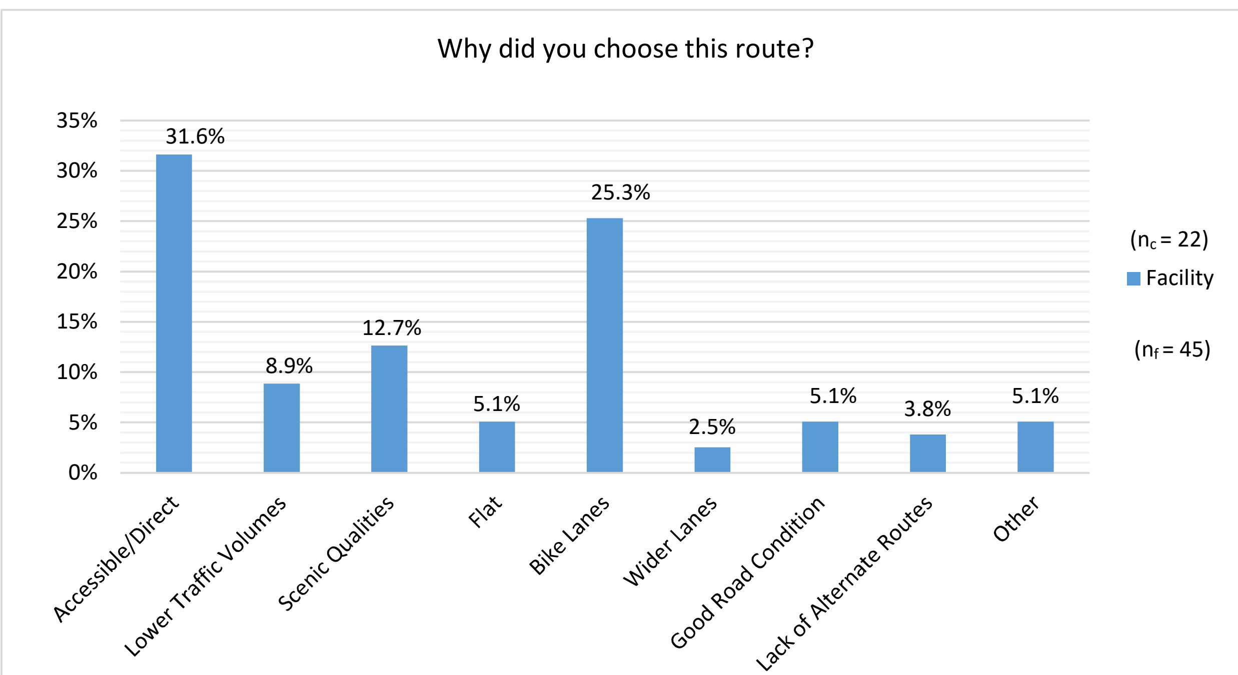

Figure 14 - Why did you choose this route? Results from contra-flow bicycle lanes.

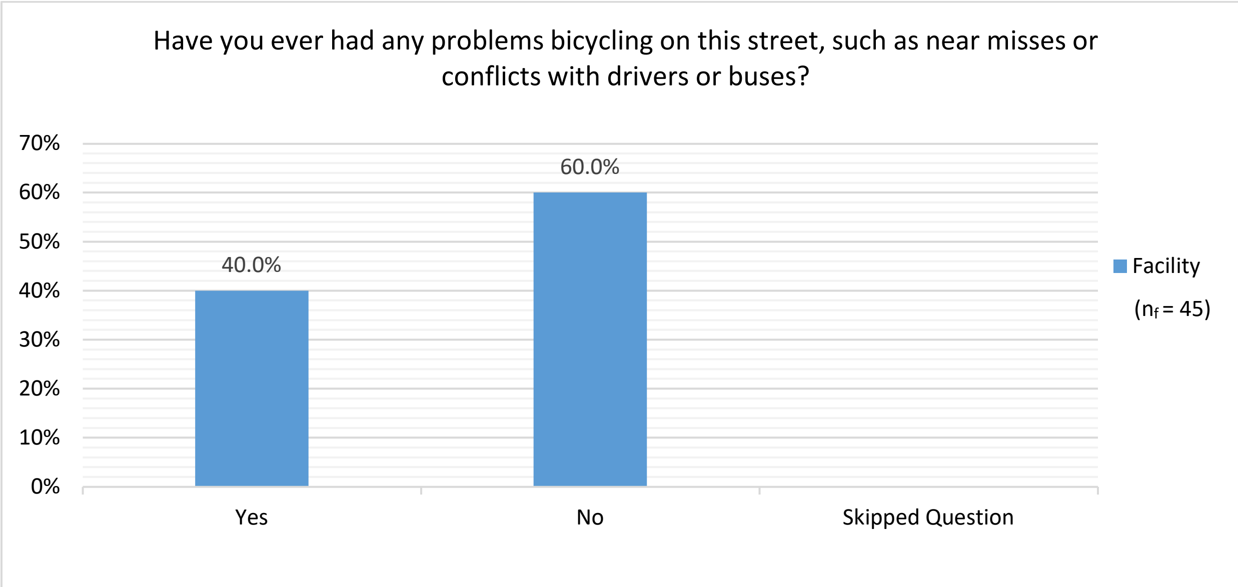

Figure 15 - Have you ever had any problems bicycling on this street such as near misses or conflicts with drivers or buses? Results from contra-flow bicycle lanes.

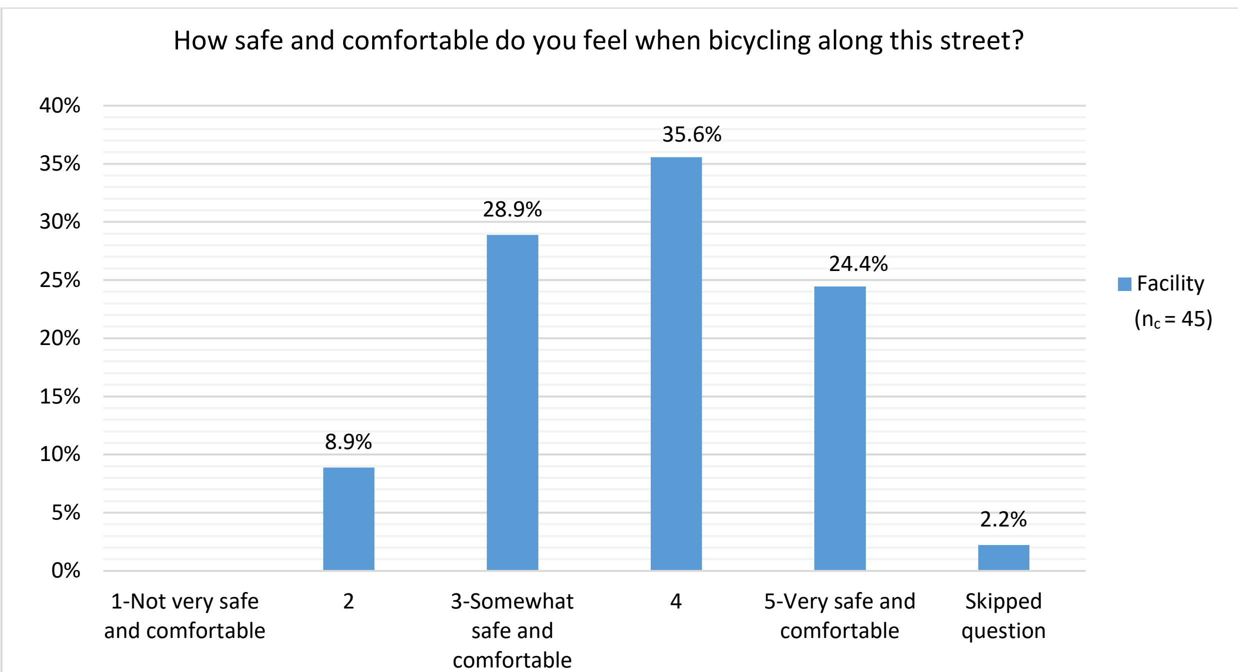

Figure 16 - How safe and comfortable do you feel when bicycling along West Ardmore Avenue from Kenmore Avenue to Sheridan Road? Results from contra-flow bicycle lanes.

Participants were given the opportunity to voice their opinions about the contra-flow bicycle lanes. Their opinions were categorized and shown below in Figure 17.

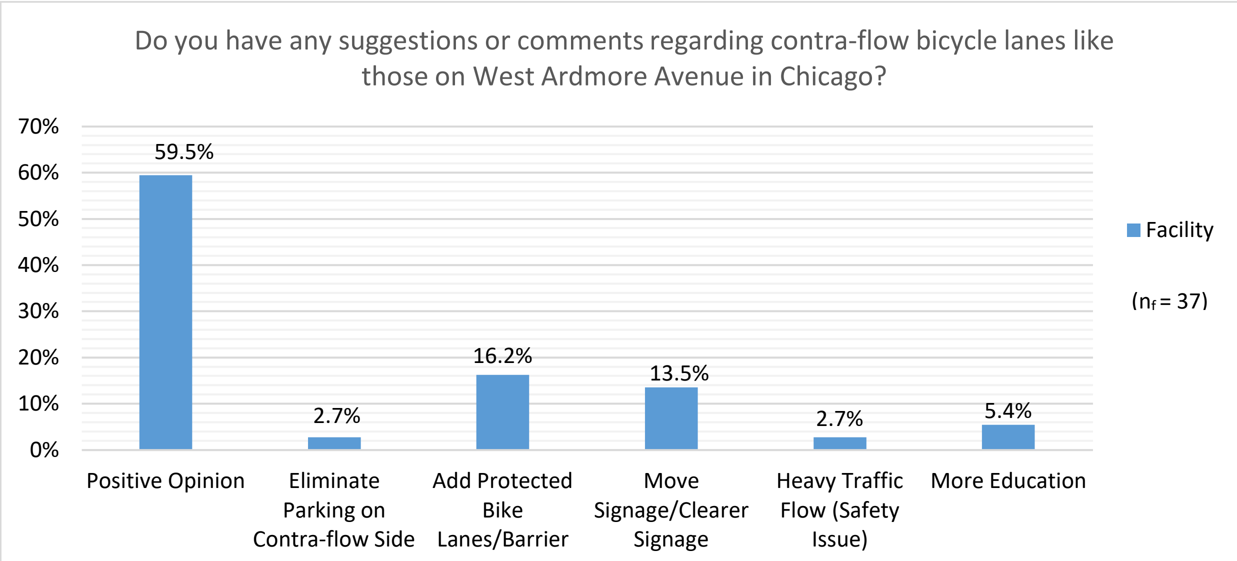

Figure 17 - Do you have any suggestions or comments regarding contra-flow bicycle lanes like those on West Ardmore Avenue in Chicago?

Discussion

For the contra-flow bike lane facility on West Ardmore Avenue, 30 paper surveys were completed and 15 online surveys were completed. The majority of participants said they were "Going to work or school", which is consistent with the contra-flow bicycle lane's location in a residential area near a commercial area. Participants' monthly usage of the facility was sporadic with 14 of the participants using the facility daily, 16 of the participants using it 11-20 times per month, 11 of the participants using it 6-10 times per month, two participants using the facility 0-5 times per month, and two participants using the facility for the first time that month. Of the participants surveyed, a good portion of participants (18) had problems bicycling on this street, such as near misses or conflicts with drivers or buses. Reasons include the fact that most drivers don't expect to see bicyclists riding on the left-side of the roadway or in the opposite direction on one-way streets. Overall, the majority of participants rated the contra flow bike lane either a 4 or 5 in terms of safety and comfort on a scale of 1 to 5, with 5 being the safest.

Participants were given the opportunity to voice their opinions on the contra-flow bike lanes on West Ardmore Avenue. Of the participants surveyed, 23 of the participants' responses were positive feelings towards the contra-flow bike lanes. Several participants had expressed specific comments and suggestions regarding the contra-flow bicycle lanes as follows: six participants would like to see barriers added, five participants would like to see improvements with the signage, two participants would like bicyclists and motorists to be more educated on how to use the facility, one participant would like to see parking eliminated on the same side of the street that contra-flow bicycle lane is located, and one participant felt that the traffic flow is too heavy and thus unsafe.

Conclusion

Overall, the responses from the surveys indicate 60% of the bicyclists felt safe and comfortable when riding in contra-flow bicycle lanes and had a positive opinion regarding the contra-flow bicycle lanes.

Motorist Compliance and Bicyclist Behavior Study

A bicyclist and motorist behavior study was conducted for the purpose of gaining further information and knowledge about the performance of contra-flow bicycle lanes in the District One Region. This study compares a corridor with contra-flow bicycle lanes already in-place (facility site) against a corridor with a similar ADT, roadway geometry, and roadway characteristics that does not have dedicated bicycle lanes (control). Aerial views of the sites are shown in Figure 18 and Figure 19.

The contra-flow bicycle lane facility is located on West Ardmore Avenue from Kenmore Avenue to Sheridan Road. The control site is a facility with no dedicated bicycle lanes and is located on West Berwyn Avenue from Kenmore Avenue to Sheridan Road.

Site Conditions

West Ardmore Avenue, from Kenmore Avenue to Sheridan Road, is a one-way west to east local road in an urban residential area with an ADT of 900 and a speed limit of 30 mph. The field study for the contra-flow bicycle lane at this location was conducted on September 29, 2014 from 4:00 p.m. to 6:00 p.m. The weather was sunny and 75 degrees. West Ardmore Avenue is under the jurisdiction of CDOT. West Ardmore Avenue bike lane surface and pavement markings appeared to be in good condition at the time of the survey.

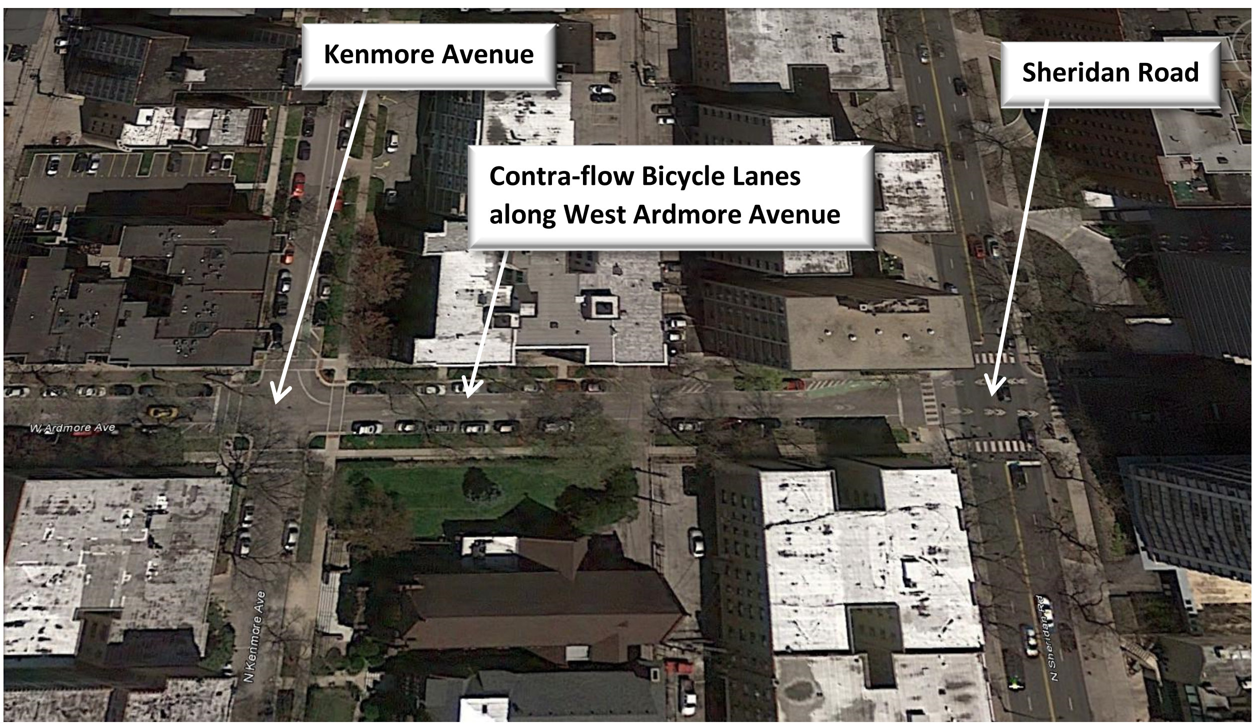

Figure 18 - Aerial view of the facility location on West Ardmore Avenue in Chicago (Map Data: Google, 2015 Google).

Berwyn Avenue, from Kenmore Avenue to Sheridan Road, is a one-way west to east local road in an urban residential area with an ADT of 1,100 and a speed limit of 30 mph. A field study was conducted at a control site for comparison on at this location on October 24, 2014 from 4:00 p.m. to 6:00 p.m. The weather was mostly cloudy and 65 degrees. Berwyn Avenue is under the jurisdiction of CDOT. Berwyn Avenue pavement surface appeared to be in good condition at the time of the survey.

Figure 19 - Aerial view of the control location on Berwyn Avenue in Chicago (Map Data: Google, 2015 Google).

Study Method

A cross sectional study was completed in order to observe and compare users' behaviors at the two facilities. During the data collection period, staff members observed from an inconspicuous position parallel to the bicycle lanes. They were dressed in a manner designed not to draw attention or distract motorists or pedestrians. For these studies, one staff member focused on vehicle counts and noncompliance, while the other staff member focused on bicyclist counts and noncompliance.

Figure 20 - Contra-flow bicycle lanes along West Ardmore Avenue (facility) and no dedicated bicycle lanes along Berwyn Avenue (control) in Chicago

Motorist Behavior

Motorist compliance was measured along the West Ardmore Avenue (facility) and the Berwyn Avenue (control) locations. Noncompliance was determined by motorists driving or parking in the bicycle lanes. A total of 271 vehicles were recorded on West Ardmore Avenue and 149 on Berwyn Avenue. All of the 420 vehicles were compliant, meaning they did not drive or park in the bicycle lanes.

Bicyclist Behavior

Bicyclist compliance on Berwyn Avenue was defined as bicyclists riding with the direction traffic (eastbound) on the roadway. Noncompliant behaviors on Berwyn Avenue included riding against the direction of traffic (westbound) on the roadway, or riding on the sidewalk in either direction. On West Ardmore Avenue compliant behaviors included riding the correct direction (westbound) in the contra-flow bicycle lane and riding eastbound in the shared lane; noncompliant behaviors were riding the wrong direction (eastbound) in the contra-flow lane, riding against traffic (westbound) in the shared lane, and riding either direction on the sidewalk.

Table 3A & 3B - Bicycle movements along West Ardmore Avenue (facility) and Berwyn Avenue (control)

Berwyn Avenue (Control)		
Movement	Westbound	Eastbound
On Road	40 (wrong direction)	32
On Sidewalk	5	1
Total	78	

West Ardmore Avenue (Facility)		
Movement	Westbound	Eastbound
In Contra-flow Lane	89	14 (wrong direction)
In Shared Lane	4 (wrong direction)	42
On Sidewalk	2	0
Total	151	

Table 4 - Compliance comparison

	Berwyn Avenue (Control) n = 78	West Ardmore Avenue (Facility) n = 151
Overall Bicycle Compliance	41.0%	86.8%
Sidewalk Riders - Noncompliance	7.7%	1.3%
Wrong Direction - Noncompliance	51.3%	11.9%

Discussion

The overall bicycle compliance was much higher on West Ardmore Avenue where a contra-flow bicycle lane was present than on Berwyn Avenue where no dedicated bicycle lanes were present. Additionally, the higher percentage of sidewalk riders on Berwyn Avenue indicated that riders were more uncomfortable when riding against traffic on a one-way streets without dedicated bicycle lanes (5 of the 6 sidewalk riders on Berwyn Avenue were riding westbound). By implementing the contra-flow bicycle lane facility on West Ardmore Avenue, illegal bicycle behavior was eliminated.

Conclusion

In summary, all motorists were compliant at both the contra-flow bicycle lane facility and the control site. The percentage of compliant bicyclists was much higher at the facility location (86.8%) than at the control location (41.0%). The percentage of sidewalk riders was higher at the control location (7.7%) than at the facility location (1.3%). From these results, one can conclude that bicyclists are riding against traffic on one-way streets regardless of whether there is a contra-flow bicycle lane present or not. Contra-flow bicycle lanes may make this movement safer and decrease illegal movements and can be an effective means of connecting legs of a bicycle route system.

Crash Analysis

As part of this Feasibility Study, a crash analysis was performed for the following locations in the District One region of the Illinois Department of Transportation (IDOT):

- West Ardmore Avenue in Chicago
- West Albion Avenue in Chicago
- West Berteau Avenue in Chicago

Eleven total crashes were recorded at the three sites in District One between 2005 and 2013. However, only one crash was recorded after the installation of contra-flow bicycle lanes, so no crash trends could be determined.

Although contra-flow bicycle lane facilities are fairly new in the United States, they can be found in several cities throughout the country.[14] Some cities in the United States were already using contra-flow bicycle lanes prior to the acceptance of these standards. Several cities such as Eugene and Corvallis in Oregon, Madison in Wisconsin, and Newport Beach in California, implemented contra-flow bicycle lanes more than ten years ago.[15] In 2001, the city of Chicago's only contra-flow bicycle lane facility was installed on West Ardmore Avenue between Sheridan Road and Kenmore Avenue.[2] In 2012, CDOT also installed contra-flow bicycle lanes at two locations in the Rogers Park Neighborhood.[1]

Table 5 – Examples of contra-flow bicycle lanes in the USA, with locations in District One shown in bold text

Country	City/County	State	Location	Install Year
USA	Tucson	AZ	University of Arizona Campus – James E. Rogers Way	2013
USA	Newport Beach	CA	Back Bay Dr.	Unknown
USA	San Francisco	CA	Lyell St. from Alemany	Unknown
USA	San Francisco	CA	Polk St. and Market St.	2014
USA	Boulder	CO	Pearl St.	2008
USA	Washington	D.C.	G St. NE from Elliot St. to 2nd St.	2014
USA	Washington	D.C	I St. NE from Florida Ave. NE to 5th St.	2014
USA	**Chicago**	**IL**	**W. Albion Ave. at Loyola Station from N. Lakewood Ave. to N. Winthrop Ave.**	**2012**
USA	**Chicago**	**IL**	**Berteau Ave. Greenway – part of W. Berteau Ave. from N. Clark St. to N. Lincoln Ave.**	**2014**
USA	**Chicago**	**IL**	**W. Ardmore Ave. from N. Kenmore Ave. to Lakefront Trail**	**2001**
USA	Cambridge	MA	Concord Ave. from Follen St. to Waterhouse St.	1994
USA	Cambridge	MA	Norfolk St. from Harvard St. to Broadway	Unknown
USA	Baltimore	MD	W. Lanvale St. from Maryland Ave. to Charles St.	2001
USA	Brooklyn	NY	Degraw from 3rd St. to Plaza St. W.	2013
USA	Brooklyn	NY	Sackett St./Berkeley Plaza from 3rd St. to Plaza St. W.	2013
USA	Baltimore	OR	Lanvale St.	Unknown
USA	Seattle	WA	6th Ave. from Dearborn and Seattle Blvd. S.	2011

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[1] Chicago Department of Transportation (CDOT). 2012. Chicago Department of Transportation 2012 Bike Program – Year in Review (Chicago, IL).

[2] National Association of City Transportation Officials (NACTO). March 2014. Urban Bikeway Design Guide, 2nd Edition. Accessed December 8, 2015. http://nacto.org/publication/urban-bikeway-design-guide/bike-lanes/contra-flow-bike-lanes/

[3] Manual on Uniform Traffic Control Devices with Revisions 1 and 2, May 2012 (MUTCD) (U.S. Department of Transportation and Federal Highway Administration, 2009 Edition).

[4] Walker, Lindsay, Mike Tresidder, Mia Birk. July 2009. Fundamentals of Bicycle Boulevard Planning & Design. Portland State University. Accessed November 13, 2015. https://www.pdx.edu/ibpi/sites/www.pdx.edu.ibpi/files/BicycleBoulevardGuidebook%28optimized%29.pdf

[5] Bushell, Max, Bryan Poole, Daniel Rodriguez, Charles Zegeer. October 2013. *Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners and the General Public*. University of North Carolina Highway Safety Research Center. Accessed August 28, 2014. http://www.pedbikeinfo.org/cms/downloads/Countermeasure%20Costs_Report_Nov2013.pdf

[6] Chicago Department of Transportation (CDOT). 2012. City of Chicago 2012 Bicycle Crash Analysis – 2005-2010 Crash Data Summary Report and Recommendations. (Chicago, IL).

[7] Gardner, Kyla. July 12, 2013. “Worst Streets for Cyclists? Diagonals, Downtown Most Dangerous, Report Says.” DNAinfo Chicago. Accessed August 6, 2014. http://www.dnainfo.com/chicago/20130712/wicker-park/worst-streets-for-bikers-diagonals-downtown-most-dangerous-report-shows

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[9] Seiderman, Cara. 2013. Contraflow Bicycle Lanes on Urban Streets. BIKESAFE. (Cambridge, MA). Accessed November 13, 2015. http://pedbikesafe.org/bikesafe/casestudies_detail.cfm?CS_NUM=209

[10] Taverner Research. May 2013. Contra-flow Bicycle Lanes: A Behavioral Study. Roads and Maritime Services. Accessed August 6, 2014. https://www.rms.nsw.gov.au/documents/roads/bicycles/bicycles-contra-flow-study-2013.pdf

[11] Department for Transport. September 1998. Contraflow Cycling. Traffic Advisory Leaflet 6/98. Accessed August 1, 2014. (United Kingdom). http://www.ukroads.org/webfiles/TAL%206-98%20Contraflow%20cycling.pdf

[12] Chicago Department of Transportation (CDOT). Chicago Department of Transportation 2011 Bike Program – Year in Review (Chicago, IL 2011). http://chicagocompletestreets.org/wp-content/uploads/2013/10/2011-Bikeways-Year-End-Report.pdf

[13] City of Madison Public Works Bikeway Maintenance. Making Bicycling a Viable Mode of Transportation. (Madison, Wisconsin). Accessed July 15, 2016. http://legistar.cityofmadison.com/attachments/e440e3df-1b4d-49fa-bbfc-5e94495a7e63.pdf

[14] Klassen, Mike. October 27, 2010. Why are Separated Bike Lanes so Controversial? Accessed November 13, 2015. http://citycaucus.com/2010/10/why-are-separated-bike-lanes-so-controversial/ (link inactive)

[15] National Committee on Uniform Traffic Control devices (NCUTCD). June 28, 2014. Bicycle Technical Committee. Accessed August 5, 2014.

Left-Side Bicycle Lanes

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation


PUBLIC
PARKING
PARK
PUBLIC PARKING
Entrance Ahead
PAULINA
1645

Left-side bicycle lanes are on-road facilities designed exclusively for bicycles that are placed on the left-side of one-way streets or median-divided two-way streets and separated from motorists with white, solid pavement marking striping. Left-side bicycle lanes are placed on the left-side of the roadway to improve bicyclist visibility for motorists by having the bicyclist on the driver's side view, to reduce potential right-side bicycle lane conflicts from right-turning motorists, delivery stops, transit vehicles, and when parking is present.

Figure 1 – Left-side bicycle lane on Jackson Boulevard in Chicago

Features

Left-side bicycle lanes in the United States feature traditional white pavement marking striping separating the bicycle lanes from motor vehicle traffic. Solid white bicycle symbols and arrow markings are used to mark the bicycle lane. Left-side bicycle lanes can be striped as conventional bicycle lanes or buffered bicycle lanes. For design guidance and additional safety, operational and maintenance information on bicycle lanes, see the Conventional Bicycle Lanes for more information. The design, materials and construction of a left-side bicycle lane are the same as those of a conventional bicycle lane, as governed by section 17-2.02(c) of the BDE Manual.

Costs

The average cost of a left-side bicycle lane is $133,170 per installation but may range between $5,360 and $536,680.[1] The average cost of a pavement marking symbol is $180 per installation but may range between $22 and $600. See the Conventional Bicycle Lanes for a more detailed cost breakdown.

$ $133,170
Average cost

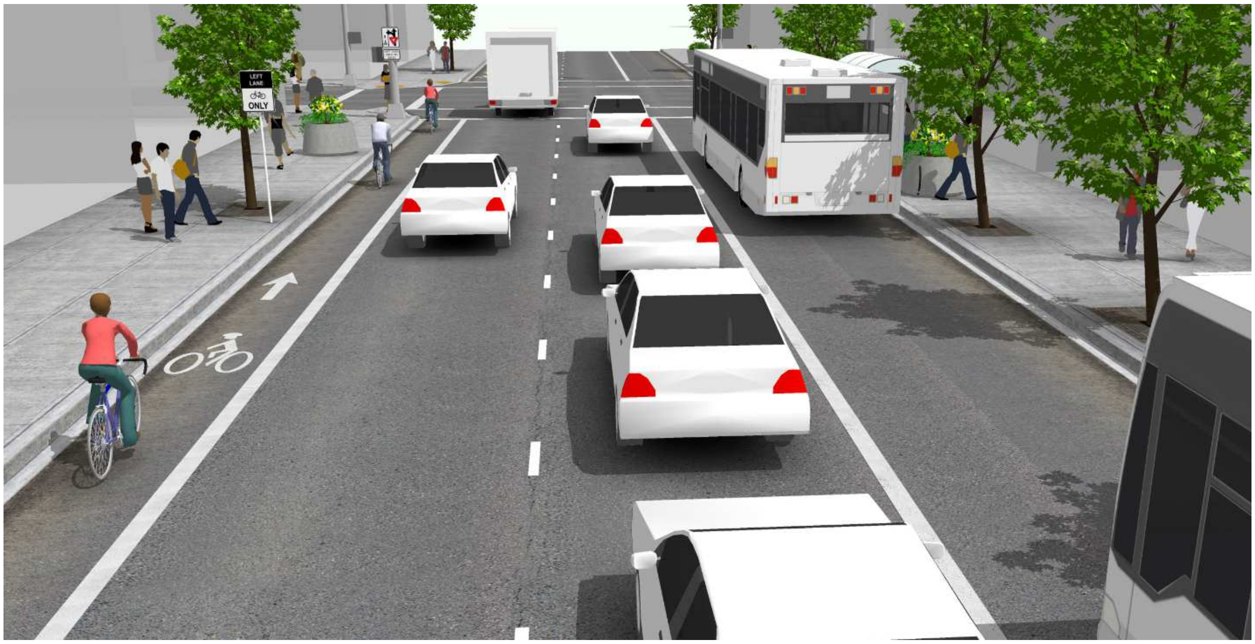


Figure 2 – Left-side bicycle lane. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Design Guidance

FHWA	MUTCD - Chapter 3D. Markings for Preferential Lanes, Chapter 9C. Markings. http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm
Illinois Department of Transportation	BDE Manual Chapter 17-2.02(c) http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Design-and-Environment/Illinois%20BDE%20Manual.pdf
AASHTO	Guide for the Development of Bicycle Facilities Chapter 4.6.3 https://store.transportation.org/Item/CollectionDetail?ID=116
NACTO	Urban Bikeway Design Guide Left-Side Bicycle Lanes http://nacto.org/publication/urban-bikeway-design-guide/bike-lanes/left-side-bike-lanes/

Figure 3 - List of design guidance manuals and documents

SAFETY

Studies have found left-side bicycle lanes provide safety benefits for both bicyclists and motorists that include:

- Reducing potential right-side bicycle lane conflicts from parking, deliveries, transit stops, and right-turning movements
- Improving bicyclist visibility for motorists by having the bicyclists on the driver's side view
- Reducing "dooring" incidents since bicyclists are riding on the right-side of parked vehicles instead of the left-side of parked vehicles. Passengers exit on the right side of vehicles less frequently than the driver side
- Providing guidance to both bicyclists and motorists

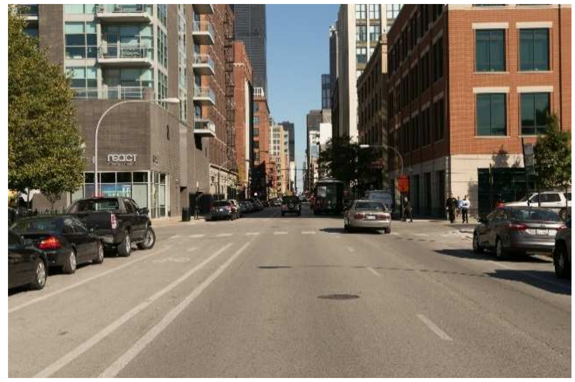


Figure 4 - Left-side bicycle lanes on Jackson Boulevard in Chicago

Left-side bicycle lanes are installed to improve bicyclist visibility for motorists, however, when a bicycle lane is moved to the left-side of the roadway, it can introduce potential conflicts since motorists are not used to seeing bicyclists riding there. Additional research is needed to verify the effectiveness within the context of northeastern Illinois.

According to BIKESAFE #19, a study was conducted on one-way streets in downtown Minneapolis, Minnesota to determine the best location for the addition of bicycle lanes.[2] The locations studied contained high traffic volumes with heavy transit presence. One of the biggest conflicts that concerned officials with bicycle lane placement was the high volume of right-turning movements of buses, with one fatality recorded involving a bus. There were also concerns with dooring crashes.[3] Officials decided to construct left-side bicycle lanes to reduce these types of conflicts, to make the roads safer for all roadway users, including bicyclists, motorists, and buses, and to provide a continuous free-flowing facility during all hours. Initial observations found unexpected crashes due to cars turning left and side-swiping bicyclists, since motorists were not familiar with bicyclists on the left-side of the road. The City of Minneapolis placed "Look for Bikes" signs and educated facility users, thus making the use of left-side bicycle lanes successful.

In September 2003, city engineers in Minneapolis measured the success of the left-side bicycle lanes by examining bicycle counts collected during peak hours, examining crash records, and conducting bicyclist surveys on four different bicycle lane facilities. Bicycle counts were recorded with 2,311 inbound bicyclists and 2,368 outbound bicyclists counted. Four different left-side bicycle lane facilities were then chosen for study at Hennepin Avenue, Nicolett Mall, Marquette Avenue, and 2nd Avenue South. Volunteers counted bicyclists at these four locations from 6:00 a.m. to 6:00 p.m., with a total of 1,475 bicyclists counted consisting of 350 bicyclists on Marquette Avenue, 325 bicyclists on 2nd Avenue South, 200 bicyclists on the Nicolett Mall, and 600 bicyclists in Hennepin Avenue. Noncompliant bicyclist behavior within the four facilities was noted, including wrong way and sidewalk riding. Approximately 75% of the bicyclists rode in the bicycle lanes on three of the four facilities. Approximately 35% of the bicyclists using the left-side bicycle lanes on two of the facilities were riding in the wrong direction. Types of crashes and crash locations were evaluated from 1999-2003 at these four facilities. Crash rates appeared to be typical along Marquette Avenue, 2nd Avenue South, and Hennepin Avenue, with many of the crashes involving bicyclists using the facilities improperly. Bicycle crashes were directly proportional to the volume of bicyclists, vehicle speed, and vehicle traffic volume. Data before installation nor cross-sectional data was provided to determine a comparison. Bicyclist and pedestrian intercept surveys were conducted in order to determine users' perception of the left-side bicycle lane facility in regards to their safety. Of the 600 bicyclist surveys dispersed, 188 responses were collected, with 28% of the participants expressing safety concerns and fear of drivers, 17% of the participants stating the number of trails and on-road bikeways were lacking, and 8% of participants expressing concern with the poor maintenance of the bikeways, roadways, and bridges. Although many of the participants felt uncomfortable using the left-side bicycle lanes and would rather ride in traffic, the city of Minneapolis engineers were still satisfied with the left-side bicycle lane system, and no changes are being planned.[2]

In Minneapolis, Minnesota, it has become standard practice to use left-side bicycle lanes on one-way streets with heavy bus traffic. In New York City, the use of left-side bicycle lanes on one-way streets with high bus traffic has also become a standard practice. The most frequent conflicts with lanes on the right side occurred between bicyclists and pedestrians getting on/off the transit system, or bicyclists trying to pass on the right-side of a stopped bus. The New York Planning Commission recommended a "street design change: left-side bicycle lanes on one-way streets where significant transit conflicts exist."[4]

The City of Madison, Wisconsin, conducted studies on some of their bicycle lanes in the early 1970's. When comparing crash data between the 1970's and 1980's the city concluded that the use of left-side bicycle lanes on one-way streets was safer than any other type of bicycle lane on one-way streets.[5]

Figure 5- Motorist parked in left-side bicycle lane on Dearborn Street in Chicago, Illinois

OPERATIONS

Left-side bicycle lanes improve travel operations by reducing potential conflicts with right-turning motorists, delivery vehicles, transit vehicles, and parking vehicles. By placing the bicycle lane on the left-side of the roadway, the bicyclist has a more prominent position in the driver's view. Moving the bicycle lane to the non-transit side may reduce instances where the bicyclists must merge with through motorist lanes, therefore improving operations for both bicyclists and motorists. If the bicycle lane was moved due to extensive driveways, then driveway entry and egress will also improve. Some of the factors that can compromise the operations of this facility are:

- Difficult to transition from a left-side bicycle lane to a conventional bicycle lane on the right-side of the roadway although bicycle boxes can aid in the transition.
- A left-side bicycle lane's effect on motorist operations is dependent on the ratio of left-turning or right-turning motorists and is therefore, project specific
- Cars and buses driving or parking in the bicycle lane
- Bicyclists using the left-side bicycle lane facility improperly
- Snow and other obstacles not being removed from the bicycle lane

Figure 6 - Bicyclist riding the wrong direction in left-side bicycle lane on Jackson Boulevard in Chicago, Illinois

Based on a Bicycle/Bus Conflict Area Study conducted by the Delaware Valley Regional Planning Commission, the following operational factors should be considered for placement of left-side bicycle lanes:

- One-way streets with frequent bus/trolley stops
- Locations with a high number of right-turning vehicles
- Locations with a high number of left-turning bicyclists
- Locations with a high parking turnover rate
- Continuity along a street

MAINTENANCE

Left-side bicycle lanes require minimal routine maintenance aside from debris removal, snow removal, restriping pavement markings, and signage maintenance. Restriping of pavement marking lines, letters, and symbols should be done in compliance with the MUTCD standards.[6]

Left-side bicycle lanes should be maintained and kept free of structural deterioration, damage, and other debris. On-site inspections, street sweeping, and snow removal should occur on a regular basis to ensure bicyclists safety in all weather conditions. Some noted issues regarding the maintenance of this facility include:

- Maintenance of bicycle lanes aren't always a high priority
- Routine inspections of the lane's conditions aren't always done on a regular, timely basis
- Bicycle lane striping isn't always maintained so striping becomes faint or disappears since bicycle lanes are initially paid for with federal funding
- Bicycle lanes are left unusable during winter months due to poor snow removal
- Snow removal is inconsistent
- Building owners shovel snow off of sidewalks into the bicycle lanes

Street Sweeping & Snow Removal

Snow removal from left-side bicycle lanes can be done with traditional snow plows. Since left-side bicycle lanes are on the same slope as the roadway, snow plows can continue routine operations without lifting plows. Some street maintenance divisions have implemented a "snow removal priority plan" which prioritizes snow removal on routes with bicycle facilities.

Figure 7 – Debris in left-side bicycle lanes on NW Everett Street in Portland, Oregon (Images: Jonathon Maus - Publisher/Editor, Bike Portland)

Drainage

Left-side bicycle lanes do not obstruct roadway surface runoff as long as adequate cross slope is provided and maintained.

Utility Cuts and Construction Damage

Left-side bicycle lanes may be impacted during utility repairs, but IDOT and most municipal utility policies require restoration to existing conditions by those conducting repairs. Utility companies may need additional information or guidance on proper repair of the facility, and their work should be inspected following completion.

District One Studies

The following is a summary of findings from three studies performed by IDOT in 2014, for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 1 - Summary of IDOT District One Studies, 2014

Study	Summary of Findings
Bicyclist Survey	Overall, the responses from the surveys indicated that most bicyclists felt safer and more comfortable riding in conventional bicycle lanes (94.4%) rather than in left-side bicycle lanes (45.8%). Additionally, the left-side bicycle lane facility had more shortcomings reported, and the conventional bicycle lane facility had significantly more positive comments. Because of the low numbers of participants surveyed, further study is warranted in order to draw a more representative conclusion.
Motorist Compliance and Bicyclist Behavior	Motorist non-compliance recorded at a left-side and conventional bicycle facility, with 9.0% of motorists driving in the bicycle lane on the right-side bicycle lane on Illinois Street compared to 1.3% on a left-side lane on Dearborn Street, and 66.7% of buses driving in the bicycle lane on Illinois Street. All buses were in compliance on Dearborn Street. The overall bicycle compliance was much higher at the control location on Illinois Street compared to the facility location on Dearborn Street, with 85% of bicyclists using the conventional bicycle lanes properly on Illinois Street and only 44% of bicyclists using the left-side bicycle lanes properly on Dearborn Street. Non-compliant bicyclists were recorded at both locations, with 48.1% of the bicyclists riding on the right-side of the roadway on Dearborn Street instead of using the left-side bicycle lane and a small number of bicyclists riding the wrong direction along both Dearborn Street and Illinois Street.
Crash Analysis	Since there were no crash data recorded before the installation of the facility chosen, no crash trends could be determined. Therefore, the crash analysis was not performed.

Bicyclist Survey

Two surveys were conducted, one at a left-side bicycle lane facility and one at a facility with conventional bicycle lanes, to compare and contrast bicyclists opinions on the respective facilities. Dearborn Street, from Kinzie Street to Chicago Avenue, is a one-way south-north major collector in an urban commercial area with an ADT of 13,100 and a speed limit of 20 to 30 mph. Illinois Street is a west to east one-way principal arterial in an urban commercial area with an ADT of 8,800 and a speed limit of 30 mph. In-person surveys regarding the left-side bicycle lanes were conducted along Dearborn Street with the intersection of Hubbard Street on October 31, 2014 from 4:00 p.m. to 6:00 p.m. During the survey, the weather condition was windy with a temperature of 55 degrees. For the control location, along Illinois Street with the intersection of Dearborn Street, the in-person surveys were conducted on October 10, 2014 from 7:00 a.m. to 9:00 a.m. During the survey, the weather condition was clear and cool with a temperature of 50 degrees. For both the facility location and the control location, online surveys were also open and available for a two week period.

Survey Method

A cross sectional study was conducted to compare bicyclists' opinions of riding on an existing left-side bicycle lanes versus riding on a similar facility with conventional bicycle lanes. The facility and control questions were kept as similar as possible in order to facilitate response comparison.

For the Dearborn Street left-side bicycle lanes, one staff member stood along Dearborn Street at the intersection of Hubbard Street. At the control location on Illinois Street, one staff member stood at the southwest corner along Illinois Street at the intersection of Dearborn Street. The staff members were wearing a safety vest for safety purposes and to attract the attention of bicyclists. The staff member would approach bicyclists asking them if they would like to take a survey. They were given the option of taking the survey in person or online at their convenience. The online survey was open for two weeks and the online submissions were analyzed to avoid multiple submissions from the same person.

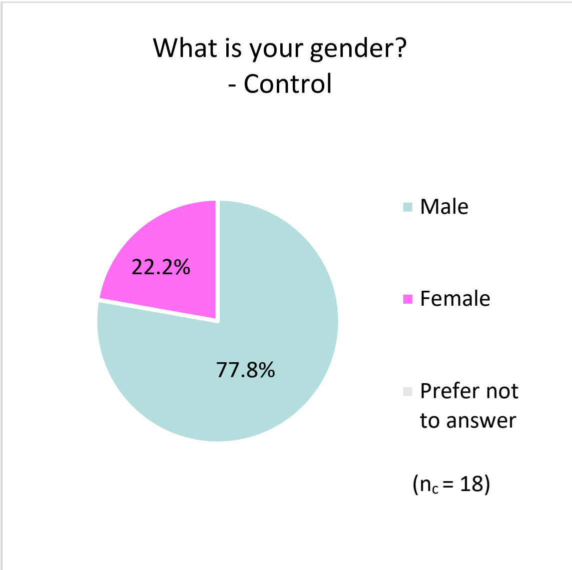
Survey Questions

Participants were asked the questions listed below in Table 2.

Table 2 - Survey questions corresponding to the following figures

Figure #	Questions Asked
8	What is your gender?
9	Were you riding a Divvy bicycle at the time of the survey?
10	In what age group do you fall?
11	What best describes why you are out here today?
12	In the past month, about how often have you ridden on Illinois Street from N. Orleans Street to Michigan Avenue (Control) or on Dearborn Street from Kinzie Street to Chicago Avenue (Facility) in Chicago?
13	Why did you choose this route?
14	Have you ever had any problems bicycling on this street, such as near misses or conflicts with drivers or buses?
15	On one-way streets, do you prefer bicycle lanes on the left-side or right-side of the street?
16	Do you use this street specifically because it has on-street bicycle lanes? (Facility)
17	Did you use this route before the left-side bicycle lane was added? (Facility)
18	How safe and comfortable do you feel when bicycling on Illinois Street from N. Orleans Street to Michigan Avenue (Control) or along Dearborn Street from Kinzie Street to Chicago Avenue (Facility) in Chicago?
19	Is there anything that can be improved to make you feel more comfortable?

Survey Results



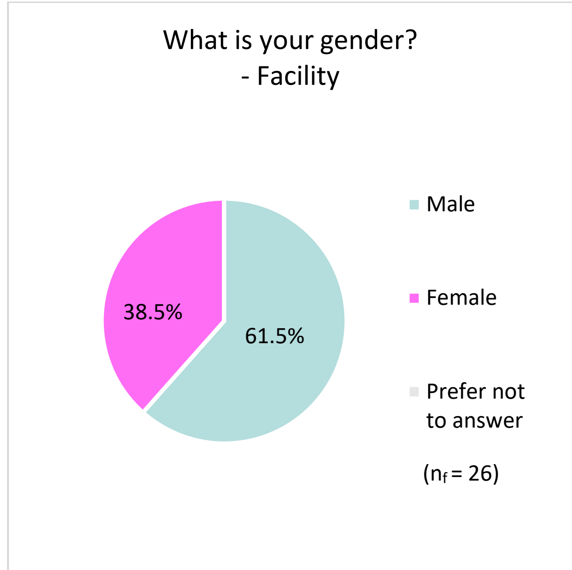
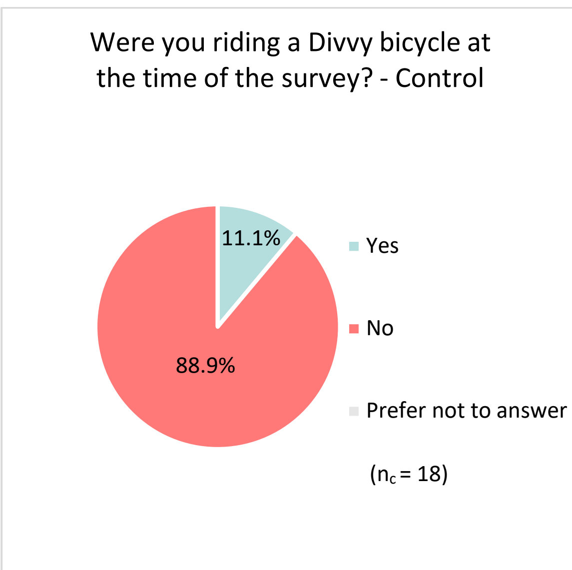


Figure 8 - What is your gender? Results from the control (left) and left-side bicycle lanes (right).



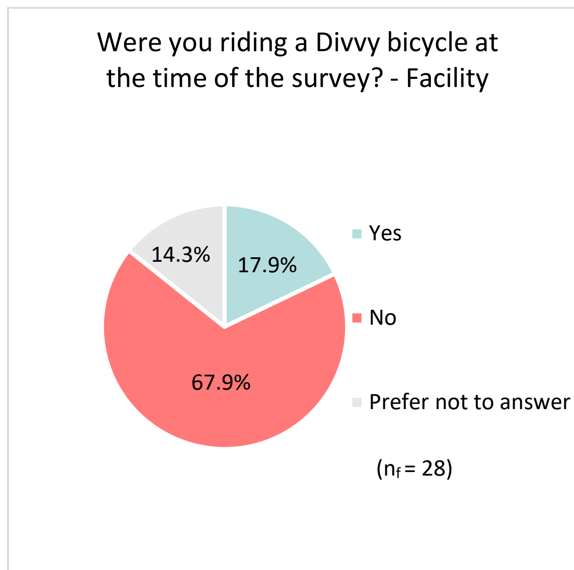


Figure 9 - Were you riding a Divvy bicycle at the time of the survey? Results from the control (left) and left-side bicycle lanes (right).

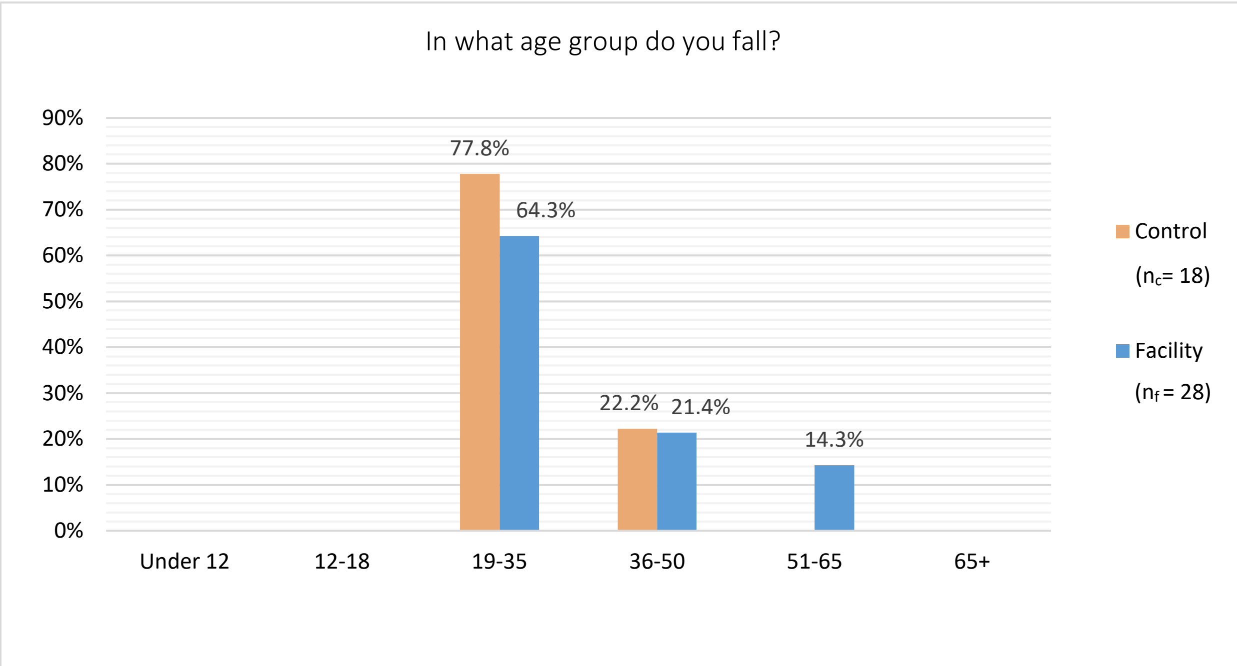


Figure 10 - What age group do you fall in? Results from the control (left) and left-side bicycle lanes (right).

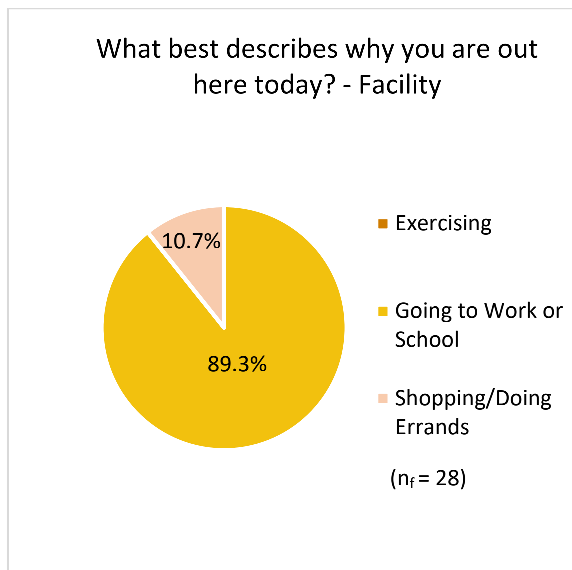


Figure 11 - What best describes why you are out here today? Results from the control (left) and left-side bicycle lanes (right).

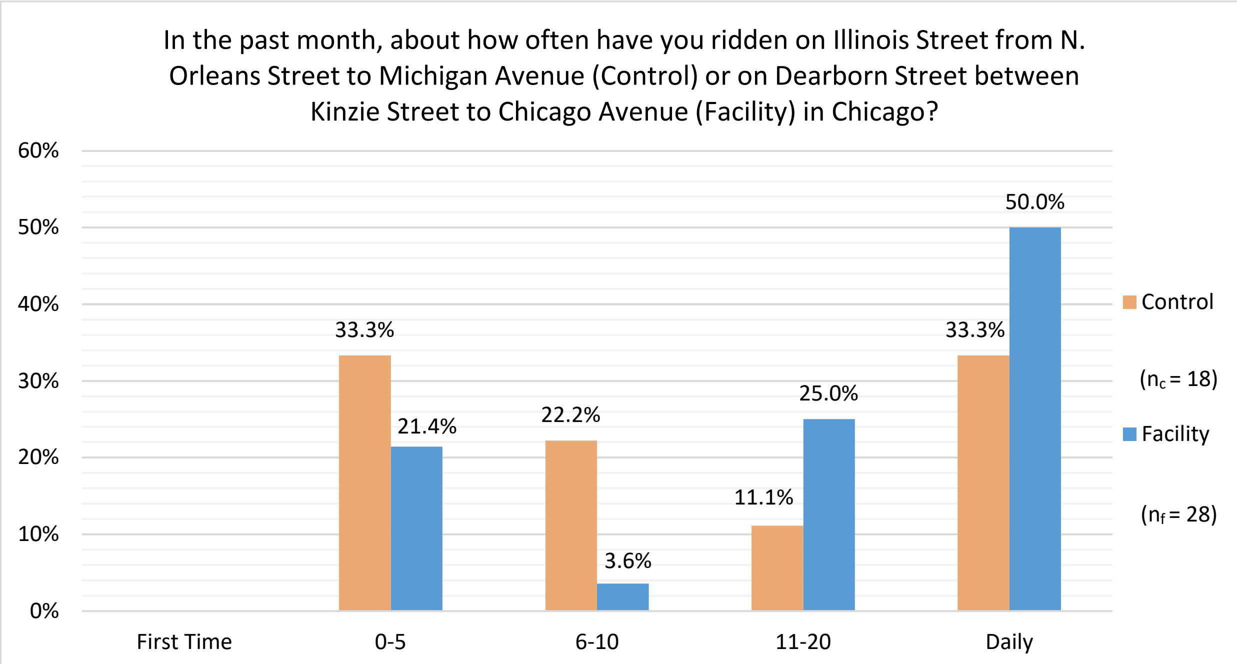


Figure 12 - In the past month, about how often have you ridden on Illinois Street from N. Orleans Street to Michigan Avenue (control) or on Dearborn Street from Kinzie Street to Chicago Avenue (facility) in Chicago?

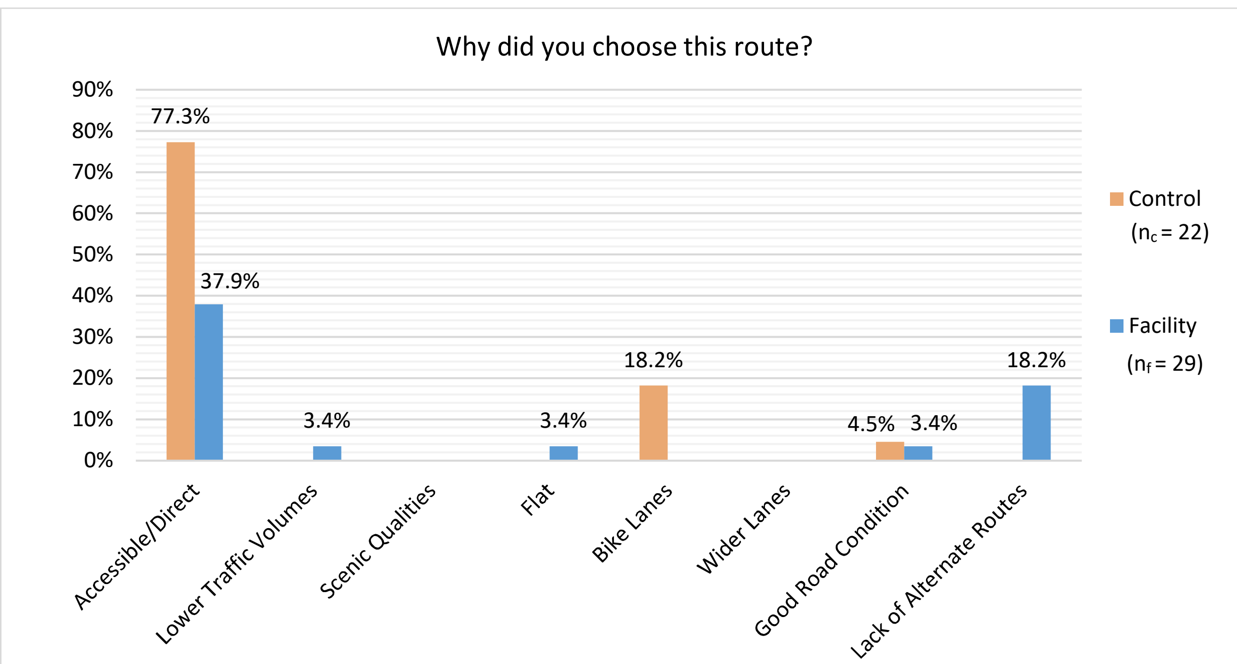


Figure 13 - Why did you choose this route?

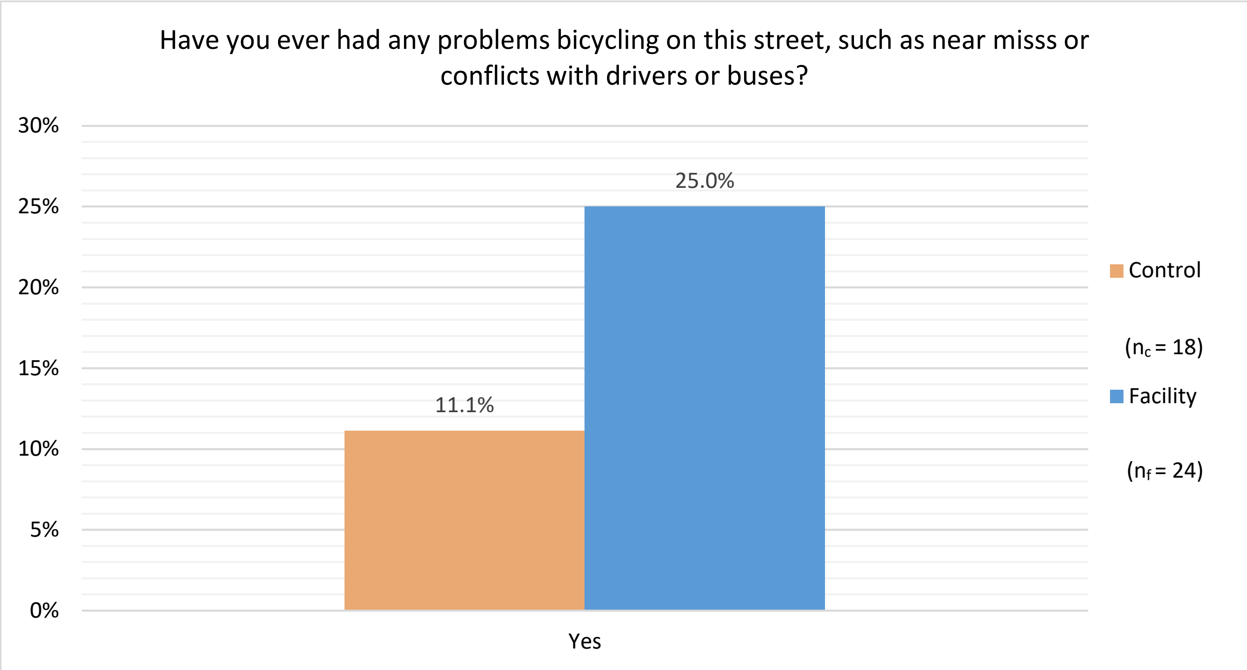


Figure 14 - Have you ever had any problems bicycling on this street such as near misses or conflicts with drivers or buses?

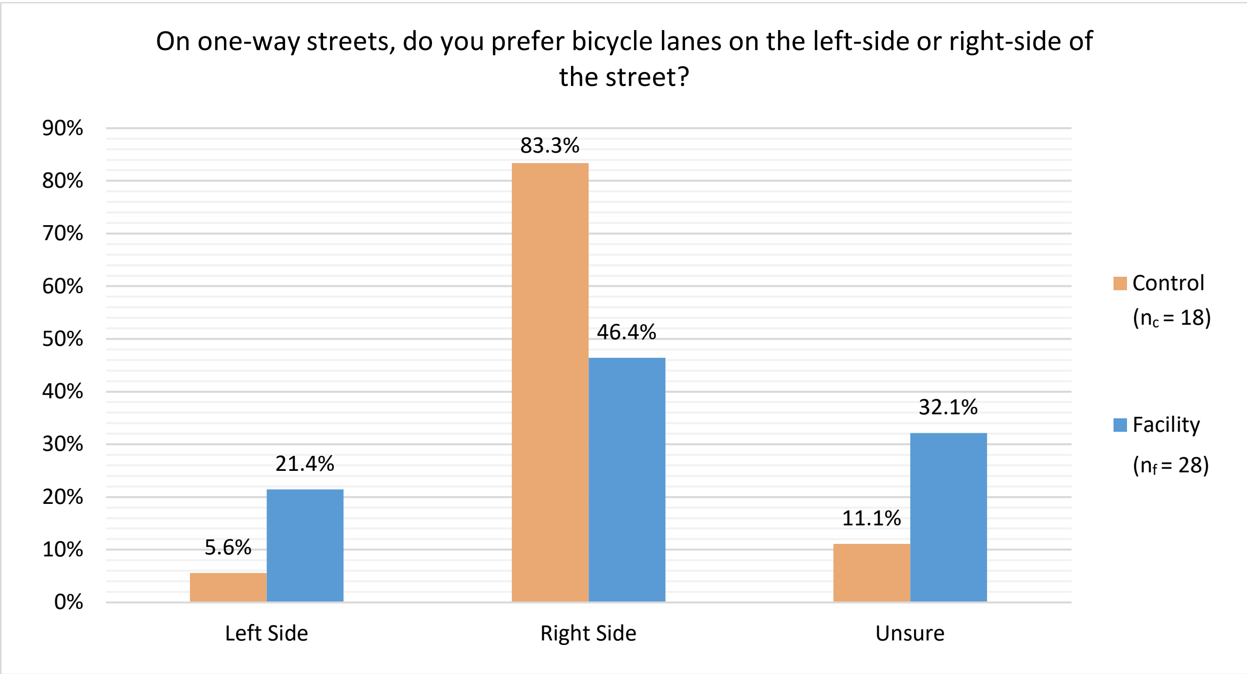


Figure 15 - On one-way streets, do you prefer bicycle lanes on the left-side or right-side of the street?

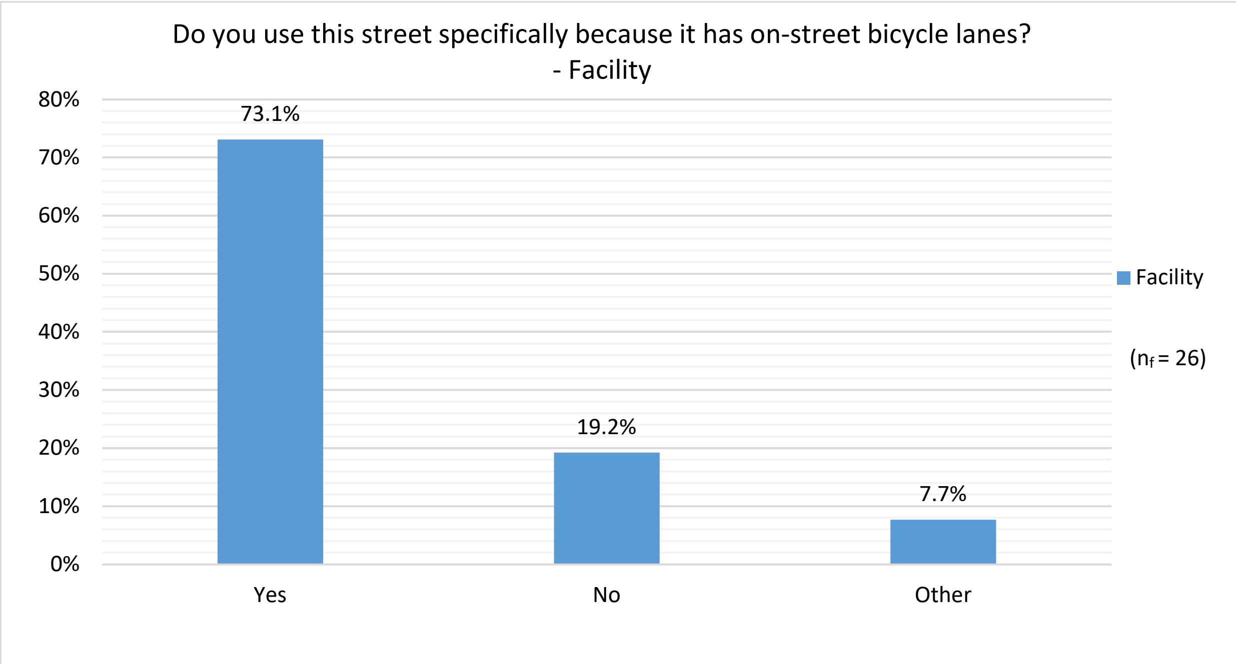


Figure 16 - Do you use this street specifically because it has on-street bicycle lanes? Results from left-side bicycle lanes.

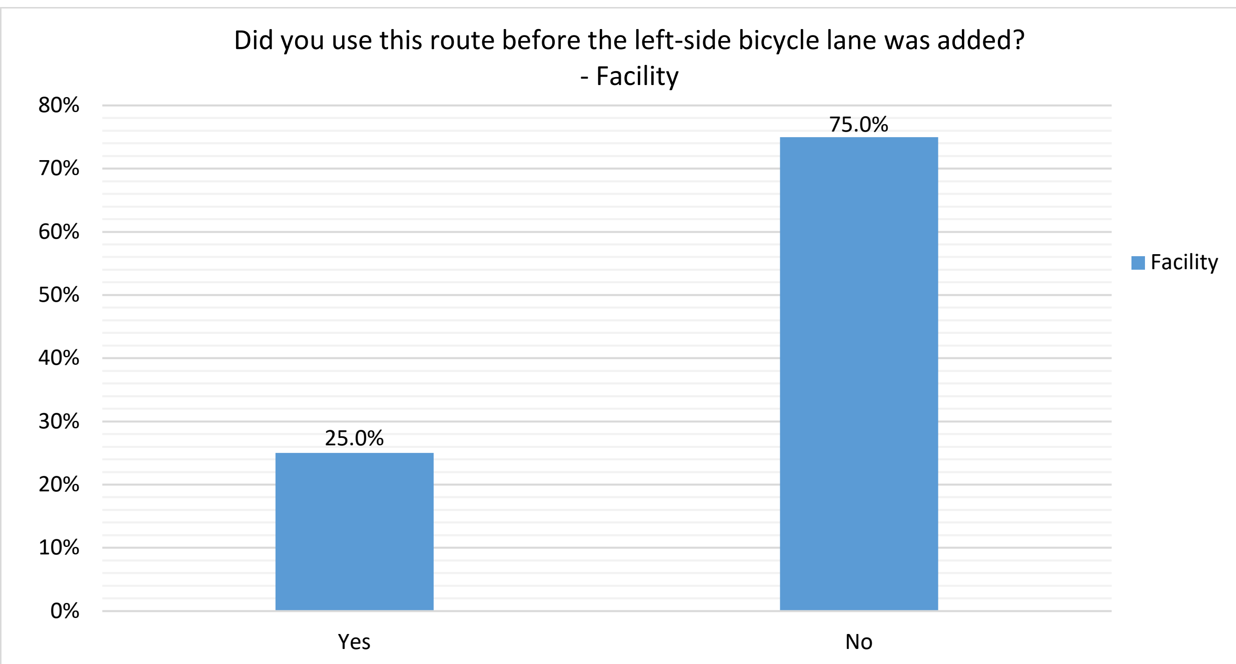


Figure 17 - Did you use this route before the left-side bicycle lane was added? Results from left-side bicycle lanes.

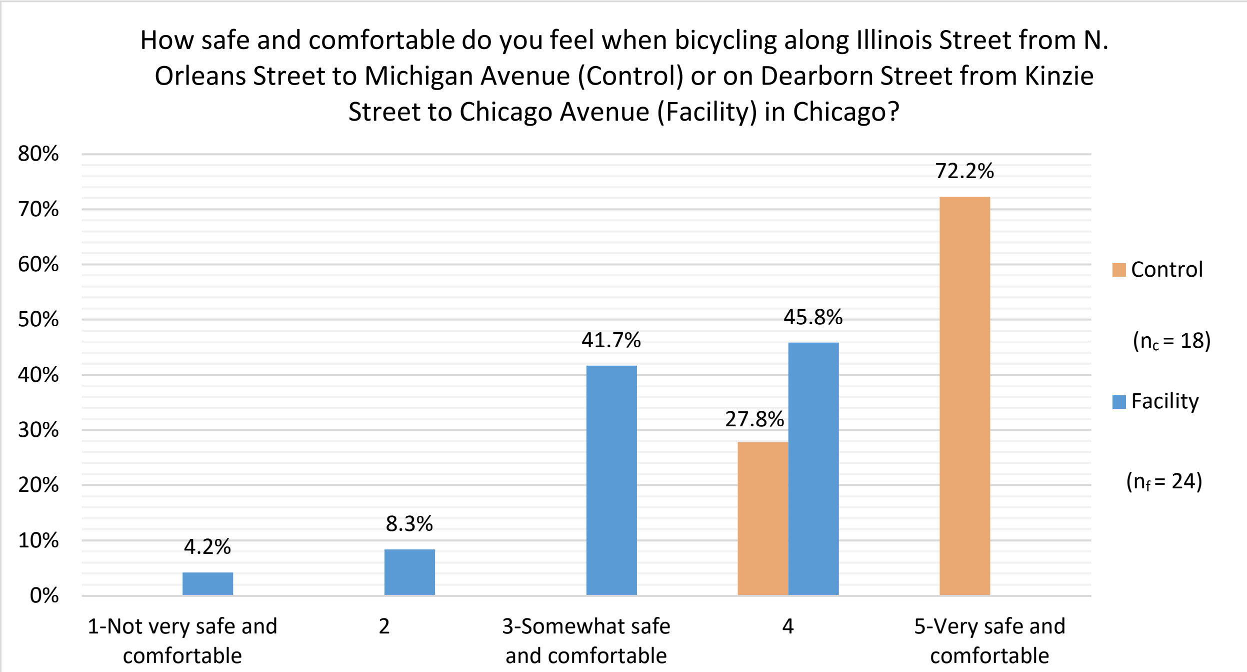


Figure 18 - How safe and comfortable do you feel when bicycling along Illinois Street from N. Orleans Street to Michigan Avenue (Control) or along Dearborn Street from Kinzie Street to Chicago Avenue (Facility) in Chicago?

Figure 19 shows the open-ended comments. Participants were given the opportunity to voice their opinions about the left-side bicycle lanes and the conventional bicycle lanes. Their opinions were categorized and shown below.

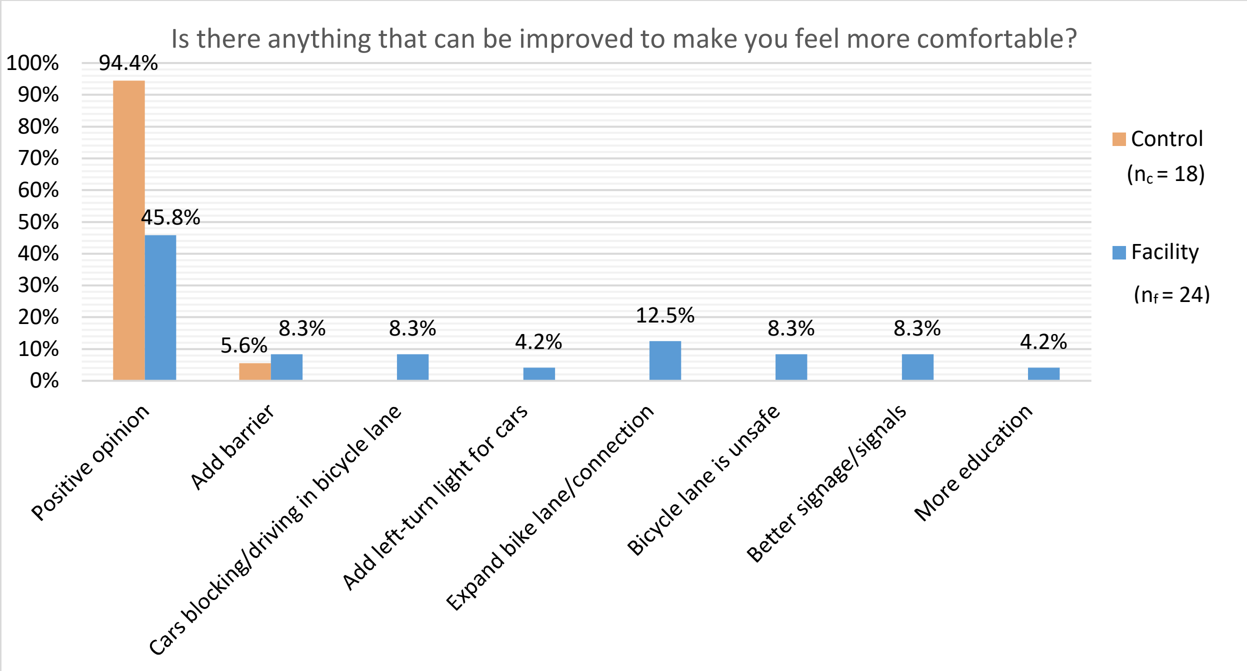


Figure 19 - Is there anything that can be improved to make you feel more comfortable?

Discussion

For the left-side bicycle lane facility, ten paper surveys were completed and 18 online surveys were completed. Of the participants surveyed, 25 participants stated they were "Going to Work or School". Of the participants surveyed, 15 participants chose this route because there are bicycle lanes present, while 11 participants chose this route because it is an accessible or direct route. Only six participants surveyed preferred bicycle lanes on the left-side of the street, 13 participants preferred bicycle lanes on the right-side of the street, while nine participants did not have a preference, and 18 of those participants did not use this street before the left-side bicycle lane was added. Only six participants had problems bicycling on this street, such as near misses or conflicts with drivers or buses, and the majority of participants rated this facility a 3 or 4 in terms of safety and comfort on a scale of 1 to 5, with 5 being the safest.

Participants were given the opportunity to voice their opinions on the left-side bicycle lane on Dearborn Street. Approximately 46% of the participants had positive feelings towards the left-side bicycle lane. Several of the participants had expressed specific comments and suggestions regarding the left-side bicycle lane which can be seen in Figure 19.

For the control location with conventional bicycle lanes, 17 paper surveys were completed and one online survey was completed. Of the participants surveyed, 18 participants stated they were "Going to Work or School", 17 participants chose this route because it is accessible or direct, four participants chose this route because there are bicycle lanes present, while 15 participants preferred bicycle lanes on the right-side of the street. Only two participants had problems bicycling on this street, such as near misses or conflicts with drivers or buses and the majority of participants rated this facility a 5, with a few participants rating this facility a 4 in terms of safety and comfort on a scale of 1 to 5, with 5 being the safest.

Participants were given the opportunity to voice their opinions about the conventional bicycle lanes on Illinois Street at the control location. Approximately 94.4% of the participants had positive feelings towards the conventional bicycle lanes, while 5.6% suggested adding a barrier.

Conclusion

Overall, the responses from the surveys indicated that most bicyclists felt safer and more comfortable riding in conventional bicycle lanes rather than in left-side bicycle lanes. Additionally, the left-side bicycle lane facility had more shortcomings reported, and the conventional bicycle lane facility had significantly more positive comments. Because of the low numbers of participants surveyed, further study is warranted in order to draw a more representative conclusion.

Motorist Compliance and Bicyclist Behavior Study

A bicyclist and motorist behavior study was conducted for the purpose of gaining further information and knowledge about the performance of left-side bicycle lanes in the District One Region. This study compares a corridor with left-side bicycle lanes already in-place (facility site) against a corridor with a similar ADT, roadway geometry, and roadway characteristics that has conventional bicycle lanes already in-place (control). An aerial view of the sites is shown in Figure 20.

The left-side bicycle lane facility is located on Dearborn Street from Kinzie Street to Chicago Avenue. The control site is a facility with conventional bicycle lanes and is located on Illinois Street from N. Orleans Street to Michigan Avenue.

Site Conditions

Dearborn Street, from Kinzie Street to Chicago Avenue, is a one-way south-north major collector in an urban commercial area with an ADT of 13,100 and a speed limit of 20 mph. The field study for the left-side bicycle lanes was conducted along Dearborn Street with the intersection of Hubbard Street, on October 9, 2014 from 4:00 p.m. to 6:00 p.m. The temperature was 53 degrees. Dearborn Street is under the jurisdiction of CDOT. Dearborn Street bicycle lane surface and pavement markings appeared to be in good condition at the time of the survey.

Illinois Street is a west to east one-way principal arterial in an urban commercial area with an ADT of 8,800 and a speed limit of 30 mph. The field study at the control site was conducted along Illinois Street with the intersection of Clark Street, on October 9, 2014 from 4:00 p.m. to 6:00 p.m. The temperature was 53 degrees.

Figure 20 - Left-side bicycle lane along Dearborn Street at the intersection with Hubbard Street

Study Method

A cross sectional study was chosen in order to observe behaviors and compare these behaviors between the two facilities. During the data collection period, staff members observed from an inconspicuous position parallel to the bicycle lanes. They were dressed in a manner designed not to draw attention or distract motorists or bicyclists. For these studies, one staff member focused on vehicle counts and noncompliance, while the other staff member focused on bicyclist counts and noncompliance.

Figure 21 - Left-side bicycle lanes along Dearborn Street (facility) in Chicago

Motorist Behavior

Motorist compliance was measured along the left-side bicycle lanes (facility) and the control location. The categories included vehicle and buses driving in the bicycle lanes and parking/stopping in the bicycle lanes.

A total of 3313 vehicles were recorded, with 2056 vehicles driving on Dearborn Street and 1257 vehicles driving on Illinois Street. Non-compliance of vehicles was recorded along Dearborn Street, with 27 vehicles driving in the bicycle lane and 13 vehicles parking in the bicycle lane. Non-compliance of vehicles was also recorded along Illinois Street, with 113 vehicles driving in the bicycle lane and 15 vehicles parking in the bicycle lane. A total of 48 buses were recorded, with 30 buses driving on Dearborn Street and 18 buses driving on Illinois Street. A total of 12 buses were recorded as noncompliant along Illinois Street.

Table 3 – Motorist movements along Illinois Street (control) and Dearborn Street (facility)

Vehicles	Illinois Street (Control) n = 1257	Dearborn Street (Facility) n = 2056
Overall Vehicle Compliance	89.8%	98.1%
Driving in Bicycle Lanes - Noncompliance	9.0%	1.3%
Parking/Stopping in Bicycle Lanes - Noncompliance	1.2%	0.6%

Table 4 – Bus movements along Illinois Street (control) and Dearborn Street (facility)

Buses	Illinois Street (Control) n = 18	Dearborn Street (Facility) n = 30
Overall Bus Compliance	33.3%	100.0%
Driving in Bicycle Lanes - Noncompliance	66.7%	0.0%
Parking/Stopping in Bicycle Lanes - Noncompliance	0.0%	0.0%

Note: Buses travelled on the right-side of Dearborn Street. The left-side had no bus stops, therefore, compliance is shown as 100% here.

Table 5 – Compliance comparison - Vehicles

Vehicles		
Movement	Illinois Street (control) Eastbound	Dearborn Street (facility) Northbound
On Road	1129	2016
Driving in Bicycle Lanes	113	27
Parking/Stopping in Bicycle Lanes	15	13
Total	1257	2056

Table 6 – Compliance comparison - Buses

Buses		
Movement	Illinois Street (control) Eastbound	Dearborn Street (facility) Northbound
On Road	6	30
Driving in Bicycle Lanes	12	0
Parking/Stopping in Bicycle Lanes	0	0
Total	18	30

Bicyclist Behavior

Bicyclist compliance on Illinois Street was defined as bicyclists riding with the direction traffic (eastbound) on the roadway. Noncompliant behaviors on Illinois Street included riding against the direction of traffic (westbound) on the roadway, riding outside of the bicycle lane, riding on the sidewalk in either direction, riding on the right-side of the roadway, or riding the wrong direction in the bicycle lane. On Dearborn Street, compliant behaviors included riding the correct direction (northbound) in the left-side bicycle lane. Noncompliant behaviors were riding against the direction of traffic (southbound) on the roadway, riding outside of the bicycle lane, riding on the sidewalk in either direction, riding on the right-side of the roadway, or riding the wrong direction in the bicycle lane.

A total of 960 bicyclists were recorded, with 876 bicyclists riding along Dearborn Street and 84 bicyclists riding along Illinois Street. Non-compliance of bicyclists was recorded along Dearborn Street, with 35 bicyclists riding outside of the bicycle lane, 421 bicyclists riding on the right-side of the roadway, 3 bicyclists riding on the sidewalk, and 31 bicyclists riding the wrong direction on the roadway. Non-compliance of bicyclists was also recorded along Illinois Street, with 1 bicyclist riding outside of the bicycle lane, 5 bicyclists riding on the right-side of the roadway, 1 bicyclist riding on the sidewalk, and 6 bicyclists riding the wrong direction on the roadway. Additionally, a total of 576 pedestrians were recorded, with 565 pedestrians walking along Dearborn Street and 11 pedestrians walking along Illinois Street. All buses were non-compliant along both the control and the facility.

Table 7 – Bicyclist movements along Illinois Street (control) and Dearborn Street (facility)

Bicyclists	**Illinois Street (Control)** n = 84	**Dearborn Street (Facility)** n = 876
Overall Bicycle Compliance	84.5%	44.1%
Outside of Lane - Noncompliance	1.2%	4.0%
Right-side Riders - Noncompliance	0.0%	48.1%
Left-side Riders - Noncompliance	6.0%	0.0%
Sidewalk Riders - Noncompliance	1.2%	0.3%
Wrong Direction - Noncompliance	7.1%	3.5%

Table 8 – Pedestrian movements along Illinois Street (control) and Dearborn Street (facility)

Bicyclists	**Illinois Street (Control) n = 11**	**Dearborn Street (Facility) n = 565**
Overall Bicyclist Compliance	0.0%	0.0%
Crossing in Bicycle Lane - Noncompliance	100.0%	100.0%

Table 9 – Compliance comparison - bicyclists

Illinois Street (Control) - Bicyclists		
Movement	Westbound	Eastbound
On Road	6 (wrong direction)	71
Outside of Lanes		1
On Right-side		5
On Sidewalk		1
Total	84	

Dearborn Street (Facility) - Bicyclists		
Movement	Southbound	Northbound
On Road	31 (wrong direction)	386
Outside of Lanes		35
On Right-side		421
On Sidewalk		3
Total	876	

Discussion

There was minimal motorist non-compliance recorded at both facilities, with 9.0% of motorists driving in the bicycle lane on Illinois Street compared to 1.3% on Dearborn Street, and 66.7% of buses driving in the bicycle lane on Illinois Street. All buses were in compliance on Dearborn Street.

The overall bicycle compliance was much higher at the control location on Illinois Street compared to the facility location on Dearborn Street, with 85% of bicyclists using the conventional bicycle lanes properly on Illinois Street and only 44% of bicyclists using the left-side bicycle lanes properly on Dearborn Street. Non-compliance was recorded at both locations, with 48.1% of the bicyclists riding on the right-side of the roadway on Dearborn Street instead of using the left-side bicycle lane and a small number of bicyclists riding the wrong direction along both Dearborn Street and Illinois Street.

Conclusion

Non-compliant bicyclists were high on the left-side bicycle lane. Bicyclists may benefit from increased education on how to use the lane properly. Bicyclists' personal perception of safety and comfort level were decreased when using left-side bicycle lanes over conventional bicycle lanes. Furthermore, bicyclists were still riding on the right-side of the street even when a left-side bicycle lane was present.

Left-side bicycle lanes are located in numerous cities throughout the United States. The use of left-side bicycle lanes is becoming more of an accepted standard practice in urbanized areas in locations where right-side conflicts between bicyclists and motorists are a problem during rush hour traffic, near transit stops, near delivery stops, and when parking is present. A few examples of known left-side bicycle lanes are included in the table below.

Table 10 – Examples of left-side bicycle lanes in the USA, with locations in District One and Illinois shown in bold text

Country	City/County	State	Location	Install Year
USA	Berkeley	CA	Various Streets	Unknown
USA	Sacramento	CA	Various Streets	Unknown
USA	San Francisco	CA	Various Streets	Unknown
USA	Denver	CO	15th St.	2013
USA	Washington	DC	L St. Northwest	2012
USA	Naples	FL	Various Streets	Unknown
USA	**Chicago**	**IL**	**N. Dearborn St. from W. Kinzie St. to W. Chicago Ave.**	**Unknown**
USA	**Chicago**	**IL**	**Jackson Blvd. from W. Ogden Ave. to S. Ashland Ave.**	**Unknown**
USA	Boston	MA	Commonwealth Ave. from Kenmore St. to Arlington St.	2010
USA	Minneapolis	MN	4th Street from Marquette Ave. to Chicago Ave.	Unknown
USA	Minneapolis	MN	9th St. (south), 10th St. (south), 12th St. (south)	Unknown
USA	Minneapolis	MN	28th St. & Portland Ave.	Early 1990's
USA	Hoboken	NJ	Various Streets	Unknown
USA	Manhattan	NY	E. 91st St. from 1st Ave. to 2nd Ave.	Unknown
USA	New York City	NY	Various Streets	Unknown
USA	New York City	NY	Allen St. and Pike St. from Delancey St. to East River	2009
USA	Eugene	OR	Various Streets	Unknown
USA	Portland	OR	NW Everett Street	Unknown
USA	University City	PA	Walnut St. from 22nd St. to 63rd St.	2012
USA	Seattle	WA	2 Streets	Unknown
USA	Madison	WI	Johnson St. from Bassett St. to Hamilton St.	2010

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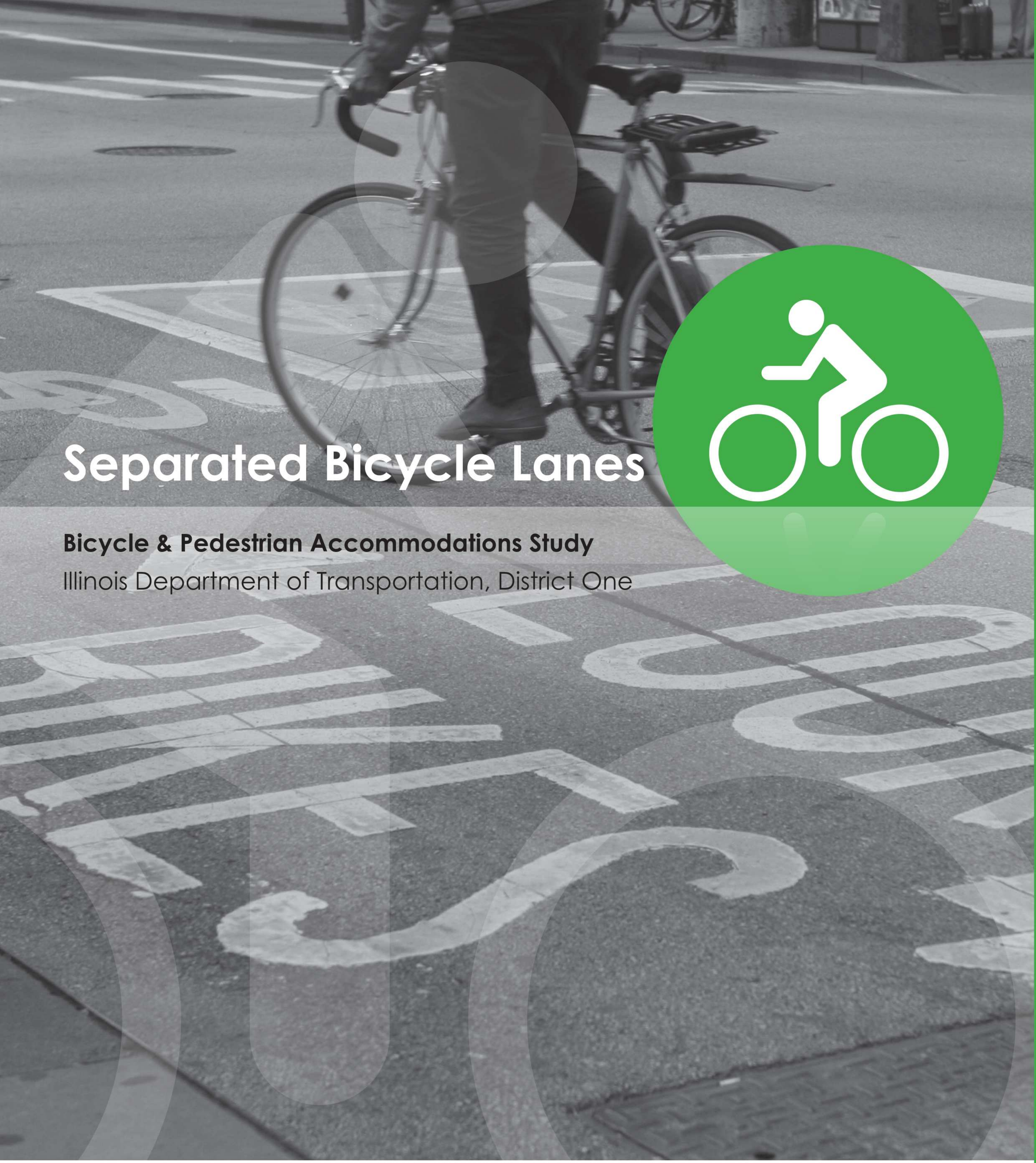

Separated Bicycle Lanes

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

A separated bicycle lane, also referred to as a protected bike lane or cycle track, is an on-road bikeway physically separated from motorist and pedestrian travel by a barrier or elevation change. Separated bicycle lanes can be installed flush with the roadway pavement, or can be raised to provide a vertical separation from motor vehicle lanes and/or sidewalk. Separated bicycle lanes can also be designed and marked for one-way or two-way operation, and placed along one side of the roadway, both sides of the roadway, or in the median.

Figure 1 – Left: one-way SBL along Milwaukee Avenue in Chicago, utilizing flexible bollards and parking lane for separation from motorists. Right: two-way SBL along Dearborn Street in Chicago, separated by flexible bollards over the Chicago River.

There are varying scenarios for separated bicycle lane (SBL) placement along the roadway. One-way SBLs are installed alongside traffic on each side of the road and operate in the same direction as the adjacent traffic. Two-way SBLs are installed on only one side of the road, typically on a one-way road. They can also be installed in the median or on a two-way road when there is lack of conflicts along one side such as at T-intersections.

Figure 2 - Example of a center-running two-way SBL in New York City. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Consideration is required at intersections and where the protection is dropped to facilitate crossings and turning movements. The barriers providing separation for the SBLs may reduce sight lines for turning vehicles. To correct for poor sight lines, additional pavement marking or colored pavement may be used to call attention to through bicyclists, as well as provide guidance for both bicyclists and motorists. See the Bicycle intersections marking report for more information.

Features

Barriers

Barriers can be comprised of existing features such as a lane of parked cars (commonly used in Chicago), or installed features such as:

- Striped buffer and bollards (flexible or fixed)
- Striped buffer, bollards, and parked vehicles
- Bicycle friendly curb or median
- Parking blocks, removable curb
- Planter boxes
- Jersey barriers
- Vertical separation (raised bicycle lane)

Table 1 - Barrier separation options. Planter Boxes and Jersey Barriers images by Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C. All other images by author.

Raised		**Parking Blocks or Removable Curbs**	
Striped Buffer & Bollards		**Planter boxes**	
Striped Buffer, Bollards & Parked Vehicles		**Jersey Barriers**	
Curb or Median			

SBLs that are vertically separated, also called raised cycle tracks, are often paired with a transition zone such as a mountable curb between the SBL and motor vehicle travel lane and/or pedestrian area. Raised SBLs may be located at the level of the adjacent sidewalk, as shown in Figure 3, or set at an intermediate level between the roadway and sidewalk to segregate the SBL from the pedestrian area as shown in Figure 4.[1] For a detailed list of various separation options see the *Separated Bicycle Lane Barrier Selection Matrix* developed by Nathan Wilkes from Austin DOT.[2]

Figure 3 - Raised SBL (level with sidewalk) in Cambridge, Massachusetts. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Figure 4 - Raised SBL (intermediate level between roadway and sidewalk) in Bend, Oregon. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Drainage

Certain barriers may cause drainage issues for the motorist travel or parking lanes as shown in Figure 5. The method for draining surface run-off may depend on the scope of the improvement; whereas a retrofitted SBL is likely to require utilizing the existing system, a reconstruction, new construction, or widening may provide opportunities for new inlets and catch basins along the offset bike lane separation. When designing a curbed median, extra consideration should be given to increase the density of survey points near existing drainage inlets, particularly when the profile is found to be relatively flat. This can help determine potential low spots more accurately and avoid additional work during construction. Construction contract plans and specifications should allow for design flexibility and engineering judgment during construction to accommodate any drainage issues encountered in the field. Solutions include adding additional cutouts, changing the elevation of raised bicycle lanes slightly to allow for proper flow, or repaving the existing street to eliminate low spots and ponding. Frequent and adequate gaps should be provided in the barrier to allow drainage to inlets, which are typically placed along the original curb. It may also be the case that the low spot exists along the original curbline and may cause ponding in the new bike lane. Engineering judgement should be applied to determine the proper corrective action. As mentioned, new inlets and sewers may also be installed but may be cost prohibitive except during reconstruction or new construction.

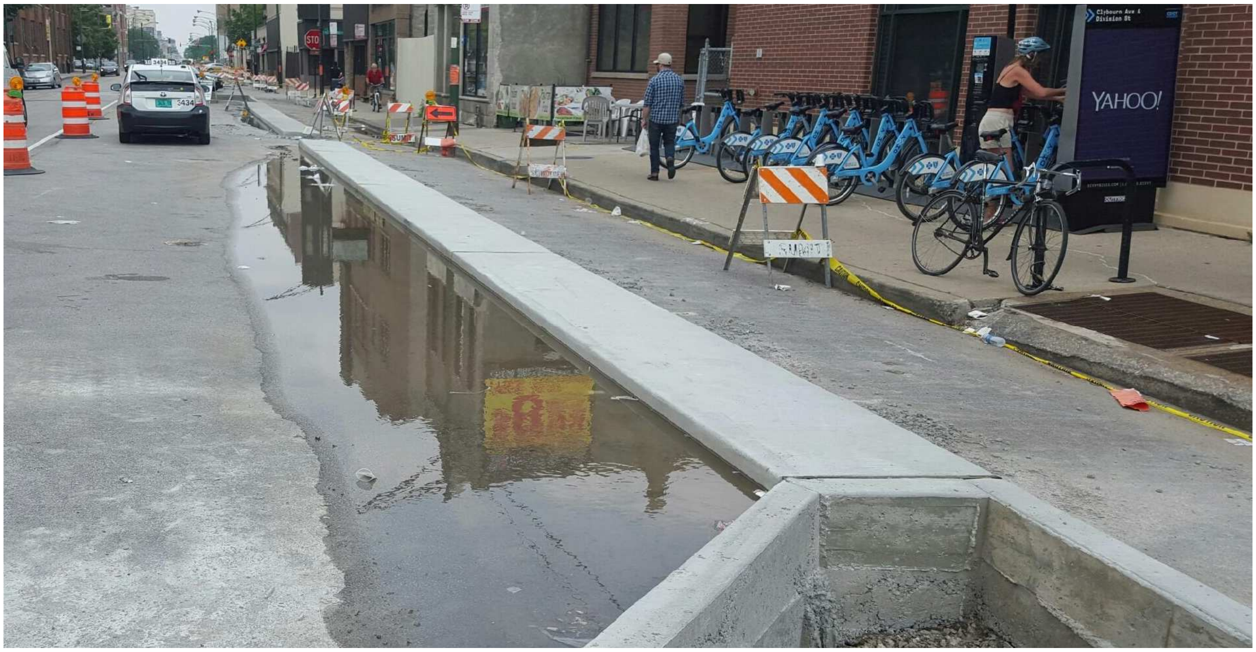

Figure 5 - Ponding in a parking lane adjacent to a curb separated bicycle lane under construction in Chicago

Costs

The cost of installation for a SBL varies greatly amongst locations and will depend primarily on the type of barrier used in the design. According to the Pedestrian and Bicycle Information Center, a SBL that utilizes a parking lane as a barrier will cost less to implement than other alternatives. It will cost more if curb lines need to be moved to construct the SBL but less if the project can utilize existing pavement or drainage features. **Costs can vary from $100,000 per mile to more than $2,700,000 per mile**. Costs will also increase if the SBL requires bicycle specific traffic signals. Table 2 lists example locations and the installation costs of built or proposed SBLs.

Table 2 - Separated bicycle lane cost examples

Location	Separation	Cost ($/mile)	Install Year	Source
Washington DC	Flexible Delineators	$ 100,000	2010	DDOT
Chicago	Parking	$ 170,000	2012	CDOT
Long Beach, California	Curb	$ 300,000	2011	City of Long Beach
Milwaukee, Wisconsin	Raised	$ 531,000	2012	City of Milwaukee
Chicago	Curb	$ 800,000	2015	IDOT
Vancouver, Canada	Raised & Parking	$ 2,700,000	2009	Fucoloro

Design Guidance:

AASHTO	Guide for the Development of Bicycle Facilities https://bookstore.transportation.org/collection_detail.aspx?ID=116
FHWA	Separated Bike Lane Planning and Design Guide* http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm
FHWA	Bicycle and Pedestrian Facility Design Flexibility http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/design_flexibility.cfm
FHWA	Interim Approval for Optional Use of a Bicycle Signal Face http://mutcd.fhwa.dot.gov/resources/interim_approval/ia16/ia16.pdf
ite	Separated Bikeways http://ecommerce.ite.org/IMIS/ItemDetail?iProductCode=IR-135
NACTO	Urban Bikeway Design Guide http://nacto.org/cities-for-cycling/design-guide/cycle-tracks/

Figure 6 - List of design guidance manuals and documents

*The FHWA Office of Human Environment's Bicycle and Pedestrian Program recently developed the Separated Bike Lanes Planning and Design Guide. The study consists of a detailed safety and mode sharing analysis incorporating design options, safety studies, and input from the transportation design community. The FHWA report also includes recommendations for planning, design, and safety for future cycle track construction.

SAFETY

Several studies have been recently released examining the safety and effectiveness of SBLs in North America. The study and data collection methods varied between studies, but all showed SBLs as being one of the safest on-road bicycle facilities.

Research in Canada found that SBLs had the lowest bicyclist accident risk out of several facility types examined including traditional bicycle lanes, shared lanes, off-street multi-use paths, or sidewalks. The bicyclist accident risk of SBLs was about one-ninth that of major streets with parked cars and no bicycle infrastructure.[3]

A NYCDOT study examined six years of before and after crash data at numerous SBL locations and found a total reduction in injuries of 2% for bicyclists and 17% for all roadway users, including bicyclists, pedestrians, and motorists.[4] NYC experienced a rise in bicyclist volumes ranging from 9% to 160% during the same period. To account for the rise in bicyclist volumes, NYC compared the crashes to 12-hour short term counts extrapolated out to a full year to develop a relative rate of injury per bicyclist. The fatality or severe injury risk decreased after installation of seven out of the eight locations shown in Table 3.

Table 3 - NYCDOT change in separated bicycle lane cycling risk

Project Corridor	Miles	Cyclist Risk Change
9th Avenue (16th-23rd)	0.33	-64.9%
Broadway (59th-47th)	0.60	-36.4%
1st Avenue (1st-34th)	1.62	-53.9%
2nd Avenue (2nd-14th)	0.59	-43.8%
2nd Avenue (23rd-34th)	0.54	-54.1%
8th Avenue (23rd-34th)	0.54	-2.40%
Broadway (23rd-18th)	0.25	11.2%
Columbus Avenue (96th-77th)	0.96	-37.6%

Another study looked at crash rates of 19 SBLs across the U.S. It calculated an overall crash rate of 3.7 crashes per one million bicycle miles traveled.[5] This is compared to generic published vehicle-bicycle crash rates collected by the author, ranging from 5.5 to 87.0 crashes per one million bicycle miles traveled. Lusk et al. provided generic crash rates in order to compare and isolate the effects of SBLs against all facility types. The 3.7 crashes per million bicycle miles is also within the range of the safest SBLs identified in the Teschke study (3.1 and 5.2 crashes per million bicycle kilometers traveled), further verifying the Lusk et al. study.[3]

Previous studies have shown that SBLs increase safety in the segments between intersections due to the barrier but decrease safety at intersections due to conflicts with turning vehicles.[6] A main factor at intersections is that a bicyclist may not be visible to turning motorists, an issue compounded by the presence of barriers such as planter boxes. In one study, 89 of the 120 crashes analyzed were at an intersection.[7] Newer designs are addressing this issue. The FHWA *Separated Bike Lane Design Guide* calls for sufficient sight distance at intersection approaches, designs that protect or provide safer interactions between movements, and signs or markings that guide and prompt safe behaviors at intersections. One particularly useful treatment involves "daylighting", which "refers to the removal of on-street parking near intersections or adjacent to curb cuts in order to improve sightlines for motorists, cyclists, and pedestrians".[8] Other features include bicycle boxes, two-stage turn boxes, intersection crossings, mixing zones, and lateral shifts, and are discussed in greater detail as part of the intersection markings report. Overall, statistics show that SBLs increase safety for bicyclists and all road users as reported by Lusk et al, Monsere, New York City DOT, Teschke, and others. With careful attention to intersection design, intersection crashes can be reduced and conflicts mitigated.

Safety in Numbers

In addition, SBLs have been proven to increase ridership at every location where installed. For instance, Chicago observed a 21% to 171% increase in bicycle volumes;[9] New York observed a 177% increase in bicycle volumes;[10] and Washington DC observed a 159% increase in bicycle volumes.[11] On average, SBLs result in increases of 75%.[9] This increase in ridership may lead to increased safety for bicyclists due to the "safety in numbers" effect.[12]

Communities that have "adopted traffic safety and operations approaches similar to those in the Netherlands have seen decreases in bicycle collision rates" despite the increase in ridership.[6] "The likelihood that a given person walking or bicycling will be struck by a motorist varies inversely with the amount of walking or bicycling. This pattern is consistent across communities of varying size, from specific intersections to cities and countries, and across time periods".[13] This effect may be more pronounced with SBLs due to the large increase in ridership compared to other installations.

Surveys

Many of the drivers and bicyclists that were surveyed in *Lessons from the Green Lane: Evaluating Protected Bike Lanes in the US* understood the intent of the SBL design at intersections (each location had between 100 and 500 respondents, depending on the location).[9] Results in San Francisco found 92-97% of residents correctly reported on the survey where a motorist must position their vehicle at an intersection. At the Portland location, 79% of respondents (in this case, bicyclists) correctly reported the proper vehicle position. "For all the mixing zone designs, nearly all [over 90%] of the bicyclists generally stated that they understood where they were supposed to ride." Most users were also observed using the SBLs as intended although various intersection treatments resulted in different compliance rates. Depending on the observation site, between 323 and 1978 users were observed. For through bicycle lanes, 87% of turning motorists and 91% of bicyclists had correct lane usage. For mixing zones, 93% of turning motorists used the lane correctly.

Ridership increase	21-171%
Resident understanding of lane positioning at intersections	92-97%
Motorist compliance with pavement markings	87-93%
Residents that would be more likely to ride a bicycle if physically separated from vehicles	85%
Support for separating bikes from cars	91%

Figure 7 – Lessons from the Green Lane - study highlights

Most surveyed residents "support separating bikes from cars" (91%), and this opinion was common among primary users of all travel modes (driving, walking, transit, bicycling), though motorists expressed concerns about the impacts of protected lanes on congestion and parking. Furthermore, 85% of the group that identified themselves as "interested but concerned" bicyclists agreed with the statement "I would be more likely to ride a bicycle if motor vehicles and bicycles were physically separated by a barrier."

Local studies were also performed as part of the study *Lessons from the Green Lane: Evaluating Protected Bike Lanes in the US*.[9] The study looked at two SBLs, a one-way SBL on Milwaukee Avenue at Elston Avenue and a two-way SBL on Dearborn Street in Chicago's Loop, where 99% of 120 Dearborn bicyclists and 96% of 224 Milwaukee bicyclists surveyed perceived the SBLs as being safer for bicycling. However, some of the pedestrians stated their feelings of safety decreased after installation of the SBLs, with 45% stating their safety decreased on Dearborn and 37% on Milwaukee. In another study done in New York City, pedestrian users reported increased feelings of safety when crossing a SBL, sometimes due to the shortened crossing distances.[4] Nearby residents of the SBLs studied in Chicago were asked if they thought the safety of bicycling on the street changed after installation, and about 75% responded that it increased along both Dearborn and Milwaukee.

OPERATIONS

SBLs provide additional, comfortable space for bicyclists and usually lead to increases in ridership after installation. However, the wider width required for most SBLs may subtract from space available for motorist traffic. Often travel lane or parking lane removals are required.

Ridership

SBLs were found to increase ridership along various routes by 21% to 171% according to one study.[9] Specific urban areas that saw high bicycle volume increases were Chicago (171%);[9] New York (177%);[10] and Washington DC (159%).[11] These increases included new bicyclists who did not ride on the previous facilities, bicyclists already using the route, and bicyclists that changed their route after installation of the SBL. An extensive survey of bicyclists using the SBLs found 24% shifted from other bicycle routes indicating the preference for SBLs over other facilities. An increase in bicycling rates may lead to a decrease in motor vehicle use and lower motorist congestion. The footprint required to accommodate this increased bicycle traffic in most cases is minor when compared to the space needed for an equivalent number of single-occupancy vehicles. However, once bicyclist volumes increase drastically, specific bicyclist congestion designs can be implemented, see *Cross Section* below for more information.

The Chicago Department of Transportation also performed two hour bicycle counts at various locations around Chicago for multiple years. Some of the locations with SBLs were included in the counts, so the percentage changes in ridership after installation were calculated and are listed in the following table.

Table 4 - Change in ridership after separated bicycle lane installation

Street Name	Percentage Change in Bicyclists After SBL Installation
55th Street	+138%
Lake Street	+63%
Elston Avenue	+56%
Dearborn Street	+123%
Desplaines Street	+71%
31st Street	+40%
Kinzie Street	+43%

Ridership increased at every site after the installation of a SBL. The increase ranged between 40% and 138%. The percent change was based on two hour counts taken before and after the installation of the SBL. Due to the short duration of the counts and also differing weather conditions between the before and after counts, the percentage changes are not necessarily precise but correspond with trends found elsewhere nationally.

Cross Section & Vehicle Speeds

SBLs require a wider cross-section than a typical bicycle lane in order to accommodate maintenance vehicles and the increased bicycling volumes that SBLs typically bring. Conventional bicycle lanes allow bicyclists to avoid crashes, obstacles, debris, or poor pavement conditions by utilizing adjacent lanes; with SBLs; however, bicyclists are restricted on avoidance maneuvers due to the barrier. Extra space for passing maneuvers is also important in order to accommodate all types of bicyclists with varying athletic abilities and speeds. Therefore, the installation of a SBL may decrease the number or width of motor vehicle lanes and/or parking lanes on a given street.

Vehicle speeds may decrease after installation of a SBL due to the reduction in number or width of lanes, the installation of barriers, or the placement of parked cars closer to the travelled way. This narrowing effect passively slows vehicle traffic as opposed to a wide open stretch of roadway with long sight lines which can encourage higher speeds. However, data collected by NYCDOT showed vehicle travel speeds remained steady in their central business district after installation of SBLs. On Columbus Avenue, NYC recorded a decrease in vehicle travel times by 35% while vehicle volumes were maintained. On 8th Avenue, travel times improved by an average of 14%.

Roadway Capacity

Chicago's decision to install a two-way SBL on Dearborn Street in the central business district was made partly because of excess vehicle capacity along that street. Capacity was approximately 40,000 ADT with an actual ADT of 13,000.[14] Therefore, one of the three existing lanes could be removed to accommodate the two-way contra-flow SBL without significantly affecting motorist level of service. Consult the HCM to determine opportunities for capacity reductions and SBL installations. See the road diet report for other aspects of lane reductions.

Intersections

Particular attention is required for SBL approaches at intersections due to the potential for barriers to block sight lines. To mitigate conflicts at intersections, installations may be accompanied by signage that reinforces state law requiring right-turning motorists to yield to through bicyclists.[15] Right-turns on red by motorists may also be prohibited; however, this may increase intersection delay. To further increase safety and eliminate all turning conflicts, SBLs can be installed with bicycle specific signals. To allow for right-turns on red, the SBL can also be designed to transition to a traditional striped bicycle lane and cross to the left side of the motorist right turn lane to continue through the intersection. This is considered a through Bicycle Lane with a lateral shift. Another option is to share the bicycle lane space with motorists using a mixing zone. Another option for intersections is the protected intersection concept. This facility continues the SBL barrier up to and in the intersection. Protected intersections are relatively new in the United States but used throughout Europe and may have additional concerns regarding capacity, turning vehicles, and speeds compared to lateral shifts or mixing zone treatments. These features are depicted and explained in further detail in the intersection markings report. Further research is needed to determine the safety and operational effectiveness of protected intersections.

Even with an increase in ridership, bicycle queuing at intersections was not mentioned as an issue by city or state DOTs, though conceivably SBLs have a user capacity that could be reached and counts should be performed before installation to anticipate the design volumes. This could be done be extrapolating existing user counts with an average assumed growth factor caused by latent demand for the facility such as in Table 3. Bicycle boxes can also be installed at intersections when SBLs are used on routes with existing or anticipated high bicycle volumes, and there is a need to provide additional space for bicyclists to queue.

Access

SBLs may restrict access to ADA users and emergency vehicles due to certain barriers like planter boxes and jersey barriers. Barrier selection should take into account ADA requirements such as existing handicap parking zones. Options include mid-block curb ramps or buffers wide enough to accommodate wheel-chair lifts. See the FHWA *Separated Bike Lane* design guide for more options that accommodate SBLs and meet ADA requirements. Low or mountable curbs, or non-rigid barriers (flexible delineator posts), can be used in lieu of a full jersey barrier or rigid bollards to accommodate fire hydrant and emergency vehicle access

MAINTENANCE

SBLs require specific maintenance operations to ensure a clear and usable path. Winter maintenance is particularly important because heavy snowfalls can result in a nonfunctional SBL. Even light snow events can negatively impact bicyclists more than motorists due to the two-wheeled nature of the bicycle and the loss of traction that requires a different riding style and braking method. These conditions may discourage riding in the winter or lead to bicyclists using the motorist lane.

Street Sweeping & Snow Removal

Since the SBL is separated from the roadway and sidewalk spaces, it usually requires special equipment to sweep up debris and clear snow. SBLs can be designed to accommodate the width of a traditional street sweeper and snow plow, but due to roadway width and site constraints, this type of design may not be feasible. The majority of North American cities with SBL installations make use of smaller sweepers or plows, sidewalk plows repurposed for clearing SBLs, or pick-up trucks with plow attachments. For instance, the City of Chicago uses a narrow-body street sweeper to maintain SBLs, which has a minimum clearance of 7’ (7.5’ preferable clearance) and is capable of sweeping snow. Sweeping is typically performed from April to November and takes a week at each location. They also utilize pickup trucks and tractors with small blades attached for plowing. However, tractors must be loaded on a flatbed and hauled to the destination, adding to maintenance costs.[16] CDOT’s maintenance goal is to remove snow and salt the roads within 24 hours of snow events; however, it is uncertain if this goal is met for SBLs given main vehicular routes are CDOT’s first priority, and may depend on the level and extent of snowfall.

Salt Lake City’s Transportation Division has also made use of bicycle-specific maintenance equipment to keep SBLs clear year round. Many of the city’s SBLs are 11 feet wide which allows enough space for a standard snow plow. However, other SBLs with narrow widths require the city to make use of pick-up trucks, and plows to the edge of pavement rather than the curb to avoid hitting and damaging the curb with a snow plow blade.

The chosen barrier may also create challenges with snow storage. Barriers such as curbs and jersey barrier may restrict snow storage, whereas a buffered area with flexible posts can provide space for snow. However, flexible posts may become damaged by snow plows. The City of Chicago removes flexible posts in some areas to allow traditional snow plows to clear the SBL, and this has the added benefit of protecting the posts until they can be reinstalled in the spring. The reduced separation and safety of the now open lane should be balanced with maintenance needs and costs. Entrances and exits to SBLs can be painted or called out with delineating posts to alert plow drivers to potentially hidden barriers that may be unexpected in the travelled way. IDOT and CDOT painted the curb yellow and installed flexible posts on the noses of the median-curb for the separated bicycle lanes on Clybourn Avenue and Division Street for this reason as shown in Figure 8.

Figure 8 - Entrance to the curb separated bicycle lane on Division Street (a state route) in Chicago. The curb is painted yellow and installed with delineating posts.

Manual labor can also be used to clear debris or snow from SBLs. For instance, in the City of Chicago, crews were observed manually shoveling salt onto one SBL using a dump truck and tossing salt into the lane from the adjacent travel lane as shown in Figure 9.

The Equipment List (Table 5 and Table 6) in this section summarizes currently available equipment for sweeping or plowing snow from SBLs. The street sweepers shown were adapted from a webpage developed by Peopleforbikes.org and the other equipment listed was found through research or interviews.[17]

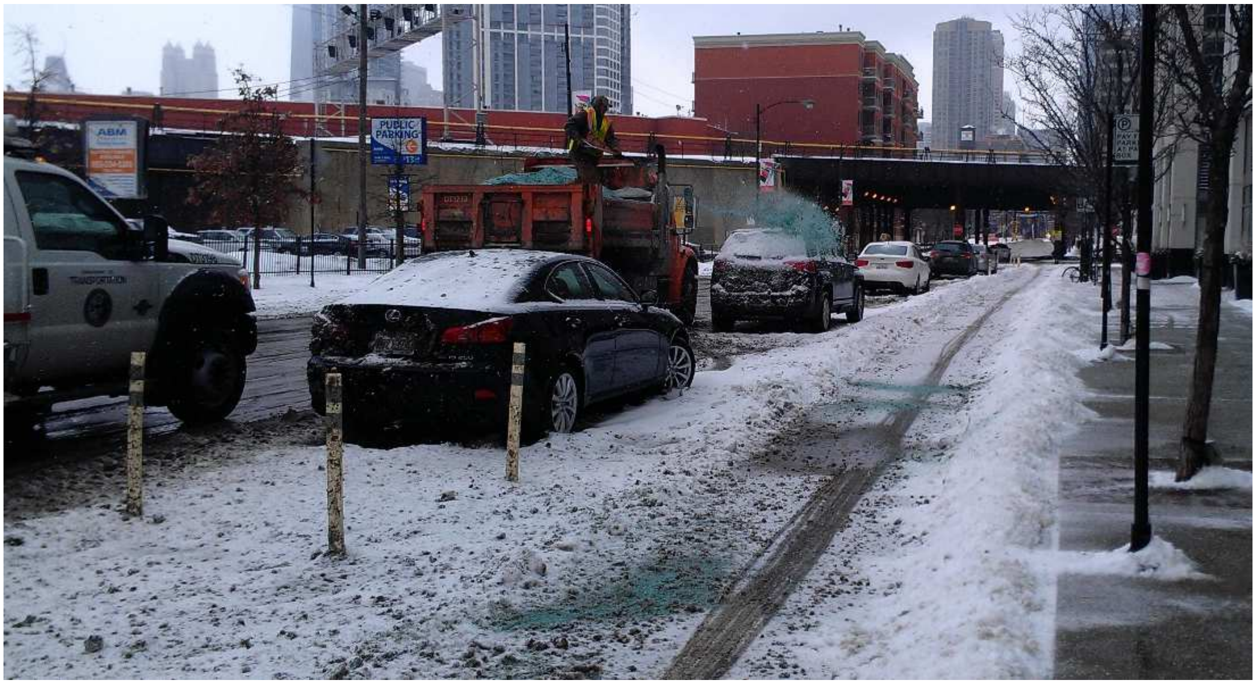

Figure 9 - CDOT crew manually shoveling salt on to the Kinzie Street separated bicycle lane to supplement their SBL snow plows in Chicago

Figure 10 - Parking separated, two-way separated bicycle lane on Dearborn Street in March in Chicago.

Figure 11 - Plowed and salted two-way separated bicycle lane along Dearborn Street in Chicago

Utility Cuts and Construction Damage

Since SBLs are separated from motorist lanes, utility companies, roadway crews, or building construction crews may at times be less concerned about maintenance of bicycle traffic along these facilities. Enforcement should be maintained to prevent construction crews from unnecessarily blocking the SBL as was done during the work shown in Figure 12. While the adjacent parking lane was paved with temporary asphalt, the SBL was left open and required a bicyclist to dismount to pass. As SBLs increase in popularity and their use becomes more ubiquitous, requirements to maintain traffic through these areas should become a more standardized and consistent practice.

Figure 12 - A one-way separated bicycle lane blocked by utility construction along Jackson Street in Chicago

Figure 13 and Figure 14 shows utility companies maintaining proper clearance of the bicycle lanes along Dearborn Street in Chicago by using specialized equipment that extends over the lane or by parking in the designated parking spots.

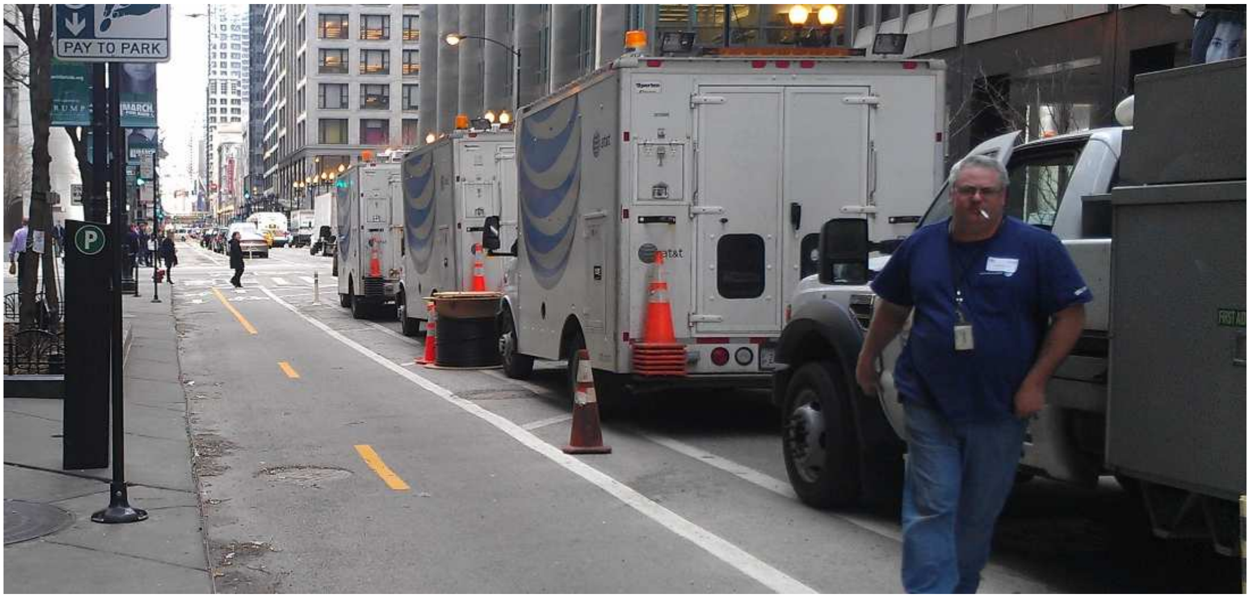

Figure 13 - AT&T crews preparing for utility work on the Dearborn Street two-way separated bicycle lane in Chicago

Figure 14 - CTA contractor cleaning out a subway station with hose boom extending over the Dearborn Street two-way separated bicycle lane in Chicago

Figure 15 – Example of maintenance of traffic that leaves an adjacent buffered bicycle lane open in Chicago

Drainage

To maintain a buffer between the bicycle lane and the motorist lanes, most SBLs are installed adjacent to the curb and gutter, to which drainage is typically designed to flow. Therefore, the existing pavement should have adequate drainage to avoid ponding which may freeze in the winter or hide potholes and other hazards. The photos in Figure 16 depict a prior drainage problem along Dearborn Street in Chicago that became an issue for cyclists after the installation of the two-way SBL. The SBL has since been repaved by CDOT to eliminate low spots and ponding.

Figure 16 - Drainage issues resulting in ice forming on the Dearborn Street two-way separated bicycle lane in Chicago

Typical Infrastructure to Maintain

- New curbs and drainage inlets
- Plastic bollards and pavement attachment plates
- Temporary separations created with the use of temporary curb
- Bicycle specific signals with unique face plates
- Green colored pavement (materials vary)
- Pavement markings

Equipment List

Table 5 – Specialized, narrow body equipment used to sweep separated bicycle lanes. Adapted from a list developed by Anderson (2014).

Street Sweeper	Min. Operating Width	Max Operating Width	Top Non-Sweeping Speed	Cost Range	Example
Madvac LS100	48 in	89 in	16 mph	$80,000-$110,000	
MacDonald Johnston CN201	52 in	123 in	25 mph	$124,000-$140,000	
Ravo 5 Series	94 in	94 in	55 mph	$226,000	
Stewart-Amos R4, R6 and Starfire S4	102 in	120 in	65 mph	Leased $5,000/week	
Schwarze A4 Storm	90 in	120 in	70 mph	$160,000	
Tennant Sentinel	70 in	126 in	25 mph	$155,000-$190,000	
Tennant Green Machines 636	47 in	80 in	25 mph	$95,000-$105,000	

Table 6 - Specialized, narrow body equipment used to clear snow and spread salt on separated bicycle lanes

Snow Plow	Min. Operating Width	Max Operating Width	Top Speed	Cost Range	Example
Toro Polar Tracs (Narciso 2011)	48 in	60 in	8 mph	$35,000	
Pickup Trucks (Murphy 2008)	80 in	90 in	15 mph	$30,000	
Bobcat (Bobcats 2013)	36 in	84 in	10.7 mph	$50,000	
Kubota Tractor (Anderson 2013)	54 in	72 in	14.3 mph	$25,000-$40,000	
Bombardier Plows (Vance 2013)	48 in	70 in	20 mph	$33,000 (used)	

District One Studies

The following is a summary of findings from two studies performed in 2014 for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 7 - Local separated bicycle lane studies performed by District One

Study	Findings
Pedestrian Survey	A preconstruction survey was conducted on Clybourn Avenue in Chicago, the site of IDOT's proposed curb separated bicycle lane. The roadway did not have any existing bicycle accommodations. In the survey, 37% of bicyclists requested a SBL compared to 26% who requested bicycle lanes. Other participants mentioned speeding traffic and the need for traffic calming, both of which SBLs can address.
Crash Analysis	A bicycle-vehicle crash analysis of 11 one-way SBLs in the Chicago area produced mixed results. The number of crashes increased after installation from 1.85 to 3.19 crashes per year; however, this analysis did not take into consideration the increase in cyclists riding on the newly installed facilities. The crash rate, which does take into account bicycle volumes, showed a drop of 67 crashes per million bicycle miles ridden (from 122 crashes pre-installation to 54 post-installation). While the drop in crash rates does show promise, the sample size used to calculate these rates was small and assumptions on volume trends were made. In order to draw more accurate conclusions, SBLs should continue to be observed in conjunction with a comprehensive bicycle count program. Crash type and severity were also examined for any trends. Results showed a slight increase in Type A (incapacitating) crashes and Type B (injury evident) crashes, and a slight decrease in Type C (injury possible) crashes with no Type K crashes (fatal) reported.

Crash Analysis

One effective measure of a bicycle facility's effectiveness is a comparison of the crashes before and after the facility was installed. Below are three types of crash analyses for SBLs: crash frequency, crashes by severity/type, and crash rates. This study analyzed 11 one-way SBLs in Chicago and in Evanston, Illinois, and one two-way SBL on Dearborn Street in Chicago. Crash data was provided by IDOT for the years 2008 to 2013.

Crash Frequency

The Federal Highway and Safety Administration uses the following method to analyze crash data when no traffic volume data is available. For this method the number of crashes are totaled then divided by the number of years of data collection and the length of segment to find the overall crashes per mile of SBL per year. Only crashes on the street with the SBL were counted, including both segmental and intersection crashes.

Table 8 – Crash frequency involving bicyclists

Segment	Length (mi.)	Bike Crashes Before Installation			Bike Crashes After Installation		
		# of Crashes	Years of Data	Crashes/mi /Year	# of Crashes	Years of Data	Crashes/mi /Year
18th St. (Canal to Clark)	0.5	3	4	1.5	3	1	6
Franklin Blvd. (Sacramento to Central Park)	0.75	3	4	1	0	1	0
31st St. (Wells to Lakefront Trail)	1.5	9	4	1.5	5	1	3.3
55th St. (Cottage Grove to Dorchester)	0.75	9	4	3	1	1	1.3
Desplaines St.(Harrison to Kinzie)	1	8	4	2	1	1	1
Elston Ave. (Chestnut to Le Moyne)	1	5	4	1.3	2	1	2
Lake St.(Central Park to Damen)	2	9	4	1.1	1	1	0.5
Church St. (Chicago to Dodge)	1	12	4	3	2	1	2
Jackson Blvd. (Hamlin to Central Park)	0.25	1	4	1	0	1	0
Jackson Blvd. (Oakley to Ogden)	0.75	3	4	1	0	1	0
Kinzie St. (Milwaukee to Wells)	0.5	6	3	4	19	2	19
Dearborn St. (Polk to Kinzie)-two way	1.0	21	4	5.3	7	1	7
Average of All Sites	-	-	-	**2.1**	-	-	**3.5**

When aggregating SBL data across Chicago and Evanston, the results show the total number of crashes per mile of SBL per year increased post-installation. While this figure increased, it doesn't take into account changing bicyclist volumes which often occurs after installation of SBLs. The "Crash Rates" section of this report analyzes sites with known bicycle volumes. Additionally, in most cases there was only one year of available crash data following the construction of the SBLs limiting the identification of any longer term trends. Regarding sample size, there were 89 crashes involving bicyclists recorded over the three to four year period prior to the installation of SBLs. In the one or two years following installation there were a total of 41 crashes.

Crashes by Severity/Type

Included in the crash data were various characteristics of the crashes such as injury types, lighting, road conditions, turning movements, etc. The severity of injuries slightly increased after the installation of a SBL, which is inconsistent with national trends. The percentage of crashes in intersections increased after the SBLs were installed, a common issue with SBLs.[5] The increase in intersection crashes can be caused by poor sight lines and visibility issues caused by the SBL barrier. In the case of the Chicago and Evanston SBLs, the barrier is typically a lane of parked cars. The type of barrier can obstruct the view of motorists who may not yield properly to bicyclists as they turn at the intersection. The crash analysis also showed a decrease in the percentage of rear-end crashes, which is consistent with national trends. This section of the study also doesn't take into account changing bicyclist volumes which often occur after installation of SBLs.

Other studies performed in the U.S. seem to indicate contradictory crash type results. According to Lusk et. al. (2011) "as the most common cause of fatal bicyclist collisions in urban areas is overtaking (vehicle passing bicycle), it is probable that an analysis accounting for the severity of injury would be still more favorable towards SBLs" whereas

District One's analysis shows an increase in severity, albeit with limited data. Further crash data in Chicago is required to corroborate or refute this claim.[7]

Table 9 – Bicycle-Vehicle Crashes by severity

Crashes by Severity	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
K-Fatal	0.0%	0.0%
A-Incapacitating Crash	5.6%	7.3%
B-Injury Evident Crash	58.4%	65.9%
C-Injury Possible Crash	32.6%	26.8%
O-Property Damage Only Crashes	3.4%	0.0%

Table 10 - Intersection crashes

Intersection Crashes	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
% of Total Crashes	66.3%	73.2%

Table 11 - Rear end crashes

Rear End Crashes	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
% of Total Crashes	16.9%	9.8%

Table 12 – Crashes by lighting conditions

Lighting Conditions	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
Unknown	1.1%	2.4%
Darkness	3.4%	0.0%
Darkness, Lighted Road	13.5%	17.0%
Dawn	1.1%	0.0%
Daylight	80.9%	75.6%
Dusk	0.0%	4.9%

Table 13 - Crash severity code descriptions. Source: NSC (2001)

Code	Severity	Injury Description
K	Fatal	Any injury that results in death within 30 days of crash occurrence
A	Incapacitating	Any injury other than a fatal injury which prevents the injured person from walking, driving, or normally continuing the activities the person was capable of performing before the injury occurred
B	Injury Evident	Any injury other than a fatal injury or an incapacitating injury that is evident to observers at the scene of the crash in which the injury occurred

C	Injury Possible	Any injury reported that is not a fatal, incapacitating, or non-incapacitating evident
O	Property Damage	Damage to property that reduces the monetary value of that property

Crash Rates

The following vehicle-bicycle crash rates were calculated based on the FHWA's crash rate formula, which takes into account the number of crashes along a segment, the length of the segment, and the Average Annual Daily Bicycle volumes (AADB). Five sites with known bicycle volumes were studied for this portion of the report. The other seven sites did not have bicycle count data so they were excluded from this section:

Table 14 - 31st Street crash rates

31st Street	2008	2009	2010	2011	2012 Before Installation	2013 After Installation
Segment AADB	47	52	59	67	77	108
Number of Crashes	2	3	3	4	5	5
Crash Rate (bicycle crashes/million bicycle miles)	89.0	119.9	106.6	125.1	181.2	129.1

Table 15 - 55th Street crash rates

55th Street	2008	2009	2010	2011	2012 Before Installation	2012 After Installation	2013
Segment AADB	95	106	119	135	154	414	476
Number of Crashes	3	2	3	1	1	1	1
Crash Rate (bicycle crashes/million bicycle miles)	123.6	74.0	98.7	28.9	47.3	20.4	17.8

Table 16 - Dearborn Street crash rates

Dearborn Street	2008	2009	2010	2011	2012 Before Installation	2013 After Installation
Segment AADB	88	97	110	125	143	301
Number of Crashes	5	6	2	8	8	7
Crash Rate (bicycle crashes/million bicycle miles)	156.5	168.6	50.0	175.9	166.9	63.7

Table 17 - Desplaines Street crash rates

Desplaines Street	2008	2009	2010	2011	2012 Before Installation	2013 After Installation
Segment AADB	27	30	34	38	44	80
Number of Crashes	3	1	1	3	6	1
Crash Rate (bicycle crashes/million bicycle miles)	304.5	91.1	81.0	213.9	406.8	37.4

Table 18 - Kinzie Street crash rates

Kinzie Street	2008	2009	2010	2011 Before Installation	2011 After Installation	2012	2013
Segment AADB	543	604	680	773	831	1105	1069
Number of Crashes	1	3	2	3	2	9	10
Crash Rate (bicycle crashes/million bicycle miles)	13.3	35.9	21.3	49.8	40.0	58.9	67.6

Table 19 - Average crash rate from five sites

Average of 5 Sites	Before Installation	After Installation	Percent Change
Crash Rate (bicycle crashes/million bicycle miles)	**122**	**54.4**	**-125%**

The average crash rate from the five sites drops significantly after the installation of the SBLs. This method factors in changes in bicyclist volumes over time and the large increase in ridership usually experienced when SBLs are installed. The average crash rate dropped by nearly 67 crashes per million bicycle miles ridden after installation.

Crash rates were also calculated for the following specific crash types: right hooks, left hooks, and angle crashes. All crashes only occurred between a motorist and a bicyclist. Bicyclists riding in the crosswalk, wrong-way riders, and bicyclists making maneuvers from the side-street were excluded. Side streets and driveways are included.

Right hooks were defined as a crash where a motorist passes on the left of a bicyclist then turns right, through the path of the bicyclist. The bicyclists and motorists must be travelling in the same direction for it to be considered a right hook crash. Left hooks involve motorists that turn left, through the path of a bicyclist. The motorist and bicyclist must be travelling in opposite directions. Left hook crashes were not reported for one-way streets such as Dearborn and Desplaines where the bicyclists and motorists are travelling in the same direction. Angle crashes involve motorists travelling on the side street, either turning onto the main street or travelling straight through. Note, that this criteria differs from typical IDOT crash reporting standards for angle crashes, which only account for straight/through motorists. In the case of SBLs, however, motorists turning from the side street are included as well. Since the SBL is located closer to the curb, the turning motorist may behave as a straight/through motorist and often do not begin their turn until further in the intersection. They are also scanning for traffic similar to a straight/through motorist and may miss seeing the bicyclist in the SBL.

Table 20 – Average right hook crash rate from five sites

Average of 5 Sites	Before Installation	After Installation	Percent Change
Right Hook Crash Rate	**7.48**	**10.3**	**27.2%**

Table 21 – Average left hook crash rate from three sites

Average of 3 Sites	Before Installation	After Installation	Percent Change
Left Hook Crash Rate	**10.1**	**7.80**	**-28.8%**

Table 22 – Average angle crash rate from five sites

Average of 5 Sites	Before Installation	After Installation	Percent Change
Angle Crash Rate	**21.1**	**6.74**	**-213%**

Right hook crashes experience an increase in 27.2% before and after installation of the SBL. Left hooks and angle crashes experienced decreases. Since this analysis looked at specific crash types within the larger dataset of all crashes at the five sites, the sample size was low with 15 right hooks, 10 left hooks, and 19 angle crashes.

For all crash rate analyses, there were two assumptions that were made to determine the rates. The AADB's were extrapolated from two hour bicycle counts provided by CDOT and a variable annual growth rate calculated from American Community Survey data on commuter's mode split in Chicago. There were two hour bicycle counts from before installation and after installation at all five sites, which were used to calculate AADBs. The brief length of the counts, along with the assumptions made to find the extrapolation factors may have compromised the accuracy of the AADBs. This is especially true at sites with lower rider volumes such as at 31st Street and Desplaines Street.

Overall the results of the SBL safety analysis are mixed. With the installation of a SBL, the overall crashes increased, most likely due to an increase in ridership, whereas the crash rates, which take into account bicycle volumes, decreased. Unlike national trends, injury rates among the most severe crashes increased. The overall crash sample is small with only 130 reported crashes over six years at the twelve sites. Assumptions were also made to calculate the AADB count extrapolation factors. Furthermore, before and after count data was only collected over a two-hour period, so numerous inaccuracies can result when extrapolating out such a small count to average annual daily counts. Additional local data should be collected in order to make more accurate conclusions on the safety impacts of SBLs in Illinois. Further analyses could be performed to examine the effect of SBL's on crosswalk and sidewalk riding. For example, did the SBL result in encouraging those types of riders (riders that may be averse to riding in traffic) to switch from the sidewalk to the street?

As of 2014, there are 104 known one-way SBLs in the United States and Canada, 19 of which are in Illinois as shown in Table 23. There are 89 known two-way SBLs in the United States and Canada, 11 of which are in Illinois as shown in Table 24. SBLs that were less than .05 miles were excluded.

Raised SBLs have been adopted in a number of cities across the country. The first raised SBL in the Midwest was recently constructed in Milwaukee, Wisconsin.[18] A raised SBL is currently being constructed at sidewalk level in Chicago along Roosevelt Road between Wabash Street and Indiana Avenue, with construction anticipated to be completed in 2015.

Table 23 – Examples of one-way separated bicycle lane locations in North America, with locations in both District One and statewide shown in bold text

One-Way Separated bicycle lanes					
Country	**City**	**State**	**Street**	**Barrier Type**	**Install Year**
USA	Tucson	AZ	Priest Dr., Washington to Van Buren St.	Bollards	2014
USA	Atlanta	GA	5th St. at W Peachtree St		
USA	Tucson	AZ	St. Mary's Rd., I-10 to Church Ave.	Bollards	2014
USA	Long Beach	CA	Broadway St.	Parking & curb stop	2012
USA	Long Beach	CA	Third St.	Parking & curb stop	2012
USA	Murrieta	CA	Nighthawk Way, Washington to Hayes Ave.	Curb	2014
USA	Palm Springs	CA	N. Belardo Rd.	Various	Unknown
USA	San Diego	CA	Friars Rd.	Curb stop separated, raised median	Unknown
USA	San Francisco	CA	Fell St.	Bollards	2013
USA	San Francisco	CA	Oak St.	Bollards	2013
USA	San Francisco	CA	Point Lobos Ave.	Bollards	2013
USA	San Francisco	CA	Alemany Blvd.	Bollards	2011
USA	San Francisco	CA	Division St.	Bollards	2011
USA	San Francisco	CA	Duboce Ave.	Curb & fence barrier	2012
USA	San Francisco	CA	Laguna Honda Blvd.	Bollards	2011
USA	San Francisco	CA	Portola Dr.	Bollards	2012
USA	San Francisco	CA	Cesar Chavez	Bollards	2012
USA	San Francisco	CA	JFK Dr.	Parking, curb, & bollard	2012
USA	San Francisco	CA	Market St.	Flexible bollards	2010
USA	San Francisco	CA	San Jose Ave.	Flexible bollards	2010
USA	San Jose	CA	4th St.	Parking & rubber curb	2012
USA	San Jose	CA	Curtner, Westgate to Shibley	Curb & landscaping	1978*
USA	Santa Cruz	CA	High St.	Parking & rubber curb	Unknown
USA	Temple City	CA	Rosemead Blvd.	Curb & landscaping	2014
USA	Boulder	CO	13th St.	Sidepath	1992
USA	Boulder	CO	Baseline Rd.	Curb stops	2013
USA	Boulder	CO	University Ave., 9th St. to Broadway	Unknown	2014
USA	Denver	CO	Bannock St.	Raised sidepath	2011
USA	Denver	CO	15th St. (Downtown)	Bollards	2014
USA	Washington DC	DC	L-St.	Bollards	2012
USA	Washington DC	DC	M-St.	Parking	2014
USA	Washington DC	DC	R-St. NE	Parking	2012
USA	St. Georges	DE	St. Georges Bridge	Bollards	2012
USA	Honolulu	HI	South King St.	Bollards	2014

USA	**Chicago**	**IL**	**Desplaines St.**	**Parking**	**2012**
USA	**Chicago**	**IL**	**Jackson St.**	**Parking**	**2011**
USA	**Chicago**	**IL**	**18th St.**	**Bollards**	**2011**
USA	**Chicago**	**IL**	**31st St.**	**Bollards**	**2012**
USA	**Chicago**	**IL**	**55th St.**	**Parking**	**2012**
USA	**Chicago**	**IL**	**Clybourn Ave., Division to North**	**Curb**	**2015**
USA	**Chicago**	**IL**	**Elston Ave.**	**Parking & curb**	**2012**
USA	**Chicago**	**IL**	**Kinzie St.**	**Parking**	**2011**
USA	**Chicago**	**IL**	**Lake St.**	**Bollards**	**2012**
USA	**Chicago**	**IL**	**Milwaukee Ave., Desplaines to Elston**	**Parking & curb**	**2013**
USA	**Chicago**	**IL**	**Franklin Blvd., Sacramento to Central Park**	**Bollards**	**2012**
USA	**Chicago**	**IL**	**Harrison St., Desplaines to Wabash**	**Bollards**	**2014**
USA	**Chicago**	**IL**	**West Side Blvd., Douglas Park to Garfield Park**	**Parking & bollards**	**2012**
USA	**Chicago**	**IL**	**Broadway, Montrose to Wilson**	**Parking & bollards**	**2014**
USA	**Chicago**	**IL**	**Canal, Roosevelt to Harrison**	**Parking & bollards**	**2013**
USA	**Chicago**	**IL**	**Halsted, 26th to Van Buren**	**Bollards**	**2013**
USA	**Chicago**	**IL**	**Randolph St., Canal to Wabash**	**Curb & sidepath**	**2015**
USA	**Chicago**	**IL**	**State St., 26th to Cullerton**	**Parking & bollards**	**2013**
USA	**Chicago**	**IL**	**Vincennes, 103rd to Summit**	**Parking & bollards**	**2013**
USA	**Chicago**	**IL**	**Washington St., Canal to Michigan**	**Curb**	**2015**
USA	**Evanston**	**IL**	**Church St.**	**Parking & raised**	**2012**
USA	**Evanston**	**IL**	**Davis St.**	**Parking & bollards**	**2014**
USA	Manhattan	KS	N. Manhattan Ave., Moro St. & Bluemont	Parking	2014
USA	Boston	MA	Western Ave.	Parking & bollards	2011
USA	Boston	MA	Mt. Vernon St.	Bollards	2014
USA	Cambridge	MA	Concord Ave., Alewife Brook Pkwy. to Blanchard Rd.	Raised sidepath	2009
USA	Cambridge	MA	Vassar St., Main St. to Massachusetts Ave.	Raised sidepath	2004
USA	Minneapolis	MN	1st Ave.	Parking	2009
USA	Minneapolis	MN	Plymouth Ave. Bridge	Bollards	2013
USA	Missoula	MT	Higgins Ave.	Parking & raised	2011
USA	New York City	NY	1st Ave.	Parking & curb	2010-2012
USA	New York City	NY	2nd Ave.	Parking & curb	2010-2012
USA	New York City	NY	8th Ave.	Parking & curb	2008
USA	New York City	NY	9th Ave.	Parking & curb	2007
USA	New York City	NY	Allen St./Pike St.	Bollards	2012
USA	New York City	NY	Broadway	Bollards	2008
USA	New York City	NY	Columbus Ave.	Parking	2010
USA	New York City	NY	E 17th St.	Planters	2010
USA	New York City	NY	Grant St.	Parking	2008
USA	New York City	NY	Borinquen Pl.	Bollards	2010
USA	New York City	NY	Hudson St., Canal to 14th	Parking	2014
USA	New York City	NY	Lafayette St./Fourth Ave., Spring St. to Union Sq.	Parking	2014
USA	New York City	NY	Ocean Pkwy.	Sidepath	2013
USA	Cincinnati	OH	Central Pkwy., Elm St. to Marshall Ave.	Unknown	2014
USA	Beaverton	OR	SW 155th Ave.	Parking, planter, & raised	1996
USA	Bend	OR	Reed Market Rd.	Raised	2003

USA	Hillsboro	OR	Veteran's Dr.	Unknown	2012
USA	Portland	OR	SW Broadway	Parking	2009
USA	Portland	OR	NE Cully Blvd.	Parking & raised	2011
USA	Portland	OR	NE Multnomah, I-5 to 13th	Bollards, planters, painted buffer	2012
USA	Pittsburgh	PA	Penn Ave., Sixth to 16th St.	Unknown	2014
USA	Rapid City	SD	Kansas City St.	Raised sidepath	Unknown
USA	Memphis	TN	Danny Thomas Blvd.	Bollards	2014
USA	Memphis	TN	Overton Park Ave.	Bollards	2013
USA	Nashville	TN	28th Ave.	Curb, bollards, & landscaping	2013
USA	Austin	TX	Barton Springs Rd.	Raised sidepath & bollard	2012
USA	Austin	TX	Guadalupe St.	Parking	2013
USA	Ogden	UT	Grant Ave., 20th to 22nd St.	Median island	2014
USA	Salt Lake City	UT	300 East	Parking & bollards	2012
USA	Charlottesville	VA	6th St. SE, Garrett St. to Monticello Ave.	Parking	2012
USA	South Burlington	VT	Swift St.	Unknown	2014
USA	Seattle	WA	Cherry St.	Bollards	2013
USA	Madison	WI	University Ave., and various others	Various	1983*
USA	Milwaukee	WI	S. Bay St., Lincoln Ave. to Potter Ave.	Raised	2013
CAN	Richmond	BC	No. 3 Rd.	Raised	2009
CAN	Vancouver	BC	Carral St.	Parking & raised sidepath	2006-2009
CAN	Vancouver	BC	Burrard St. Bridge	Concrete barrier	Unknown
CAN	Winnipeg	MB	Pembina Highway	Bollards	2012
CAN	Guelph	ON	Stone Rd. W.	Raised curb	2010
CAN	Ottawa	ON	Laurier Ave.	Curb	2011
CAN	Toronto	ON	Sherbourne St.	Curb	2013

* These installation dates are an estimate based on the best available information during the study period

Table 24- Examples of two-way separated bicycle lane locations in North America, with locations in both District One and statewide shown in bold text

Two-way Separated bicycle lanes					
Country	**City**	**State**	**Street**	**Barrier Type**	**Install Year**
USA	Alameda	CA	Fernside Blvd.	Planters	2008
USA	Carpenteria	CA	Via Real, Casitas Pass Rd. and Vallecito Rd.	Curb	1970
USA	Davis	CA	J St., near Drexel Dr.	Bollards	2014
USA	Los Angeles	CA	W. 2nd St., Figueroa St. to Hill St.	Bollards	2014
USA	Oxnard	CA	Ventura Rd., 7th St. to 5th St.	Curb	1970
USA	Redondo Beach	CA	Harbor Dr., Herondo St. to Pacific Ave.	Landscaped median	2015
USA	San Francisco	CA	Cargo Way	Raised curb & chain link fence	2012
USA	San Francisco	CA	John Muir Dr.	Raised curb & bollard	2012
USA	San Francisco	CA	Polk St.	Landscaped median	2014
USA	Santa Cruz	CA	Beach St.	Parking & rubber curb	2006
USA	Washington DC	DC	1st St. NE, G St. to M St.	Bollards and precast curb	2014
USA	Washington DC	DC	15th St.	Parking	2010
USA	Washington DC	DC	Pennsylvania Ave.	Traffic barrel	2010
USA	St Petersburg	FL	1st Ave., Pinellas Trail	Curb, parked cars	2008
USA	Atlanta	GA	10th, Monroe to Charles Allen	Bollards	2013
USA	**Aurora**	**IL**	**River St., North Ave. to Downer Pl.**	**Curb**	**2016**
USA	**Champaign**	**IL**	**4th St.**	**Raised sidepath**	**1970s***
USA	**Champaign**	**IL**	**6th St.**	**Raised sidepath**	**1970s***
USA	**Champaign**	**IL**	**E Armory Ave.**	**Raised sidepath**	**1970s***
USA	**Champaign**	**IL**	**Lorado Taft Dr.**	**Raised sidepath**	**1970s***
USA	**Champaign**	**IL**	**Peabody Dr.**	**Raised sidepath**	**1970s***
USA	**Champaign**	**IL**	**Wright St.**	**Curb**	**1970s***
USA	**Chicago**	**IL**	**Clinton St., Harrison to Fulton Mkt**	**Parking & bollards**	**201**
USA	**Chicago**	**IL**	**Dearborn St., Polk to Kinzie**	**Parking & bollards**	**2012**
USA	**Chicago**	**IL**	**Roosevelt Rd., Wabash to Indiana**	**Raised sidepath**	**2015**
USA	**Urbana**	**IL**	**S. Matthews Ave.**	**Raised sidepath**	**1970s***
USA	**Urbana**	**IL**	**Springfield Ave.**	**Curb & landscaping**	**1970s***
USA	**Urbana**	**IL**	**W. Green St.**	**Raised sidepath**	**1970s***
USA	**Urbana**	**IL**	**W. Pennsylvania**	**Curb & landscaping**	**1970s***
USA	Indianapolis	IN	30th St., N. White River Pkwy. to N Harding St.	Curb	2014
USA	Indianapolis	IN	Cultural Trail, Various St.s	Sidepath	2007-2013
USA	Indianapolis	IN	Keystone Ave	Curb	2014
USA	Indianapolis	IN	Shelby St.	Curb	2011

USA	White Flint (North Bethesda)	MD	Woodglen Dr., Edson Lane to Nicholson Lane	Parking & bollards	2014
USA	Minneapolis	MN	36th St., Richfield Rd. to Dupont Ave. S.	Bollards	2014
USA	Missoula	MT	Maurice Ave., S. 6th St. E. to S. 5th St. E.	Bollards	2013
USA	Hoboken	NJ	Sinatra Dr.	Parking & raised	2001
USA	New York City	NY	Eastern Pkwy., Grand Army Plaza to Washington	Raised sidepath	2012
USA	New York City	NY	Flushing Ave.	Concrete barrier	2010
USA	New York City	NY	Kent Ave.	Parking	2009
USA	New York City	NY	Manhattan Waterfront Greenway, West side	Sidepath	1993
USA	New York City	NY	Park Circle	Parking & planter	2009
USA	New York City	NY	Plaza St. W.	Curb	2010
USA	New York City	NY	Prospect Park W.	Parking	2012
USA	New York City	NY	Sands St.	Concrete barrier & raised	2009
USA	New York City	NY	Tillary St.	Concrete barrier	2005
USA	New York City	NY	Williamsburg St. W.	Concrete barrier	2010
USA	Syracuse	NY	University Ave.	Curb	Unknown
USA	Akron	OH	South St., Manchester Rd. to Lake Shore Blvd.	Unknown	2014
USA	Eugene	OR	Alder St.	Parked cars and painted buffer	2011
USA	Eugene	OR	Ayers Rd.	Raised	2002
USA	Portland	OR	SW Moody	Curb	2011
USA	Tigard	OR	Durham Rd., 85th to 92nd	Landscaped sidewalk	1986
USA	Woodburn	OR	Parr Rd., Stubb to Boones Ferry	Curb & landscaping	Unknown
USA	Munhall	PA	E. Waterfront Dr.	Bollards	2011
USA	Pittsburgh	PA	Saline St., Greenfield Ave. to Swinburne St.	Flexible bollards	2014
USA	Pittsburgh	PA	Schenley Dr.	Parking & flex bollards	2014
USA	Memphis	TN	BRd. Ave.	Parking & bollards	2014
USA	Memphis	TN	Riverside Dr.	Curb & landscaping	2014
USA	Austin	TX	Furness Dr., Park Plaza Dr. to North Plaza	Bollards	2014
USA	Austin	TX	Bluebonnet Lane	Bollards	2012
USA	Austin	TX	E. 4th St.	Zebra bumps	2010
USA	Austin	TX	Pedernales St.	Curb	2013
USA	Austin	TX	Rio Grande St.	Bollards	2012
USA	Denton	TX	Ave. C	Raised	2013
USA	Houston	TX	Lamar St.	Zebra bumps	2015
USA	Pentagon City (Arlington)	VA	S. Hayes St., 15th St. to S. Eads St.	Parking, curb, & bollard	2014
USA	Seattle	WA	2nd Ave, Pike Pl. Market to Pioneer Sq.	Flexible bollards, curbs, & planters	2014

USA	Seattle	WA	40th St. NE, 15th Ave. to Brooklyn Ave.	Bollards	2014
USA	Seattle	WA	65th	Unknown	2013
USA	Seattle	WA	Alki Ave. Southwest	Raised	Unknown
USA	Seattle	WA	Broadway	Parking & curb	2013
USA	Seattle	WA	High Point Way	Bollards	2014
USA	Seattle	WA	Linden Ave.	Parking & curb	2013
CAN	Calgary	AB	7 St. SW	Curb	2013
CAN	Vancouver	BC	Dunsmuir St.	Curb & landscaping	2010
CAN	Vancouver	BC	Hornby St.	Curb & landscaping	2011
CAN	Winnipeg	MB	Assiniboine Ave.	Curb	Unknown
CAN	Winnipeg	MB	Queen Elizabeth Way, Norwood Bridge	Concrete barrier	1996*
CAN	Hamilton	ON	Cannon St.	Flexible bollards, rubber curbs, & planter boxes	Unknown
CAN	Toronto	ON	Simcoe St.	Bollards	2014
CAN	Montreal	QC	Ave. Christophe-Colomb	Curb, bollards, & raised	1985
CAN	Montreal	QC	Berri St.	Curb, rigid bollards, & parked cars	1985
CAN	Montreal	QC	Blvd. de Maisonneuve Ouest	Curb	2007
CAN	Montreal	QC	Blvd. Rene-Levesque E.	Curb	1991
CAN	Montreal	QC	Chemin de la Cote-Sainte-Catherine	Curb & landscaping	2010
CAN	Montreal	QC	Rue Boyer	Parking & bollards	1985
CAN	Montreal	QC	Rue Cherrier	Parking, curb, & bollard	Unknown
CAN	Montreal	QC	Rue Clark	Parking	Unknown
CAN	Montreal	QC	Rue de Brebeuf	Parking, curb, & bollard	1984
CAN	Montreal	QC	Rue Rachel E.	Parking, curb, & bollard	1990
CAN	Montreal	QC	Rue University	Curb	2010

* These installation dates are an estimate based on the best available information during the study period.

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Bicycle Boulevards

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

Bicycle boulevards are shared roadways that incorporate and connect various bicycle facilities, encourage lower motorist volumes and speeds, and improve bicyclist priority, comfort, and accommodation. The purpose of bicycle boulevards is to provide a direct, safe route that is inviting to bicyclists of all ages and skill levels. This is accomplished by providing specific treatments on roadways intended to discourage motorist through travel while accommodating local travel. A combination of speed and volume management measures, signage and pavement markings, and minor and major street crossing elements are used to accomplish this objective.[1]

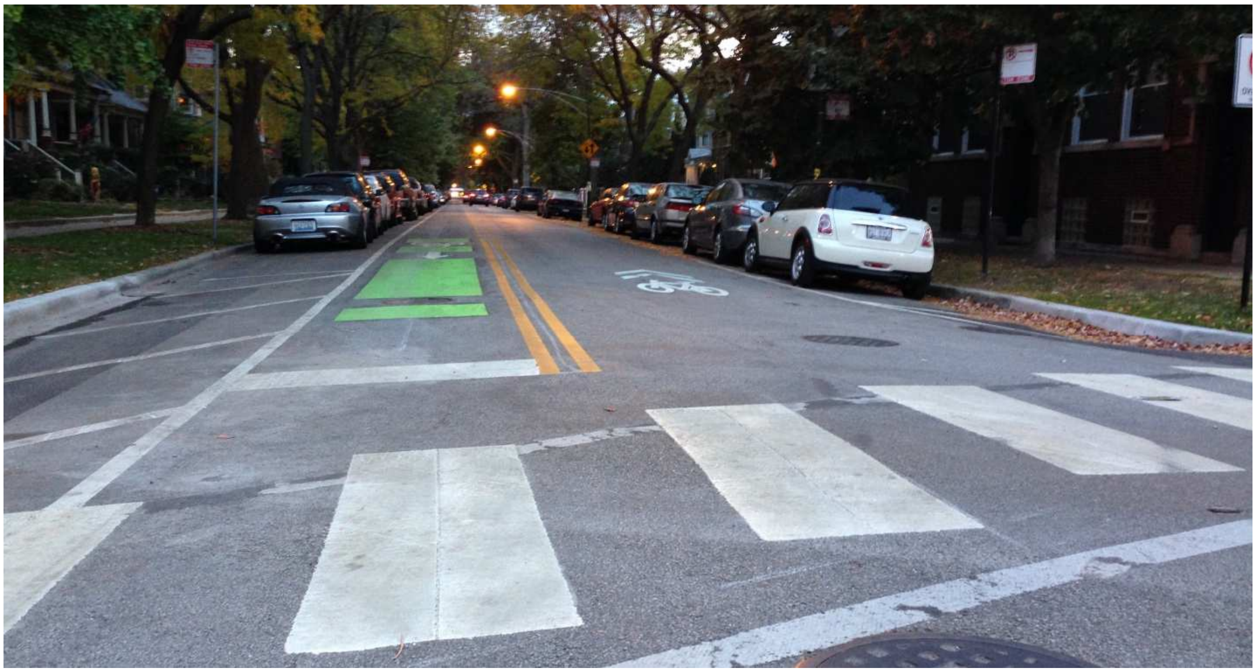


Figure 1 - Bicycle boulevard that includes a contra-flow bicycle lane in one direction and a marked shared lane in the other, on Berteau Avenue in Chicago

Bicycle boulevards are typically designed to be part of a network. They are routed in order to pass major attractions and key locations within a city. CDOT currently identifies bicycle boulevards as “neighborhood greenways” on their Chicago Complete Streets website.[2] CDOT identifies two bicycle boulevards in Chicago, and these have been defined and included in the inventory section of this report.

A bicycle boulevard is, at its most basic, a version of what is called a shared lane by IDOT’s Bureau of Local Roads (BLR) Manual or shared roadway by the Bureau of Design and Environment (BDE) Manual. The BLR defines a shared lane as “a lane of traveled way on any roadway upon which a separate bicycle lane is not designated and which may be legally used by bicyclists regardless of whether such facility is specifically designated as a bikeway.” The BLR also states that “shared lanes may be unmarked. However, the shared lane marking [abbreviated SLM and also called a ‘sharrow’] shall be considered as the preferred treatment”. Bicycle boulevards are typically installed on roadways with existing low traffic volumes and speeds. Therefore, local/residential roads are ideal for bicycle boulevards. Chicago’s bicycle boulevards occur on local/residential roads with on-street parking, low traffic volumes, and constrained roadway elements that encourage low traffic speeds.

When selecting a route for a bicycle boulevard, the following design considerations should be examined:

- Connectivity to popular or key destinations
- Proximity to:
  - Schools
  - Office buildings
  - Parks
  - Commercial centers
  - Neighborhoods
- Transit networks
- Existing bicycle infrastructure
- Directness of route

Figure 2 - A bicycle cut through, a bicycle boulevard feature, at Plymouth Court and Polk Street in Chicago

Features

Bicycle boulevards can include an array of roadway treatments, all of which contribute to the end goal of reducing and slowing traffic, and providing an overall comfortable, attractive corridor for riding a bicycle. The treatments may include:

- Identification, wayfinding, and warning signage
- Pavement and intersection markings
- Stop/yield signs on cross streets
- Bicycle signals
- Raised crosswalks and speed tables
- Median refuge islands
- Chicanes
- Curb bump outs
- Speed limit reductions
- Conventional, buffered, and/or contraflow bicycle lanes
- Non-motorized crossings
- Traffic circles

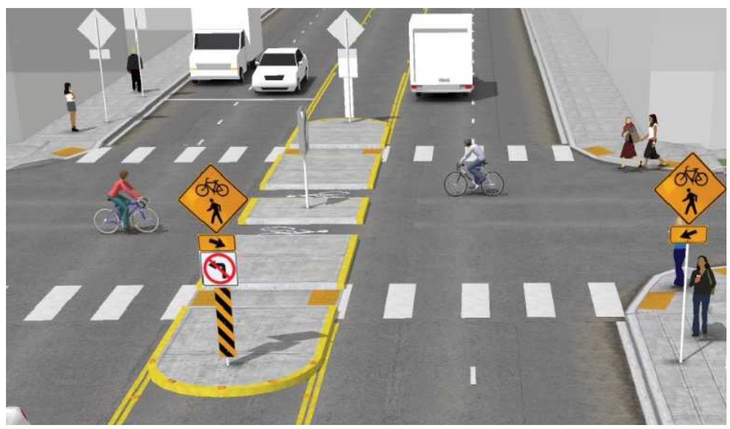


Figure 3 - Example of a median refuge island for both pedestrians and bicyclists, facilitating crossings of high traffic intersection. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press.

Warrants

NACTO provides guidance on the following conditions that should be present along candidate streets for a bicycle boulevards:

- Fewer than 3,000 motor vehicles per day (1,500 preferred)
- 85th percentile speed of no more than 25 mph (20 mph preferred)

Motorist speeds can be further reduced by the addition of features such as speed tables, traffic circles, a painted or patterned roadway surface, chicanes, and curb bump outs. Once actual speeds decrease, lower speed limits can be posted to reinforce desired traffic speeds.

Costs

The cost of bicycle boulevards is variable because of the wide range of features that can be incorporated within the boulevard. Based on four case studies in San Luis Obispo, CA, Palo Alto, CA, Eugene, OR, and Portland, OR, the cost of implementing bicycle boulevards can range from $20,000 per mile up to $1,460,000 per mile (Walker et al, 2009).[3] The extensive research by Bushell et al. found bicycle boulevards range between $200,000 and $650,000.[4] Traffic signals, HAWK signals or TOUCAN signals for example, are typically the most expensive components of bicycle boulevards with price tags up to $500,000, whereas signage can cost as little as $30 per sign. Some of Chicago's bicycle boulevards were constructed with pavement markings and signage only which reduces the cost. The total cost depends on which roadway treatments are selected and further study will be required on a case by case basis in order to develop an accurate cost estimate. For costs of individual features, see the *Fundamentals of Bicycle Boulevard Planning & Design* guide.[5]

Design Guidance

FHWA	Manual on Uniform Traffic Control Devices (MUTCD) Part 9, Interim Approval (IA-14) http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm
Illinois Department of Transportation	BLRS Manual: 42-3.03(c) http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Local-Roads-and-Streets/Local%20Roads%20and%20Streets%20Manual.pdf
Illinois Department of Transportation	BDE Manual: 17-2.02(b), 17-2.02(i), 17-2.03 http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Design-and-Environment/Illinois%20BDE%20Manual.pdf
AASHTO	Guide for the Development of Bicycle Facilities Chapters 4.10, 4.12.6-7 https://store.transportation.org/Item/CollectionDetail?ID=116
ite	FHWA Sponsored Traffic Calming Website https://www.ite.org/technical-resources/traffic-calming/traffic-calming-measures/
NACTO	Urban Bikeway Design Guide Bicycle Boulevards http://nacto.org/publication/urban-bikeway-design-guide/bicycle-boulevards/
Portland State UNIVERSITY	Fundamentals of Bicycle Boulevard Planning & Design https://www.pdx.edu/sites/www.pdx.edu.syndication/files/BicycleBoulevardGuidebook.pdf

Figure 4 - List of design guidance manuals and documents

SAFETY

In general, safety on bicycle boulevards is improved as a result of the decrease in traffic volumes and speed that is attained by implementing this facility. Fewer, slower motorists leads to safer, more comfortable bicyclists. A 2011 study by Teft found that an motorist-bicyclist impact at 20 mph carries a risk of death of about 7%, whereas an impact at 50 mph carries a risk of death of 75%.[6] By utilizing local roads and maintaining a lower traffic speed through various treatments, safety is increased.

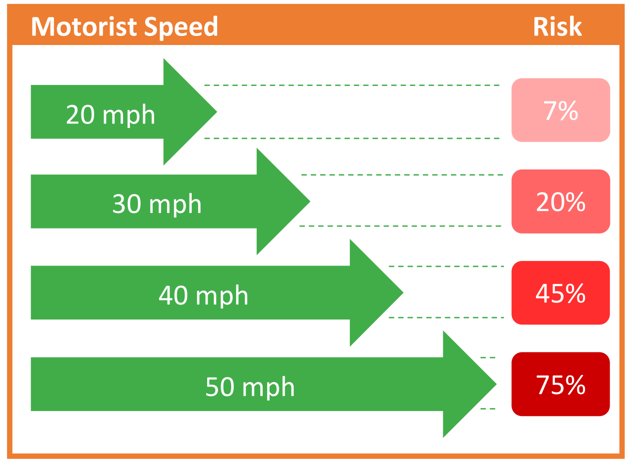


Figure 5 - The risk of death if a pedestrian is struck by a vehicle at varying speeds[6]

It is difficult to directly determine the effect of bicycle boulevards on bicyclist safety due to the various elements that can be used, the low volume nature of the facility, and the rarity of crashes on local streets. However, additional research has been performed on individual elements of bicycle boulevards. Refer to the respective facility reports linked above for more information. Safety information on the other treatments can be found in the design guidance links mentioned above.

Of the few studies that have been conducted, most were in Berkeley, CA and Portland, OR. One study, conducted in 2011, showed collision rates on Berkeley's bicycle boulevards were lower than those on parallel arterials (Minikel, 2011)[7]. "The risk ratio – the collision rate on the arterial divided by collision rate on the bicycle boulevard – ranges from 1.8 to 8.0" depending on the site. The researchers further examined the effect of bicyclist volume on those collision rates to determine if bicycle boulevards drew higher bicycle volumes resulting in a "safety in numbers" effect that could be causing the lower crash rates. They found that "at a minimum, the street type – bicycle boulevards vs. arterial – also matters. The results shown… cannot be explained away by safety in numbers." The study also found no difference in injury severity between bicycle boulevards and arterials although the results were not statistically significant.

Figure 6 – Speed humps, a potential speed reduction treatment, can contain cutouts that do not impact bicyclist speed or comfort. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press.

Another study examined varying levels of exposure to exhaust fumes. High-traffic routes, such as arterials, were found to have pronounced levels of pollutants when compared to low-traffic routes, such as bicycle boulevards.[8] Decreased exposure can potentially reduce detrimental health effects. A different study comparing separated bicycle lanes to conventional bicycle lanes also found significantly higher concentrations of ultra-fine particulates (UFPs) in the conventional lane compared to the separated lane (exact concentrations varied depending on traffic speed, volumes, specific site and facility type)(Kendrick et. al. 2011).[9] The separated bicycle lane in this study is only separated from traffic by approximately 10-11 feet, therefore, similar or greater reductions in UFPs may be expected on Bicycle Boulevards which experiences low traffic volumes.

Bicycle boulevards also have simultaneous benefits for pedestrians as they provide easier crossings through bump outs or median refuge islands. Less traffic and slower speeds allow for more frequent gaps and increased opportunities for crossing.

Figure 7- A bicycle boulevard crossing with intersection markings in Chicago

Another safety concern with bicycle boulevards is that they will inhibit the movement of emergency vehicles. There is a trade-off between the effectiveness of bicycle boulevards and response times of emergency vehicles which should be analyzed on a case by case basis. Bicycle boulevard designs should receive approval of local emergency services and should not be installed on emergency priority routes.

OPERATIONS

Bicycle boulevards fundamentally are shared roadways that incorporate and connect various bicycle facilities, encourage lower motorist volumes and speeds, and improves bicyclist priority, comfort, and accommodation. The purpose of bicycle boulevards is to provide a direct, safe route that is inviting to bicyclists of all ages and skill levels. This is accomplished by providing specific treatments on roadways intended to discourage motorist through travel while accommodating local travel. Operations of motorists is not a priority on bicyclist boulevards. Motorists may experience additional travel time depending on the treatments utilized. However, bicycle boulevards are installed on lower volume (3000 ADT) local roads where long distance travel is not intended. By definition, local roads are designed to discourage through traffic.[10]

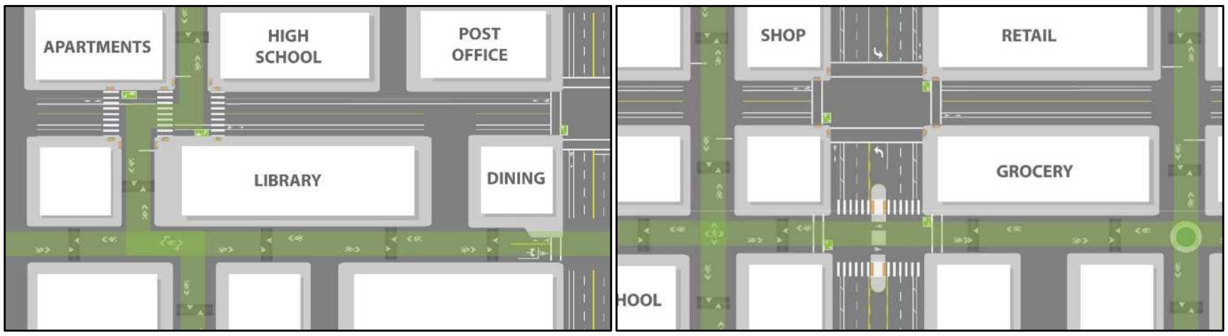


Figure 8 - A network of bicycle boulevards adjacent to collectors and arterial roads. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press.

Traffic volume can be minimized by intermittently adding non-motorized intersection crossings as seen in Figure 11. Volume may reduce naturally once a bicycle boulevard is in place and drivers adjust to optimize their route, accounting for this new infrastructure. Furthermore, certain treatments such as medians may reduce left-turn movements by motorists. Access is maintained, however, by providing alternate routes.

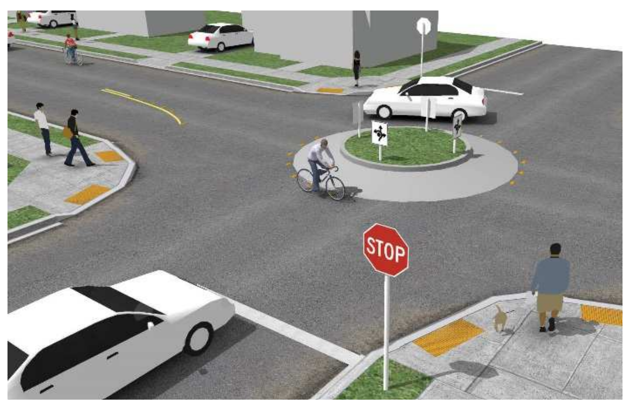


Figure 9 - Traffic circle with stop sign controls on the side streets and no control on the bicycle boulevard. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press.

Frequent stopping and starting can be tedious and off-putting for bicyclists. "A typical bicycle trip of 30 minutes is increased by 33% to 40 minutes if there is a STOP sign at every block."[11] "This extra time also takes a significant amount of extra energy on the part of the bicyclist." Bicyclist operations can be improved and travel times reduced with particular attention to bicyclist's energy requirements. A common technique is to install stop sign controls on side streets and only occasionally on the bicycle boulevard as shown in Figure 9. Direct routes are also an important element of bicycle boulevards. While treatments may be installed that discourage or prohibit motorists from taking direct routes, most can be designed with bicycle specific cut throughs that allow bicyclists to make direct connections between major and minor intersections. For example, applying bicycle boulevards in cul-de-sac style road networks is possible if the necessary right-of-

Figure 10 - Contraflow bicycle lane in Chicago

way can be procured to establish bicycle path connections to the next cul-de-sac. Bicycle boulevards work best in grid-style road networks that allow for higher connectivity as well as higher potential for direct, efficient routes.

Adequate and ample signage should be used where applicable. The large amount of bicycle and pedestrian treatments along the boulevard may cause some confusion without signage to give bicyclists direction.

Bicycle boulevards have the potential to increase bicycle volumes. From the user's perspective, bicycle boulevards provide "a quieter, less stressful bicycling environment that is especially attractive to children and casual or inexperienced bicyclists" and bicyclists unaccustomed to riding with traffic.[11] Boulevards also provide an environment for gaining "experience riding on the roadway, as opposed to bike paths or the sidewalk." One bicycle boulevard in Portland, Oregon was implemented starting in the 1980s and continuing through 2005 with various enhancements. Between 1996 and 2008, bicycle volumes increased 755%.

Figure 11 - Example of a cul-de-sac type with restricted openings only for bicyclists on either side of the landscaped median. The cut through connects a bicycle boulevard to the shared use Lake Front Trail in Chicago.

MAINTENANCE

The selected treatments for a specific bicycle boulevard will dictate the level of maintenance required. Simple bicycle boulevards can be comprised of pavement markings and signage, minimizing maintenance requirements. Additional treatments may require maintenance of curb, drainage and landscaping.

Generally, local roads are not typically prioritized when it comes to roadway maintenance. Rough or uneven pavement can be an annoyance to motorists, but may become uncomfortable and hazardous to bicyclists. It may deter the younger or less experienced bicyclists that bicycle boulevards are intended to attract. Because pavement quality is important to bicycling, it is prudent that pavement maintenance is prioritized along bicycle boulevard routes

Figure 12 - Traffic diverter with landscaping in Chicago

Typical Infrastructure to Maintain

- Pavement markings
- Curbs and planters
- Landscaping
- Flexible delineators
- Signage
- Lighting

Street Sweeping & Snow Removal

Street sweeping and snow removal may be a challenge depending on treatments used. For basic bicycle boulevards comprised of pavement markings and signage only, sweeping and snow removal can be accomplished through traditional means. Snow removal should be made a priority on bicycle boulevard routes which may receive less frequent plowing due to their location on mostly local roads. Additional treatments may increase sweeping and snow removal costs. Treatments with curbs extending into the traveled way such as median refuge islands, traffic circles, diverters, bump outs and chicanes may experience damage by snow plows or result in restricted street widths and prohibit operations of certain equipment depending on the width. Treatments in the travelled way should be properly signed, and their conspicuity increased with flexible delineator posts, retro-reflective markers, or yellow paint. See the respective facility reports and the separated bicycle lane report for more information on challenges, solutions, and specialized equipment that may be used.

Utility Cuts and Construction Damage

Bicycle boulevards require a smooth and consistent pavement to maintain a comfortable and aesthetically appealing riding surface. Utility cuts leave ruts and rough pavement. Patches may also be made with rough concrete finishes. Care should be made to ensure utility cuts are minimized and quickly patched or plated with bicycle friendly steel plates. Final finishing should be made with hot mix asphalt.

Drainage

The use of curbs in median refuge islands, curb bump outs, and chicanes within the travelled way may impact drainage. Existing drainage should be evaluated before and during installation of treatments. Drainage corrections may be instituted during construction such as installing additional gaps in curbs. Post installation inspections should be made to check for positive drainage away from the curb. Bioswales, if used, should be inspected and cleaned frequently. Sediment and trash build up may occur. Additional drainage challenges and solutions can be found in the respective facility reports.

As of June 23, 2014, there are seven states with bicycle boulevards, including two bicycle boulevards (referred to as neighborhood greenways by CDOT) in Chicago.

Table 1 - Examples of bicycle boulevards in North America, with locations in District One shown in bold text

Country	City	State	Street Example	Installation Year
USA	Tucson	AZ	Third St.	2007
USA	San Luis Obispo	CA	Morro St.	2003
USA	Berkeley	CA	Virginia St.	Unknown
USA	Palo Alto	CA	Bryant	1972
USA	**Chicago**	**IL**	**Berteau Ave. from Lincoln Ave. To Clark St.**	**2013**
USA	**Chicago**	**IL**	**Wood St. from Augusta Blvd. to Milwaukee Ave.**	**2014**
USA	Ocean City	NJ	Haven Ave.	Unknown
USA	New York City	NY	Various Locations	Unknown
USA	Eugene	OR	Monroe-Friendly	2007
USA	Portland	OR	Bryant St.	Unknown
USA	Seattle	WA	Various Locations	Unknown

[1]NACTO. "Bicycle Boulevards." National Association of City Transportation Officials. 2013. http://nacto.org/publication/urban-bikeway-design-guide/bicycle-boulevards/

[2] CDOT. "Neighborhood Greenways." Chicago Complete Streets. Accessed June 18, 2015. http://chicagocompletestreets.org/neighborhood-greenways/

[3] Walker, Lindsay, Mike Tresidder and Mia Birk. 2009. Fundamentals of Bicycle Boulevard Planning and Design. Portland, OR: Initiative for Bicycle and Pedestrian Innovation Center for Transportation Studies of Portland State University. Print and Online. Accessed June 23, 2014. http://nacto.org/wp-content/uploads/2012/06/Alta-and-IBPI.-2009.pdf

[4] Bushell, Max A., Bryan W. Poole, Charles V. Zegeer, Daniel A Rodriguez. 2013. *Costs for Pedestrian and Bicyclist Infrastructure Improvements*. University of North Carolina Highway Safety Research Center.

[5] Walker, Lindsay, Mike Tresidder, Mia Birk, Lynn Weigand, Jennifer Dill. *Fundamentals of Bicycle Boulevard Planning & Design.* Portland State University. Portland, Oregon. July 2008. https://www.pdx.edu/ibpi/sites/www.pdx.edu.ibpi/files/BicycleBoulevardGuidebook%28optimized%29.pdf

[6] Teft, Brian C. *Impact Speed and a Pedestrian's Risk of Severe Injury or Death.* AAA Foundation for Traffic Safety. Washington, D.C. September 2011. http://nacto.org/wp-content/uploads/2012/06/Tefft-B.C.-2011.pdf

[7] Minikel, Eric. 2011. Cyclist safety on bicycle boulevards and parallel arterial routes in Berkeley, California. Cambridge, MA: Department of Urban Studies and Planning, Massachusetts Institute of Technology. http://nacto.org/wp-content/uploads/2012/06/Minikel-2011.pdf

[8] Jarjour, Sarah, et al. 2013. Cyclist route choice, traffic-related air pollution, and lung function: a scripted exposure study

[9] Kendrick, Christine M., Adam Moore, Ashley Haire, Alexander Bigazzi, Miguel Figliozzi, Chirstopher M. Monsere, and Linda George. *Impact of Bicycle Lane Characteristics on Exposure of Bicyclists to Traffic-Related Particulate Matter.* Transportation Research Record: Journal of the Transportation Research Board. No. 2247, pp. 24-32. http://web.cecs.pdx.edu/~maf/Journals/2011_Impact_of_Bicycle_Lane_Characteristics_on_Exposure_of_Bicyclists_to_Traffic-Related_Particulate_Matter.pdf

[10] Federal Highway Administration (FHWA). *Highway Functional Classification Concepts, Criteria, and Procedures.* 2013. https://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/

[11] *Berkeley Bicycle Boulevard Design Tools and Guidelines*. April 2000. http://nacto.org/wp-content/uploads/2012/06/City-of-Berkeley-2000.pdf

Widened Shoulders

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

Paved, widened shoulders are becoming a common feature on rural highways and on highways in urban areas with rural cross sections. Paved, widened shoulders can increase a bicyclists' perception of comfort and safety by allowing a greater separation between bicyclists and motorists, by reducing conflicts between bicyclists and motorists, and by providing a stable riding surface. IDOT's Bureau of Design and Environment (BDE) Manual requires the use of 4 feet to 8 feet wide paved shoulders for bicycle accommodation, dependent on the posted speed and ADT.[1] The North Carolina Complete Streets Policy directs the North Carolina Department of Transportation to consider and incorporate a five feet wide paved bicycle zone on rural highways.[2] Tennessee Complete Streets Policy recommends using a five feet to seven feet wide paved shoulder on rural roads with no curb and gutter.[3] Widened shoulders help maintain traffic operations by providing additional space for motorists and bicyclists to share the roadway system. Illinois law requires motorists to maintain at least 3 feet between their vehicles and bicyclists when passing them.[4] When widened shoulders are constructed for bicyclist use, they are not typically marked or signed for bicycle use, but still provide a safer travel area for bicyclists. The addition of widened shoulders is a practical means of connecting communities while maintaining a safer facility for all users.

Widened shoulders are usually constructed as part of a roadway improvement project. Typically, they are not marked or signed for bicycles. IDOT has created regional Bicycle Maps for the state which show state, county, and local roads depicted in various colors. The colors indicate the grade or rating of service for each road based on various factors, one of which includes the presence of widened shoulders. The rating system was developed by B. W. Landis in 1978 and is the standard system used for rating roadways for bicyclist use.[5]

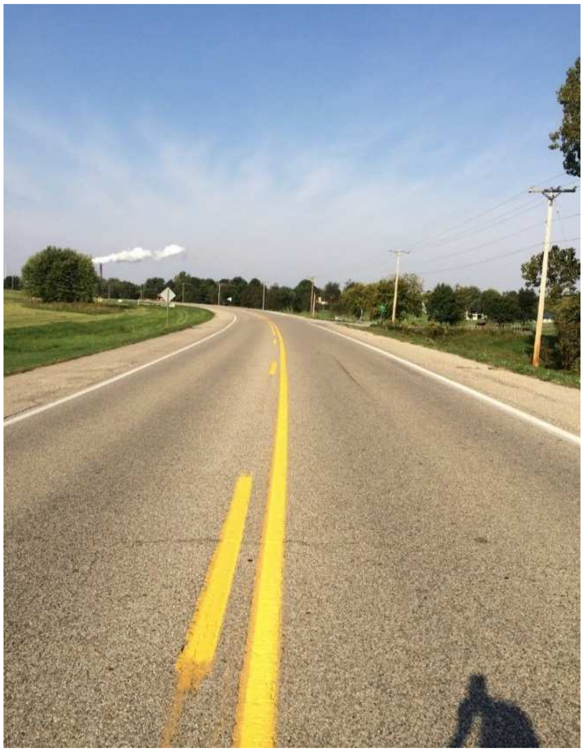


Figure 1 – Widened shoulders on County Highway 56 (Rochester Road) from East Lake Shore Drive in Springfield, Illinois, to Ebel Drive in Rochester, Illinois

Features

Paved shoulders allow for greater comfort and safety for both motorists and bicyclists by providing a more stable riding surface for bicyclists, increasing bicyclist visibility to motorists, and widening the separation between bicyclists and the traveled way.[6]

IDOT BDE Manual, Chapter 17 requirements for paved shoulders along a rural roadway for the noted posted speed limits and traffic volumes include the following:

- Paved surface
- Positive surface drainage by sloping 2% to 4%
- Rumble strips
- Solid white pavement marking line at edge of pavement

Table 1 - Paved Shoulder Widths along a Rural Roadway

Speed Limit	ADT	Width of Paved Shoulders
< 30 mph	< 2000	Not Required
< 30 mph	2000 or greater	4 feet
30 – 35 mph	8000 or less	4 feet
30 -35 mph	> 8000	6 feet
36 – 44 mph	All traffic volumes	6 feet
> 44 mph	< 2000	6 feet
> 44 mph	2000 -8000	8 feet

Warrants

"In January 1999, the FHWA task force members recommended against trying to create specific warrants for different facilities and determined that warrants leave little room for engineering judgement and have often been used to avoid providing facilities for bicycling and walking."[7] Instead of using warrants, FHWA issued a Policy Statement on Accommodating Bicyclists and Pedestrians in Transportation Projects as follows:

- An acknowledgement of the issues associated with balancing the competing interests of motorized and non-motorized users
- A recommended policy approach to accommodating bicyclists and pedestrians (including people with disabilities) that can be adopted by an agency or organizations as a statement of policy to be implemented or a target to be reached in the future
- A list of recommended actions that can be taken to implement the solutions and approaches described above
- Further information and resources on the planning, design, operation, and maintenance of facilities for bicyclists and pedestrians

Costs

$ $59/linear foot Average cost (HMA)

$ $150/linear foot Average cost (concrete)

Shoulder widening is typically part of a roadway improvement. The cost of a typical 4foot wide HMA paved shoulders can vary in Illinois. The Illinois Department of Transportation Awarded Bid Prices, from 11/18/2013, show the cost of a 6" HMA shoulder to be approximately $150 per ton.[8] In Illinois, the state will pay 100% of the cost for construction and maintenance of widened shoulders on state routes. In Illinois, the average cost of shoulder paving on rural two-lane highways is approximately $59 per linear foot for hot-mix asphalt shoulders and $580 per cubic yard for Portland cement concrete shoulders.[9] In Indiana, the cost of adding widened shoulders to an existing facility (both sides) is approximately $145,000 per mile and includes project development costs and construction costs.[10] The cost of adding widened shoulders to a new facility (both sides) is approximately $955,000 per mile and includes project developments costs, right-of-way acquisition costs, and construction costs for the entire facility.

Design Guidance

FHWA	Manual on Uniform Traffic Control Devices (MUTCD) Chapter 3D. Markings for Preferential Lanes Chapter 9C. Markings. 2009 Edition, Revisions 1 & 2, May 2012 http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm
Illinois Department of Transportation	Bureau of Design and Environment Manual Chapter 17-2. Design Criteria for Bicycle Facilities http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Design-and-
AASHTO	Guide for the Development of Bicycle Facilities 2012 – Fourth Edition https://bookstore.transportation.org/collection_detail.aspx?ID=116

Figure 2 - List of design guidance manuals and documents

SAFETY

Studies have found that widened shoulders provide safety benefits for both bicyclists and motorists. In the studies, a widened shoulder:

- Improves sight distance[1]
- Reduces passing conflicts and numerous crash types between bicyclists and motorists[11]
- Provides a stable riding surface outside of the motorist travelled way for bicyclists and pedestrian use[11]
- Increases bicyclist visibility for motorists
- Provides emergency stopping space for broken down vehicles[11]
- Provides a safer separation between motorists and bicyclists
- Addition of rumble strips at the edge of pavement alerts errant vehicles and decreases chance of workers being struck in construction zones
- Provides an increased level of comfort for bicyclists[11]

The most common error resulting in a crash between motorists and bicyclists on rural highways is inattentive motorists causing run-off road accidents. According to a study conducted by the FHWA, approximately 25% of nationwide bicyclist/pedestrian fatalities and injuries occur on rural highways.[12] “In 2012, 726 bicyclists were killed and another 49,000 bicyclists were injured in motor vehicle traffic fatalities nationally. This is a 6% increase from 2011. Thirty-one percent of those bicyclist deaths in 2012 occurred in rural areas.”[4] Rumble strips were installed as a warning to motorists. The addition of rumble strips at the edge of pavement in construction zones also protects workers from drift-off-the-road accidents. Although rumble strips were originally developed to help reduce run-off-road accidents for motorists, they also create a concern for bicyclists using the shoulders. Poor maintenance on shoulders, such as pot holes and debris, is another common hazard to bicyclists. All of these items mentioned above can contribute to the bicyclist moving off of the shoulder, across the rumble strip, and into the travel lane, thus increasing the potential for an accident.

Nationwide Bicyclist/Pedestrian Fatalities & Injuries Occurring on Rural Highways	25%

In 2011, the FHWA organized a study to understand rural pedestrian and bicycle crashes. Bicycle and pedestrian crash statistics on rural roadways with no dedicated bicycle accommodations were compared to those on urban roadways. From this study, the FHWA found that crashes occurring at rural locations had higher vehicle speeds, higher fatality rates, less roadway lighting, less paved shoulders and fewer intersections than those at urban locations. Rural locations also had a higher crash rate per vehicle-mile. One of the most prominent crashes on rural highways occurred due to bicyclists turning/merging into the path of drivers and drivers overtaking the bicyclists. Recommendations to improve rural facility locations included adding paved shoulders, improving roadway lighting, and providing marked pavement space for bicyclists.[12]

OPERATIONS

Widened shoulders improve travel operations for both bicyclists and motorists through provision of separate travel space and increased clearances. Vehicular traffic movement is uninterrupted by bicyclists, since they are traveling on the widened shoulders in a dedicated space. Bicyclists can ride on widened shoulders with little or no interruption from vehicular traffic. When vehicles have mechanical difficulty, a flat tire, or any emergency, the widened shoulders provide a space for motorists out of the travel lane, thus keeping vehicular traffic at a normal operational level with some interruption to bicyclist movement. Some of the factors that can compromise the operations of this facility are:

- Routes not designated or marked as bicycle routes and lack of signage
- Inoperable vehicles pulling out of the travel lane onto the widened shoulders causing interruption to bicyclist movement[11]
- Space used for maintenance operations and snow storage[11]

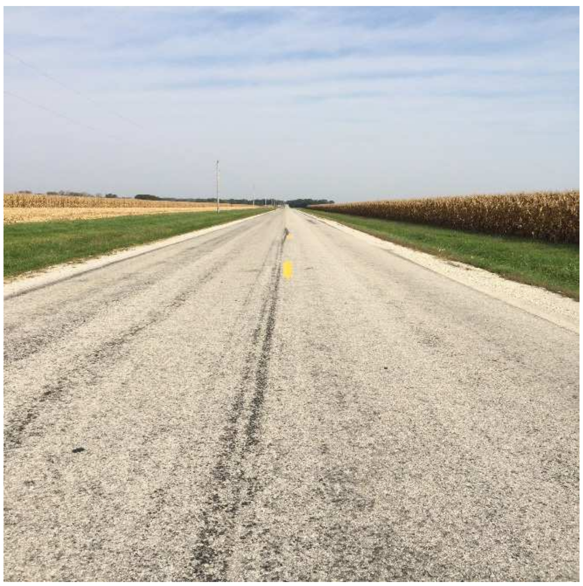


Figure 3 - C.H. 46 (Lincoln Trail) from Illinois Route 97 to County Highway 3 ½ in Sangamon County, Illinois (control)

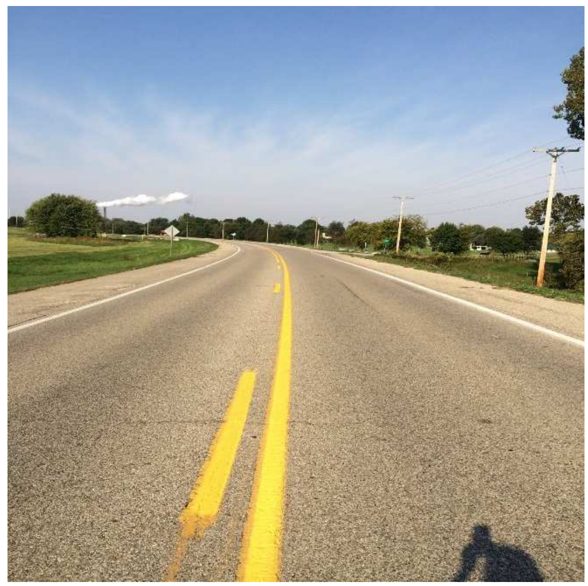


Figure 4 - C.H. 56 (Rochester Road) from East Lake Shore Drive in Springfield, Illinois, to Ebel Drive in Rochester, Illinois (facility)

Currently, IDOT BDE Chapter 17 BDE specifies required widths for paved shoulders based on posted speed limit and traffic volumes. Shoulders that are narrower than the required widths may negatively impact the operations of the widened shoulders facility for both motorists and bicyclists.

In 2003, a bicycle suitability analysis was conducted by the highway department in Kane County, Illinois. Bicycle Level of Service (BLOS) was measured using a formula developed in 1997.[5] "BLOS together with FHWA's Bicycle Compatibility Index (BCI) are emerging national standards for quantifying "bicycle-friendliness" of a roadway."[13] Existing data from state roads, county roads, and local roads was collected from the IDOT IRIS database. Additional roadway information was requested from surrounding towns and townships using a questionnaire, phone calls, and field visits. Data collected included roadway types, roadway conditions, and traffic volumes. This data was entered into a GIS database. A map was then developed, thus scoring Bicycle Level of Service (BLOS) for individual roads. Scores ranged from A (highest score) to F (lowest score). Most roads with 10 feet paved shoulders received a score of A. From this study, it was concluded that experienced bicyclists felt comfortable riding on roads with a "C" rating or higher, but would still use roads with a "D" rating.[13]

A report was introduced by the League of Illinois Bicyclists entitled "Complete Streets" in Aurora, Illinois. It used a similar scoring methodology based on the Landis study to rate Bicyclist Level of Service.[5] While other level-of-service indices relate to traffic capacity, these measures indicate bicyclist comfort level for specific roadway geometries and traffic conditions."[13] A minimum bicycle accommodation score was calculated for each road, with the maximum score possible of 35 points. Points were then added to that score depending on what features were located within the corridor, including widened shoulders. Shoulders that met or exceeded the minimum Illinois BDE width requirement greatly increased the BLOS. "The goal of the Complete Streets audit scoring methodology was to rate the effectiveness of bicycle and pedestrian accommodation in road designs in a way that adapted to a particular situation."[14] The results from this report concluded that this scoring methodology system works.[13, 14]

A study was conducted by the North Carolina Department of Transportation on the benefits of bicycle connectivity, which included shoulder widening. Although some of the benefits were hard to quantify, the study found positive economic benefits, transportation benefits, environmental benefits, health benefits, fitness benefits, and social benefits.[15]

MAINTENANCE

Widened shoulders require minimal routine maintenance aside from debris removal and snow removal. Widened shoulders should be periodically maintained to repair pavement damage and ensure proper parkway drainage in order to minimize structural deterioration and preserve a smooth riding surface for bicyclists.

Street Sweeping & Snow Removal

Snow removal from widened shoulders can be done with traditional snow plows. Since widened shoulders are on the same slope as the roadway, snow plows can continue routine operations without lifting plows. The Sangamon County Highway Department is responsible for the maintenance and repair of the widened shoulders along County Highway 56 (Rochester Road) between Springfield, Illinois and Rochester, Illinois, including pavement repair, sweeping, and snow removal. The County uses their standard roadway equipment for all operations. The County tries to remove snow and salt within 24 hours of snow fall events.

Drainage

Widened shoulders do not obstruct roadway surface runoff as long as an adequate cross slope is provided and maintained for the paved shoulder.

Utility Cuts and Construction Damage

Widened shoulders may be impacted during utility repairs, but IDOT and most municipal utility policies require restoration to existing conditions by those conducting repairs. Utility companies may need additional information or guidance on proper repair of the facility, and their work should be inspected following completion.

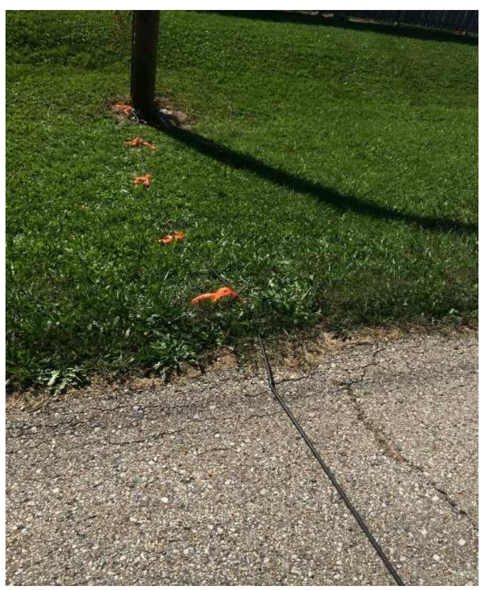


Figure 5 - Small cracks in widened shoulders along County Highway 56 (Rochester Road) from East Lake Shore Drive in Springfield, Illinois, to Ebel Drive in Rochester, Illinois. Timely maintenance of these cracks will increase the longevity of the paved shoulder and preserve riding surface.

District One Studies

The following is a summary of findings from studies performed by IDOT in 2014, for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 2 - Summary of IDOT District One Studies, 2014

Study	Summary of Findings
Bicyclist Survey	Overall, the responses from the surveys indicated that the majority of bicyclists felt some degree of safety and comfort riding on a roadway with widened shoulders, while nearly one third of bicyclists felt a high degree of safety and comfort.
Motorist Compliance and Bicyclist Behavior	No motorist compliance and pedestrian behavior studies were performed at the widened shoulders facility in Springfield, Illinois. A short-term study was not feasible due to the rural location of the facility along with the low motorist and bicycle volumes.

Bicyclist Survey

Two surveys were conducted, one at a location with widened shoulders present and one at a location with existing four feet aggregate shoulders, to compare and contrast bicyclists' opinions on the respective facilities. In-person surveys regarding the widened shoulders were conducted along County Highway 56 (Rochester Road) in Springfield, Illinois, on October 1, 2014 from 3:00 p.m. to 5:00 p.m. During the survey, the weather condition was overcast with a temperature of 83 degrees. For the control location, on County Highway 46 (Lincoln Trail), also in Springfield, Illinois, no in-person surveys were conducted due to a lack of bicyclists present at the time of the survey on October 1, 2014. For both the facility location and the control location, online surveys were also open and available for a two week period.

Survey Method

A cross sectional study was conducted to compare bicyclists' opinions of riding on a roadway with widened shoulders already in-place versus riding on a roadway with no shoulder or additional space for bicyclists to ride. For this type of study, the control location could not be located in the vicinity of the widened shoulders facility being studied, and both roadways had similar roadway characteristics, including similar ADT. The facility and control questions were kept as similar as possible in order to facilitate response comparison.

For the County Highway 56 (Rochester Road) widened shoulders facility, one staff member stood on the northeast corner along County Highway 56 at the intersection of Red Bud Lane. Another staff member stood along County Highway 56 at the intersection of Ebel Drive. Both members were wearing safety vests, for both safety purposes and to attract the attention of bicyclists. The staff would approach bicyclists asking them if they would like to take a survey. They were given the option of taking the survey in-person or online at their convenience. The online survey was open for 2 weeks, and the online submissions were analyzed to avoid multiple submissions from the same person.

Figure 6 – Facility location with widened shoulders. C.H. 56 (Rochester Road) from East Lake Shore Drive in Springfield, Illinois, to Ebel Drive in Rochester, Illinois.

At the control location on County Highway 46 (Lincoln Trail), one staff member was positioned at the northeast corner at the intersection of Illinois Route 97. The staff member was wearing a safety vest, for both safety purposes and to attract the attention of bicyclists using the facility. No in-person surveys were conducted due to a lack of bicyclists present at the time of the survey.

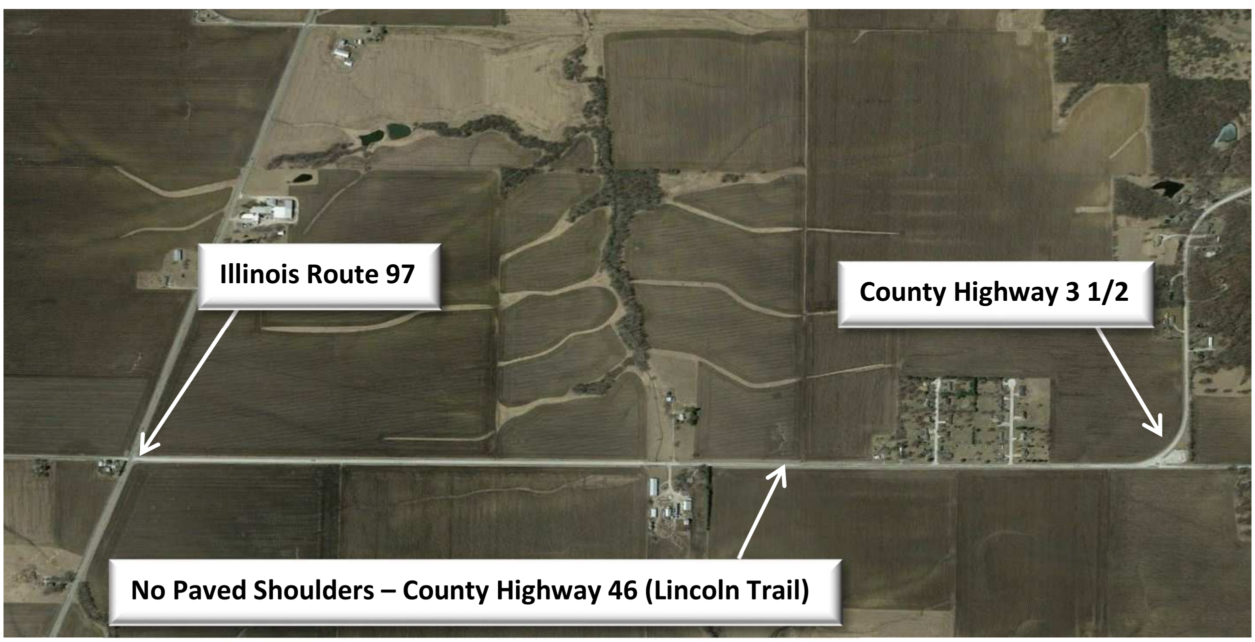


Figure 7 – Control location with no widened shoulders. C.H. 46 (Lincoln Trail) from Illinois 97 to County Highway 3 ½ in Sangamon County, Illinois.

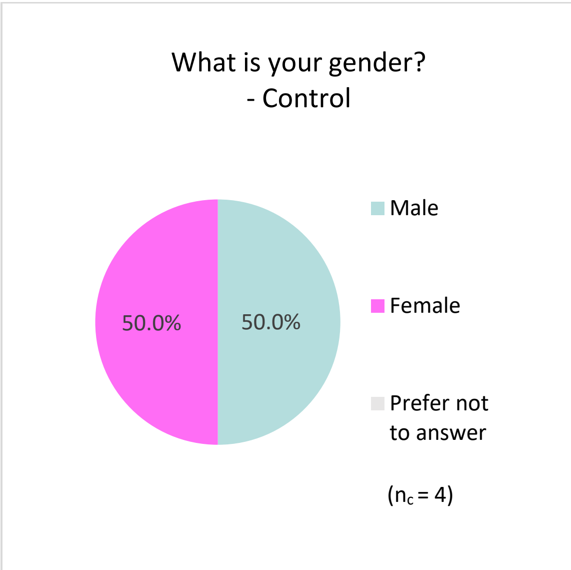
Survey Questions

Bicyclists at the facility location with widened shoulders and the control location with no paved shoulders were asked the questions listed below in Table 3. The results were aggregated for comparison purposes, and the results are displayed in Figure 8 through Figure 17.

Table 3 - Survey questions corresponding to the following figures

Figure #	Questions Asked
8	What is your gender?
9	In what age group do you fall?
10	What best describes why you are out here today?
11	In the past month, about how often have you ridden on County Highway 46 (Lincoln Trail) from Illinois Route 97 to County Highway 3 ½ in Sangamon County, Illinois (control), or along County Highway 56 (Rochester Road) from East Lake Shore Drive in Springfield, Illinois, to Ebel Drive in Rochester, Illinois (facility)?
12	Have you ever had any problems bicycling on this street, such as near misses or conflicts with drivers or other vehicles?
13	Do you use this route specifically because it has widened shoulders (facility)?
14	Did you use this route before the widened shoulders were added in 2006 (facility)?
15	How does this route compare to other routes that you use (facility)?
16	How safe and comfortable do you feel when bicycling on County Highway 46 (Lincoln Trail) from Illinois Route 97 to County Highway 3 ½ in Sangamon County, Illinois (control), and along County Highway 56 (Rochester Road) from East Lake Shore Drive in Springfield, Illinois, to Ebel Drive in Rochester, Illinois (facility)
17	Is there anything that can be improved to make you feel more comfortable?

Survey Results



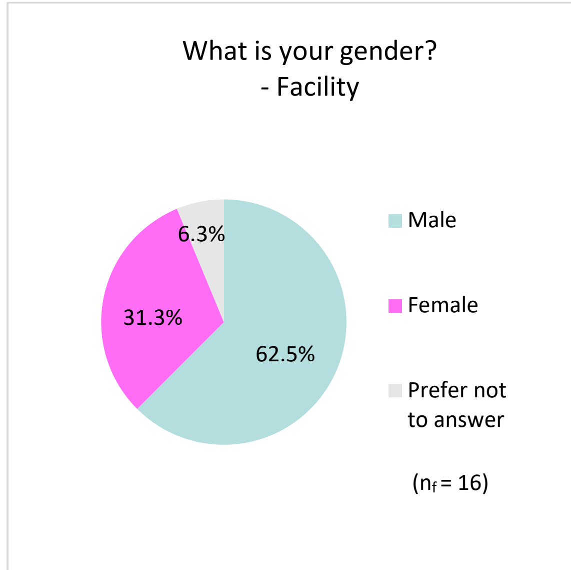


Figure 8 - What is your gender?

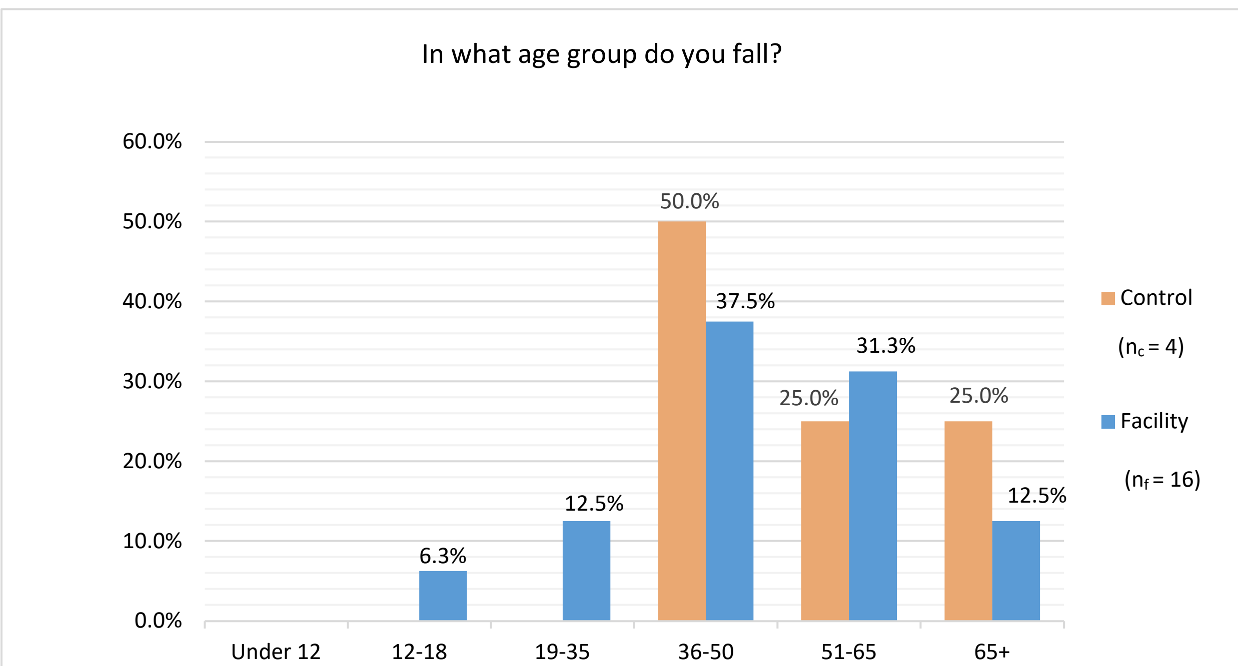


Figure 9 – In what age group do you fall?

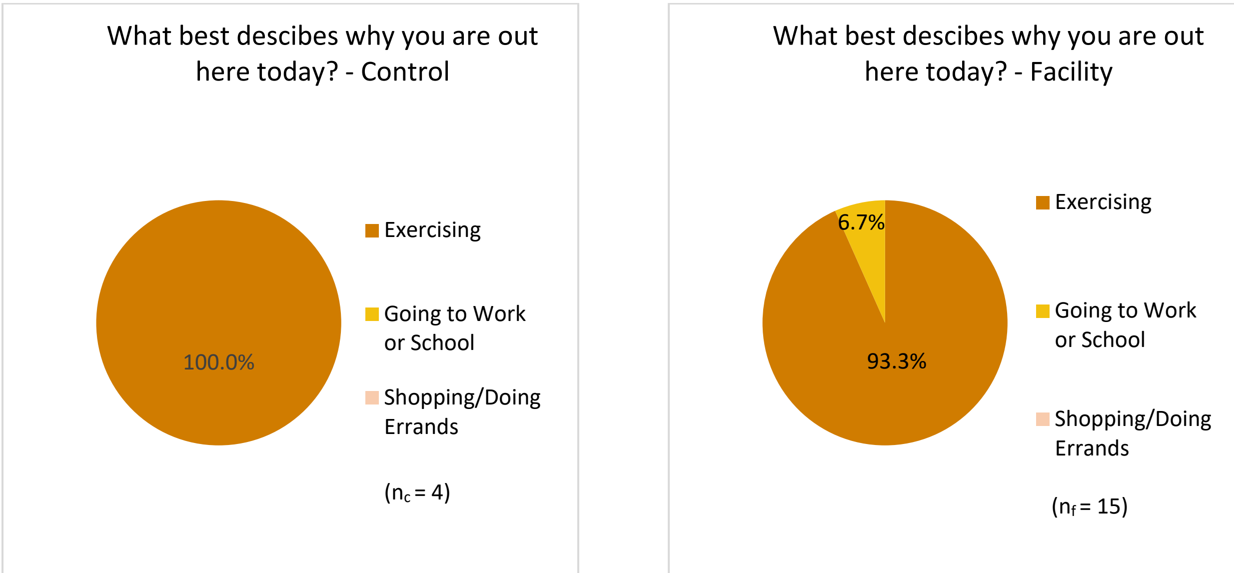


Figure 10 – What best describes why you are out here today? Results from the control (left) and the widened shoulders (right).

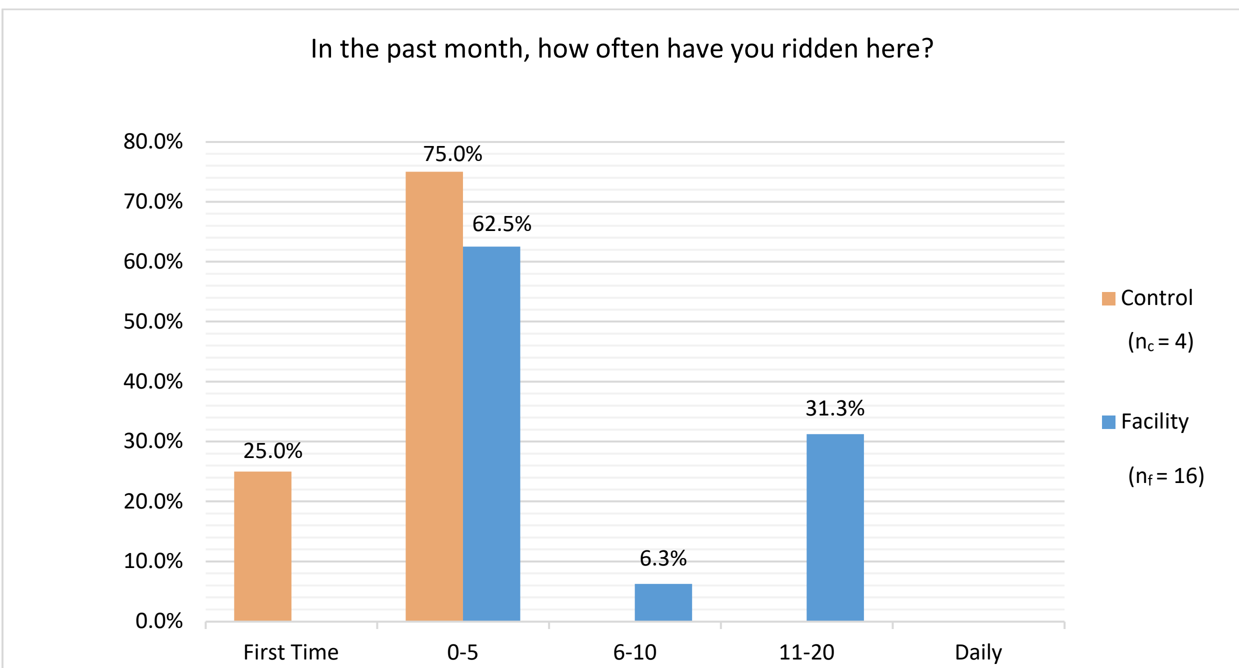


Figure 11 – In the past month, about how often have you ridden on County Highway 46 (Lincoln Trail) from Illinois Route 97 to County Highway 3 ½ in Sangamon County, Illinois (control), or along County Highway 56 (Rochester Road) from East Lake Shore Drive in Springfield, Illinois, to Ebel Drive in Rochester, Illinois (facility)?

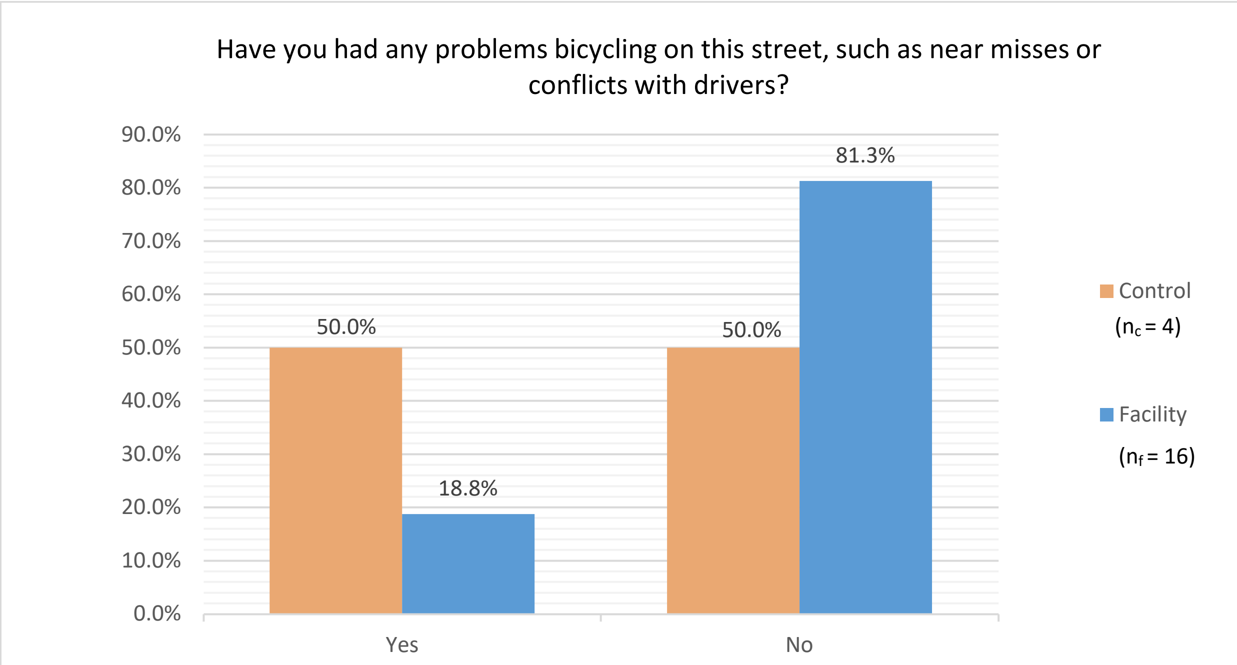


Figure 12 – Have you ever had any problems bicycling on this street such as near misses or conflicts with drivers?

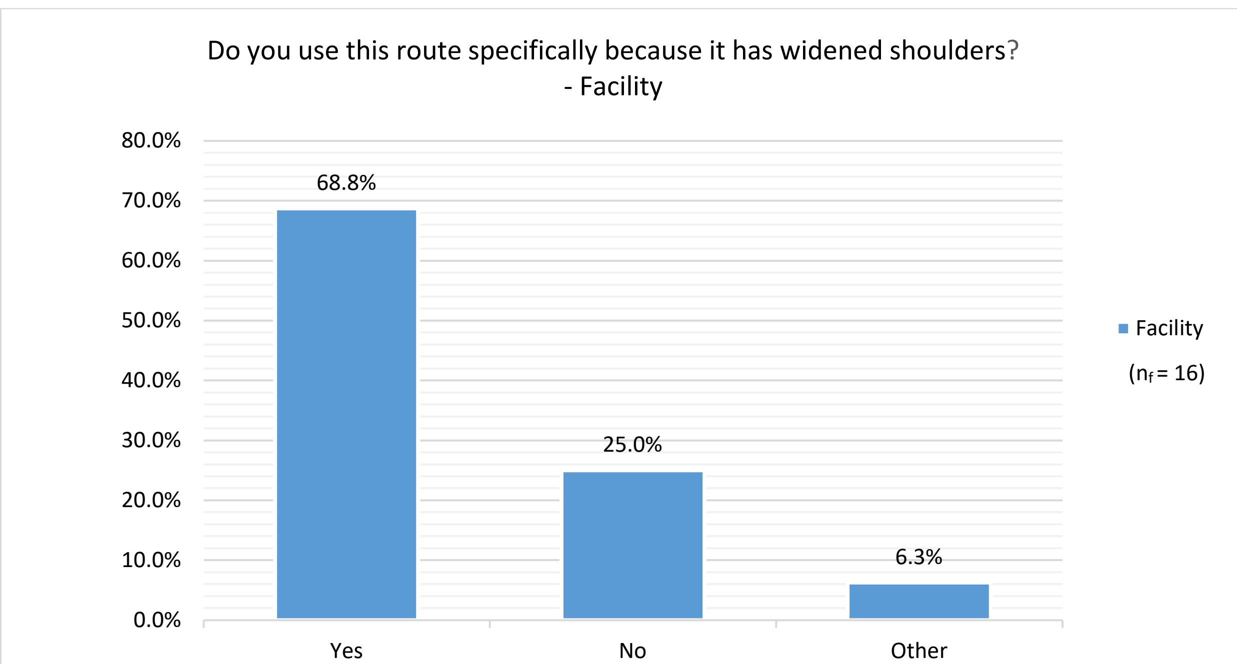


Figure 13 – Do you use this route specifically because it has widened shoulders? Results from widened shoulders.

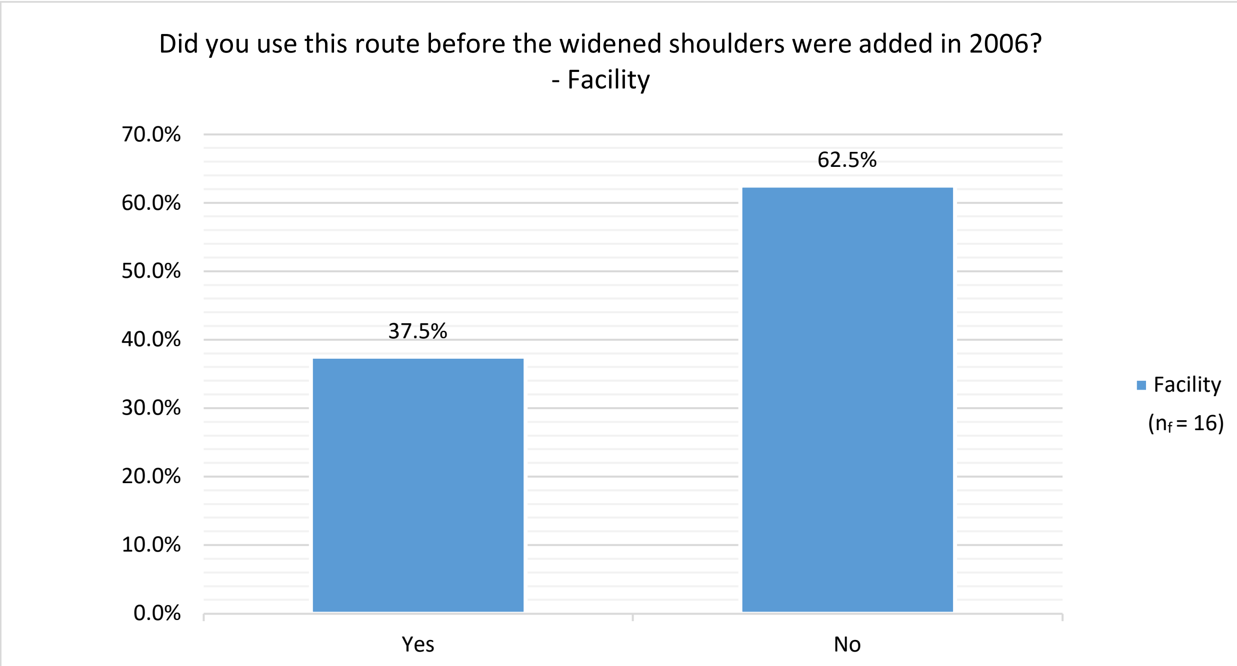


Figure 14 – Did you use this route before the widened shoulders were added in 2006? Result from widened shoulders.

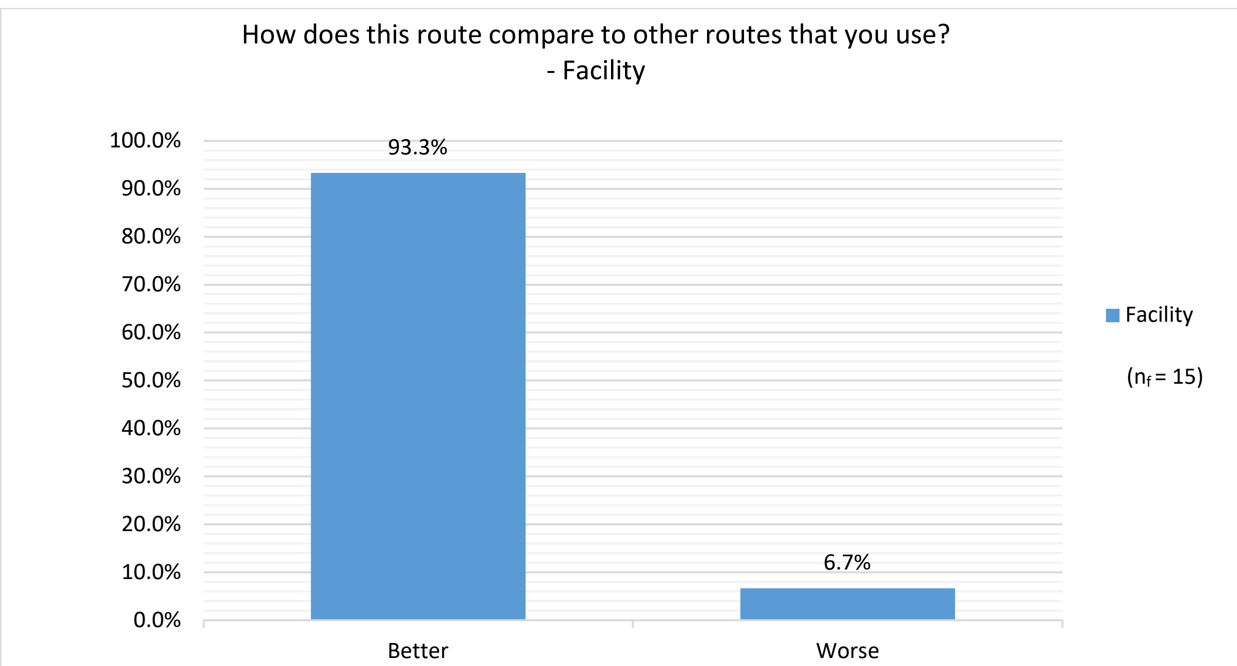


Figure 15 – How does this route compare to other routes that you use? Results from widened shoulders.

For the following question, the participant was asked to choose a rating between 1 and 5 on how safe they felt when using the widened shoulders, 1-not very safe or comfortable, 3-somewhat safe and comfortable, and 5-very safe and comfortable.

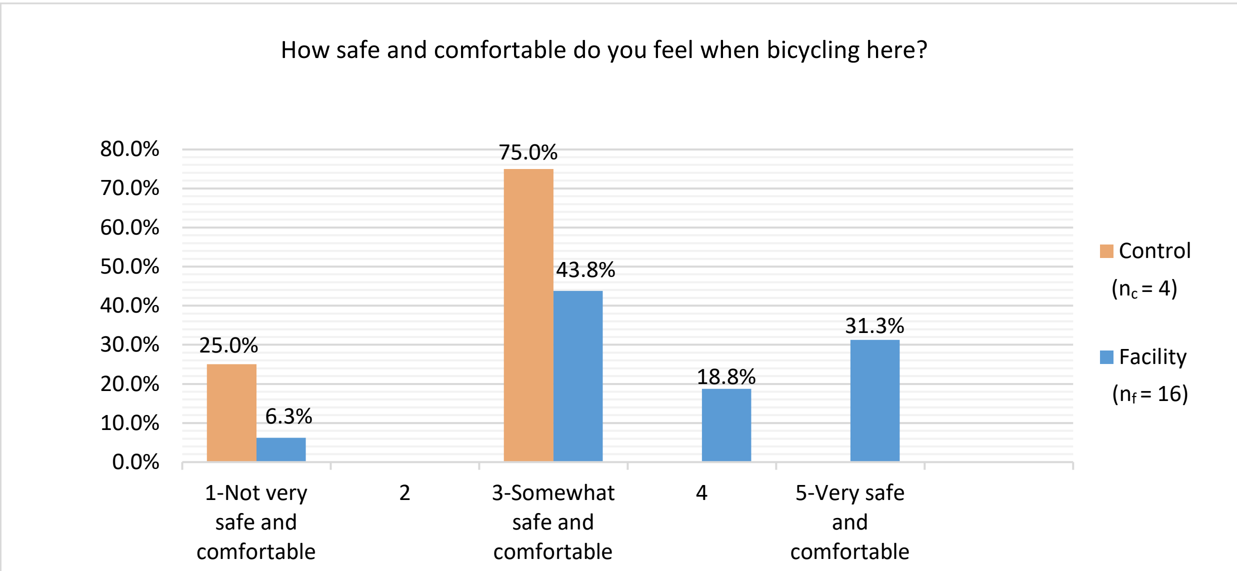


Figure 16 – How safe and comfortable do you feel when bicycling on County Highway 46 (Lincoln Trail) from Illinois Route 97 to County Highway 3 ½ in Sangamon County, Illinois (control), or along County Highway 56 (Rochester Road) from East Lake Shore Drive in Springfield, Illinois, to Ebel Drive in Rochester, Illinois (facility)?

Participants were given the opportunity to voice their opinions about the widened shoulders. Their opinions were categorized and shown below In Figure 17.

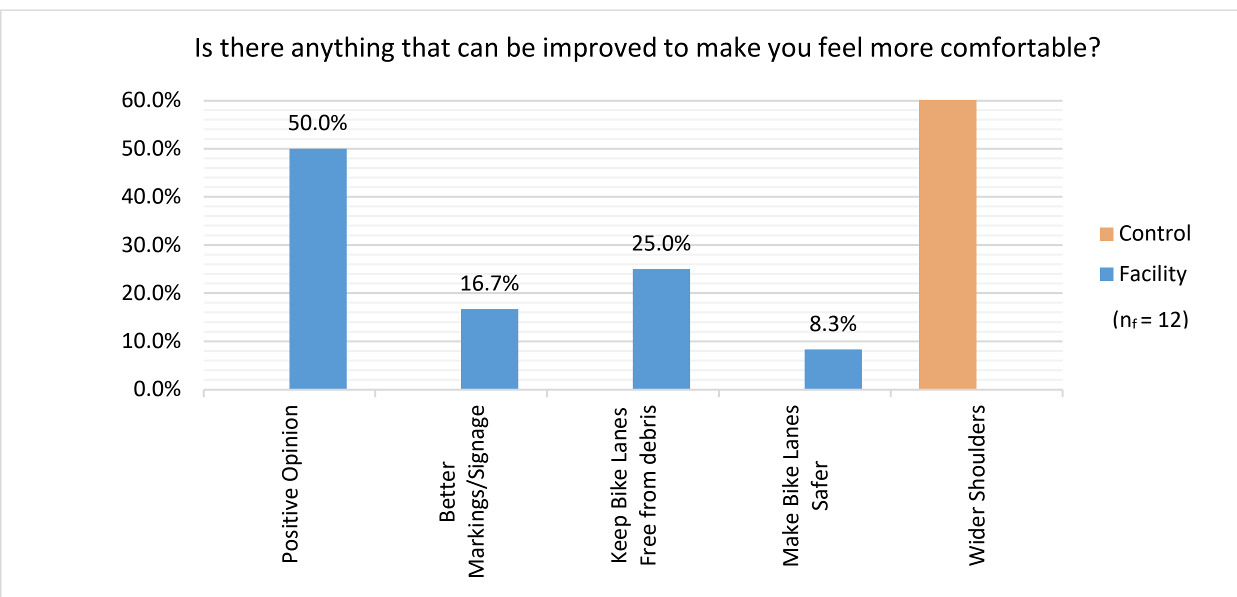


Figure 17 – Is there anything that can be improved to make you feel more comfortable?

Discussion

For the widened shoulders facility, four paper surveys were completed and 12 online surveys were completed. Of the participants surveyed, 14 participants said they were "Exercising" since the road featuring widened shoulders is located in a rural residential area. However, none of the participants frequent the area regularly, the majority of participants have ridden on the widened shoulders zero to five times per month, and one third of the participants have ridden on the widened shoulders 11-20 times per month. Only three participants out of 16 had problems bicycling on this street, such as near misses or conflicts with drivers. Of the participants surveyed, 11 of the 16 participants use the widened shoulders facility specifically because widened shoulders are present, while only six of them used the facility before widened shoulders were added in 2006. When asked how this route compared to other routes used, nearly all (14) of the participants felt that it was better. Seven participants rated this facility a 3, five participants rated it a 5, three participants rated it a 4, while only one participant rated it a 1 in terms of safety and comfort on a scale of 1 to 5, with 5 being the safest.

Participants were given the opportunity to voice their opinions on the widened shoulders on C.H. 56 (Rochester Road). Approximately 50% of the participants had positive feelings towards the widened shoulders. Several of the participants had expressed specific comments and suggestions regarding the widened shoulders with one participant wanting the route made safer, three participants wanting debris cleared from the widened shoulders, and two participants wanting better pavement marking and signage.

For the control location with no paved shoulders, no paper surveys were completed and only 4 online surveys were completed. All four participants said they were "Exercising" since the control facility is located in a rural, residential area. None of the participants frequent the area regularly, with the majority of participants using the facility zero to five times per month. Two participants, out of the four surveyed, had problems bicycling on this street, such as near misses or conflicts with drivers. Three of the four participants rated this facility a 3 and one participant rated it a 1 in terms of comfort and safety, with 5 being the safest.

Participants were given the opportunity to voice their opinions about the control location on C.H. 46 (Lincoln Trail). Three participants had no suggestions on how to improve the facility, while one participant would like wider shoulders added to the facility.

Conclusion

Overall, the responses from the surveys indicated that the majority of bicyclists felt some degree of safety and comfort riding on a roadway with widened shoulders, while nearly one third of bicyclists felt a high degree of safety and comfort. These results were likely the result of reduced bicyclist conflicts with motorists, and bicyclists' personal perception of increased safety and comfort level when provided additional space to ride with further separation from motorists.

Widened shoulder facilities are being used on rural roadways throughout the United States, largely as a result of their inclusion in the Federal Complete Streets Policy, as well as complete streets policies implemented by various states across the country. A few examples of known widened shoulder locations are included in the table below.

Table 4 – Examples of widened shoulder locations in the USA, with locations in District One and Illinois shown in bold text

Country	City/County	State	Location	Install Year
USA	**Alton/Grafton**	**Illinois**	**IL 100 from Redbud Ln. to Grafton and Hazelnut Ln. in Alton**	**Unknown**
USA	**Batavia/Village of Lakewood**	**Illinois**	**Randall Rd. from Ice Cream Dr. in Batavia to Ackman Rd. in the Village of Lakewood**	**Unknown**
USA	**Edwardsville**	**Illinois**	**Illinois Route 157 from W. Schwartz St. to Old Carpenter**	**2008**
USA	**Peoria**	**Illinois**	**Knoxville Ave. from Glenn Ave. to Prospect Rd.**	**2013**
USA	Baton Rouge	Louisiana	Lobdell Ave. from Jefferson Highway to north of Rue Henri and Crown Oak Dr.	Unknown
USA	Nags Head	North Carolina	Kitty Hawk to Whale Bone Jct.	1999
USA	Kitty Hawk	North Carolina	Kitty Hawk	2000
USA	Currituck County	North Carolina	North Carolina 12 from Corolla Lighthouse to Dare County Rd.	2002
USA	Piscataway County	New Jersey	Davidson Rd. near Buccleuch Park	Unknown
USA	Piscataway County	New Jersey	Joyce Kilmer Ave. from Metlars Lane to Road 3	Unknown
USA	Virginia Beach	Utah	Shore Dr. from Kendall St. to 83rd St.	2012
USA	Moose Lake	Vermont	Road L – 6 foot Widened Shoulder for bicycles	2012

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[3] Tennessee Department of Transportation Complete Streets Design Guidelines. July 2009. Tennessee Department of Transportation. Accessed October 10, 2014. http://www.tdot.state.tn.us/bikeped/CompleteStreets.pdf.

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[14] Barsotti, Ed, Stephen Hunt, Christopher Trigg, *"Complete Streets" Road Design Audits for Bicycles and Pedestrians*, League of Illinois bicyclists. (http://www.peoplepoweredmovement.org/site/images/uploads/CompleteStreetsAudit.pdf).

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Road Diets

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

A road diet is the removal of at least one vehicular travel lane and the reallocation of that space for other uses such as bicycling, pedestrian crossing refuge, parking, and transit. Although there are multiple configurations for road diets, the most common is the conversion of an undivided four-lane road to a three-lane road. This is achieved by the removal of one existing through traffic lane in each direction and using the extra space within the roadway footprint for the addition of a center lane marked for left turning traffic and either a bicycle lane or on-street parking along the outside. The center lane can include markings for dedicated left turn lanes as well as a “two-way left turn lane” (TWLTL), where vehicles from both directions can make a left turn. Motorist ADT is often unchanged after installations of road diets yet bicycling and walking increases.[1]

While bicycle lanes are often included, road diets also benefit pedestrians by increasing separation between traffic and pedestrians and decreasing their exposure to traffic while crossing. The intention of a road diet is to calm traffic and make the roadway more accessible for all users by reusing excess capacity. Road diets result in fewer conflict points for both through and turning traffic, decrease the number of vehicle lanes to cross while turning as a motorist or crossing as a pedestrian, improve compliance rates, and decrease crash severity. Removing outer travel lanes results in decreased exhaust, particulate matter, and noise within the pedestrian realm. Space created by the center lane allows for installation of median refuge islands at midblock locations or one-way street intersections without turning movements.

Figure 1 - Road diet on Wabash Avenue in Chicago. Left: photo of the after design. Right: before and after marking designs (graphic from FHWA).

Features

The majority of road diets are comprised of restriping the pavement and adding supplemental signing. However, restriping existing pavement for a road diet may not be ideal due to difficulty for motorists to differentiate between new and removed pavement striping. A road diet is much easier to implement after a road reconstruction or resurfacing. Road diets can also provide room for additional improvements such as raised medians and median refuge islands, and curb bump outs if parking lanes are added.

Warrants

Road diets are ideal on multi-lane roads with excess capacity and an identified need to accommodate bicyclists and/or pedestrians. Good roadway candidates for four to three lane conversions typically have an average daily traffic (ADT count) below 20,000,[2] however, Kentucky allows road diets up to 23,000 ADT, and Seattle up to 25,000 ADT. Roadways in areas with high crash rates and severities are also good candidates, especially for the following crash types: pedestrian, rear-end, opposing left-turn and sideswipe crashes.[1] Roadways with multiple or closely spaced driveways and access points also are good candidates for a road diet if a center turn lane is provided, as it reduces the rear end crash conflict with stopped turning vehicles on the thru lane.

A simple metric to determine suitability for road diets is to ask the question: does the roadway operate as a de facto three-lane roadway anyway?[3] Ultimately, road diets should be considered on a case by case basis. See design guidance in Figure 3 for additional warrants.

Furthermore, the Pedestrian and Bicycle Information Center summarized a list of factors identified by Knapp and Giese to consider in assessing the feasibility of road diet conversions.[4,5] "These factors included the desired as well as current purposes (function and environment) of the roadway, and a number of operational, design, network, and safety factors including:

- Turning patterns and access density
- Signal timing and phasing
- Presence of turn lanes
- Presence of frequently stopping or slow-moving vehicles
- The acceptable levels of service or delay for the corridor and intersections
- The current situation and acceptable operations for side streets and driveways
- Pedestrian and bicycle activity and safety
- Availability of parallel routes
- Prevalence of crash types that may be most amenable to improvement with a road diet
- The ability to enforce the left-turn-only function of the center lane (if created)"

Costs

When planned in conjunction with a road reconstruction or resurfacing, a road diet might not cost any more or less than striping the new surface in the previous configuration.[6] When not done in conjunction with other construction the two main costs are pavement striping removal and pavement striping. Costs for additional features such as bicycle lanes, median refuge islands, curb bump outs, or other crosswalk enhancements can be found in the respective facility reports.

$ Varies

Figure 2 - Lawrence Avenue road diet in Chicago

Design Guidance

FHWA	Manual on Uniform Traffic Control Devices (MUTCD) http://mutcd.fhwa.dot.gov/htm/2009/part9/part9_toc.htm
FHWA	Road Diet Information Guide http://safety.fhwa.dot.gov/road_diets/info_guide/rdig.pdf
FHWA	Road Diet Desk Reference http://safety.fhwa.dot.gov/road_diets/desk_ref/sa_15_046.pdf
Illinois Department of Transportation	BLR Manual: 42-3.03(d) On Existing Roads and Streets http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Local-Roads-and-Streets/Local%20Roads%20and%20Streets%20Manual.pdf
AASHTO	Guide for the Development of Bicycle Facilities Chapters 4.9.2 https://store.transportation.org/Item/CollectionDetail?ID=116
NACTO	Urban Street Design Guide Neighborhood Main Street http://nacto.org/publication/urban-street-design-guide/streets/neighborhood-main-street/

Figure 3 - List of design guidance manuals and documents

SAFETY

Road diets are often installed on roadways to improve safety and reduce certain crashes such as sideswipe, left-turn crashes and rear-end crashes. According to a study by Thomas for the FHWA, positive results have come from the implementation of road diets with differences related to the locations of the road diets. Thomas stated in a synthesis of research for the FHWA that road diet installation reduced crashes by an expected average of 29%, with reductions higher in rural, small urban areas and ADTs of 5,000 to 12,000 vehicles per day at 47% and lower in larger urban/suburban areas and ADTs of 5,000 to 24,000 vehicles per day at 19%.[4] Earlier studies have shown no change in crashes but those studies did not account for regression to the mean nor include a large group of control sites.

Road diets also reduce the speed differential because of the reduction to a single through lane in each direction, and therefore motorist speeds are dictated by the lead vehicle in a platoon. Reducing operating speed can reduce the severity of a crash when one does occur (Knapp et al. 2014). There is also a reduction in sideswipe crashes due to a reduction in motorists changing lanes or passing a left turning motorist. Center lanes provide shelter for motorists and bicyclists waiting to make a left turn and improves visibility of oncoming traffic, reducing rear-end and turning crashes. The reduction to a single through lane in each direction also reduces the likelihood of "multiple threat" crashes by reducing the number of conflict points. Road diets also make it easier to implement a raised median or refuge island for pedestrians, as well as bicycle lanes.

Figure 4 – Median refuge islands on two separate road diet conversions in Chicago. Bottom image reprinted with permission by Skyity.com.

A study for the Michigan DOT calculated a CMF of .91 for road diets (Lyles et al. 2012). A safety analysis determined that road diets can have one or more of the following: "…decreases in crashes since, for example, left-turning vehicles are moved out of a through lane and into the reserved turning lane (the TWLTL) at mid-block non-intersection locations; increases in crashes since two lanes of through vehicles are moved into a single through lane (e.g., rear-end crashes in the right-hand lane become more likely simply due to higher volumes in the lane); and decreases in pedestrian and bicyclist crashes because of the provision of better infrastructure for these users" (Lyles et al. 2012).

"Earlier research and reviews… suggest that optimal safety benefits from road diets may be attained when: [5,7,8]

- The roadway has a moderately high density of driveways and other uncontrolled access
- Crash severities are high
- Speeding contributes to safety problems
- Pedestrians and others crossing/accessing the main corridor are affected by the higher exposure to traffic when crossing
- Multiple lanes
- Frequent crash types that may be most amenable to improvement

Each candidate site should be reviewed on a case by case basis."[9]

OPERATIONS

Road diets affect operations of traffic in various ways. Reduction in motorist lanes reduces capacity but according to the FHWA, a road diet will be more successful if the road already operates as a "de facto three-lane roadway," or a roadway that motorists treat as a two-lane roadway unless they need to pass a left-turning or slow vehicle.[10] Bicyclist volumes may increase due to the addition of bicycle facilities. Pedestrian volumes may also increase over time due to the increase comfort that road diets bring to the pedestrian realm via increased separation from traffic and decrease in exposure to traffic while crossing.

Figure 5 - Bicycle lanes and dedicated left turn lanes at an intersection on the Wabash Street road diet in Chicago

Generally, through-vehicle delay due to turning traffic should decrease but delays for left turning vehicles may increase. Through-vehicle delay and queueing along the main line and minor street approaches may also increase. Increases in delays are generally minor since the roadway may have been operating as a three lane roadway before the road diet conversion. Side-street traffic, pedestrians, and bicyclists can cross more comfortable as speeds, traffic volumes and lanes to cross will be reduced.[10] ITE recommends the use of the HSM 2010 Urban Streets Multimodal Level of Service (MMLOS) method.[11] The MMLOS can help evaluate the benefits that removing a lane of traffic can bring to other modes. It can also help determine whether road diet features that mitigate the lost lane capacity offset any intended improvements to pedestrian or bicycle LOS, which may be one of the original goals. As mentioned elsewhere throughout this feasibility study, and supported by ITE, "designs for increased level of service should be held secondary to designs that seek to provide a safe travel experience to the most vulnerable road users."

Traffic flow will remain consistent because motorists will have to follow the speed of the lead vehicle. Speed differential can be reduced, as a case study found that average and 85th percentile speeds are more likely to decrease by 3 to 5 mph.[10] As mentioned in the facility description, various ADTs can be considered for a road diet conversion. The FHWA compiled a list of several different jurisdictions and what their thresholds are, as shown in Figure 6. PBIC further states:

> Road diet treatment generally seems compatible with maintaining motor vehicle capacity under the volume conditions studied, most often in moderate ranges from around 5,000 up to 24,000 vehicles per day, or up to around 1,500 – 1,750 vehicles per peak hour. Case study evidence suggests that other types of traffic, including bicycles and pedestrians, may increase after a road conversion. It is not entirely clear whether the mobility assessments to date have well-captured actual operational effects of road diets, or whether short term traffic diversion noted in some instances have continued over time. Some studies have shown a short term shift in flows to other corridors, with volumes returning in time. Much of the information to date is in anecdotal or case study format, or based on simulation modeling exercises, which necessarily simplify and omit parameters that may have a bearing on flows. Many of the "worst case" volume scenarios in simulation studies might never occur, or might be mitigated through optimizing signal timing, provision of intermittent turn

Figure 6 - Road diet implementation maximum volume thresholds by Agency. Graphic produced by FHWA.

pockets or roundabouts at intersections, shifts in travel mode if alternate facilities are provided, and other outcomes that have been reported by practitioners.[4]

Ultimately, as the Michigan Department of Transportation recommends, "local conditions (e.g., varying geometry, significant variation in turning movements, and variations in cross-street traffic) can have a significant impact on the viability of any proposed road diet. Thus, while an initial culling of potential road diet sites can be accomplished using [basic ADT guidelines], in all instances a detailed operational analysis of the corridor (including operations at each intersection)" should be undertaken before and after conversion.[12] Consult the FHWA Road Diet Information Guide when choosing and designing road diets to ensure operational effects are mitigated.

MAINTENANCE

Road diets should not require any additional maintenance outside of restriping the pavement markings and maintaining the supplemental signage for TWLTLs and parking lanes. If additional features, such as raised medians or pedestrian refuge islands, are implemented, additional maintenance may be required.

Figure 7 - Striping crew on Washington Street in Chicago

Street Sweeping and Snow Removal

Road diets do not affect street sweeping and snow removal operations since they typically only involve pavement markings installed on existing roadways.

Drainage

Road diets do not influence roadway surface runoff since they typically only involve pavement markings installed on existing roadways.

Utility Cuts and Construction Damage

Pavement markings may be affected during utility repairs, but IDOT and most municipal utility policies require restoration to existing conditions upon utility repair completion by those performing the work.

Typical Infrastructure to Maintain

- Pavement markings
- Supplemental signage for TWLTLs and parking lanes
- Raised medians (optional)
- Bicycle lanes (optional)
- Median refuge islands (optional)

Since their introduction in the 1970's Road Diets have been widely used throughout the country. Below is a list of some road diets around the country.

Table 1 - Examples of road diet locations in the USA, with locations in District One highlighted

Country	City	State	Street	Install Year
USA	San Francisco	CA	Valencia St	1999
USA	Iowa City	IA	Lower Muscatine Rd	2015
USA	**Hoffman Estates**	**IL**	**Huntington Blvd**	**2012**
USA	**Chicago**	**IL**	**Lawrence Ave**	**2012-2013**
USA	Versaille	KY	Lexington Rd	2008
USA	Alpena	MI	Chisholm St	2000
USA	Minneapolis	MN	Riverside Ave	2009-2010
USA	Portland	OR	NE Gilsan	1997
USA	Lewistown	PA	Electric Ave	1980s
USA	Merrifield	VA	Oak Street	2013
USA	Seatle	WA	Nickerson St	2010

[1] Ridgway, Matthew. *Countermeasure Strategies for Pedestrian Safety: Road Diets.* Pedestrian and Bicycle Information Center. October 2015. http://www.pedbikeinfo.org/pdf/Webinar_PSAP_100615.pdf

[2] Rosales, Jennifer A. *Road Diet Handbook: Setting Trends for Livable Streets.* Parsons Brinckerhoff Monograph 20. 2006. New York, New York.
http://archive.northamptonma.gov/WebLink/0/edoc/471721/Road%20Diet%20Presentation.pdf
https://www.ci.wheatridge.co.us/DocumentCenter/View/3153/Road-Diet-Overview-and-Case-Studies?bidId=
https://www.amazon.com/Road-Diet-Handbook-Setting-Livable/dp/B007ZGY35A

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http://www.pedbikeinfo.org/cms/downloads/WhitePaper_RoadDiets_PBIC.pdf

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http://publications.iowa.gov/2888/1/4to3lane.pdf

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http://www.nctcog.org/trans/sustdev/bikeped/workshops/documents/6_DPS201_RoadDiets.pdf (link inactive).

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[8] Welch, T.M. *The conversion of four lane undivided urban roadways to three lane facilities*. Prepared for the TRB/ITE Urban Street Symposium, June 28-39, 1999, Dallas, Texas.

[9] Knapp, K.K, Giese, K.L., and Lee, W. (2003a). "Urban Four-lane Undivided to Three-Lane Roadway Conversion Guidelines." *Proceedings of the 2003 Mid-Continent Transportation Research Symposium*. Ames, Iowa: Iowa State University.

[10] Federal Highway Administration. *Road Diet Informational Guide.* By Knapp, Keith et. al. November 2014. http://safety.fhwa.dot.gov/road_diets/info_guide/rdig.pdf

[11] Pande, Anurag, Brian Wolshon. *Traffic Engineering Handbook: Seventh Edition.* Institute of Transportation Engineering. 2016. John Wiley & Sons, Inc.
http://www.wiley.com/WileyCDA/WileyTitle/productCd-1118762304.html

[12] Michigan Department of Transportation. 2012. *Safety and Operational Analysis of 4-lane to 3-lane Conversions (Road Diets) in Michigan,* By Richard W. Lyles, PhD, M. Abrar Siddiqui, PhD, William C. Taylor, PhD,

Bilal Z. Malik, Gregory Siviy and Tayler Haan. Accessed January 8, 2015.
http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC1555_376149_7.pdf

Bicycle Intersection Markings

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

Summary

Bicycle intersection markings are a collection of tools to reduce conflicts and crashes, increase motorist and bicyclist compliance, and ultimately improve the safety of bicyclists at intersections. Intersection markings can be utilized in tandem with other intersection features or corridor type facilities such as separated bicycle lanes or buffered bicycle lanes. Some features are appropriate for driveway crossings as well. Bicycle specific signals can also be used as an intersection treatment. They fully separate bicycle and vehicle turning movements and are described in a separate report (See bicycle specific signals).

Bicycle Intersection Markings
Bicycle Boxes
Two-Stage Turn Boxes
Intersection Crossings
Mixing Zones
Lateral Shifts

This report is similar to other facility reports with additional subsections for each intersection marking feature. That is, each facility description, safety analysis, and operations analysis section includes a subsection for bicycle boxes, turn boxes, crossings, mixing zones and lateral shifts. The maintenance analysis section shares similar challenges and information across all features so that section is combined.

Intersection markings may contain the following features:

- Dotted white lines
- Shared lane symbols or bicycle symbols
- Colored pavement, traditionally green

Dotted white lines are conventional for intersection markings, typically used as guidance for motorists and bicyclists at complex intersections. They are the minimum design feature of mixing zones and intersection crossing markings. Shared lane markings are bicycle symbols with two chevrons above the symbol. They are used to denote a shared lane or space and alert motorists to the possibility of bicyclists in the lane as well as encourage motorists to yield to bicyclists that are within the shared space. Shared lane markings are used in conjunction with intersection crossing markings, lateral shifts, and mixing zones. The bicycle symbol is used alone in the bicycle box or with a turn arrow in the two-stage turn box. Colored pavement is used for bicycle boxes and two-stage turn boxes, and may be used for lateral shifts, intersection crossing markings and mixing zones.

Bicycle Boxes

A bicycle box, or advanced stop line, is a designated area for bicyclists at the head of a traffic lane at a signalized intersection.[1] Motorists are required to stop behind the near stop line while bicyclists may stop at the far stop line (see Figure 1 below). This provides bicyclists an opportunity to queue and proceed ahead of motorists, offering various safety and comfort benefits.

Figure 1 – Bicycle boxes at the head of both southbound traffic lanes along Milwaukee Avenue at the intersection with Desplaines Street and Kinzie Street in Chicago

Bicycle boxes are designed to increase visibility of bicyclists by placing them ahead of motorists, reduce signal delay for bicyclists, and help reduce right-hook crashes that can occur between a right turning motorist and a through moving bicyclist. The boxes also group bicyclists together so that the intersection may be cleared at a faster rate. Bicycle boxes further prevent conflicts between bicyclists crossing and motorists and assist riders in queuing for left turns where bicycle boxes extend into the left turn lane. Motorist yielding rates increase and bicyclists generally feel safer in bicycle boxes. [1] See the safety and operations analysis for more detailed information. Bicycle boxes have experimental status with the MUTCD.

Figure 2 - MUTCD signage (R10-6a) instructing motorists to stop at the stop bar and discourage encroachment on the bicycle box.

Features

- Bicycle lane opens up to a full lane width waiting area designated for bicyclists.
    - Some cities color the lane and waiting area to make them more visible to motorists.
    - Waiting area is large enough to accommodate several bicyclists.
- 24" stop line at near side of box indicates where motorists must stop for a red light in order to give maximum space to bicyclists at the front of the lane.
- NACTO recommends that boxes be sized 10 to 16 feet deep[1]. The City of Austin, Texas Bicycle Team study "Effects of Bicycle Boxes on Bicyclist and Motorist Behavior at Intersections" states that "feedback from the public indicates that 8 feet is not large (deep) enough (for a bicycle) to comfortably maneuver into the box."[2]

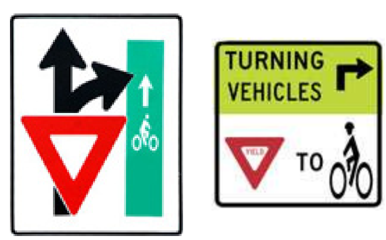

Figure 3 - NACTO suggested signage that modifies MUTCD R10-15 and R1-5.

- Pavement markings are usually reinforced with signage instructing motorists to stop before the bicycle box and to first yield to bicyclists before proceeding through the intersection or turning. See Figure XX for examples, MUTCD, and NACTO for further sign guidance.

Figure 4 - Locally designed signage in Vancouver, British Columbia, Canada. Photo of the sign by Greg Raisman.

Warrants

NACTO suggests considering the installation of a bicycle box in the following situations[1]:

- At signalized intersections with high volumes of bicycles and/or motor vehicles, especially those with frequent bicyclist left-turns and/or motorist right-turns.
- Where there may be right or left-turning conflicts between bicyclists and motorists.
- Where there is a desire to better accommodate left turning bicycle traffic.
- Where a bicyclist left turn is required to follow a designated bicycle route, access a shared-use path, or when the bicycle lane moves to the left side of the street.
- When the dominant motor vehicle traffic flows right and bicycle traffic continues through (such as a Y intersection or access ramp).

Cost

$ | $1,850 | Average cost (2015)

Typical cost of installation as part of new paving or repaving projects is between $200 to $800 per intersection and $1000 to $2000 for retrofitted installations on existing pavement, depending on the size of the box. Adding signage costs $200 each. Individually, shared lane markings cost an average of $180 each, which are similar to bicycle and turn arrow markings.[3] Bushell reported green pavement costing $11.50 per square foot in 2013 dollars. Solid white striping must also be factored into the cost. An example bicycle box 13 FT deep and on an 11 FT wide lane would cost about $1850.

Two-Stage Turn Boxes

Two-stage turn boxes provide a designated area for bicyclists to make a safe, comfortable left turn from a right side bicycle lane or cycle track, or a right turn from a left side bicycle lane or cycle track, through a multi-lane signalized

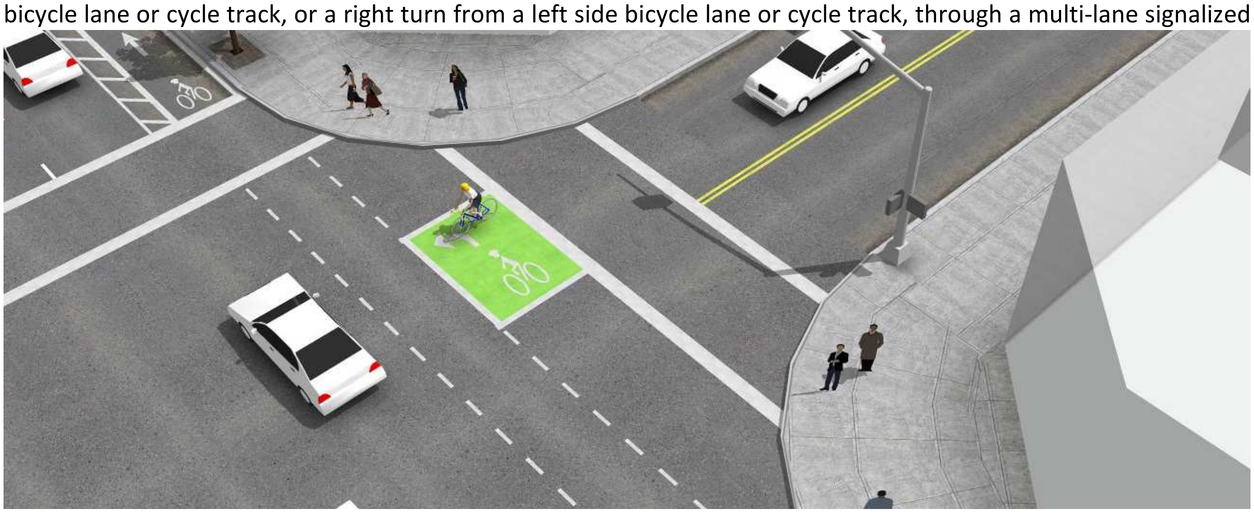

Figure 5 - Two-stage turn box diagram on a one-way separated bicycle lane. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

intersection .[1] The turning maneuver required is known as a Copenhagen Left or a Jug Handle turn. To use, bicyclists ride into the intersection, stop in the turn box, orientate their bicycle in the direction of cross traffic, and wait for the cross street signal to turn green before continuing. They are useful for bicyclists unaccustomed to making left turns through heavy traffic. While they may increase intersection delay for turning bicyclists, providing a designated space encourages bicyclists to stay clear of through bicyclists, pedestrians, and motorists which in turn decreases the intersection delay for those users. As of 2014, two-stage turn boxes are considered experimental and require FHWA approval before installation. Two-stage turn boxes are particularly helpful when used at multilane signalized intersections, on roadways with high speed limits and/or high traffic volumes, and at intersections with a high number of bicyclists turning left from a right side cycle track or bicycle lane.[4] Since the turn box is used as a bi-directional pavement marking and symbol, it will contain an arrow signifying entry from only one direction; however, the facility may be approached and used from both directions.

Figure 6 - A two-stage turn box in Chicago

Features

NACTO notes the following for two-stage turn boxes:

- They should contain bicycle and turn arrow pavement marking symbols to clearly define proper bicycle direction and positioning.
- They must be placed in an area protected from cross traffic, typically in an on-street parking lane or between the bicycle lane and pedestrian crossing.
- A "No Turn on Red" sign shall be installed overhead to prevent motorists encroaching into the queuing area.

NACTO also recommends coloring the pavement inside the queue box to further define the box, and adding markings to guide bicyclists through the intersection. In cases where the two-stage turn box will not fit due to roadway geometry constraints, the pedestrian crosswalk may be adjusted or realigned to create additional space for the queue box, or the box may be placed behind the pedestrian crossing. The latter option should only be considered if pedestrian volumes are low.[1]

Costs

Shared lane markings cost an average of $180 each, which are similar to bicycle and turn arrow markings.[3] Bushell reported green pavement costing $11.50 per square foot in 2013 dollars. Solid white striping must also be factored into the cost. An example turn box, 5' wide and in line with an 8' wide parking lane, would cost about $650.

$ | $650 Average cost (2015)

Intersection Crossings

Bicycle pavement markings through an intersection define the intended path of bicyclists, and provide a boundary between bicyclists and motorists within the intersection. Similar to mixing zones, they help guide bicyclists through intersections and provide a continuation of a bicycle lane. Intersection crossings reinforce bicyclist right of way and alert turning motorists, on either leg, to expect bicyclists travelling through the intersection. Furthermore, by defining a path, bicyclists are encouraged to travel in a more predictable fashion. Intersection crossings are useful at offset intersections or lanes and at complex, wide intersections. They can also be utilized at driveway or expressway ramp crossings.

Figure 7 - Various bicycle pavement markings through an intersection. Images from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Figure 8 – Driveway/alley intersection marking with shared lane marking and green pavement on Harrison Street in Chicago.

Figure 10 - Dotted and colored intersection marking with bicycle symbols orientated toward the cross traffic direction on Kinzie Street in Chicago.

Figure 9 - Intersection marking with shared lane marking on the Wabash Street buffered bicycle lane in Chicago.

Figure 11 - Intersection crossing marking with dotted striping, colored pavement, and bicycle symbols orientated in the direction of approaching traffic. The crossing includes associated signage and is located on a separated bicycle lane on Kinzie Street in Chicago.

Figure 12 - Shared lane marking intersection crossings along Ardmore Avenue in Chicago

Figure 13 - Dotted striping and colored pavement intersection marking along the 18th Street separated bicycle lane in Chicago.

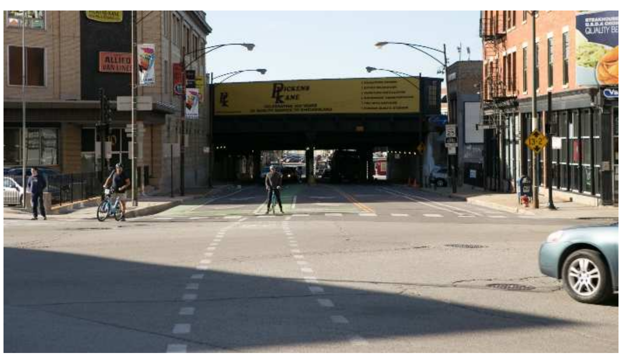

Figure 14 - Dotted striping intersection crossing marking on Milwaukee Avenue in Chicago.

Figure 15 - Intersection crossing marking with dotted striping, shared lane markings, and pedestrian warnings inside the crosswalk on the Dearborn Street two-way separated bicycle lane in Chicago.

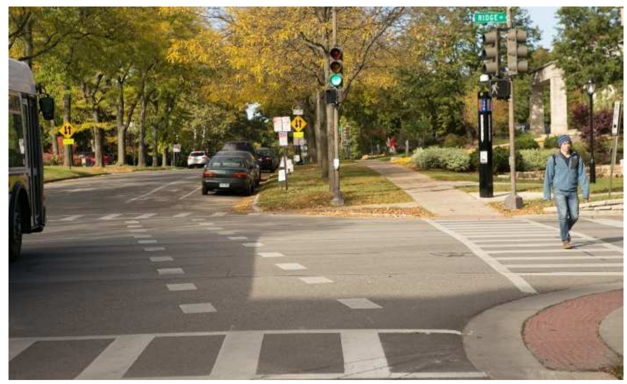

Figure 16 - Intersection crossing marking with "elephants feet" striping along the Church Street separated bicycle lane in Evanston. The markings help guide bicyclists at an offset intersection. See the section on Lateral Shifts below for more information on various striping options.

Figure 17 - Intersection crossing marking with dotted striping, colored pavement, and a shared lane marking on Milwaukee Avenue at an angled intersection in Chicago

Features

Intersection crossings utilize the following:

- Dotted lines
- Green pavement
- Shared lane markings

Costs

$ | $5,000 Average cost (2015)

Cost estimates for an intersection crossing markings are similar to lateral shifts. They vary depending on the complexity of the installation and features used. The simplest installation is two parallel dotted white lines, therefore use the estimate for conventional bicycle lanes which cost $133,170 per mile (or $25.20 per foot) on average in 2013 dollars ($25.78 in 2013 dollars).[3] Other features, such as shared lane markings cost an average of $180 each. Bushell reported green pavement costing $11.50 per square foot in 2013 dollars. An example 80 FT crossing with dotted white lines, green pavement and two shared lane markings would cost about $5,000 with the bulk of the cost coming from the green pavement.

Mixing Zones

A mixing zone, also known as a combined bicycle lane / turn lane, is a tool for creating a shared use space between bicyclists and turning motorists when approaching an intersection. The mixing zone is a dedicated turn lane with shared lane markings or a dotted bicycle lane. The markings instruct through bicyclists on the best lane usage and positioning while alerting the motorist to expect bicyclists in the lane. Proper lane positioning helps reduce right hooks where a motorist turns right colliding with a bicyclist who is passing on the right. Mixing zones provide a continuation of a preceding bicycle facility and help maintain bicyclist comfort through a critical conflict area.

Figure 18 – Two mixing zone variations, one with a shared bicycle lane symbol (left) and another with a dotted bicycle lane (right). Images from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Figure 19 - Mixing zone on Milwaukee Avenue in Chicago

Figure 20 – A mixing zone with yield markings and a right-side dotted bicycle lane on Madison Street in Chicago.

Mixing zones are typically used on streets with a high volume of right turning vehicles. This solution is ideal for roads that are not wide enough for both a bicycle lane and a full size right turn lane. They can be used with separated bicycle lanes, buffered bicycle lanes, conventional bicycle lanes, or shared bicycle lanes.

Features

Mixing zones are designed with striping and signage and borrow elements from traditional bicycle facility design such as shared lane markings or bicycle lane markings.

Warrants

According to NACTO *Urban Bikeway Design Guide*, some of the typical applications for mixing zones include:

- Streets where there is a right turn lane but there is not enough room for a standard width bicycle lane.
- Streets where there is a high volume of right turning vehicles. Extra consideration should be made for streets with very high volumes of peak motorist demand.
- On cycle track corridors where there is a dedicated turn lane on the side of the street with the cycle track, but where a separate bicycle signal phase is not appropriate or feasible.

Mixing zones are not allowed by the MUTCD with dotted bicycle lane markings such as shown in Figure 18. The MUTCD does allow shared lane markings be striped within the turn lane, however.[5]

Costs

$ | $700-$3,500 (see text)

Cost estimates for a mixing zone vary depending on the complexity of the installation and features used. The simplest installation is installing two shared lane markings and a dedicated right turn lane (for basic intersections similar to those found throughout Chicago, existing conditions are composed of a bicycle lane, a left turn lane, and a through motorist lane so therefore the right turn lane cost is incidental to the bicycle facility). The individual components are estimated at $100 for 6 inch white thermoplastic striping and assuming $250 per right turn arrow and lettering, the total cost would be $710. If green pavement and dotted bicycle lanes are used, the example cost would be $3500. Bushell reported green pavement costing $11.50 per square foot in 2015 dollars.[3]

Lateral Shifts

Lateral shifts, also called through bicycle lanes, include the shifting of turning motorists across a conventional bicycle lane, or buffered bicycle lane in advance of the intersection. The bicycle lane then continues in a dedicated through lane adjacent to the turn lane. Bicyclists can continue straight through the intersection or merge into the turn lane. There are a variety of ways to stripe the shift and weave area; Figure 5 shows a few of the more common methods. Green coloring is often added through these facilities to bring more attention to a high conflict area. Lateral shifts are also similar to bicycle intersection crossings.

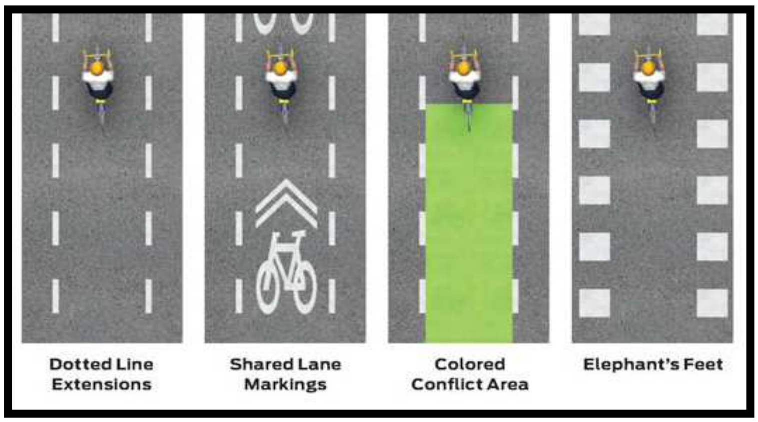

Figure 21 – Various striping methods for lateral shifts. Image from Urban Bikeway Design Guide*, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.*

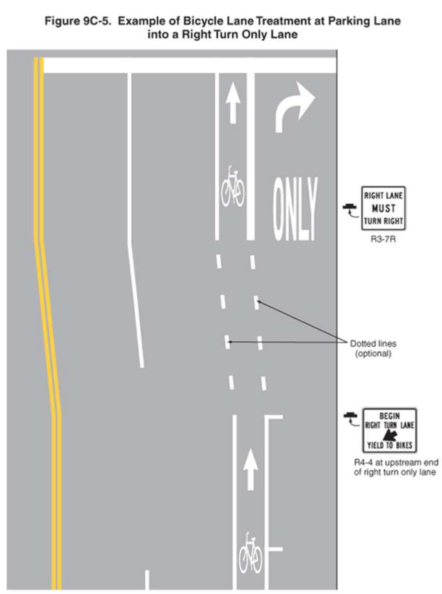

Figure 22 - MUTCD example of a mixing zone

Regulations concerning lateral shifts only dictate bicycle lane widths, taper requirements, and use of dotted lines. Transportation engineers have additional freedom to design optional enhancements to lateral shifts to accommodate the specific needs of the bicyclists and motorists at different intersections.

Lateral shifts help guide bicyclists in a situation where the bicycle lane might be dropped prior to the intersection, maintain bicyclist comfort and priority in the absence of a dedicated signal phase, reduce motor vehicle speed prior to turning, and angle motor vehicles so that bicyclists are more visible prior to merging.

Figure 23 - Skip-dash striping lateral shift in Chicago. The bicycle lane is tapered out into the street to allow room for a turn lane and parking up ahead.

Figure 24 - Approach to a skip-dash striping, colored pavement, and shared lane lateral shift on 18th Street in Chicago

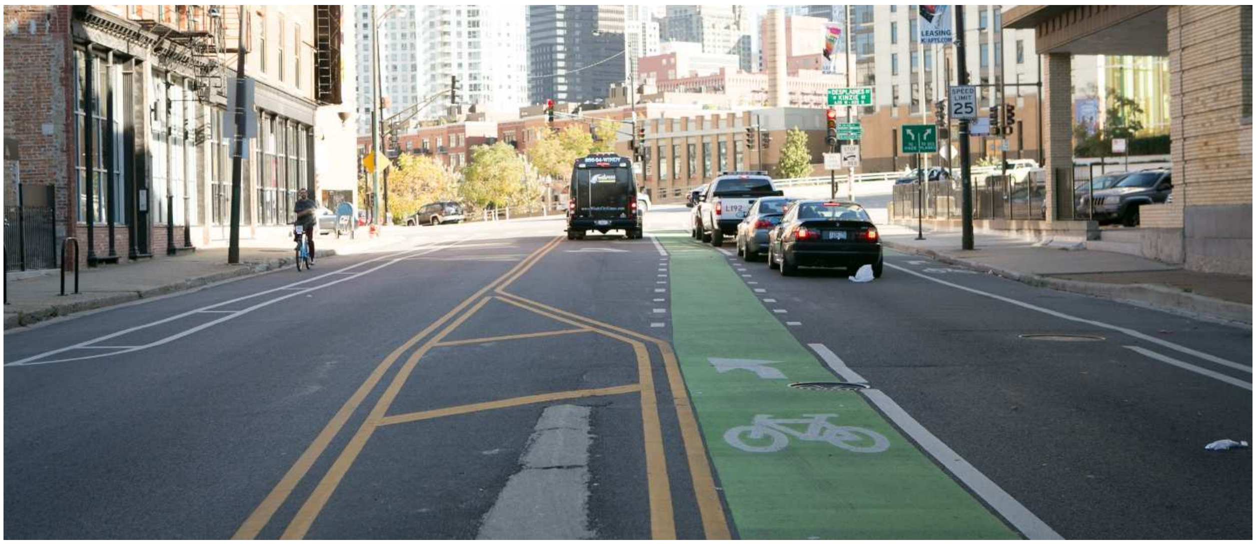

Figure 25 - A lateral shift adjacent to a left turn lane with skip-dash striping with colored pavement and turn lane symbol on Milwaukee Avenue in Chicago

Figure 26 - Lateral shift with thick dotted striping, dotted colored pavement, and shared lane markings during the transition to an expressway onramp on Kedzie Avenue, Chicago

Figure 27 – Example lateral shift. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Features

Lateral shifts may include:

- Green pavement
- Dotted lines
- Shared-lane markings

Costs

$ | $4,600 Average cost (2015)

The simplest installation is two parallel, dotted white lines, therefore use the estimate for 6 inch white thermoplastic pavement markings, which will result in a minimal cost. Shared lane markings cost an average of $180 each and bicycle lane symbols with arrows cost $160 each(2013 dollars).[3] Bushell reported green pavement as costing $11.50 per square foot in 2013 dollars. An example 80 FT weave and storage area with dotted white lines, green pavement, and two bicycle lane symbols with arrows would cost about $4,600 with the bulk of the cost coming from the green pavement.

Design Guidance

AASHTO	Guide for the Development of Bicycle Facilities https://store.transportation.org/Item/CollectionDetail?ID=116
FHWA	Separated Bike Lane Planning and Design Guide* http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm
FHWA	Bicycle and Pedestrian Facility Design Flexibility https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_flexibility.cfm
FHWA	Interim Approval for Optional Use of Green Colored Pavement for Bike Lanes http://mutcd.fhwa.dot.gov/resources/interim_approval/ia14/
ite	Separated Bikeways http://ecommerce.ite.org/IMIS/ItemDetail?iProductCode=IR-135
NACTO	Urban Bikeway Design Guide http://nacto.org/publication/urban-bikeway-design-guide/intersection-treatments/

Figure 28 - List of design guidance manuals and documents

SAFETY

Bicycle intersection markings are an important safety element of bicycle facility design. They are designed to reduce conflicts and crashes and maintain bicyclist comfort on the approach and through intersections, especially when used in conjunction with separated bicycle lanes (SBL).

Intersections typically experience higher rates of crashes. For instance, USDOT found 33% of fatal bicycle crashes and 57% of bicycle injury collisions occurred at intersections.[6] Furthermore, 57% of intersection collisions involved turning movements. Previous studies on SBLs show increased safety in the segments between intersections due to the barrier but decreased safety at intersections due to conflicts with turning vehicles.[7] Summarizing a study in Copenhagen, Lusk et. al. stated that crashes increased by 18% at the intersection and decreased by 4% to 10% in the segment after installation of a separated bicycle lane.[8] A main factor at intersections is that a bicyclist may not be visible to turning motorists, an issue compounded by the presence of the barriers such as parked cars or planter boxes. In another study, 74% of bicyclist-motorist crashes over a four year period in Palo Alto were at an intersection [9] "In New York City, intersections account for 88% of bicyclist injuries and 84% of bicyclist fatalities."[10] Therefore, particular attention is required at intersections where SBLs are to be implemented (see the SBL report for more information). Markings that indicate the path of bicycle lanes across intersections should be included to reduce crashes at intersections.[11] Since many conflicts occur with turning vehicles, bicycle facility design should also include marking installations on the approach to the intersection and before turn lanes to reduce crashes during merges.

Besides SBLs, intersection markings can be used for buffered and conventional bicycle lanes, shared lanes, and bicycle boulevards, which share the same challenges as SBLs regarding conflict and crashes at intersections. For most bicycle facilities, the protection of a buffer or physical separation drops at an intersection due to restricted widths and often to accommodate turn lanes and maintain traffic operations.

Figure 29 - Dotted white lines delineating an SBL intersection crossing on Church Street in Evanston, IL

As mentioned in the facility description, intersection markings may contain the following features:

- Dotted white lines
- Shared lane symbols or bicycle symbols
- Colored pavement, traditionally green

Dotted White Lines

Dotted white lines are considered as a minimum for striping application at mixing zones, lateral shifts and crossing markings. They help guide bicyclists and motorists on proper lane usage and promote predictable riding patterns. Predictability is important, because when motorists know where bicyclists will ride next, especially at offset intersections or lane merges, collisions can be prevented. Many bicycle safety websites state the importance of predictable riding in reducing crashes.[12,13,14,15]

Figure 30 - Shared lane markings calling attention to a popular intersection crossing from the Lake Front Trail on Ardmore Avenue in Chicago

Shared Lane Markings

Shared lane markings (SLMs) are used to denote a shared lane or space, alert motorists to the possibility of bicyclists in the lane, and encourage motorists to yield to bicyclists within the shared space. "In the absence of bicycle lanes, motorists often neglect to safely share travel lanes with bicyclists, which can compel bicyclists to ride closer to parked motor vehicles".[16] Riding close to passing vehicles is uncomfortable for bicyclists and leaves little margin for error. Therefore, SLMs are useful for maintaining position in the center of a lane that is too narrow for both the bicyclist and a motorist to share. SLMs also assist bicyclists with lateral positioning to encourage bicyclists to ride outside the door zone. They alert motorists of the lateral position that bicyclists are likely to occupy, further promoting predictability. The chevrons and orientation of the bicycle symbol help reduce the incidence of wrong-way riding. See the FHWA's report on the effectiveness of shared lane markings for more information.[16]

Figure 31 - Green colored pavement, with shared lane markings and dotted white lines, delineating an SBL intersection crossing marking on Davis Street in Evanston, IL

Green (or colored) Pavement Marking

Colored pavement is typically used in conflict areas or where special attention is warranted. Any bicycle intersection marking may contain colored pavement. Colored pavement helps enforce the priority of the space for bicyclists. Similar to dotted bicycle lanes and shared lane markings, they help designate locations where bicyclists are expected to operate. Green, blue and red have been tested for bicycle facility use but green is the only color approved by the FHWA for experimental use. FHWA has noted positive effects such as "bicyclists positioning themselves more accurately as they travel across the intersections and through conflict areas… Research has also shown that bicyclists and motorists both have a positive impression of the effect of the green colored pavement, with the bicyclists saying that they feel safer when the green colored pavement is present and the motorists saying that the green colored pavement gives them an increased awareness that bicyclists might be present and where those bicyclists are likely to be positioned within the traveled way."[17] See the FHWA memorandum concerning interim approval of green colored pavement for more information.

Figure 32 - Green pavement on the approach to a bicycle box at Desplaines Street and Milwaukee Avenue in Chicago

A study by NYCDOT "indicates that the green paint treatment resulted in fewer instances of motorists encroaching on the bicycle lane by driving on the bicycle lane boundary line. Overall, 7% of motorists on the green paint treated streets drove on the bicycle lane boundary line as opposed to 16% of motorists on streets with the typical non-painted bicycle lane treatment. The data also showed fewer instances in driving in the bicycle lane; on average, 4% of motorists drove in the bicycle lane on green paint treated streets as opposed to 7% on typical streets. The frequency of standing or parking in the bicycle lane between the two different paint treatments was comparable."[10]

Bicycle Boxes

Bicycle boxes increase bicyclist safety and comfort at intersections. They encourage bicyclists to ride to the front of the traffic queue, increasing their visibility to motorists.[18] Bicycle boxes also help prevent "right-hook" crashes since bicyclists can position themselves ahead of turning traffic instead of behind it, where the bicyclist may confuse turning traffic with straight through traffic and pass on the right or motorists may have trouble seeing the bicyclist.[19]

Positioning bicyclists ahead of the traffic queue also reduces breathing vehicle exhaust, a serious and sometimes overlooked aspect of bicycle facility design.[20,21] Reducing one's proximity to heavy traffic can reduce the occurrence of asthma attacks and abnormal heart rhythms (health.gov). Even separation of a few feet can result in reduced particulate matter intake by the bicyclist.[22] By providing additional buffer space between the crosswalk and the motorist stop bar, bicycle boxes also reduce vehicle encroachment into the crosswalk thus increasing safety for pedestrians as well. Two studies are summarized below detailing the effectiveness of bicycle boxes.

Figure 33 - Bicycle box on Milwaukee Avenue in Chicago

The City of Austin installed bicycle boxes along a roadway that served as a common commuter path for college students.[2] Three separate conditions were analyzed using before and after video footage: prior to the installation of the boxes, after the installation of a skeleton bicycle box (color absent inside the box), and after the installation of color inside the bicycle box. The roadway had a speed limit of 25 mph and an hourly traffic volume between 150 and 250 vehicles. After the skeleton bicycle box installation, there was a decrease in avoidance maneuvers, an increase in the percentage of bicyclists departing the intersection prior to motorists (which may indicate increased yielding by motorists), and an increase in bicyclists remaining in the bicycle lane while approaching the intersection (as shown in Figure 34 and Figure 35). Adding green color to the bicycle box decreased encroachment of motorists into the bicycle box, and increased the visibility and use of the facility (see Figure 38 for examples of encroachment). The increase in encroachment may have been "due to motorists being unaware of the intention of the bicycle box. The study results did not elaborate with numerical values except through charts and with bicyclist positioning.

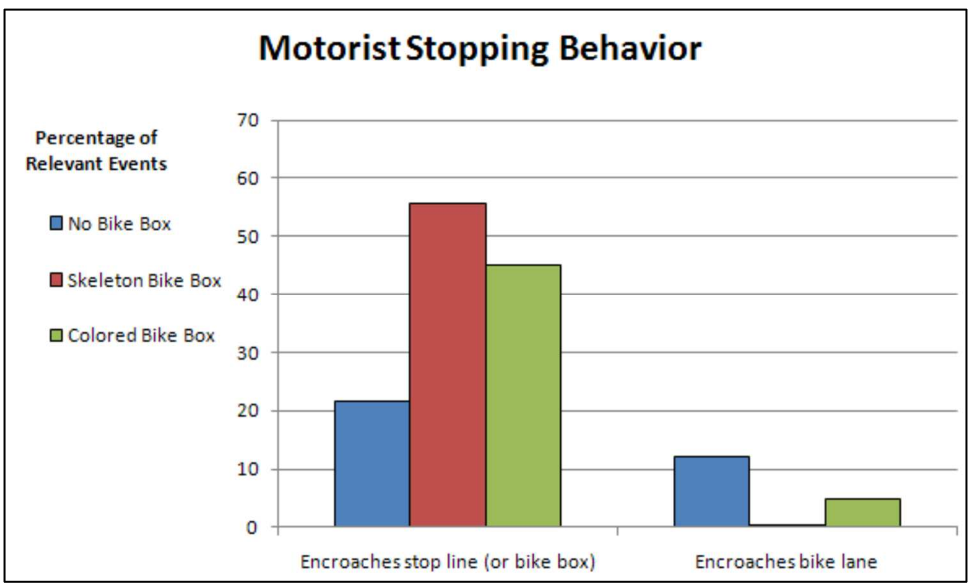

Figure 34 - Motorist encroachment on bicycle box on Speedway and 38th Street in Austin, Texas. Figure by Jeff Loskorn for the City of Austin, reprinted with permission.

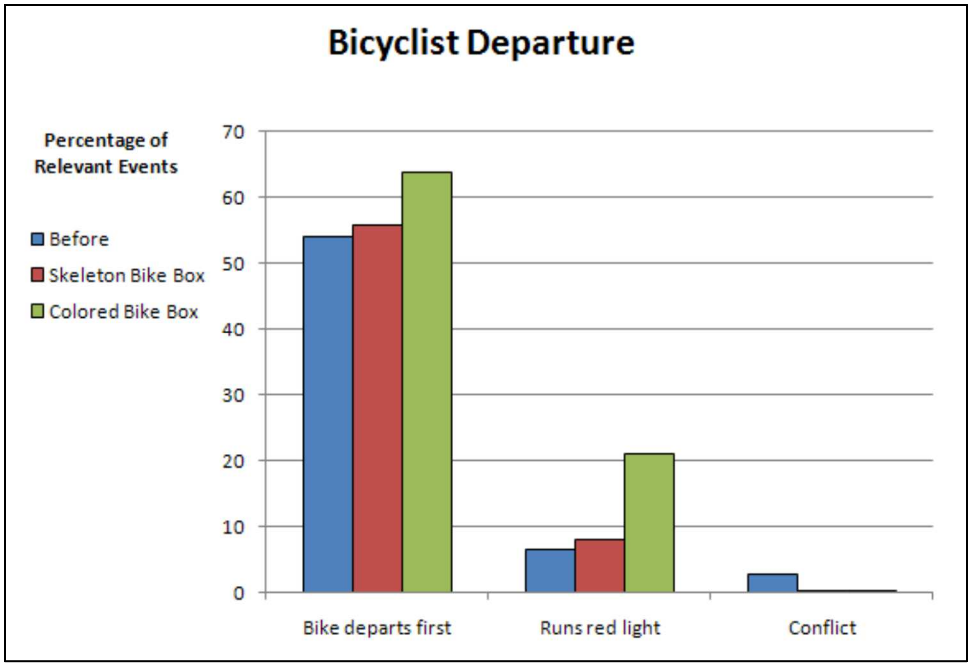

Figure 35 - Bicyclists behavior before and after installation of a bicycle box on Speedway and 38th Street in Austin, Texas. Figure by Jeff Loskorn for the City of Austin, reproduced with permission.

Based on the two study sites, Austin's Bicycle Team noted that "bicycle boxes accompanied with "No Right Turn on Red" signs can improve the safety of bicyclists and motorists at intersections."[2] They also suggest that color be added to the box, if financially feasible. Motorist encroachment on bicyclist space was less frequent and bicyclists were given the right of way more often with the colored box in comparison to the skeleton box. If coloring the box is not an option, Austin still recommends installing the skeleton bicycle box based on positive results from their study. Figure 36 shows bicyclist stopping position by percentage for both of the study sites, before and after color was added to the box.

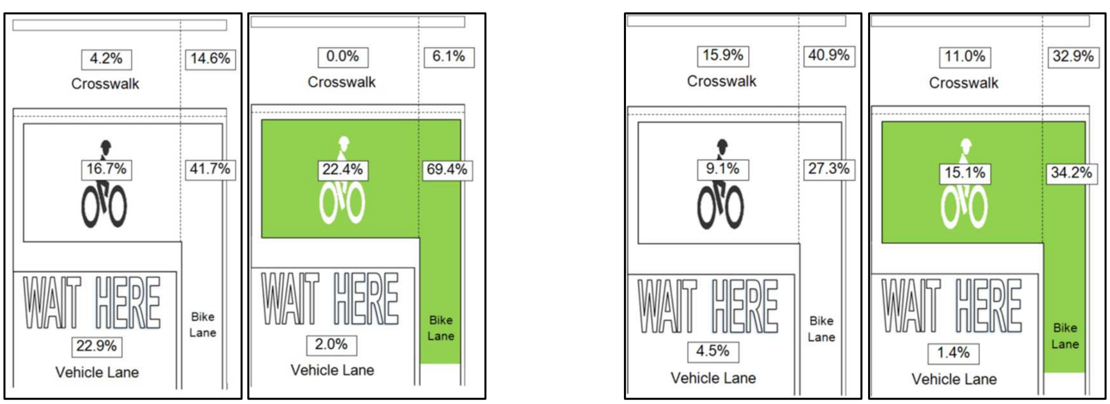

Figure 36 - Bicyclist stopping position before and after installation of colored pavement on Speedway and 38th Street in Austin, Texas. Graphic by Jeff Loskorn for the City of Austin, reprinted with permission.

Figure 37 -"STOP HERE" lettering preceding a bicycle box on Augusta Boulevard in Chicago

Another robust study was completed in Portland, OR that examined encroachment and stopping position, and conducted a motorist and bicyclist survey. The researchers found "77% of motorists stopped at the appropriate position before the installation (at the stop bar prior to the pedestrian crosswalk), while 73% stopped at the appropriate position after the installation at (at the stop bar prior to the bicycle box)".[23] This decrease in compliance is similar to the Austin study. Both studies included "WAIT HERE" lettering before the stop bar after the bicycle box was installed, similar to Chicago's "STOP HERE" lettering as shown in Figure 37. Motorist and bicyclist encroachment of the crosswalk both dropped after installation of the bicycle box with bicyclist encroachment declining from 41% to 25% (the percent drop for motorists was not given). The number of conflicts between motorists and pedestrians "decreased from 29 to 20 after installation, while the total number of bicyclists increased 94% and motor vehicle right-turn volumes increased by 15%." Conflicts were defined in another study as "interactions that could potentially lead to a collision if evasive action was not taken by the bicyclist or motorist."[33]

Furthermore, researchers found motorist yielding to bicyclists increased by 500% and 429% at two bicycle box locations and decreased at the control location. They claim the "increase is partially driven by additional interactions as a result of increased volumes; however, the increase in yielding is proportionally more than the volume increase." Similar to the Austin study, researchers found that the presence of color in the bicycle box encouraged more bicyclists to stop ahead of the vehicle stop bar, increasing from 66% to 75%. Additionally, "without color, a higher proportion (23%) chose to stay [in the bicycle lane before the vehicle stop bar] while only 5% did with color" (this position was not distinguished in the Austin study).

Many bicyclists (77%) that were surveyed for this report felt intersections were safer with the bicycle boxes installed compared to 2% that felt it was more dangerous. Many motorists also agreed; 42% of the motorists who are not also bicyclists felt driving at intersections with bicycle boxes was safer compared to 14% who felt it was more dangerous. "The observational data [for the Portland study] did not detect significant differences between the green and no-color boxes… the vast majority of surveyed motorists [90%] preferred the green boxes."

No robust crash analysis research was found that isolated bicycle boxes. Researchers in the Portland study also performed a meta-analysis of other bicycle box studies and found none of the studies had an adequate amount of crash data to make firm conclusions.[23] However, "Newman found an overall trend toward accident reduction after installation, while Allen et al. found some sites with increased casualties and others with decreased causalities."[19] As bicycle boxes grow in popularity in Northeast Illinois and around the country, and bicycle counting capabilities increase, more detailed crash analysis should be performed that isolates bicycle boxes from other facilities such as separated bicycle lanes or other intersection facilities.

Figure 38 - Various levels of compliance with bicycle boxes in Chicago

Two-Stage Turn Boxes

Figure 39 - Two-stage turn box between the SBL and the travel lanes on the two-way SBL on Dearborn Street in Chicago

The FHWA has issued experimental approval to several communities but there have not been any studies published online evaluating the effectiveness of the facility. The National Committee on Uniform Traffic Control Devices (NCUTCD) has; however, recommended two-stage turn boxes for full inclusion in the MUTCD. Furthermore, many safety benefits are inherent and apparent without studies. Two-stage turn boxes often accompany separated bicycle facilities to provide a comfortable route for turning bicyclists that separates them from motorists and other bicyclists. Thus, the turn boxes reduce conflicts and intersection complexity. For some separated bicycle lanes, two-stage turn boxes may be the only means of allowing bicyclists to make a left-turn movement either due to SBL barrier or one-way traffic moving in the opposite direction. Two-stage turn boxes also separate left turn bicyclists from through bicyclists, reducing bicyclist-bicyclist conflicts.

Figure 40 - Two stage turn box adjacent to a street-car route. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Numerous installations have been approved for experimental installation by the FHWA and will be evaluated for their effectiveness over the coming years. Some data being collected include the method of turning bicyclists, vehicle encroachment, “No Turn on Red” compliance, and conflict and crash analysis (Egan 2014).[24] Maddox posted about her field observations on bicyclists at Dearborn and Washington Street in Chicago .[25] For two hours, she observed 100% of left turning bicyclists use the two-stage turn box installed in that intersection, suggesting the treatment was used properly and is effective in separating turning bicycle traffic.

Two-stage turn boxes may also be used on street-car routes, as seen in Figure 40 [26] where left-turning bicyclists traveling parallel to in-pavement train tracks would otherwise be required to weave across the rail lines. This creates a dangerous situation where the bicycle tire could be caught between the pavement and track. Turn boxes are not seen with traditional railroad crossings or cases where the railroad tracks cross at an oblique angle, because the bicycle lane is used instead to steer bicyclists to cross at a perpendicular angle. Most railroad crossings do not require a 90 degree turn for bicyclists like streetcar routes.

Intersection Crossings

Bicycle pavement markings through intersections are implemented mainly as a safety device aimed at decreasing intersection crashes. Intersection crossings define the intended path of bicyclists, provide a boundary between bicyclists and motorists, guide motorists, reinforce right-of-way, and alert motorists to the presence of bicyclists. They are sometimes used with innovative features such as green pavement to call further attention to the presence of bicyclists.

Figure 41 - Dotted stripe intersection marking with shared lane marking on the Wabash Street buffered bicycle lane in Chicago

Some studies that examined specific features of crossing markings have shown benefits. For instance, Hunter et al. looked at blue-colored pavement markings installed at bicycle crossings of expressway on-ramps in Portland, Oregon.[31] Yielding by motorists increased from 71.7% to 92.0% after installation of the colored pavement. Furthermore, bicyclists traveling on the intended path increased from 85% to 93% after installation. The intended path crossed the bicyclist at a perpendicular angle to the on-ramp, decreasing crossing distance. However, fewer bicyclists turned their head to check for approaching motorists after installation (42% to 26%). The authors believe this indicates increased comfort with the crossing but may result in a false sense of security. Opinion surveys found that 76% of bicyclists felt the locations with blue pavement were safer and 1% felt they were less safe. The surveys found 49% of motorists thought the blue pavement made the area more safe compared to 12% who felt it made the area less safe. Finally, the authors found "the rate of conflicts per 100 entering bicyclists decreased from 0.95 in the before period to 0.59 in the after period." Overall, the authors conclude their findings point to safer conditions with blue pavement crossings.

Another study examining blue pavement was conducted in the Netherlands.[27] Intersections with one blue pavement crossing found a 10% reduction in crashes after installation. However, intersections with two or more bicycle intersection crossing paths saw increases in non-targeted types of crashes such as rear end collisions between motorists. Jensen postulates that "perhaps motorists disregard the 'warning messages' if there are too many of them or are confused and spread their focus too much." The complex four-way colored pavement intersections are rare in the United States and have only recently been attempted in a couple US cities. Most instances of colored pavement intersection crossings in Illinois' District One have been with one crossing on one-way streets or two crossings, one for each direction, on two-way streets. Therefore, the intersections in Illinois may perform better than indicated in the Jensen study due to the simpler designs. If considering using more complex intersection crossing markings or protected bicycle intersections, especially on large size and high volume intersections, then using more than one or two crossing markings should be evaluated carefully for their benefit. Engineers should review the performance of the US installations or follow up with the Jensen study locations.

As mentioned earlier regarding green pavement, an element of bicycle intersection crossings, the FHWA has noted positive safety effects such as bicyclists positioning themselves more accurately as they travel across intersections, bicyclists feel safer when green pavement is present, and motorists saying that green pavement increased their awareness that bicyclists might be present and predicting where bicyclists will position themselves.[16]

Mixing Zones

In Lessons from the Green Lane, Monsere et al. evaluated several mixing zones around the US; they are summarized in the following paragraphs.[28] "With some exceptions… the large majority of [motorists] and bicyclists stated that they understood the intent of the mixing zone designs and were observed to use them as intended. In addition, a majority of bicyclists using the intersections stated feeling safe." Monsere et al. evaluated mixing zones with either dotted bicycle lanes or shared lane markings denoting the mixing. The variations of the two mixing zones that were observed are shown in Figure 43. Note, "Turning Zones" in Monsere study refer to dotted mixing zones. The mixing zones with dotted bicycle lanes "helped position bicyclists and reduce confusion compared to sharrows in mixing zones." In Washington D.C., 87% of turning motorists and 91% of through bicyclists used the lane correctly. Most bicyclists (64%) agreed they felt safe in the turn lane. At another dotted mixing zone in San Francisco, 66% of turning motorists and 81% of through bicyclists used the lane correctly, and 74% of bicyclists agreed they felt safe.

Figure 42 - Mixing zone with shared lane markings and yield markings on the Desplaines Street separated bicycle lane in Chicago

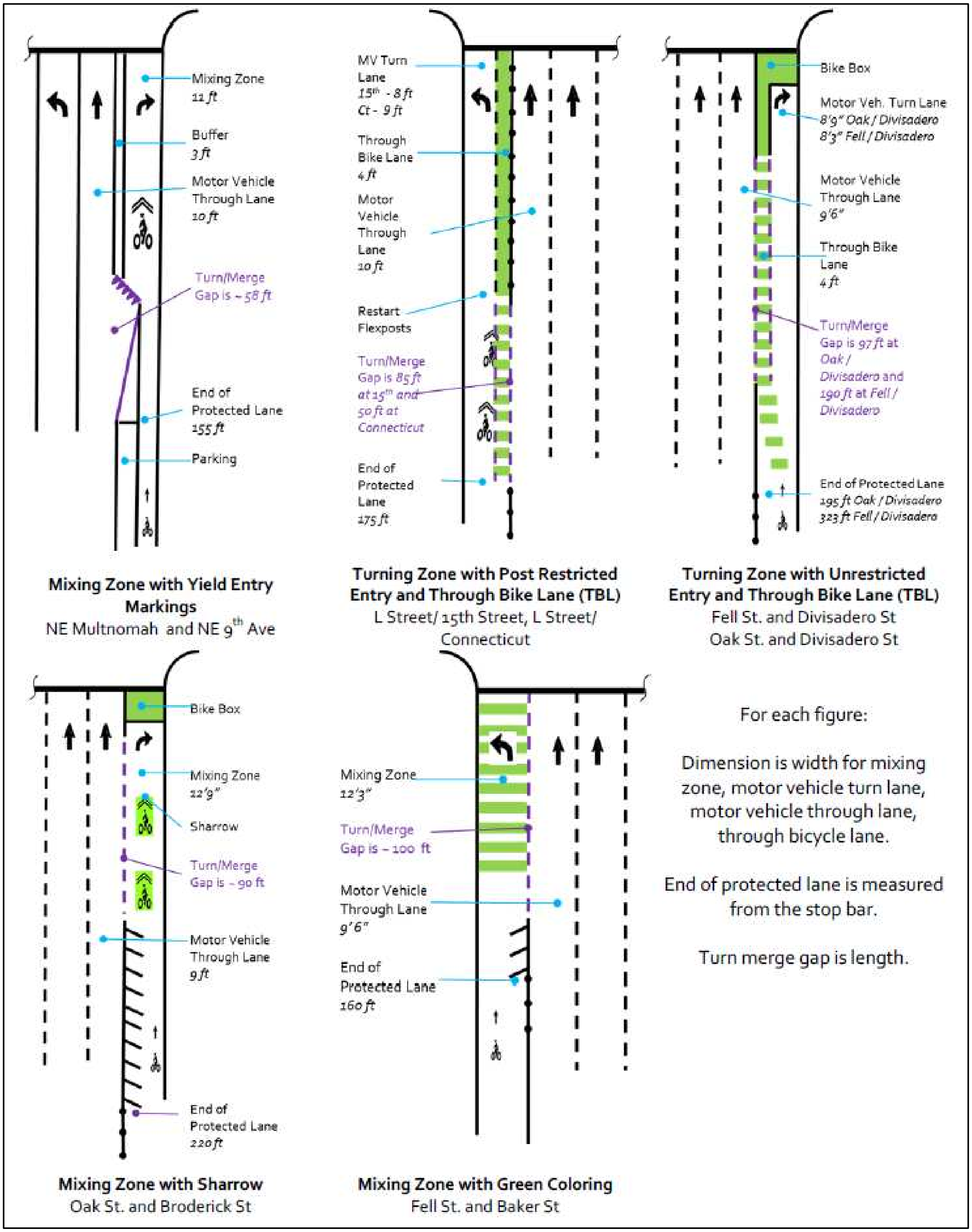

Figure 43 - Variations of mixing zones studied in Lessons from the Green Lane (Monsere et al. 2014). *Reprinted with permission.*

By contrast, Monsere et al. found that mixing zones with shared lane markings performed less effectively.[28] At shared lane marking mixing zones in San Francisco, an average of 49% of turning motorists and 30% of through bicyclists used the lane correctly, and 82% agreed they felt safe. In Portland, a SLM mixing zone saw 93% of turning motorists and 63% of through bicyclists using the lane correctly, and 73% of bicyclists agreeing they felt safe. While the Portland location has better lane usage rates, the SLM mixing zones overall rated lower than the dotted bicycle lane mixing zones. This may have been due to the lack of flexible delineator posts and restrictions at the SLM mixing zones, compared to the dotted mixing zones which had the flexible delineators to encourage proper usage. Feelings of safety were slightly higher at the SLM mixing zones as shown in Figure 24.

"Communicating when a street space is shared for two purposes – right turning vehicles and through bicycles – is a design challenge." The study also asked questions on understanding of each mixing zone. For the dotted mixing zone, 93-94% of respondents identified the correct lane for the through bicyclist. For the SLM mixing zone, 79% correctly identified the mixing zone as the proper location for bicyclists continuing straight and 20% incorrectly identified the adjacent motorist through lane as the space for bicyclists. Another mixing zone with green skip dash bars saw similar results to the SLM mixing zone (73% correctly identified and 25% incorrectly identified) although the pavement markings may be communicating right-turn only. The results were opposite when the researchers asked about where turning bicyclists should position themselves with 25% of bicyclists incorrectly stating they should turn from the through bicycle lane in the dotted mixing zones and 96% of bicyclists responding correctly with turn lane positioning in SLM mixing zones. See the *Lessons from the Green Lane* report for more information as it pertains to the variability of mixing zone designs and the results of the surveys.

Furthermore, a "low of 1% to a high of 18% of turning motorists at mixing zones actually turned from the wrong lane…[therefore] clear marking of the vehicle entry point to the turning lane is beneficial." Monsere et al. also mentioned the effectiveness of green pavement markings at communicating proper use of each space but overuse may cause some motorists to avoid using the space. This may have resulted in motorists entering at the wrong point such as before or after the encouraged mixing point; "Sometimes a motorist would drive all the way past the weaving area to move into the right-turn lane, even though there was plenty of space ahead of the bicyclist to enable use of the weaving area." The researchers also recorded video at the mixing zones and only found 1 conflict for every 1,200 through bicyclists recorded, although control locations were not used and a comparison was not made against non-mixing zone sites. However, there was generally a higher rate of conflicts observed in the SLM mixing zones than in the dotted mixing zones; an average of 0.15 conflicts per turning vehicles present with bicyclists occurred on the dotted mixing zones versus 0.32 conflicts per turning vehicles present with bicyclists at the SLM mixing zones. Conflicts were defined as any motor vehicle-bicycle interaction that involved precautionary braking, precautionary change of direction, emergency braking, emergency change of direction, and/or full stop by either the motorist or bicyclist.

Some mixing zone designs include "sharks teeth" yield markings as shown in Figure 42 and Figure 43 (Multnomah and 9th Avenue). The Monsere study found only 41% of motorists understood it to indicate they should yield to bicyclists.

Another study was performed in Eugene, Oregon by the University of North Carolina for the Highway Safety Research Center that looked at a mixing zone and control site (lateral shift bicycle lane). At the mixing zone, they observed that bicyclists were occasionally forced into the adjacent lane, typically the result of a heavy vehicle in the turn lane. Motorists making right turns on red were common, even when a bicyclist was present at the front of the queue.

A survey was conducted to bicyclists and the results show that "18% of the surveyed bicyclists using the narrow-lane intersection felt that it was safer than the comparison location with a standard-width right-turn lane, 27% said it was less safe, and 55% felt that the narrow-lane site was no difference." Since traffic is relatively slow on that road, many bicyclists already felt comfortable riding there. After videotaping bicyclists going through both intersections, it was found that in the "narrow-lane" intersection bicyclists were able to squeeze through the intersection without any conflicts. Overall, no conflicts were observed in the video of both intersections. The study authors recommend further evaluation of mixing zones.

Image	Design Type	Video: Correct Lane Use		Survey: % of Bicyclists Agreeing They Feel Safe
		Turning Motorist	Through Bicyclist	
	Turning Zone with Post Restricted Entry and Through Bike Lane (TBL): L Street	87%	91%	64%
	Mixing Zone with Yield Entry Markings: NE Multnomah / 9th	93%	63%	73%
	Turning Zone with Unrestricted Entry and Through Bike Lane (TBL): Oak/ Divisadero	66%	81%	74%
	Mixing Zone with Sharrow Marking: Oak/Broderick	48%	30%	79%
	Mixing Zone with Green Skip Coloring: Fell/Baker	49%	-	84%

Figure 44 - Results of video observations and comfort survey from the Lessons from the Green Lane report (Monsere et al. 2014). Reprinted with permission.

Lateral Shifts

According to AASHTO, “merging movements that occur away from the intersection… are often easier to manage for bicyclists and other road users than a turning conflict.” Motorists are required to yield to bicyclists before entering the weaving area (Chicago Streets) due to the “road rule that an operator leaving his lane yields to an operator on a path being entered or crossed.”[29]

Similar to intersection crossings, lateral shifts and through bicycle lanes encourage predictable riding. It also encourages predictable driving for motorists as a designated crossing area is provided. Lateral shifts help reduce motorist-bicyclist conflicts by guiding bicyclists, maintaining bicyclist comfort and priority in the absence of a dedicated signal phase, reducing motor vehicle speed prior to turning, and angling motor vehicles so that bicyclists are more visible prior to crossing paths with motorists. They are used in situations similar to mixing zones but require extra width for a standard conventional bicycle lane (minimum 5 feet) or buffered bicycle lane. With lateral shifts, potential conflicts occur before the intersection and “places the responsibility for yielding clearly on motorists turning right, and brings bicyclists in a highly visible position.”[30]

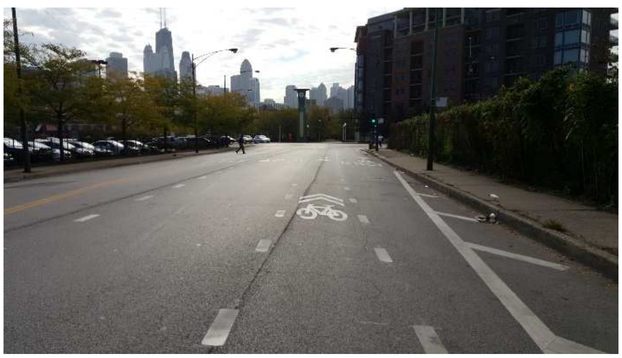

Figure 45 - Lateral shift on Clybourn Avenue at Division Street in Chicago.

One study examining the use of a green colored weave at a lateral shift in St. Petersburg, Florida, found a significantly higher percentage of motorists that yielded to bicyclists after installation of the green colored pavement, improving from 86.7% to 97.5%.[31] The weave already included a dotted bicycle lane and only the effectiveness of green pavement was examined before & after installation of the color.

OPERATIONS

Bicycle intersection markings have some impact on traffic operations. Generally, they improve operations for bicyclists (bicycle box and two-stage turn box), and have no or little effect on motorist operations (except for bicycle box).

Bicycle Boxes

Bicycle boxes are intended to improve operations at an intersection by positioning bicyclists at the front of a vehicular queue, allowing them to proceed through the intersection ahead of vehicles. This can improve traffic flow by reducing bicyclists weaving through traffic as they attempt to move toward their desired lane. They allow bicyclists to enter the intersection first, increasing visibility of bicyclists as well as facilitate left turning bicyclists, and reduce bicyclist signal delay.

Figure 46 - Bicycle boxes at the head of both southbound traffic lanes along Milwaukee Avenue at the intersection with Desplaines Street and Kinzie Street in Chicago

In 2013, a study was conducted for OTREC on the effects of bicycle-specific traffic signals at intersections in Portland, Eugene, Corvallis, Beaverton and Clackamas County in Oregon. The authors found that bicycle boxes affect discharge characteristics at signalized intersections. "The addition of a bicycle box decreases the discharge time with queues of equal length compared to a bicycle lane," and the discharge time between the two is more evident with larger queue sizes (five or more bicyclists, see Figure 47).[32] Queuing allows "cyclists to move into the intersection more quickly" as they are not as restricted by other bicyclists that would have been ahead of them, creating multiple effective lanes to discharge. This also enables faster discharge of right-turning motorists at locations with large volumes of bicyclists because those motorists might otherwise by obstructed by the slow discharging bicyclists. As Monsere et al. notes, bicycle boxes are a useful way of reducing discharge rates in areas of constrained right-of-way. For future studies of bicycle boxes, the traditional HCM method for calculating headways and discharge times do not apply since bicyclists line up side by side. See the study by Monsere et al. for lessons learned and tips for measuring bicyclist discharge from a bicycle box.

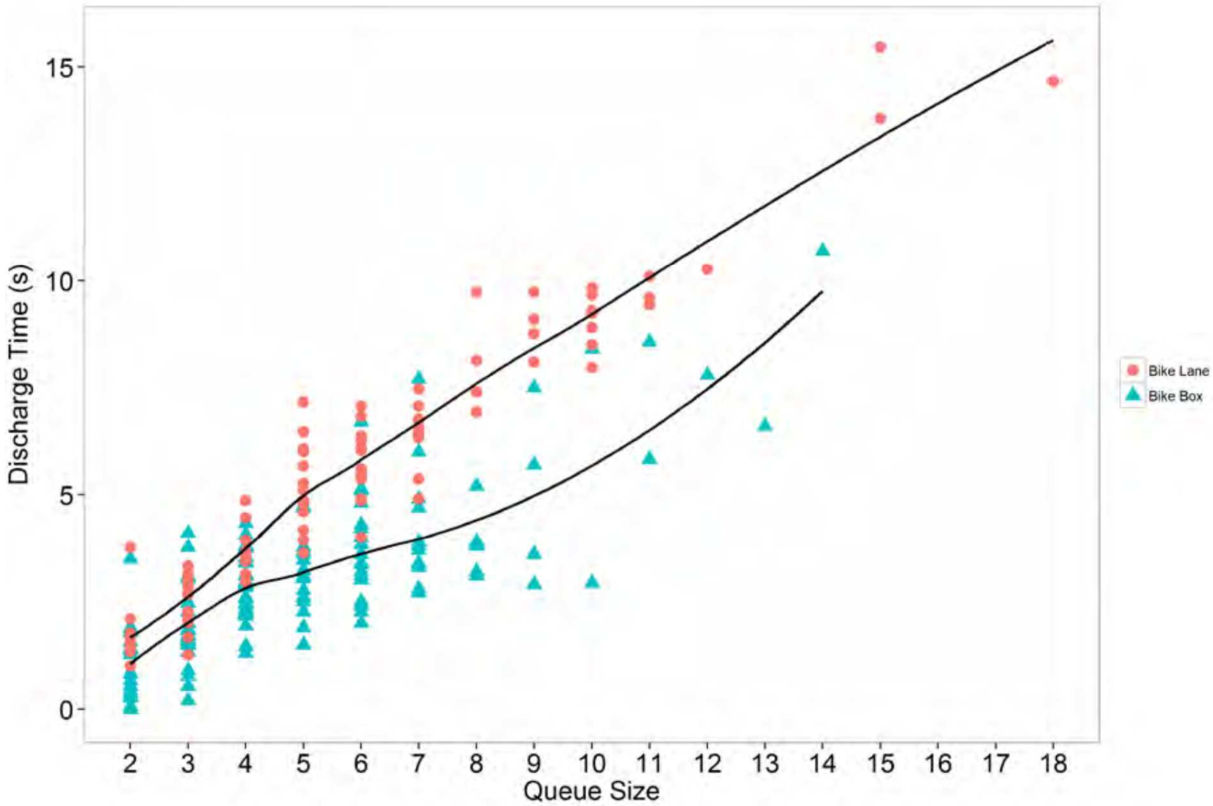

Figure 47 - Discharge times of bicycle boxes versus bicycle lanes at intersections. Source: Chris Monsere et al. 2013, reprinted with permission.

Of course, motorists must comply with the advanced stop bar to permit the discharge benefits. Loskorn et. al believes that the "decrease in the percentage of motorists that encroach on the bicycle lane after the installation of a skeleton bicycle box… allows for bicyclists to safely bypass a queue of motorists and access the bicycle box.[18] Thus motorist compliance leads to greater use of the bicycle box, decreased discharge times for bicyclists, and by extension, decreased discharge times for motorists. Adding green pavement also encourages more bicyclists to stop ahead of the motorist stop bar and lead to greater usage.[23] See the Bicycle Box - Safety Analysis section for more information on compliance and stopping behavior rates.

Wall et al. researched the effects of advanced stop lines, similar to bicycle boxes but without colored pavement, on roadway capacity.[33] The researchers found "At the two sites where the number of traffic lanes remained the same there was a slight (but not statistically significant) increase in saturation flow (pcu/hr) of 1.5% and 5.5% respectively. At the two sites where a traffic lane was removed there were, as would be expected, large reductions in saturation flow of 47% and 38% respectively." They ultimately concluded from video observations that bicyclist "queuing/ positioning behavior had [no] noticeable effect on capacity (although the bicycle flows at the four sites were small)." Wall et al. recommends further research on safety and capacity relationships.

Two-stage Turn Boxes

Figure 48 – Bicyclist making a turn from a two-way SBL and positioned within the two-stage turn box on Dearborn Street in Chicago

Two-stage turn boxes have benefits and disadvantages to operations. They separate bicyclist turns from motorist traffic and through bicyclists reducing delays for both modes and queuing in the bicycle lane. However, they require turning bicyclists to stand until the next cycle to complete their turn, increasing delay for those movements. For some separated bicycle lanes, two-stage turn boxes may be the only means of allowing bicyclists left-turns either due to the SBL barrier or one-way traffic moving in the opposite direction as shown in Figure 48.

Additionally, two-stage turn boxes increase intersection comfort for bicyclists and therefore help encourage increased ridership volumes as quantified with numerous SBL installations. See the *Local Studies – Two-Stage Turn Box*, below, for usage rates at one Chicago location.

Intersection Crossings

The FHWA has given interim approval of green pavement markings, a component of bicycle intersection crossings. In their approval they note that no negative operational effects have been observed. As mentioned in the safety section, intersection crossing markings lead to more predictable riding by bicyclists and awareness by motorists.

As long as the complexity of intersection crossings is kept to a minimum, ideally no more than two crossing markings per intersection, then no negative operational effects should arise. Similar to how overuse of signage may lead to road users disregarding certain signs or becoming confused, overuse of intersection crossing marking may also cause confusion and lead motorists to spread their focus.[27] This may cause delays as users navigate the intersection.

Mixing Zones

No major operational effects are noted for either motorists or bicyclists. Mixing zones may create minor traffic delays for through bicyclists by requiring them to queue behind right turning vehicles, although observations from *Lessons from the Green Lane* found most bicyclists ride around queued cars. At three out of four locations, 62% of bicyclists agreed that motorists rarely blocked their path for traveling straight.[28]

Lateral Shifts

A study by FDOT examining the use of green colored weave areas observed a lower percentage of motorists (6.2% less) used the designated weave area after installation of the green color and instead merged before or after it.[31] The researchers surmise the motorists may not have understood the intent of the weave and sought to avoid it. FDOT also points out that long queues of motorists sometimes led to motorists maneuvering outside of the green pavement area. It's unclear what effect the lateral shift had on the queues beyond what is caused by the turn lane storage area.

MAINTENANCE

Visibility is crucial to the performance of each of these facilities, so pavement markings must be properly maintained.[1] The facilities should also be kept free of potholes, broken glass, and other debris. The amount of maintenance can vary from facility to facility depending on the marking material, use of pavement color, traffic volumes, pavement surface condition, and location. Snow plows can also diminish the vibrancy of the markings.

Clear and maintained pavement markings are especially useful for new and innovative facility types, where the public may not understand how to operate within the facility. For example, Figure 49 shows a faded mixing zone on the approach of a separated bicycle lane to a turn lane. This lane configuration is uncommon in Chicago so it's imperative that pavement markings are maintained for innovative facility types to ensure compliance and safety of each facility.

Figure 49 - Faded shared lane symbol and "sharks teeth" yield markings on a mixing zone on Desplaines Street in Chicago

Cambridge, Massachusetts has used both tape and thermoplastic markings for their symbols, but the bicycle coordinator for the city stated that they had problems with the tape installation so they shifted to thermoplastic exclusively.[34] Additionally, symbols can be placed between the wheel paths to prevent excessive fading and wear.[1]

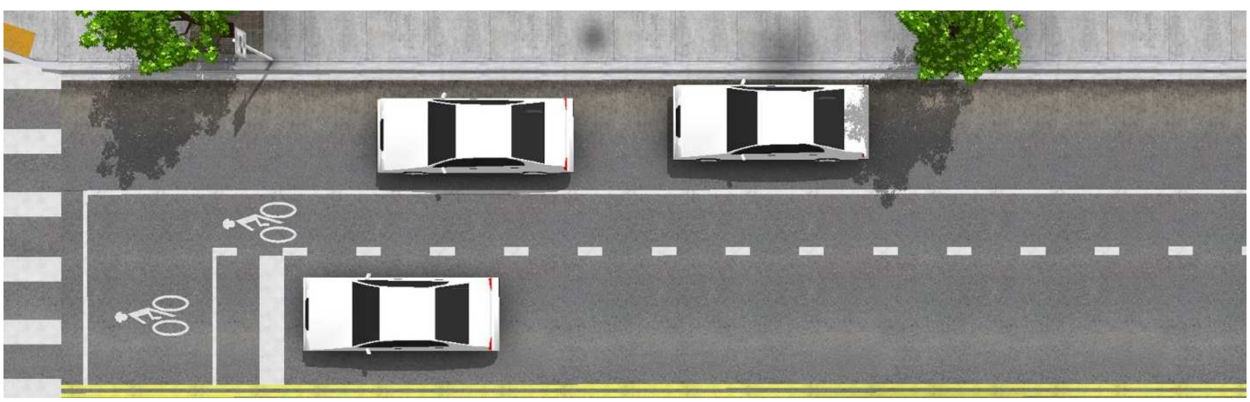

Figure 50 - Bicycle symbol within bicycle box, located between wheel paths. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Colored Pavements

Pavement coloring is normally installed on facilities with conflicting vehicle and bicycle movements, with the intention that the color will increase the visibility of the facility and draw more attention to bicyclists. Green is the only color that has received official FHWA approval for colored pavement experiments on bicycle facilities, although other colors have been used previously without FHWA approval.

There are a variety of ways to obtain the green color on the pavement, such as colored asphalt or concrete, paint, or other coloring materials.[17] NACTO published a section on their website entitled "Colored Pavement Material Guidance" that lists the attributes of various materials. A summary of this report is listed in Table 1.

There is no industry-wide accepted material for coloring pavements; however, a study conducted in 1998 in Portland Oregon found thermoplastic to be the best material to color pavement based on cost and durability. Other materials considered included paint, methyl methacrylate-based marking, cold plastic, dried asphalt, imprinted and sealed asphalt, and colored acrylic coating.[34]

CDOT typically utilizes skid-resistant, preformed thermoplastic with a minimum thickness of 120 mm and a minimum of 30% graded glass beads for retro-reflectivity.[35] Several locations with green thermoplastic panels installed in 2011 still maintain a visible and undamaged presence. Chicago experimented with rolled on epoxy but found that it didn't last long. The City of Des Moines, Iowa, however, notes that while thermoplastic is durable and can last several years, they have chosen not to use it due to the tendency of snow plows removing the marking. Instead, they use epoxy markings which they consider to be an extremely durable material that can last from 3 to 5 years. NACTO's website published a report on green colored intersections in Chicago, which said "In the Fall of 2007, nine problematic intersections throughout the City of Chicago were painted with a green preformed thermoplastic marking to test the effectiveness of the color in alleviating conflict between bicyclists and motorists turning right at intersections. In most cases, color was applied between the thru lane and the weaving area, where bicyclists most often experience obstruction and discomfort. Maintenance issues with the material have occurred, such as flaking of the markings following the winter months, though this may be attributed to poor installation." Figures 1a through 3b show the aging of various green thermoplastic markings at facilities around Chicago. Recently, Chicago has installed colored asphalt on a new parking separated bicycle lane on Clinton Street in Chicago although the durability of colored asphalt in Chicago is unknown.

For more information on maintenance, including examples of equipment, sweeping and plowing best practices, please see the *Separated Bicycle Lanes* report.

Figure 51 - Two stage turn queue box. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Figure 52 - Cycle track transition to bicycle lane and bicycle box. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

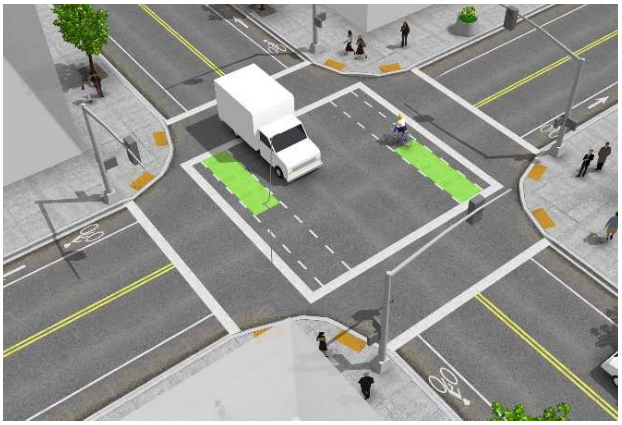

Figure 53 - Pavement markings at intersection. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

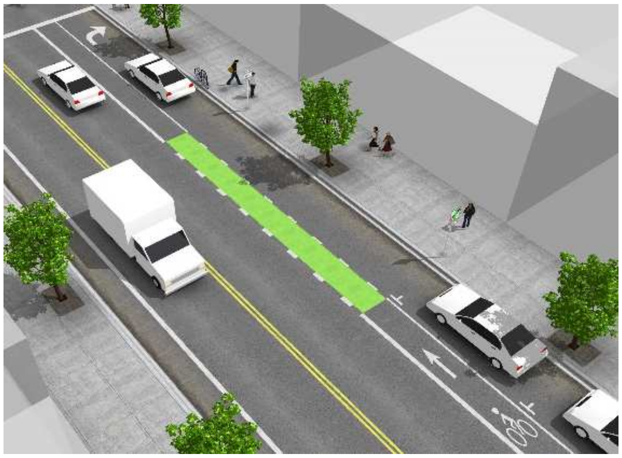

Figure 54 - Vehicle/bicycle mixing zone. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

Table 1 - Material Attributes, NACTO

	Paint	Durable Liquid Pavement Markings (Epoxy and MMA)	Thermoplastic	Colored Pavement
Maintenance Considerations	Spot maintenance requires a simple reapplication of paint.	Some cities have reported that epoxy color intensity fades over time due to color instability under ultraviolet lighting (sunlight) exposure. Pooling water can reduce material longevity.	Spot fixes are simple: a small piece of plastic is torched into place. Thermoplastic can be recessed to make edge flush with pavement or tamped down to form a seal with the roadway to reduce likelihood of snow plow impact.	It is expected that colored asphalt at least 1 cm thick will last for the life of the pavement.
Cost	$1.20 – $1.60 Sq. Ft. installed.	$8-11 Sq. Ft. installed.	$10 – $14 Sq. Ft installed.	More expensive than standard asphalt installation based on cost of pigment. When applied as a thin top layer within new construction, pigmented asphalt costs between 30 and 50% more than a non-colored structural asphalt section.
Longevity	Six months to two years based on weather, motor vehicle traffic and snow removal operations	Similar to thermoplastic. Poor pavement quality impacts treatment longevity.	Average of 5 years, or 3 times the lifetime of paint under the same conditions. Many installations have lasted significantly longer. Poor initial pavement quality shortens lifespan.	Based on motor vehicle traffic, but typically similar to conventional asphalt.
Experience	Several cities have reported satisfactory performance in corridors without motor vehicle wear.	Epoxy paint used in peer cities has proven skid resistance and longevity of 3 – 5 years. MMA may last as long as 3-6 years.	Most common material used for colored bikeways in North America. Many treatments are too new to report long-term results. Cities with a longer history of report positively on durability, skid resistance, and maintenance.	Embedded colored pavement is used in few North American cities but many have expressed interest for longer corridor installations.

District One Studies

The following is a summary of findings from four spot studies performed in 2014, for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 2 - Local intersection marking studies performed by District One

Study	Findings
Bicycle Box	There were a total of 111 bicyclists recorded during the study. Of those bicyclists, 75% took full advantage of the bicycle box, 19% partially used the bicycle box, and 6% did not use the bicycle box facility. Similarly there were 46 vehicles observed during the compliance portion of the study. Of those, 57% remained properly behind the stop bar, complying with the advanced stop bar, and 43% passed over the stop bar, encroaching into the bicycle box.
Two-Stage Turn Box	Of the 21 bicyclists observed turning at this intersection, 57% used or nearly used the queue boxes and 43% did not use the boxes.
Mixing Zone – Left-Side Bicycle Lane	Of the 1,120 bicyclists observed on this left-side green bicycle lane mixing zone only 12% checked for merging motorists. Of the 106 motorists observed, 75% checked their mirror, 0% checked their blind spot and 25% did not check either.
Mixing Zone – Right-Side Bicycle Lane	There were a greater percentage of bicyclists who checked for motorists (60%) in comparison to motorists checking for bicyclists (19%).

Bicycle Boxes

A bicyclist and motorist behavior spot study was completed focusing on the bicycle box at Elston Avenue and North Avenue in Chicago on September 25th, 2014. The study took place during the PM Peak hours of 4-6pm, and the temperature was in the 60's to 70's with no precipitation. No turn on reds are allowed at this intersection.

Study Method

The study analyzed the compliance of bicyclists and motorists at the bicycle box. For this study, a staff member stood on the southeast corner of Elston Avenue and North Avenue to monitor motorist and bicyclist behaviors. The evaluator observed whether motorists stopped behind the stop bar placed prior to the bicycle box (the compliant behavior), within the bicycle box or past it (noncompliant). The evaluator also observed how bicyclists used the bicycle box, noting whether they stopped within the box, within the bicycle lane portion of the box, or behind the box within in the bicycle lane. Figure 1 shows a bicycle box diagram of the existing conditions at Elston Avenue.

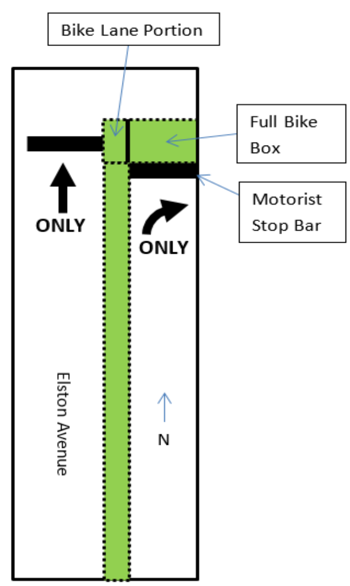

Figure 55 - Elston Ave. and North Ave. bike box layout

Bicyclist Behavior

During the two hour period of data collection, 111 bicyclists were observed. The data collected was compiled and is summarized in the figures below. Figure 56 shows bicyclists usage based on where the bicyclists stopped, either in the bicycle box, in the bicycle lane portion of the bicycle box, or outside the bicycle box.

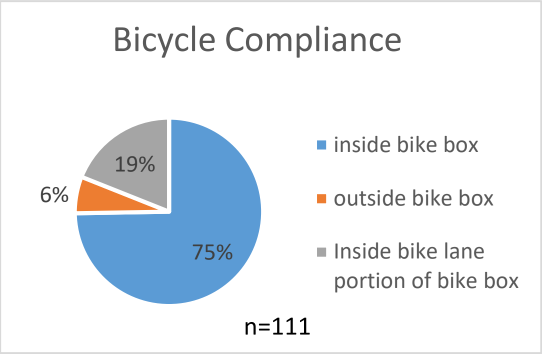

Figure 56 - Bicyclist behaviors

Motorist Behavior

Within the two hour period, 46 cars were observed in the right turn lane. The observer recorded whether motorists encroached on the bicycle box, hindering the bicyclists' usage, or correctly complied with the bicycle box expectations by stopping behind the stop bar and not entering the bicycle box limits. The chart in Figure 57 shows compliance rates of the motorists who stopped behind the stop bar (compliant) and those who stopped in the bicycle box obstructing bicyclists' usage (non-compliant).

Discussion

In previous studies in Portland, Oregon, Dill et. al. found that "73% of the stopping motor vehicles did not encroach at all into the bicycle box" compared to a 43% compliance rate at the North Avenue and Elston location (the Portland bicycle boxes were installed in 2008 and the study was performed in 2010).[23] The Elston Avenue bicycle box was installed in 2012 and this IDOT study was performed in 2014. While this Elston location studied a bicycle box on a dedicated right turn lane, the Portland locations were on through lanes. Both locations had No Turn on Red restrictions in place.

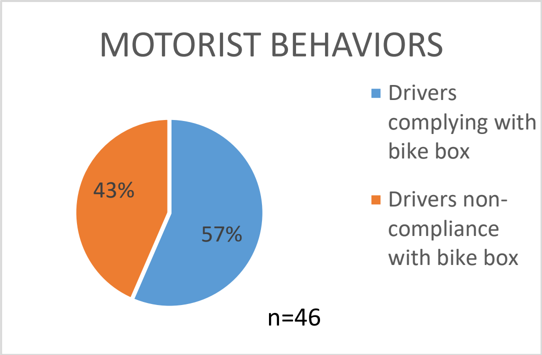

Figure 57 - Motorist behaviors

Bicyclist usage is also dependent on the compliance of motorists, which was not recorded in this study. The number of bicyclists who did not fully use the bicycle box could be a result of an instance where a noncompliant motorist stopped in the facility. If motorist compliance rates were higher, bicyclists might have fully utilized the bicycle boxes more often.

Conclusion

There were a total of 111 bicyclists recorded during the study. Of those bicyclists, 75% took full advantage of the bicycle box, 19% partially used the bicycle box, and 6% did not use the bicycle box facility. Similarly there were 46 vehicles observed during the compliance portion of the study. Of those, 57% remained properly behind the stop bar, complying with the bicycle box, and 43% passed over the stopping bar, encroaching into the bicycle box.

If motorist compliance increases, it will lead to an increase in the bicycle box being vehicle-free and available for bicyclist use. Increased compliance could bring a decrease in conflicts and an increase in intersection safety.

Two-Stage Turn Boxes

A bicyclist behavior spot study was completed for a two-stage turn box at the intersection of Dearborn Street and Monroe Street in Chicago. The study was conducted on September 17th, 2014 during the evening peak traffic hours of 4:00 to 6:00 p.m., and weather conditions were 65 degrees and sunny.

Study Method

A staff member was positioned at the southwest corner of Dearborn Street and Monroe Street to monitor the bicyclists' behaviors. The evaluator recorded the number of bicyclists that used the queue box when attempting to make a left or right turn at the intersection. The evaluator observed and recorded the following instances: 1) bicyclists who fully used the queue box, 2) nearly used the queue box, or 3) completely disregarded the queue box. "Nearly used the queue box" meant that the bicyclist stopped near the box but not inside the box, and then turned at the appropriate time. The two-stage turn box within this intersection is placed adjacent to the two-way cycle track that runs along the west side of Dearborn Street, in order to accommodate bicyclists turning and crossing three northbound traffic lanes to travel eastbound along Monroe Street.

Figure 58 - Two-stage turn box at intersection of Dearborn Street and Monroe Street in Chicago

Bicyclist Behavior

The data collected during the behavior study was compiled and summarized in the figures below. The data shows bicyclist volumes by movement at the intersection and queue box usage. There were 450 bicyclists observed within the two hour period. Figure 59 below shows the total number of bicyclists traveling through the intersection during this time period and whether they turned or continued through. Figure 60 shows the extent of usage of the queue box by the bicyclists that turned onto Monroe Street.

Discussion

Based on the data, the majority (57%) of turning bicyclists used or nearly used the turn queue box. The number of turning bicyclists was low, 21 in two hours. The through bicyclist volumes were high especially compared to the turning volumes. Since queue boxes are not legally regulated facilities, bicyclists are not required to use the boxes.

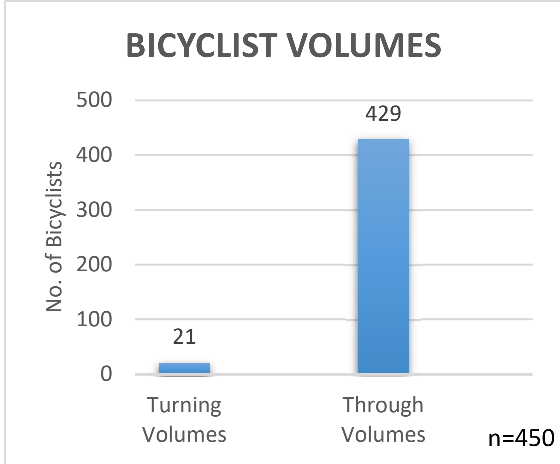

Figure 59 - Intersection bicyclist volumes

Figure 60 combines the volumes of bicyclists fully using the turn queue box and nearly using the turn queue box, and shows that more bicyclists used or attempted to use box than neglected box. "Nearly used" accounts for instances where bicyclists may have intended to use the box even though it was occupied by other bicyclists. Of the bicyclists that used or nearly used the box, five fully used it by positioning themselves within the white striping and seven nearly used it by positioning their bicycles near the box and in the proper orientation for the new direction facing east.

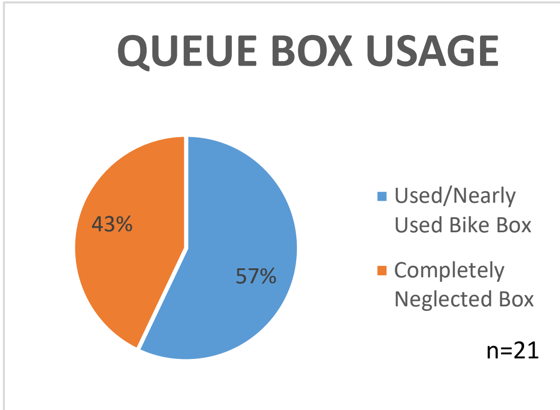

Figure 60 - Queue box usage

Another study by Portland State University, researchers found that "while 76% of survey responses stated that bicyclists SHOULD wait in the green box until the signal changes to make a left turn, only 54% stated that they ACTUALLY turn left in that way."[23] Portland's usage rates mirror the Dearborn and Monroe Street observations.

A negative of the queue boxes is the increased intersection delay for bicyclists because they have to wait for the next cycle to complete their turn regardless of oncoming traffic gaps. This could be a determining factor for some bicyclists who would prefer not to wait, and could explain the data.

Conclusion

Of the 21 bicyclists observed turning at this intersection, 57% used or nearly used the queue boxes and 43% did not use the boxes. The location of the two-way cycle track along the west side of Dearborn Street makes it challenging for bicyclists turning to head eastbound along Monroe Street given they must cross three lanes of traffic. The presence of the marked queue box was observed to be beneficial to the operation of intersection by providing a dedicated area for bicyclists to wait prior to making their turn, and creating awareness of the two-stage bicyclist turning technique for both bicyclists and motorists.

Mixing Zones – Left Side Bicycle Lane

A bicyclist and motorist behavior study was completed for a mixing zone along southeast bound Milwaukee Avenue at the intersection with Chicago Avenue in Chicago. The study was conducted on September 24, 2014 during the morning peak traffic hours of 7:00 to 9:00 a.m., and weather conditions were 55 degrees and sunny.

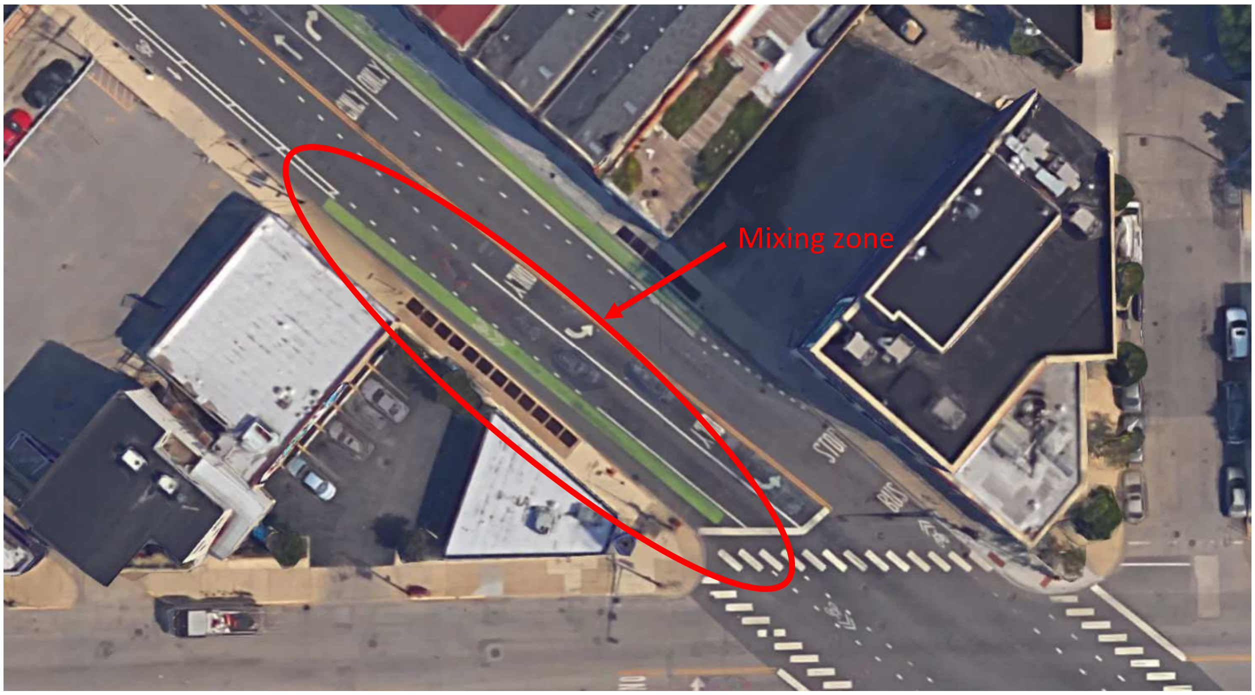

Figure 61 - Aerial view of Milwaukee Avenue and Chicago Avenue. Image: Google.

Study Method

A spot study was conducted to evaluate the safety of the mixing zone and the ability of motorists and bicyclists to merge within the turn lane. Two evaluators were positioned at the northwest corner of Milwaukee Avenue and Chicago Avenue and monitored the southeast bound traffic merging into the mixing zone. Evaluator one recorded the total number of bicyclists and how many checked for motorists before merging. Evaluator two recorded the total number of motorists and how many checked their mirrors and blind spots for bicyclists before merging.

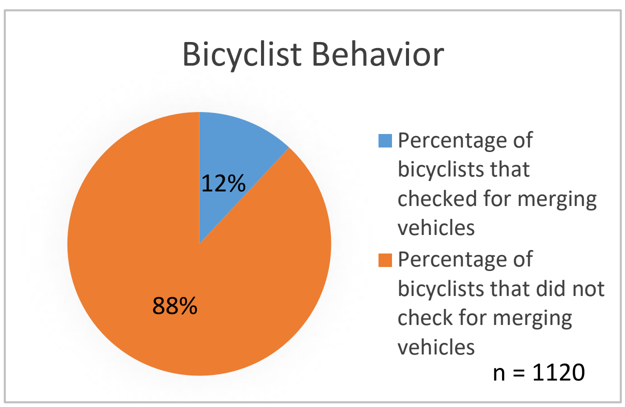

Figure 62 - Bicyclist behavior

Bicyclist Behavior

The data collected for bicyclist behavior during the study was compiled and is shown in Figure 62. The data represents the percentage of bicyclists that either checked or did not check for merging motorists. During the two hour study period, 1,120 bicyclists were observed traveling through the turn lane, and the majority (88%) did not check for merging motorists. This is lower than another mixing zone studied on Desplaines

Street which saw 60% of bicyclists checking for merging motorists (see the Mixing Right–Side Bicycle Lane study below).

Motorist Behavior

The data collected regarding motorists' behavior in mixing zones was compiled and summarized to show the ability of motorists to merge into the turning lane without endangering bicyclists present in the bicycle lane. The data represents the motorists who check their mirror, their blind spot, or those who neglect to check either for the presence of bicyclists. Within the two hour period, 106 turning motorists were observed. Of those 106 motorists, zero checked their blind spot but 79 checked their mirror as shown in Figure 63.

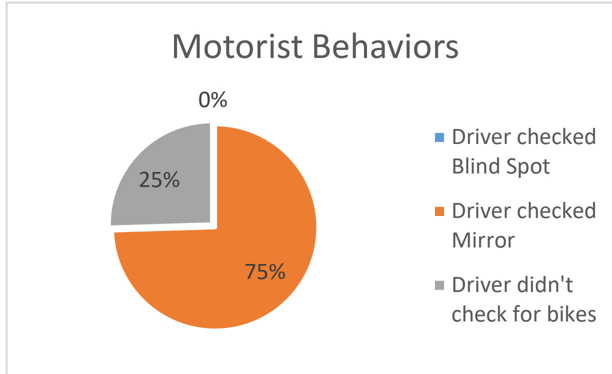

Figure 63 - Motorist behavior

Discussion

Figure 64 shows the comparison of motorists checking for bicyclists, to bicyclists checking for motorists. Motorists are encouraged to yield to the bicyclists before coming into the right turn lane; however, 25% of motorists are not checking which may indicate a sense of complacency or over-confidence in the safety of the mixing zone, a sense mirrored in other separated bicycle lane or green pavement studies.

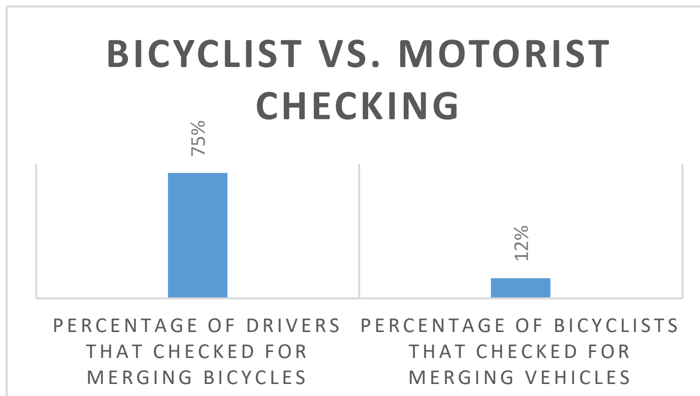

Figure 64 - Bicyclists versus motorists observed checking for merging traffic

Conclusion

In summary, there were a total of 1,120 bicyclists observed to determine their ability to watch for merging motorists, only 12% checked for merging motorists. There were also 106 motorists observed to see if they checked for bicyclists before merging, and how they checked. 75% checked their mirror, 0% checked their blind spot and 25% did not check either. This factor may indicate the recognition of motorists to yield to the bicyclists. The yielding of the motorists affects the ability for bicyclists to safely remain in their bicycle lane while in the mixing zone.

Mixing Zones – Right Side Shared Lane with Yield Markings

A bicyclist and motorist behavior study was completed for a mixing zone at the intersection of Desplaines Street and Monroe Street in Chicago on September 23, 2014. The study was conducted during the evening peak traffic hours of 4:00 to 6:00 p.m., and weather conditions were 68 degrees and sunny.

Study Method

A spot study was conducted to evaluate the frequency of motorists and bicyclists checking their blind spots for merging traffic when entering a mixing zone. Two staff members were positioned at the northwest corner of Desplaines Street and Monroe Street to monitor the southbound traffic as they approached the intersection. One evaluator monitored motorists entering the mixing zone and observed if they checked their mirror or their blind spot for merging bicyclists. The other evaluator monitored bicyclists entering the mixing zone and observed if they checked for merging motorists.

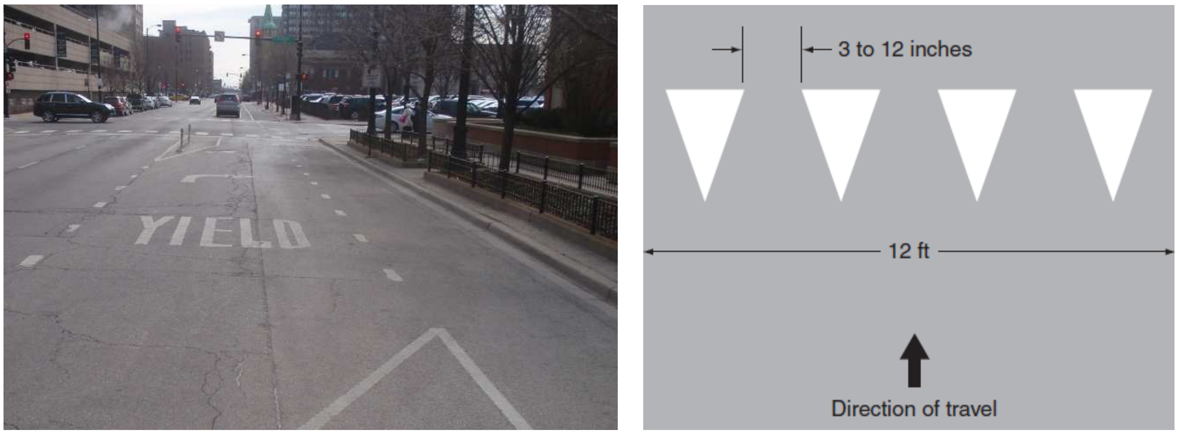

Figure 65 – Left: A mixing zone with yield markings and a right-side dotted bicycle lane on Desplaines Street at Madison Street in Chicago and identical to the one studied. Right: Detail of yield markings as depicted in the MUTCD.

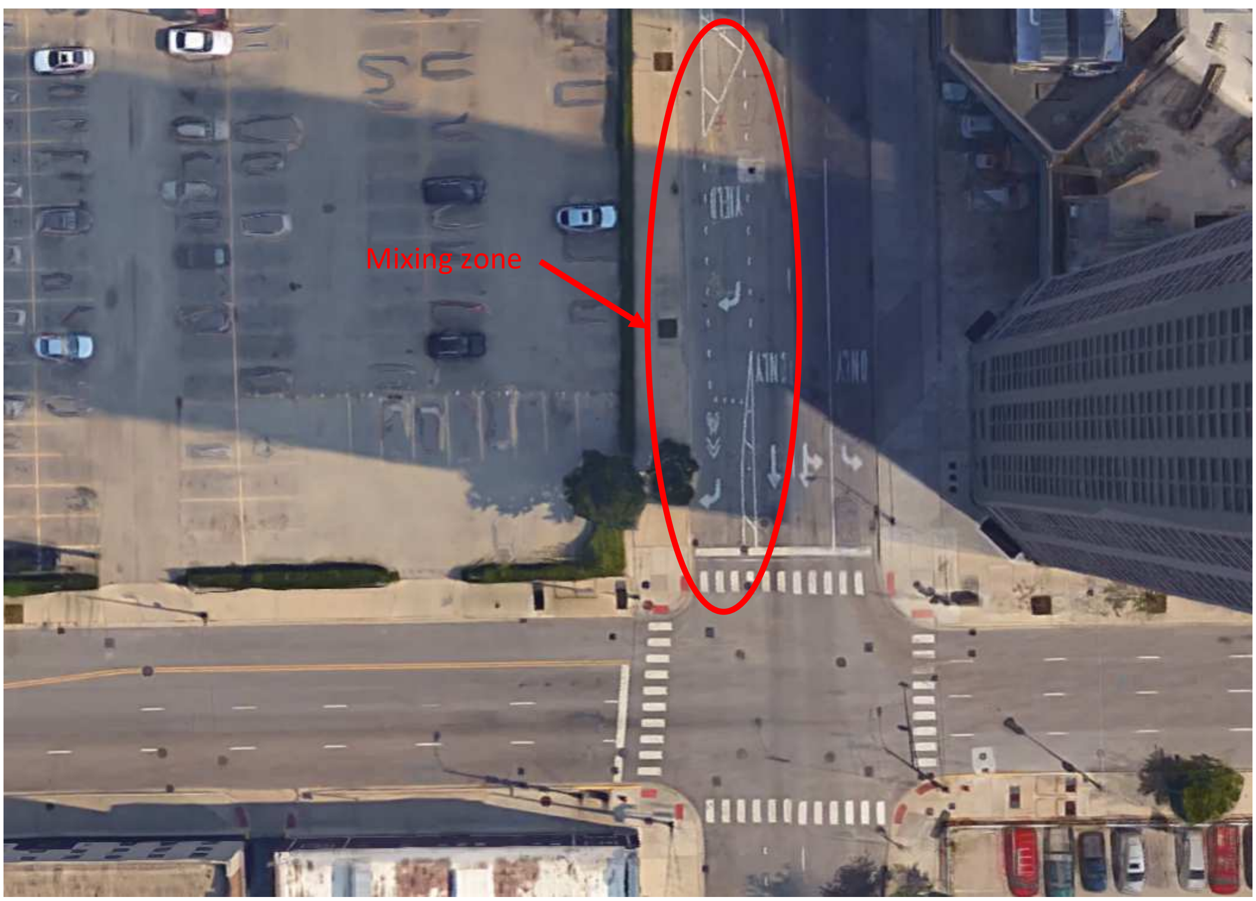

Figure 66 - Aerial view of Desplaines Street and Madison Street in Chicago. Image: Google.

Bicyclist Behavior

Data collected pertaining to bicyclist behavior was compiled and is summarized in Figure 67. The chart represents the percentage of bicyclists that checked or did not check for merging motorists. During the two hour study period, 68 bicyclists were observed. More than half (60%) of the bicyclists checked for motorists merging into the shared lane. This is a higher percentage than the mixing zone on Milwaukee Avenue which saw only 12% of bicyclists checking for merging motorists. However, that study had a significantly higher volume of bicyclists to observe.

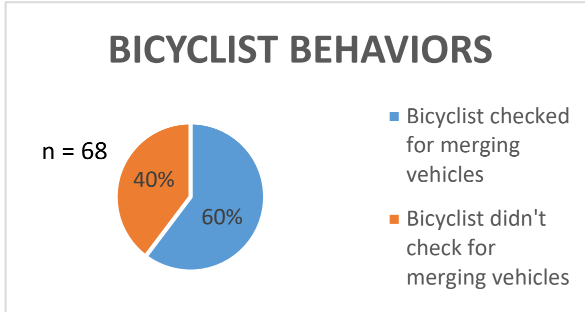

Figure 67 – Bicyclist behavior

Motorist Behavior

Data collected pertaining to motorist behavior was compiled and is summarized in Figure 68. The chart represents the percentage of motorists who either checked or neglected to check their mirrors or blind spots for the presence of bicyclists while entering the mixing zone. During the two hour study period, 151 motorists were observed, and the vast majority did not check for bicyclists. Of the 19% of motorists who checked for bicyclists, 26 checked only using their mirror while only 2 checked by turning their head back and to the right.

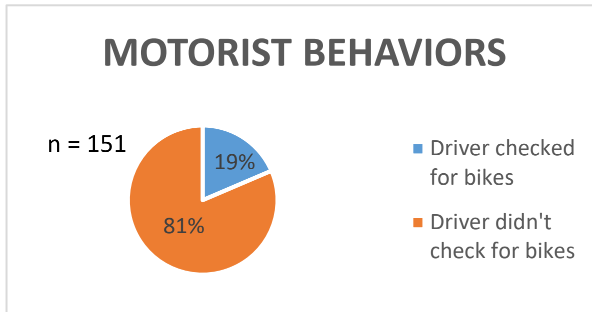

Figure 68 - Motorist behavior

Conclusion

There was a greater percentage of bicyclists who checked for motorists (60%) in comparison to motorists checking for bicyclists (19%). Motorist compliance could be increased by educating the public on mixing zones, potentially through signage or educational programs. Bicyclists must assume that motorists may not check for them before entering the mixing zone, and therefore, proceed with caution and check for merging motorists. Note, the Mixing Zones – Right Side Shared Lane with Yield Markings (Desplaines Street) study has different context compared to the Mixing Zones – Left Side Bicycle Lane (Milwaukee Avenue) study, the results of which should not be compared directly to each other to judge the efficacy of either mixing zone design. Whereas the Desplaines storage and merge was short and led to an expressway on-ramp, the Milwaukee mixing zone was longer but with a bus stop and presumably less right turns due to the oblique turn angle. These studies are merely a snap shot of behaviors at each location and provide a base for which to plan and perform more detailed longitudinal or cross-sectional analyses.

The following inventories provide a sample of facilities around North America. District One locations are in bold.

Bicycle Boxes

Table 3- Bicycle boxes in North America

Country	City/County	State	Intersection	Installation Year
CA	Edmonton	AB	106th St. & 87th Ave.	2012
CA	Vancouver	BC	-	Unknown
USA	Phoenix	AZ	E. Jefferson St. & S 7th St.	2009
USA	Tucson	AZ	Grant & N. Fontana	2011
USA	San Francisco	CA	-	Unknown
USA	San Luis Obispo	CA	-	Unknown
USA	Washington	DC	-	Unknown
USA	Decatur	GA	-	Unknown
USA	Roswell	GA	-	Unknown
USA	**Chicago**	**IL**	**W. Kinzie St. and N. Wells St.**	**2011**
USA	Boston	MA	-	Unknown
USA	Cambridge	MA	-	Unknown
USA	Baltimore	MD	-	Unknown
USA	Minneapolis	MN	-	Unknown
USA	New York	NY	-	Unknown
USA	Portland	OR	W. Burnside & 14th Ae.	Unknown
USA	Austin	TX	-	Unknown
USA	Alexandria	VA	-	Unknown
USA	Seattle	WA	-	Unknown
USA	Madison	WI	-	Unknown

Two – Stage Turn Boxes

Table 4- Two – stage turn queue boxes in North America

Country	City/County	State	Intersection	Installation Year
USA	Washington D.C.	-	L St. and 15th St. NW	Unknown
CA	Vancouver	BC	Smithe St. and Hornby St.	2012
USA	San Francisco	CA	11th and Howard St.	2014
USA	Ventura	CA	Main St. and Telephone Rd.	2011-2013
USA	Durango	CO	US 160 and US 550	2014
USA	Atlanta	GA	Charles Allen Dr. NE and 10th St. NE	2013
USA	**Chicago**	**IL**	**Jackson Blvd. and Wood St.**	**2011**

USA	**Chicago**	**IL**	**Dearborn St. and W. Harrison St.**	**2013**
USA	Boston	MA	Forsyth St. and Huntington Ave.	2012
USA	Cambridge	MA	Church and Massachusetts	Unknown
USA	New York	NY	-	Unknown
USA	Rochester	NY	Court St. and Chestnut St.	2014
USA	Canton	OH	Walnut Ave. and 5th St.	Unknown
CA	Toronto	ON	Sherbourne St. and Shuter St.	Unknown
USA	Portland	OR	SW Broadway and SW Market St.	Unknown
USA	Portland	OR	NW 9th St. and NW Lovejoy St.	Unknown
USA	Philadelphia	PA	Benjamin Franklin Pkwy. and 20th St.	Unknown
USA	Austin	TX	S. Lamar Ave. and Barton Springs Rd.	2013
USA	Salt Lake City	UT	200 S. and Main St.	2011
USA	Charlottesville	VA	University Ave. and Rugby Rd.	2014
USA	Seattle	WA	Maynard Ave. and S. Jackson St.	2014

Intersection Crossings

Table 5 - Intersection crossing markings in North America

Country	City/County	State	Location	Installation Year
USA	Denver	CO	15th St. and Champa St.	2013
USA	Washington DC	DC	M-street	2014
USA	**Chicago**	**IL**	**Ardmore Ave. and Sheridan Rd.**	**2005**
USA	**Chicago**	**IL**	**Desplaines St. and Harrison St.**	**2012**
USA	**Chicago**	**IL**	**Desplaines St. and Madison St.**	**2012**
USA	**Chicago**	**IL**	**Franklin St. and Randolph St.**	**2012**
USA	**Chicago**	**IL**	**Elston Ave. and Milwaukee Ave.**	**2012**
USA	**Chicago**	**IL**	**Milwaukee Ave. and Chicago Ave.**	**2012**
USA	**Chicago**	**IL**	**Canal St. & Polk St.**	**2014**
USA	**Chicago**	**IL**	**Canal St. & Taylor St.**	**2014**
USA	**Evanston**	**IL**	**Church St.**	**2012**
USA	Indianapolis	IN	Shelby St. and Palmer St.	2011
USA	New York	NY	Grand St. and Mercer St.	Unknown
USA	New York City	NY	Prospect Park W.	2012
USA	New York City	NY	1st Ave.	2010
USA	Eugene	OR	Patterson St. and E. 13th Ave.	1998
USA	Austin	TX	Pedernales St.	2013

Mixing Zones

Table 6- Mixing zones in North America

Country	City/County	State	Location	Installation Year
USA	Washington D.C.	-	L St. NW and 12th St. NW	2012
USA	Mountain View	CA	N. Shoreline Blvd. and Middlefield Rd.	Unknown
USA	Denver	CO	15th St. and Champa St.	2013
USA	Kihei	HI	Piilani Hwy and Kilohana Dr.	2012
USA	**Chicago**	**IL**	**Desplaines St. and Harrison St.**	**2012**
USA	**Chicago**	**IL**	**Desplaines St. and Madison St.**	**2012**
USA	**Chicago**	**IL**	**Desplaines St. and Monroe St.**	**2012**
USA	**Chicago**	**IL**	**Franklin St. and Randolph St.**	**2012**
USA	**Chicago**	**IL**	**Elston Ave. and Milwaukee Ave.**	**2012**
USA	**Chicago**	**IL**	**Milwaukee Ave. and Chicago Ave.**	**2012**
USA	**Chicago**	**IL**	**Canal St. & Polk St.**	**2014**
USA	**Chicago**	**IL**	**Canal St. & Taylor St.**	**2014**
USA	Evesham Township	NJ	Malton Pkwy. and Evans Rd.	Unknown
USA	New York	NY	Grand St. and Mercer St.	Unknown
USA	Bend	OR	NE 8th St. and NE Penn Ave.	2012
USA	Eugene	OR	Patterson St. and E. 13th Ave.	1998
USA	Memphis	TN	Bellevue and Overton park Ave.	2012

Lateral Shifts

Table 7- Lateral shifts in North America

Country	City/County	State	Location	Installation Year
USA	San Francisco	CA	Folsom St. and 8th St.	Unknown
USA	Colorado Springs	CO	Cresta Rd. and Presidential Heights	Unknown
USA	**Chicago**	**IL**	**N Milwaukee Ave. and W Augusta Blvd.**	**2008**
USA	**Chicago**	**IL**	**S Wabash Ave. and E Roosevelt Rd.**	**2012**
USA	**Chicago**	**IL**	**Dearborn St. and Chicago Ave.**	**2007**
USA	**Chicago**	**IL**	**N Milwaukee Ave. and W Kinzie St.**	**2013**
USA	Portland	OR	SW Stark St. and SW Broadway	Unknown

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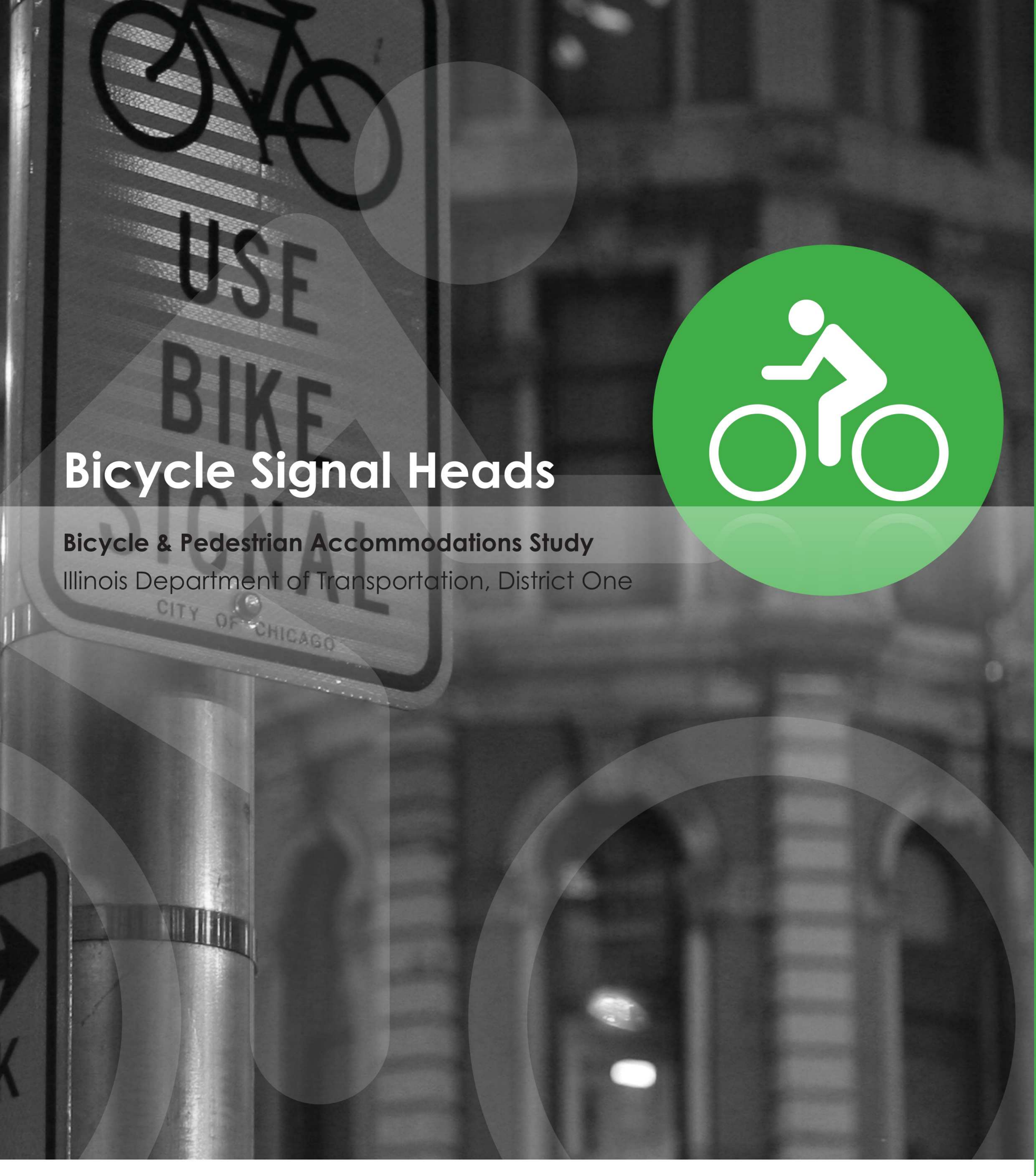


Bicycle Signal Heads

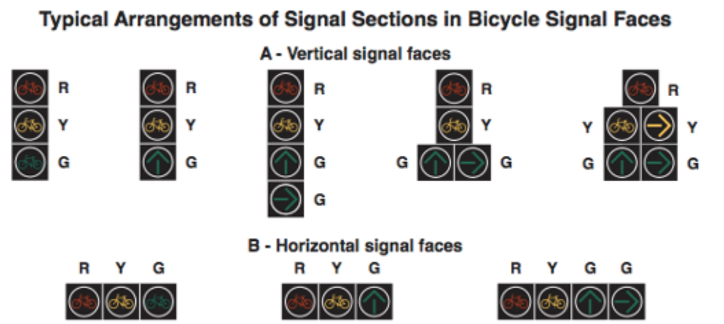
Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation


USE
BIKE
SIGNAL

A bicycle signal head is a facility put into place to increase the safety and flow of bicycle, pedestrian, and vehicular traffic. Bicycle signal heads are traffic control devices, most often installed at intersections with existing conventional traffic signals, to reduce conflicts and aid bicyclists in navigating through intersections. They work in the same manner as conventional vehicular traffic signals. Bicycle signals can be used in conjunction with separated bicycle lanes, especially those operating in contra-flow environments such as the two-way separated bicycle lane on Dearborn Avenue shown to the right. Typically, separated bicycle lanes offer increased safety midblock, but may result in higher intersection crashes. Bicycle signal heads can alleviate this issue by separating motorist and bicyclist movements in the intersection. Additionally, bicycle signals may improve both real and perceived safety for bicyclists by alerting motorists to their presence and enforcing the idea that bicyclists belong on the roadway.



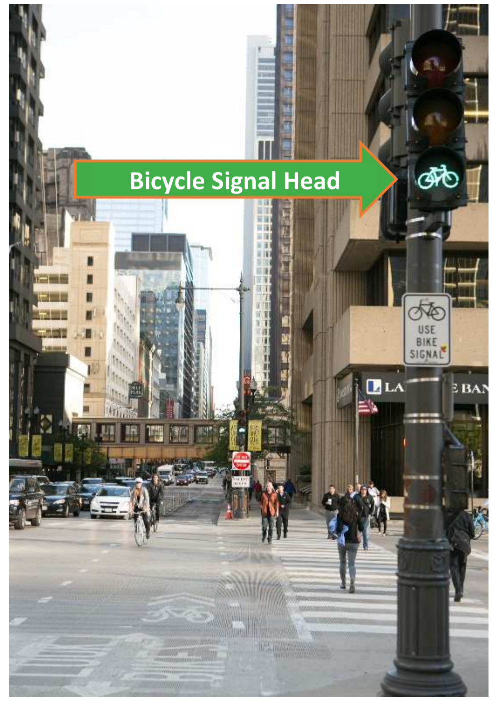


Figure 1 – Left: typical arrangements of signal sections in bicycle signal faces (MUTCD 2013). Right: Bicycle signal head on the approach side of the intersection of Dearborn Street and Wacker Drive in Chicago

Features

Signal Activation

There are three ways a bicycle signal phase can become activated: pre-timed, active detection, and passive detection. Pre-timed means the signal will run on a certain cycle and will turn green with or without the presence of bicyclists. Active detection means the signal will remain red until a bicyclist makes the system aware of its presence via a push-button. Passive detection is when the signal stays red until it detects the presence of bicyclists via loop detectors, video detection, or microwave detection.

The FHWA Bicycle Safety Guide and Countermeasure Selection System recommend detection for bicyclists at signalized intersections saying, "Signalized intersections should include detection for bicyclists to facilitate safe, comfortable, and convenient crossings at intersections for bicyclists while also minimizing delay".[1] Bicyclist detection at every signalized intersection might be excessive though; the IDOT BDE Manual states, "At signalized intersections where frequent bicyclists need access to a green signal phase, a number of acceptable alternative methods are available including timed signals (where a cyclist must wait for the signal to change), traffic-actuated detectors, and push-button actuation. This opportunity (to access a green signal) should be provided where a marked bikeway crosses the project corridor".[2]

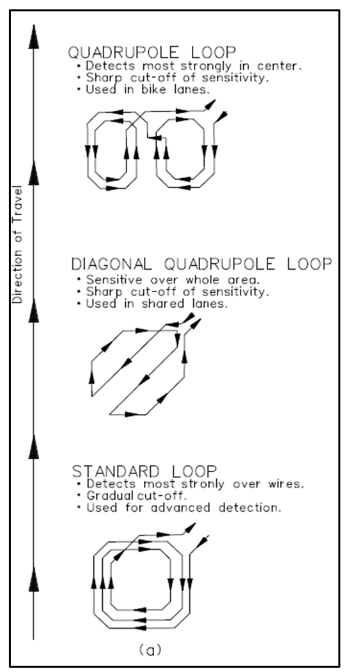


Figure 2 – Recommended loop types from IDOT BDE Manual)

The FHWA guide also gives the following considerations for detection devices:

- Detection devices should be placed in the expected path of the bicyclists, and aimed to maximize efficiency and responsiveness.
- It may be desirable to install advanced bicycle detection on the approach to the intersection to extend the phase, or to prompt the phase and allow for continuous bicycle through movements.
- If a pushbutton is used, the location of the device should not require bicyclists to dismount or be rerouted out of the way or onto the sidewalk to activate the phase. Signage should supplement the signal to alert bicyclists of the required activation to prompt the green phase.
- Signal timings should be adjusted to account for the unique operating characteristics of bicycles. For additional details, see the countermeasure optimizing signal timing for bicycles.
- It is important that the design of loop detectors consider the amount of metal in typical bicycles. Certain types of loop configurations are better at detecting bicyclists than others and settings for loop detectors should be adjusted to properly detect bicycles.[3]

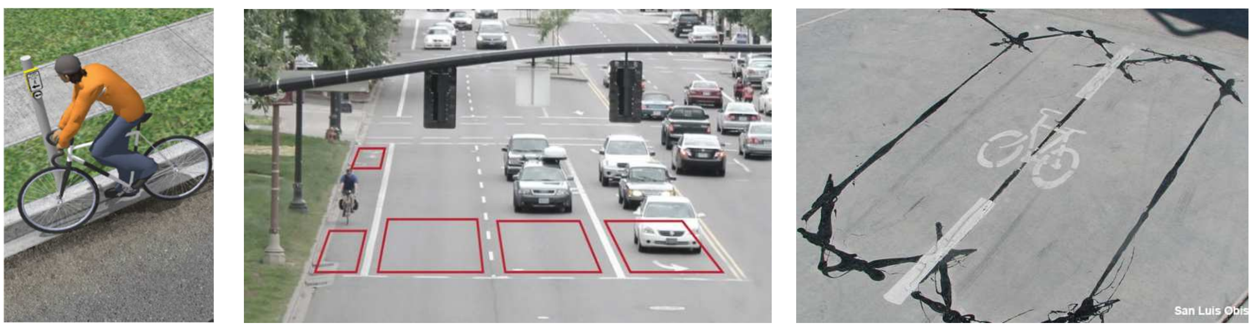


Figure 3 - Bicycle push button (left), simulated video detection target areas (middle), and bicycle loop detector (right). Images from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press.

Warrants

In a State-of-the-Practice Review for bicycle traffic signals, presence of contraflow bicycle lanes, safety concerns for bicyclists, and unique bicycle paths through the intersection were listed as the top motivational factors for installing bicycle signal heads in the United States and Canada.[4] Furthermore, the Pedestrian and Bicycle Information Center recommends the installation of a bicycle signal be considered in the following scenarios:

- At intersections with bicycle-specific movements such as a contra-flow bicycle lane or separated bicycle lane; a bicycle signal may be necessary to indicate right-of-way to the bicyclist.
- At intersections where bicycle movements need to be separated from conflicting vehicular movements, such as locations with a high volume of left- or right-turns; bicycle signals can allow for a separate bicycle phase or movement.
- At locations with high vehicle turning volumes, cyclists could benefit from a bicycle signal with a leading bicycle interval (LBI). Similar to a leading pedestrian interval, an LBI gives bicyclists a head start at intersections by giving cyclists several seconds of green time before the concurrent vehicular movement receives the green indication. This reduces the risk of conflicts between bicyclists and turning traffic and also provides bicyclists an opportunity to make a lane change or left turn.
- At intersections with high bicycle volumes where bicyclists would otherwise follow the pedestrian indication, such as shared-use path crossings, a bicycle signal can reduce confusion. Pedestrian signal timing is inappropriate for bicyclists who travel at higher speeds, so a bicycle signal would allow bicyclists to cross legally during most of the flashing "don't walk" interval.

- At intersections where bicyclists would normally follow the vehicular signal, a bicycle signal provides a longer clearance interval more suitable to cyclist speeds.[1]

Figure 4 - Bicycle signal heads and signage for bicyclists and crossing pedestrians

Costs

Typical cost of a bicycle signal head installation will vary depending on the complexity and the size of the intersection, but, on average, they cost $12,800 each.[5]

Table 1- Bicycle signal head cost examples

	Median Cost	Average Cost	Minimum	Maximum	No. of Observations
New Bicycle Signal ($/EA)		$12,800	$10,000	$100,000	Bushell et al, Walker
Bicycle Detection ($/EA)	-	$1,920	$1,070	$2,680	Bushell et al
Retrofitting a signal with a pushbutton at an existing pedestrian signal ($/EA)	$230	$350	$61	$2,510	34

Design Guidance:

FHWA	Pedestrian and Bicycle Information Center – Bicycle Signal Heads http://www.pedbikeinfo.org/pdf/Webinar_PBIC_042518.pdf
FHWA	MUTCD - Interim Approval for Optional Use of a Bicycle Signal Face http://mutcd.fhwa.dot.gov/resources/interim_approval/ia16/ia16.pdf
Illinois Department of Transportation	Illinois Supplement to the MUTCD - Section 4D.04 - Meaning of Vehicular Signal Indications http://mutcd.fhwa.dot.gov/htm/2009/part4/part4d.htm
Illinois Department of Transportation	IDOT BLR – 42-3.06 Signing, Pavement Marking, and Traffic Control http://idot.illinois.gov/assets/uploads/files/doing-business/manuals-split/local-roads-and-streets/chapter%2042.pdf
Illinois Department of Transportation	IDOT BDE – 17-2.02(j) Signing, Marking, and Traffic Control http://www.idot.illinois.gov/assets/uploads/files/doing-business/manuals-split/design-and-environment/bde-
AASHTO	Guide for the Development of Bicycle Facilities https://store.transportation.org/Item/CollectionDetail?ID=116
NACTO	Urban Bikeway Design Guide http://nacto.org/publication/urban-bikeway-design-guide/bicycle-signals/bicycle-signal-heads/

Figure 5 - List of design guidance manuals and documents

SAFETY

Bicycle signal heads reduce conflicts between bicyclists, pedestrians and motorists by providing an independent bicyclist phase that separates turning motorist movements from through bicyclist movements. They provide guidance for bicyclists at intersections, especially with atypical movements like contraflow lanes or LBIs where bicyclists are given a head start. They can also simplify bicyclist movement through complex intersections. Conflicts between bicyclists and motorists may still arise, however, if it is unclear to the bicyclist that they have separate signals. Another concern is that motorists may confuse bicycle signal heads for motor vehicle signal indicators. In order to reduce that risk, bicycle signal heads commonly use bicycle insignias in the signal lenses. Some intersections also have a "No Turn on Red" sign which can serve as an additional tool to prevent intersection collision.[6]

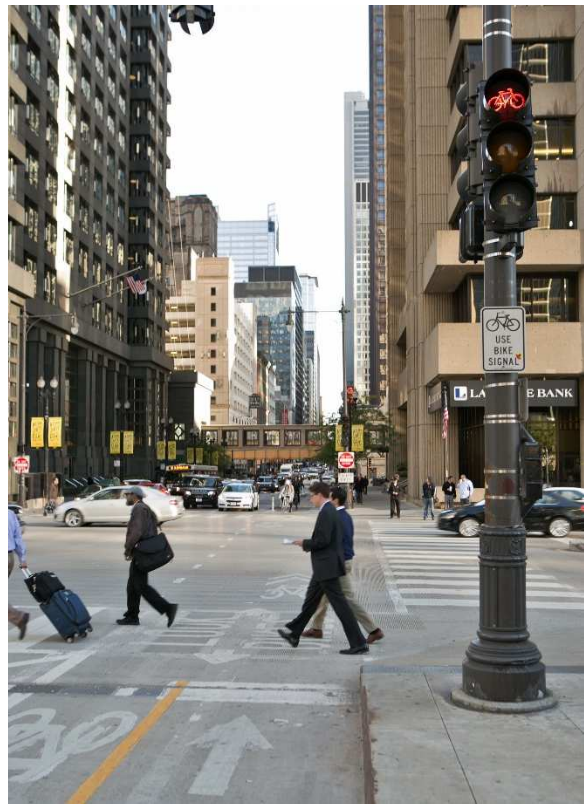


Figure 6 - Bicycle compliance rates have been shown to improve slightly. This may provide additional benefits for pedestrians as well.

A before and after bicycle signal head implementation study was conducted by the Chicago Department of Transportation (CDOT) in 2013. It was found that the installation of bicycle signal heads on Dearborn Street at Madison Avenue in Chicago reduced the incidence of bicyclists running red lights from 69% to 19%. Of the bicyclists surveyed, 97% reported that they felt the bicycle signal heads made the intersection safer as well. In a study performed by the Oregon Department of Transportation in 2013, analysis was performed on both traditional signalized intersections and intersections equipped with bicycle-specific signals. Overall, compliance was found to be 90% and is comparable at intersections with or without the bicycle-specific signals. The authors put forward a possible conclusion that the bicycle-specific signal "design is not likely to influence non-complying cyclists. Enforcement and/or work to change the culture of cyclists may be needed." A more detailed study of compliance rates was performed by the National Institute for Transportation and Communities which looked at post-installation compliance rates at bicycle signals in Chicago and found average rates ranging from 77% to 93%. Compliance by bicyclists with all traffic signals (regular or bicycle-specific) ranged from 67% to 98%". The study also surveyed users about their perspectives on how well motorists treated the facility. "Overall, only 25% [of the bicyclists] somewhat or strongly agree that they often see motorists turning illegally when the bicycle signal is green".[7]

The FHWA released the following statement regarding the safety benefits of bicycle signal heads

> "The Federal Highway Administration (FHWA) Office of Transportation Operations has reviewed the available data and considers the experimental bicycle signal face to be satisfactorily successful for the bicycle applications that were tested. Positive operational effects have been documented in the experiments such as a discernible and earlier behavioral adjustment(s) to newly installed bicycle traffic signals and traffic patterns as opposed to other devices, thereby resulting in an increased compliance by bicyclists with the traffic control. Additionally, depending on the specific application of the bicycle signal face, the research and experiments have shown that bicycle signal faces can reduce the overall number of

bicycle crashes or reduce the bicycle crash rate up to 45 percent where bicycle volumes concurrently increase."[8]

Further research should be performed to determine the compliance rates of motorists before and after installation of bicycle signals. As shown in Figure 7, some motorists may still confuse the bicyclist lights for motorist lights.

Figure 7 – A turning motorist brakes to avoid colliding into a bicyclist who has the right of way. Located on the Dearborn Street two-way, separated bicycle lane in Chicago.

OPERATIONS

Bicycle signal heads help maintain the flow of both bicycle and motor traffic, which is why they are typically installed at intersections where "…cross-traffic speed and/or volume is high enough to hinder cyclists' crossing of an intersection".[6] At locations with a turn lane and through bicyclist movement, intersection delay may increase for all users due to the addition of another signal phase. NACTO states that no right turn on red signs are also required which further increases intersection delay for turning motorists.[9] This can be resolved by reconfiguring the timing of the pedestrian signals to run with the timing of the bicycle signal head, and it will allow bicyclists to move through the intersection legally with a sufficient amount of time. NACTO also states that "…bicycle signal heads are generally the preferred option over installing a sign instructing bicycles to use pedestrian signals. While instructing bicyclists to use pedestrian signals is a low-cost option, the length of the pedestrian clearance interval (typically timed at 3.5 feet per second) is usually inappropriate for bicyclists. The result is that approaching bicyclists have poor information about when it is safe and legal to enter the intersection".[9]

A bicycle signal head was installed on a side path along a one-way street in San Francisco, California in September of 2008 by the San Francisco Municipal Transportation Agency (SFMTA). Originally, the bicycle through phase came after the dedicated motorist left-turn phase to allow for a longer green bicycle phase. However, motorists came into conflict with bicyclists at the end of their turn phase when turning on yellow or red movements. Bicyclists also disliked the lack of priority at the intersection. San Francisco then reversed the phasing to allow the bicyclists to travel through first. Although this results in a shorter bicyclist phase, bicyclists "felt that they were prioritized and vehicles violated the left red arrow less frequently." Therefore, while operations performance decreased slightly for bicyclists, safety and comfort increased.[10]

Figure 8 - Left: bicyclists have the green light and continue straight. Right: the turning motorist has the green light while the bicyclist stops on red.

MAINTENANCE

Bicycle signals are identical to traditional traffic signals with the exception of the faceplate bicycle symbols. They are maintained the same way as traffic signals, where they need attention during power outages and occasional bulb replacements. Maintenance crews should use caution when taking bicycle signals out of service for maintenance. Adequate maintenance of traffic is required and extra attention should be paid to avoiding motorist turn lane conflicts at two-way separated bicycle lanes.

While the maintenance for bicycle signal heads is not directly mentioned, a 2009 report published by the FHWA on traditional heads gives insight into the maintenance requirements for bicycle signal heads. In this report they touch on a few key points for signals:

- Signals should be re-timed at least every two to three years.
- Agencies should have one traffic engineer for every 75 to 100 signals, and one technician for every 40 to 50 signals.
- Field maintenance of controllers normally takes between 30 minutes and 3 hours.
- Maintenance of detectors should not be performed for prolonged periods of time.
- The average controller is between 5-10 years old.
- Certification for maintenance technicians is available but not required everywhere.
- Controller failure rate widely varies. Determining the causality of this variation might yield productive modifications for maintenance practices.
- Most traffic control systems provide notification of critical equipment failure. It is recommended that when the traffic operations center is not staffed, this information be provided directly to the maintenance facility if the agency has not already made provision.
- Most isolated traffic signals are neither connected to a traffic control system nor is provision made for monitoring their failure status. As a result, notification of equipment failure is often considerably delayed. It is recommended that greater emphasis be placed on providing such feedback to the responsible maintenance facility.[11]

Figure 9 - Bicycle Signal Head in Chicago

The Portland Bureau of Transportation states that a large portion of their traffic signal maintenance is preventative. Their goal is to repair or replace controller and signal equipment, intersection hardware, and auxiliary equipment before they fail. Their green and red signals are LED type lamps, which they replace every 5 to 6 years. Their yellow signal is incandescent and lasts up to 10 years.[12]

District One Studies

The following is a summary of findings from two studies performed in 2014 for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 2 - Local bicycle signal head studies performed in District One

Study	Findings
Behavior Study	Only 1% to 2% of motorists violated the traffic signals. On the other hand, 14% to 19% of bicyclists disregarded the conventional traffic signal and went through the red indication.
Crash Analysis	Crash data is inconclusive due to the small sample size. Only 13 bicyclist crashes occurred before installation and five crashes after installation. More sites and more data must be studied in order to properly evaluate the effects of bicycle signal heads on motorist/bicyclist crash rates.

Motorist Compliance and Pedestrian Behavior Study

A bicycle and motorist signal compliance study was conducted on Clybourn Avenue in the City of Chicago. The goal of this study is to measure the before and after effects of implementing bicycle specific signals on bicycle compliance. As a part of a separate IDOT project, bicycle specific signals are tentatively proposed on Division Street for through and right turning bicyclists in both westbound (at Clybourn Avenue) and eastbound (at Orleans Street) directions. Data was collected on Thursday, July 24, from 4:30 to 6:00 PM. Weather was 70° and sunny.

Study Method

The study reviewed driver compliance with signals for the right turn and through movements. The Right Turns on Red after Stop observations were based on ITE recommended studies.[13] The through movement sheet was developed by Primera for this study and also based on nationally used compliance measures. Staff members were dressed in street clothes and sat in inconspicuous locations noted in Figure 10. There were two staff members for each signal. The light that was active when the motorist or bicyclist passed through the intersection was recorded. The four signal conditions studied were 1) green, 2) yellow after green, 3) red (after yellow), and 4) running the red light. The red (after yellow) condition meant the light turned red as the road users were already travelling at speed during the yellow phase. Running the red light meant the user was at a stop during a red phase and then accelerated through the intersection during the red phase.

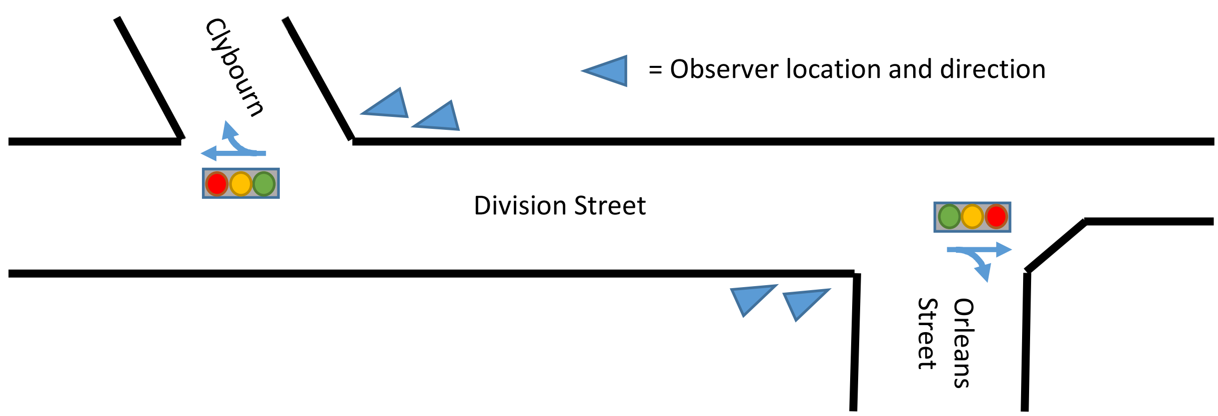


Figure 10 - Observation Diagram

At least 98% of motorists for both directions obeyed the traffic signals with only 1%-2% of the drivers passing through the red phase after a change from yellow. No motorists ran a red light. Bicyclists exhibited higher non-compliance; 80% of westbound bicyclists and 86% of eastbound bicyclists went through the intersection when the signal was either green or yellow. However, 19% of westbound and 14% of eastbound bicyclists went through the red signal.

Table 3 - Motorist and bicyclist behaviors during various signal phases.

Westbound Through			Eastbound Through		
	Motorists	Bicyclists		Motorists	Bicyclists
Green	94%	77%	Green	94%	84%
Yellow After Green	4%	3%	Yellow After Green	5%	2%
Red	2%	0%	Red	1%	2%
Running the Light	0%	19%	Running the Light	0%	12%

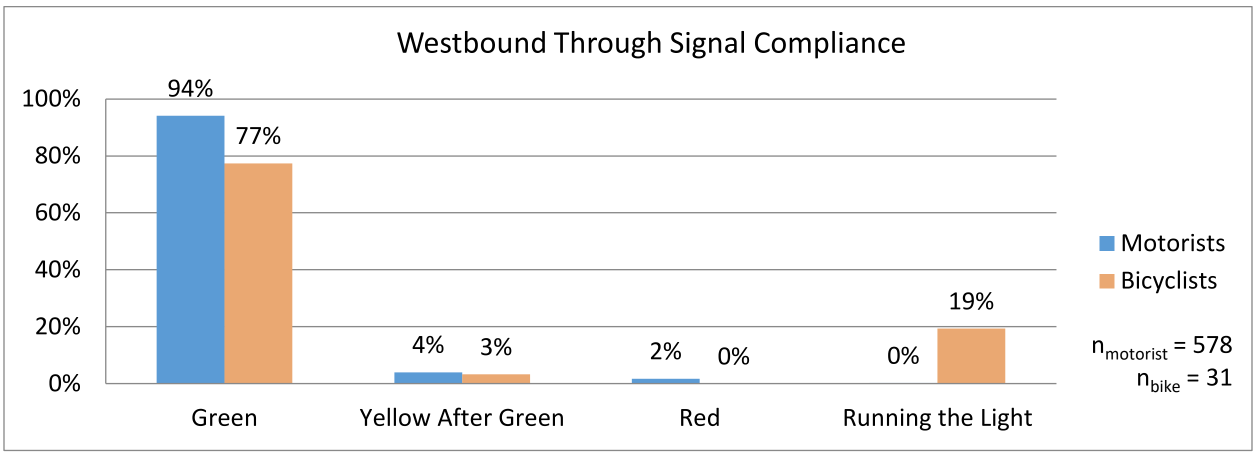


Figure 11 - Westbound through signal compliance

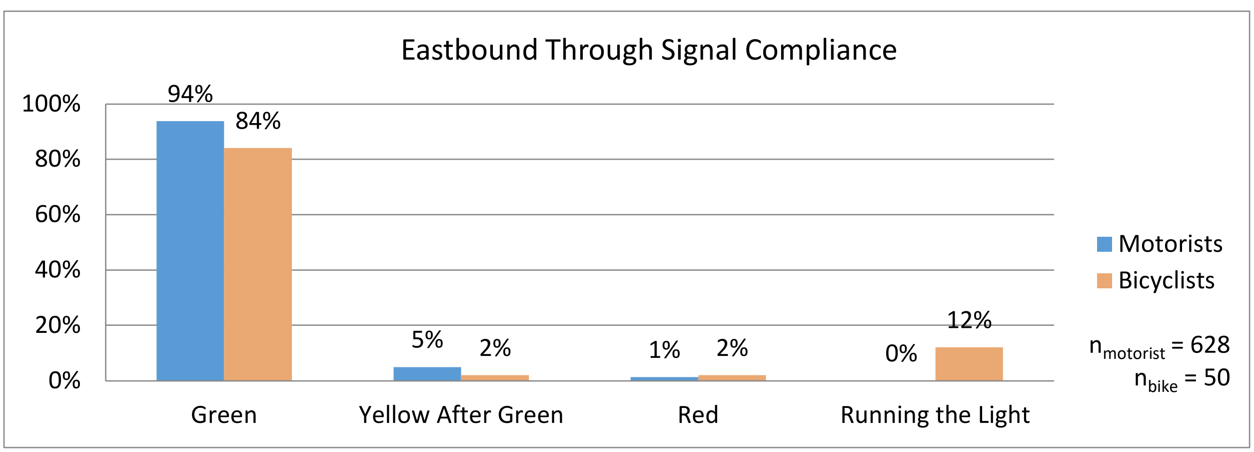


Figure 12 - Westbound through signal compliance

Right Turn on Red Signal Compliance

The right turn signal compliance study was inconclusive. During the rush hour periods the right turn movements from Division Street north on to Clybourn or south on to Orleans Street are given a continuous green signal indication. There is only a one second duration red signal as the cycle resets or a 36 second duration red signal if pedestrians activate the crosswalk button. Few pedestrians activated the crosswalk signal and therefore the sample size for right turning motorists or bicyclists approaching a red light was small. However, of the few times the right turn signal changed to red, many right turning motorists were observed as non-compliant.

Discussion

Bicyclist compliance at the signalized intersections of Clybourn Avenue and Orleans Street along Division Street (with a conventional traffic signal) is higher compared to data measured by the Chicago Department of Transportation (CDOT). CDOT measured bicyclist compliance at signalized intersections before and after installation of bicycle specific signals along Dearborn Street. Compliance increased from 31% pre-installation to 81% post-installation.[14] In comparison, the Division Street observations showed an average 83% compliance rate *before* installation of the bicycle signals (after installation study has not been performed yet pending construction of the signals). This discrepancy may be due to intricacies between observation sites and compliance classifications. Dearborn Street has a four second all-red interval whereas Division Street does not. Many bicyclists on Dearborn Street used this opportunity to get a head start on traffic and become more visible as they pass through the intersection, however those bicyclists still waited during the duration of the main red interval. If this group is counted as compliant then the Dearborn street percentage becomes 72% before installation of the bicycle signals and 89% after installation.

The Division Street results more closely compare to compliance rates measured in Portland, Oregon in a separate study. That study, performed by Chris Monsere from Portland State University, found a pre-bicycle signal compliance rate of 88.9% and a post-installation rate of 89.8% showing little effect of the bicycle signal on bicyclist compliance, a finding consistent with another Oregon Study that reached a "possible conclusion that [bicycle-specific signals] are probably not likely to influence noncomplying cyclists. Enforcement and/or work to change the culture of cyclists may be needed." [15]

Conclusion

Division Street has slightly higher compliance rates when compared to another Chicago location (if the discrepancy between Chicago sites is adjusted for comparison purposes) and slightly lower rates compared to Portland, Oregon. After installation of bicycle signals compliance rates increased by only 1% in Portland and 17% in Chicago. A study will be conducted by IDOT to determine the post-installation results of installing bicycle specific signal heads at the signalized intersections along Division Street.

Crash Analysis

Crashes were analyzed before and after bicycle signal heads were installed. Below are three different types of crash analyses for bicycle signal heads: total crashes, crashes by severity/type, and crash rates. This study examined several bicycle signal head intersections on Dearborn Street in Chicago. The bicycle signal heads were installed simultaneously with a two-way separated bicycle lane in 2012, so the changes in crash trends might not be exclusively due to the bicycle signal heads. Crash data was provided by IDOT for the years 2005 to 2013.

Total Crashes

Only crashes taking place at intersections with bicycle signal heads on Dearborn Street were counted. The number of crashes were totaled then divided by the number of years of data collection to find the overall crashes per year.

Table 4 - Total crashes

Intersection (Cross Street with Dearborn)	Bicycle Crashes Before Installation			Bicycle Crashes After Installation		
	# of Crashes	*Years of Data*	*Crashes/Year*	*# of Crashes*	*Years of Data*	*Crashes/Year*
Polk Street	0	7	0.000	1	1	1.000
Harrison Street	2	7	0.286	1	1	1.000
Congress Parkway	2	7	0.286	1	1	1.000
Van Buren Street	1	7	0.143	0	1	0.000
Jackson Street	0	7	0.000	0	1	0.000
Adams Street	0	7	0.000	0	1	0.000
Monroe Street	1	7	0.143	0	1	0.000
Madison Street	1	7	0.143	0	1	0.000
Washington Street	2	7	0.286	0	1	0.000
Randolph Street	1	7	0.143	0	1	0.000
Lake Street	1	7	0.143	0	1	0.000
Wacker Drive	1	7	0.143	1	1	1.000
Kinzie Street	1	7	0.143	1	1	1.000
AVERAGE	-	-	**0.143**	-	-	**0.358**

Table 5 – Average of total crashes

Crashes by Number (Average of All Intersections)	Before Installation	After Installation
Bicycle Crashes per Intersection per Year	0.143	0.385

The results show the average crashes per year went up post-installation of the bicycle signal heads. While this figure nearly tripled, it does not take into account changing bicyclist volumes that often occur after the installation of a bicycle facility.

Crashes by Severity/Type

The crash data provided by IDOT included various characteristics of the crashes such as injury types and lighting. In regards to injuries, the severity of injuries decreased after the installation of the bicycle signal heads. In regards to lighting, the percentage of crashes increased in dark conditions. However, there were only 13 crashes before installation and 5 crashes after installation, so the small sample size hinders the credibility of the results.

Table 6 - Crashes by severity

Crashes by Severity	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
A-Incapacitating Crash	7.7%	0%
B-Injury Evident Crash	61.5%	60.0%
C-Injury Possible Crash	23.1%	40.0%
O-Property Damage Only Crashes	7.7%	0%

Table 7 - Crashes by lighting conditions

Lighting Conditions	Before Installation (% of Total Crashes)	After Installation (% of Total Crashes)
Darkness, Lighted Road	15.4%	20.0%
Daylight	69.2%	80.0%
Dusk	15.4%	0.0%

Table 8 - Crash severity code descriptions. Source: NSC (2001)

Code	Severity	Injury Description
K	Fatal	Any injury that results in death within 30 days of crash occurrence
A	Incapacitating	Any injury other than a fatal injury which prevents the injured person from walking, driving, or normally continuing the activities the person was capable of performing before the injury occurred
B	Injury Evident	Any injury other than a fatal injury or an incapacitating injury that is evident to observers at the scene of the crash in which the injury occurred
C	Injury Possible	Any injury reported that is not a fatal, incapacitating, or non-incapacitating evident injury
O	Property Damage Only	Property damage to property that reduces the monetary value of that property

Crash Rates

These crash rates were calculated based on the Federal Highway Administration's intersection crash rate formula, which uses the number of crashes, the Average Annual Daily Bicycle Volumes (AADB) entering the intersection and the number of years of data.

Table 9 – Dearborn Street crash rates at intersections between Kinzie Street and Polk Street

Dearborn Intersections	2005	2006	2007	2008	2009	2010	2011	2013
AADB	86	90	94	98	103	108	112	263
Number of Crashes	3	1	2	2	4	0	1	5
Crash Rate (bicycle crashes/million bicycles)	98.6	30.4	58.3	55.91	106.4	0.0	24.46	52.1

Table 10 - Average crash rates

Average of Years	Before Installation	After Installation
Intersection Crash Rate (bicycle crashes/million bicycles)	53.0	52.1

The crash rate essentially remained the same at the intersections after the installation of the bicycle signal heads.

A number of assumptions were made to find the crash rates. The AADB's were extrapolated from two hour bicycle counts provided by the Chicago Department of Transportation and a 4.3% yearly growth rate found from existing ACS data on worker's mode split in Chicago was used. AADB's were found from counts at the intersection of

Dearborn and Washington before and after the installation of the signal heads, however, bicycle volumes most likely varied along the length of Dearborn. Additionally, the sample size is small (only 18 crashes).

Conclusion

The crash data is inconclusive due to the small sample size. Only 13 bicyclist crashes occurred before installation and five crashes after installation. More sites and data must be studied in order to properly evaluate the effects of bicycle signal heads on motorist/bicyclist crash rates. Future study locations include the intersection of North Milwaukee Avenue and North Elston Avenue in Chicago. A bicycle signal head was installed at this intersection in 2013 and unlike the bicycle signal heads installed on Dearborn, no other simultaneous improvements were made. IDOT also installed bicycle signal heads in 2016 on Division Street at Clybourn and at Wells Street as part of the Clybourn separated bicycle lane pilot project.

As of January 2, 2015, there are at least 24 known cities in the United States and Canada utilizing bicycle signal heads. Below are the locations:

Table 11 - Examples of bicycle signal head locations in the USA with District One highlighted

Country	City	State	Example Street/Intersection	Installation Year
CA	Vancouver	BC	Hornby Street	2010
CA	Montreal	QC	Christophe Colomb Avenue and Saint-Gregoire Street	-
USA	Tuscon	AZ	Ft. Lowell Road and Fontana Avenue	2009
USA	Davis	CA	Russell Boulevard and Sycamore Lane	1996
USA	Long Beach	CA	W Broadway and Magnolia Ave	2011
USA	San Francisco	CA	Market and Valencia	2012
USA	San Luis Obispo	CA	Santa Barbara Avenue and Upham Street	2007
USA	Denver	CO	14th Avenue and Bannock Street	2012
USA	Washington	DC	New Hampshire Avenue and U Street	2010
USA	Atlanta	GA	5th Street and Peachtree Street	2011
USA	**Chicago**	**IL**	**Dearborn Street**	**2012**
USA	Cambridge	MA	Western Avenue between Massachusetts and Memorial	2014
USA	Minneapolis	MN	Broadway Street and 5th Street	2010
USA	New York	NY	W 28th Street and 9th Avenue	2010
USA	Ashland	OR	Johnson Creek Boulevard and Bell Avenue	2012
USA	Clackamas County	OR	Interstate 5 Exit 14	2012
USA	Eugene	OR	Adler and 18th	2011
USA	Portland	OR	Broadway and Williams	2010
USA	Austin	TX	Martin Luther King Jr Boulevard and Rio Grand Ave	2012
USA	Salt Lake City	UT	Main Street and 200 South	2011
USA	Alexandria	VA	South Washington and South Alfred Street	2010
USA	Arlington	VA	N Oak Street and Lee Highway	2011
USA	Seattle	WA	Linden Avenue	2013
USA	Madison	WI	E Mifflin Street and N Blair Street	2012

[1] Pedestrian & Bicycle Information Center. "Bicycle Detection." *Pedestrian & Bicycle Information Center*. U.S. Department of Transportation Federal Highway Administration, n.d. Web. October. 2015. <http://www.pedbikeinfo.org/planning/facilities_crossings_bikesignals.cfm>.

[2] Illinois Department of Transportation. *Signing, Marking, and Traffic Control*. Rep. no. IDOT BDE – 17-2.02(j). N.p.: 2013. http://www.idot.illinois.gov/assets/uploads/files/doing-business/manuals-split/design-and-environment/bde-manual/chapter%2017%20bicycle%20and%20pedestrian.pdf

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[10] San Francisco Municipal Transportation Agency. *Fell-Masonic Bicycle Signal, San Francisco, CA*. Rep. National Association of City Transportation Officials, n.d. Web. 30 Mar. 2015. http://nacto.org/cities-for-cycling/projects/fell-masonic-bicycle-signal-san-francisco-ca/

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Facility Reports: Pedestrian

Bicycle & Pedestrian Accommodations Study

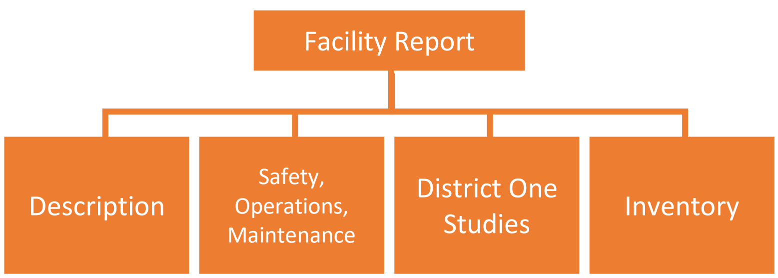
Illinois Department of Transportation, District One

VOLUME 3

Illinois Department of Transportation

Pedestrian

Included in each Facility Report:



- Facility Description
  - Summary
  - Features
  - Warrants
  - Costs
  - Design Guidance
- Safety Analysis
- Operations Analysis
- Maintenance Analysis
- District One Studies
  - Summary
  - Field Survey
  - Behavior
  - Speed
  - Crash Analysis
- Inventory
- References

Notes:
Safety analysis includes the following potential topics: *crashes, conflict points, user comfort, signal/stopping compliance, etc…*
Operations analysis includes: *traffic volumes, delay, speed, pedestrian wait times, etc...*
Maintenance analysis includes: *drainage, utilities, street sweeping, snow removal, unique materials & equipment, etc…*

Median Refuge Islands

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

Median refuge islands are intended to make street crossings safer and easier. They separate crossings into two phases so the pedestrian has only one direction of traffic to cross at a time. The island provides a safe and visible place to wait. Median refuge islands are ideal at roadway crossings with high traffic volumes and wide street widths, and also higher speeds in certain situations. They can also be used at signalized intersections to allow pedestrians with disabilities, seniors, children, and other pedestrians who cannot cross the entire crosswalk in one phase, to make a partial crossing and then safely wait for the next cycle to complete their crossing. They can facilitate bicycle crossings as well, especially on bicycle boulevards, shared use path or trail crossings.

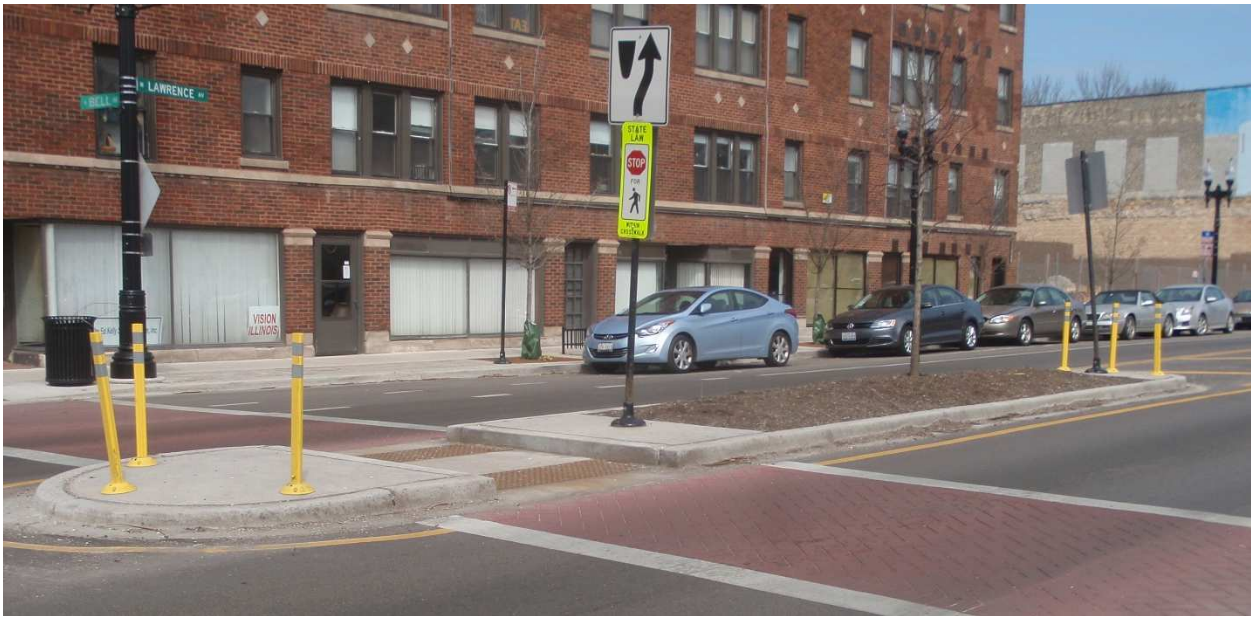


Figure 1 - Median refuge island with "stop for pedestrian" sign and flexible bollards on West Lawrence Avenue in Chicago

Features

A median refuge island has the following features: [1]

- A waiting area for pedestrians (required)
- Barrier curb surrounding the median (required)
- Retroreflective solid yellow markings should be placed on median's approach curb ends in accordance with Section 31.02 of the MUTCD (required)
- Reflective delineators in areas with snow (required)
- Reflective pavement markers should be used on the nose of the medians approach (recommended)
- Advanced "stop for pedestrians" signage and pavement markings
- Landscaping and lighting to improve the crosswalks visibility may be placed in the median

Figure 2 - Example of a median refuge island for both pedestrians and bicyclists. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press.

- May be combined with other facilities such as Rectangular Rapid Flashing Beacon
- Gaps for pedestrians and bicyclists can be installed with a "S" jog or at a 45 degree angle so the user is looking towards oncoming traffic while they wait in the median

Right Turn Corner Islands

It should be noted refuge islands are also useful as right turn corner islands, also known as a right turn bypass island or "pork chop". The right turn corner island is a curbed island that directs right turning motorists into a dedicated turn lane with a turning radius that encourages slow speeds and promotes pedestrian visibility. The island has the added benefit of shortening the crossing distance and providing a refuge for pedestrians, similar to median refuge islands. See the curb bump out report for more information on turning radii and its effect on traffic as well as the benefits of increased pedestrian visibility. Pork chop islands are recommended by Ride Illinois (formerly called the League of Illinois Bicyclists).

Right turn corner islands reduce conflict points, allow the stop bar to be placed closer to the intersection. According to observations by Ride Illinois, right turning motorists are more likely to yield for shared-use path users going to a right turn corner island compared to those users crossing at standard turn lanes and crosswalks.

Most of the following research reports on the effectiveness of midblock or intersection median refuge islands. More information on right turn corner islands may be provided in future supplements to this study.

Figure 3 – Left: right turn corner island with a cut-through crossing and properly orientated detector pads. Right: right turn corner island with raised crosswalk and yield markings. Images: www.pedbikeimages.com / Dan Burden

Costs

According to Bushell et al., which looked at 17 different sources, the cost for installing a median refuge island ranges from $2,140 to $41,170, with an average cost of $13,520.[2] Costs depend on the design, site conditions, and whether or not the median is being implemented to an existing roadway or new construction.

$ $13,520
Average cost (2013)

Warrants

Refuge islands should be installed at crosswalks on roadways with traffic volumes more than 12,000 ADT, intermediate to high traffic speeds, high bicycle/pedestrian volumes, and/or wide street widths.[3] They can also be installed where it is desirable to restrict vehicle movements. AASHTO recommends the installation of median refuge islands for these conditions:[4]

- Midblock locations where the crossing (width) exceeds 60 feet and/or there are limited gaps in traffic

- Local roads with low speeds & traffic volumes with special pedestrian circumstances (senior citizen homes, day cares, hospitals, etc.)
- Collector roads with moderate-to-high speeds & traffic volumes
- Midblock multilane arterials; supplementary traffic control devices should be considered

The FHWA lists conditions in which pedestrian refuge islands are not beneficial and potentially harmful as:

- Narrow streets and/or streets where substandard-width refuge islands are used
- Instances in which a high turning volume of large trucks exists
- Conditions under which the roadway alignment obscures the island, thereby making it more likely that motorists drive onto the island

Design Guidance

FHWA	Proven Safety Countermeasures – Medians and Pedestrians Crossing Islands in Urban and Suburban Areas http://safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_011.cfm
FHWA	MUTCD Chapter 1A – Uniformity of Traffic Control Devices http://mutcd.fhwa.dot.gov/htm/2009/part1/part1a.htm#section1A06
AASHTO	A Policy on Geometric Design of Highways and Streets (8th) (Previous 6th Edition: Page 2-79 and Section 9.6.3) https://store.transportation.org/Item/CollectionDetail?ID=180
AASHTO	Guide to the Development of Bicycle Facilities Chapter 5.3.5 https://store.transportation.org/Item/CollectionDetail?ID=116
AASHTO	Guide for the Planning, Design, and Operation of Pedestrian Facilities - Chapter 3.3.2, 3.4.1 https://store.transportation.org/Item/CollectionDetail?ID=131
NACTO	Urban Bikeway Design Guide http://nacto.org/cities-for-cycling/design-guide/intersection-treatments/median-refuge-island/

Figure 4 - List of design guidance manuals and documents

SAFETY

According to the FHWA Safety Program, pedestrian crashes account for approximately 12% of all traffic related fatalities annually, and over 75% of those fatalities occur at non-intersection locations.[6] In order to cross a roadway, pedestrians must find a safe gap in traffic. Having to estimate vehicle speeds and predict vehicle paths can make crossing a wide street a complex task for some pedestrians. Median refuge islands make it easier to find gaps by letting the pedestrian cross one direction of traffic at a time, ultimately reducing conflicts between motorists and pedestrians.

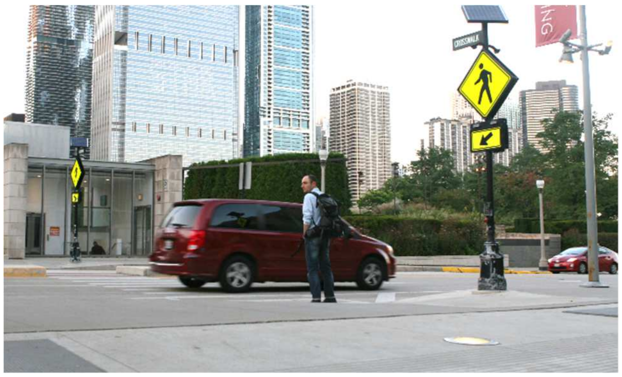


Figure 5 - Phase 1: Pedestrian waits for a gap in eastbound traffic to reach the median refuge island on Monroe Street in Chicago.

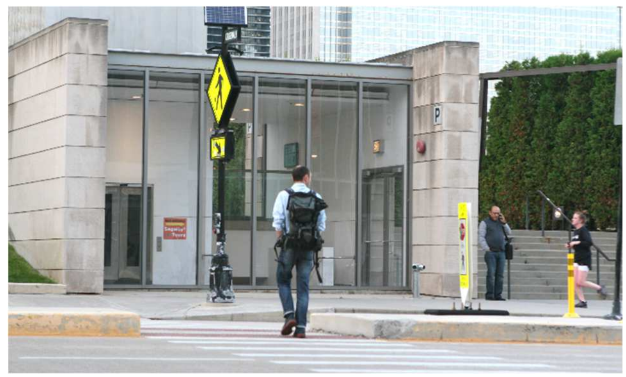


Figure 6 - Phase 2: Pedestrian reaches the median refuge island and then looks for a gap in westbound traffic to complete his crossing of Monroe Street in Chicago.

At night, crossing may be even more difficult for pedestrians due to low lighting and difficulty in judging speed and distance of approaching motorists.

Reduction in crosswalk pedestrian crashes after the installation of a median refuge island	46%

Median refuge islands are one of the Federal Highway Administration's nine proven safety counter measures for reducing vehicle-pedestrian crash frequency and severity. Adding a median refuge island has been shown to lower pedestrian crashes by 46% at marked crossing locations and by 39% at unmarked crossing locations.[3] The installation of median refuge islands also creates an area where additional lighting can be implemented if desired, further increasing the visibility and safety of crossing pedestrians.

Median refuge islands have been extensively studied by the Georgia and Florida Departments of Transportation. One study was conducted at Sunken Gardens in St. Petersburg, Florida with an ADT of 31,500 vehicles per day with speeds averaging more than 10 mph above the posted limit (the speed limit was not provided in the report). A raised pedestrian refuge island and a rectangular rapid flashing beacon (RRFB) were installed in front of Sunken Gardens. In the first week after the installation, over 85% of motorists yielded to crossing pedestrians (900 crossings recorded).[5] It is unclear what effect the RRFB had.

Another study was conducted by the Michigan Department of Transportation.[6] On Mission Street in Mount Pleasant, Michigan, a new pedestrian refuge island was found to have decreased pedestrian and angle or turning crashes, while other types of crashes such as fixed-object and driveway related crashes increased. There were various factors, such as location and surrounding signage, which made it difficult to determine the effectiveness of the pedestrian refuge island. Ultimately it was concluded that MDOT should consider installing larger, longer medians as opposed to short pedestrian refuge islands, or to install additional temporary signage and pavement markings where short refuge islands are installed.

Figure 7 - Median refuge island with stamped pavement and an at-grade cut through for pedestrians on Lawrence Avenue in Chicago.

Figure 8 - Median refuge island with crossing guard during a snow event at Chicago Avenue and Hoyne Avenue in Chicago.

Median refuge islands can also be designed with an offset crossing that orientates the pedestrians in the direction of oncoming traffic. Orientating the pedestrian toward incoming traffic encourages them to observe first before crossing. Care should be made when designing for persons with disabilities, especially those with vision impairments as they may not expect the crosswalk to jog or change directions abruptly, especially in the middle of the intersection. Offsets can only be installed on roadways with adequate street width and require curbs within the crossing to aid with the visually impaired following the correct path. Proper alignment of the median detectors and curbs allow for safe exits of the refuge area by the visually impaired. Offset crossings are necessary for signalized, two-stage phase crossings so pedestrians do not confuse the opposite direction signal for their near-side crossing signal. If signals are used, egg-crate visors should be installed to further restrict views by the opposite side pedestrians.

Figure 9 - Midblock median refuge island with an offset median cut through and accessible detector pads perpendicular to the roadway. Image: www.pedbikeimages.com / Lyubov Zuyeva

A potential safety disadvantage with this facility pertains to its visibility to approaching motorists; median refuge islands and raised medians are not always clearly visible, especially at night, during and after snowfall events. This can lead to motorists colliding with the median. However, with adequate signage, pavement markings, and reflective flexible delineators such as those shown in Figure 6, and regular facility maintenance this issue can be minimized. Furthermore, the FHWA found motor vehicle crashes were reduced by up to 39% after the installation of larger scale raised medians due to the reduced conflict points.[3] The FHWA also notes that median refuge islands may induce a false sense of security in pedestrians that expect motorists to automatically stop.

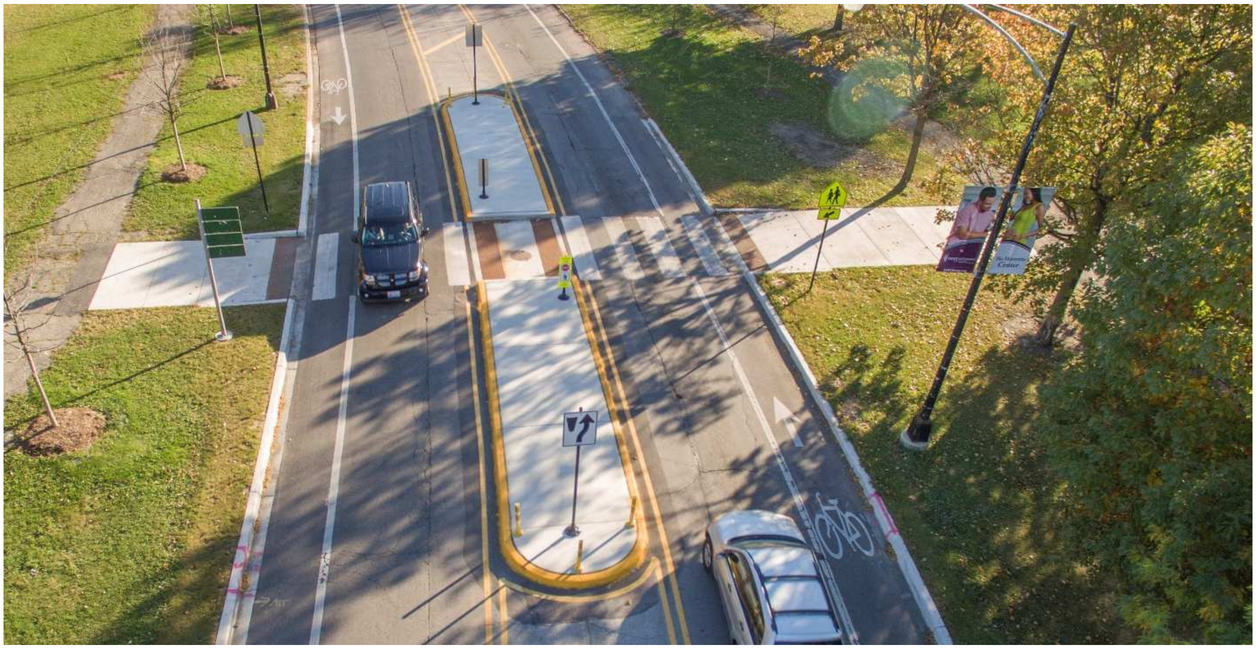


Figure 10 - Median refuge island on Sacramento Drive in Chicago. Copyright 2015, Skyity.com. Reprinted with permission.

Furthermore, for right turn corner islands, the crosswalk should be marked at the midpoint of the crossing since speeds are generally slower at the midpoint of the turn.[7]

OPERATIONS

Median refuge islands permit a two phase roadway crossing for pedestrians. This reduces the effective crossing length and allows them to focus on crossing one direction of traffic at a time. Median refuge islands are appropriate on multi-lane streets with both marked and unmarked crosswalks and on two-lane roads with or without a center left-turn lane.[8] NACTO suggests they are installed, "where a pedestrian must cross three lanes of traffic in one direction (on a 1-way or a 2-way street), but may be implemented at smaller cross-sections where space permits."

Figure 11 - Median refuge island on West Lawrence Avenue in Chicago

Median refuge islands can be designed to block left-turning movements into driveways or side roads. This improves the flow of traffic and overall safety by reducing potential vehicle turning collisions at the intersection. They can also be strategically placed to encourage pedestrians to cross at desirable locations with better lighting or where gaps between vehicles are more frequent.

According to NCHRP Report 294A, pedestrians crossing an undivided, multi-lane street may experience delays 10 times longer than the delay incurred crossing a street with a median.[9] It is important to note, NCHRP Report 294A was published in 1987, so some of the information may be dated.

The Safe Routes to School Guide notes the following for the operations of the Median Refuge Island:[10]

- Can benefit motor vehicle operations by reducing potential head-on crashes.
- Potential local business opposition due to loss of access from left-turning vehicles.
- May hinder ability of large vehicles to make right-hand turns.
- Especially effective on high volume, multi-lane streets.
- Must be ADA compliant, accessible to pedestrians with mobile and visual impairments.

Figure 12 - Median refuge island on Sacramento Drive in Chicago. Copyright 2015, Skyity.com. Reprinted with permission.

MAINTENANCE

Median refuge islands may require frequent maintenance due to the road debris it accumulates such as sand, gravel, glass, and auto parts, and due to motorist collisions with the median curb or signage.

Street Sweeping & Snow Removal

In times of snowfall, median refuge islands must be kept visible to snow plow crews and kept free of snow that will block pedestrian access.[11] Snow plows may strike and damage the curb as shown in Figure 13 below. Flexible delineators should be installed around the facility so the curb is visible to plow operators. Regions with heavy snowfall may also accumulate additional road debris that will need to be cleared out in the spring. Regular street sweeping around the edges of the median should help keep the median refuge island visible and accessible. Periodic sweeping of the crosswalk portion may be required as dirt and debris can also accumulate there. Sidewalk specific sweepers or hand sweeping can be used. See the SBL maintenance report for more information on specialized sidewalk sweepers.

Figure 13 - Median refuge island covered in snow at Chicago Avenue and Hoyne Avenue in Chicago.

Upkeep

Motorists sometimes collide with median refuge islands and may damage the curb, brick pavers, post mounted signs, flexible delineators or the "stop for pedestrian" signs. Reinstallation of signs or placement of new curb may be required. Pavement markings on the approach to a median refuge island should be maintained, especially if traffic is diverted around the median.

Other maintenance issues that may arise over time include damage to the signing, pavement markings, raised pavement markers, and landscaping or pavement inside the median. Median refuge islands with landscaping will require additional mowing or care.

Drainage

Cut-through sidewalks within median and corner islands should have adequate slope to maintain proper drainage.

Typical Infrastructure to Maintain:

- Signage and pavement markings
- Pavement, landscaping, or brick pavers inside the median
- Flexible delineators
- Barrier curb surrounding the island

Figure 14 - Damaged median refuge island on Chicago Avenue and Hoyne Avenue in Chicago

Figure 15 - Damaged median refuge island on Chicago Avenue and Hoyne Avenue in Chicago. All flexible delineators have been knocked down.

Median refuge islands are used across the U.S. and Canada. The following table shows a few cities that are currently implementing refuge islands.

Table 1 - Examples of median refuge islands in North America

Median Refuge Islands					
Country	**City**	**State**	**Street**	**Description**	**Install Year**
USA	**Chicago**	**IL**	**Chicago Avenue and Hoyne Avenue**	**Barrier Curb with Brick Pavers in the Middle and Stop for Peds Sign**	**2009**
USA	**Chicago**	**IL**	**Lawrence Avenue between Ashland and Western Avenues**	**Barrier Curb, Concrete and Landscaping in the Middle, Bollards on Ends, and Stop for Peds Sign**	**2014**
USA	**Chicago**	**IL**	**Clark Street and Berteau Avenue**	**Barrier Curb, Concrete and Street Signs in the Middle, Bollards on Ends**	**2014**
USA	Portland	OR	Prescott Street and 18th Street	Barrier Curb, Concrete and Traffic Signs in the Middle, Reflectors on Ends	2014
USA	St. Paul	MN	Jefferson and Cleveland		2010
USA	Staten Island	NY	Luten Avenue and Billiou Street	Barrier Curb, Concrete and Landscaping in Middle, Bollards and Traffic Signing on Ends.	2009
USA	Bronx	NY	Allerton Avenue	Barrier Curb, Concrete and Landscaping in Middle, Bollards on Ends.	2009
USA	Flushing	NY	College Point Boulevard between 33rd and Maple Avenue	Barrier Curb with Concrete in the Middle	
USA	New York	NY	1st Avenue	Barrier Curb, Concrete and Landscaping in Middle	
USA	Palo Alto	CA	El Camino Real and Stanford Avenue	Barrier Curb, Concrete and Landscaping in Middle	2011
USA	Milwaukee	WI	Wisconsin Avenue Between 16th and 13th Street	Brick Pavers, RRFB's, Landscaping, and Pedestrian Push Signals. Facility is on a busy college midblock crossing for Marquette University Students.	Before 2009
USA	Springfield	VA	Frontier Drive near Springfield Mall	Barrie Burb, Landscaping in Middle	Before 2008

[1] NACTO. "Median Refuge Islands." *Urban Bikeway Design Guide*. Washington, DC: Island, 2014. http://nacto.org/cities-for-cycling/design-guide/intersection-treatments/median-refuge-island/

[2] Bushell, Max, Bryan Poole, Daniel Rodriguez, Charles Zegeer. July 2013. *Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners and the General Public*. University of North Carolina Highway Safety research center. Accessed August 28, 2014. http://www.pedbikeinfo.org/cms/downloads/Countermeasure%20Costs_Report_Nov2013.pdf

[3] FHWA. "Proven Safety Countermeasures - Medians and Pedestrian Crossing Islands in Urban and Suburban Areas - Safety | Federal Highway Administration." *Safety Benefits of Raised Medians and Pedestrian Refuge Areas*. Federal Highway Administration, 15 Oct. 2014. Web. 15 Oct. 2015. http://safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_011.cfm

[4] AASHTO, Guide for the Development of Bicycle Facilities, 1999. http://nacto.org/wp-content/uploads/2011/03/AASHTO-Guide-for-the-Development-of-Bicycle-Facilities-1999.pdf

[5] "Safety Benefits of Raised Medians and Pedestrian Refuge Areas." FHWA Safety Program. Accessed February 10, 2015. http://safety.fhwa.dot.gov/ped_bike/tools_solve/medians_trifold/

[6] "Case Study Report." MDOT. April 1, 2012. Accessed February 10, 2015. http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC1572_Part4_387510_7.pdf

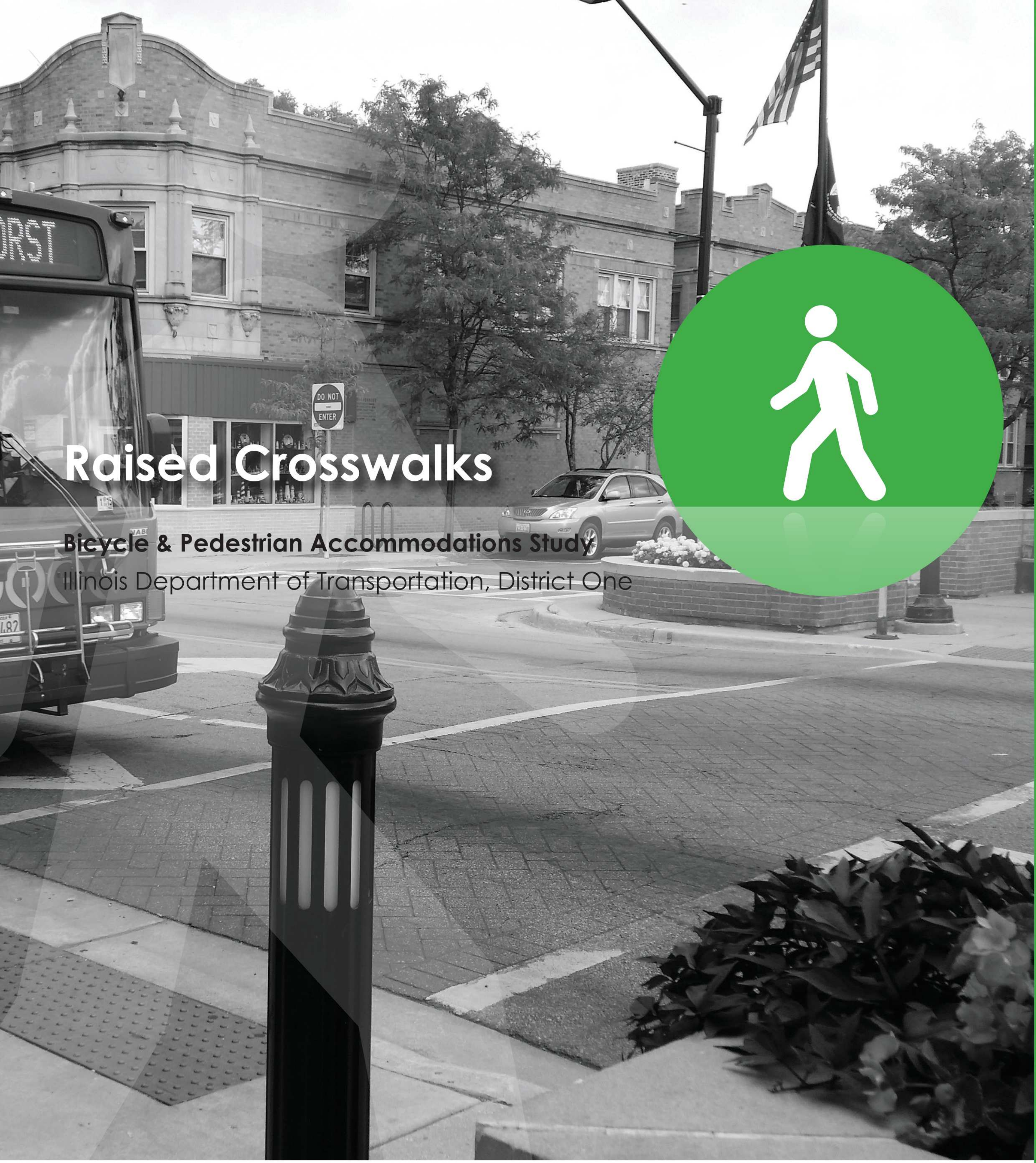
[7] Fitzpatrick, Kay, William H. Schneider IV. *Turn Speeds and Crashes Within Right-Turn Lanes.* February 2005. http://tti.tamu.edu/documents/0-4365-4.pdf

[8] Bowman, B. & Vecellio, R. (1994). Effects of urban and suburban median types on both vehicular and pedestrian safety. Transportation Research Record: Journal of the Transportation Research Board. (1445).

[9] Transportation Research Board. *PLANNING AND IMPLEMENTING PEDESTRIAN FACILITIES IN SUBURBAN AND DEVELOPING RURAL AREAS: RESEARCH REPORT*. Publication no. NCHRP Report 294A. Washington D.C.: Transportation Research Board, 1987.

[10] Pedestrian and Bicycle Information Center, and National Highway Traffic Safety Administration. "Crossing Islands." SRTS Guide. Safe Routes to School Guide, n.d. Web. 16 Mar. 2015. http://guide.saferoutesinfo.org/engineering/tools_to_reduce_crossing_distances_for_pedestrians.cfm

[11] NACTO. "Median Refuge Islands." *Urban Bikeway Design Guide*. Washington, DC: Island, 2014. http://nacto.org/cities-for-cycling/design-guide/intersection-treatments/median-refuge-island/



Raised Crosswalks

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation


RIVER FORST
pace
DO NOT
ENTER

A raised crosswalk is a pedestrian crossing at or near the same height as the adjacent sidewalks with sloped sides, a flat top, and crosswalk markings. A raised crosswalk is intended to provide a safer crossing for pedestrians via the elevated height. The elevated height facilitates pedestrian entrance to the crosswalk by reducing or flattening the sidewalk ramp grade, alerts roadway users to crossing activity by increasing pedestrian and crosswalk visibility, and limits vehicle speeds by providing a vertical deflection along the roadway.

Figure 1 - Raised crosswalk on Madison Street in Forest Park, Illinois

Features

The raised crosswalk is signed and marked as a crosswalk and sometimes enhanced with a textured surface. Crosswalk markings can vary but must comply with the MUTCD and BLR Manual. As shown in Figure 1, speed hump markings are placed on the ramps on either side of the crossing in accordance with MUTCD Section 3B.25. The use of advanced warning signs is recommended to notify motorists of the raised crosswalk ahead.[1]

Warrants

Raised crosswalks are typically applied along two-lane, local streets and are installed at both intersection and mid-block crossings. Raised crosswalks at intersections can also include raised intersection facilities which are built with ramps on all approaches leading to an intersection-wide table. Raised crosswalks may also be installed with curb bump outs to further increase pedestrian visibility and decrease crossing distance.

Figure 2 – Raised intersection. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

NYCDOT has developed the following warrants for installing a raised crosswalk:[2]

- School crossings with a posted speed limit of 20 mph or less
- Midblock crosswalks with high pedestrian volumes where the posted speed limit is 30 mph or less
- Locations where the posted speed limit is 30 mph or less and pedestrian crash rates are substantially above or double the statewide average
- Single-lane roundabouts that experience or anticipate high pedestrian demand
- A multilane roundabout regardless of approach posted speed
- Locations where shared-use paths cross commercial driveways or ramps

Costs

The average cost of a mid-block raised crosswalk is $8,170 per installation according to Bushell et al. but may range between $1,290 and $30,880.[3] Costs vary based on the length and width of the crosswalk, addition of pedestrian activated LEDs within sign perimeter, addition of textured and/or colored crossing surface, and additional drainage structures based on drainage conditions. An entire raised intersection costs $50,540 on average.

$ | $8,170 Average cost (2013)

Design Guidance

Illinois Department of Transportation	IDOT BLR 41-12 Speed Humps and Tables http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Local-Roads-and-
FHWA	MUTCD Section 3B.25 – Speed Hump Marking http://mutcd.fhwa.dot.gov/pdfs/2009/part3.pdf
FHWA	Bicycle and Pedestrian – Designing Sidewalks and Trails for Access http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/sidewalk2/sidewalks209.cfm
ite	Traffic Calming Measures – Fact Sheets https://www.ite.org/technical-resources/traffic-calming/traffic-calming-measures/
NACTO	Urban Street Design Guide http://nacto.org/publication/urban-street-design-guide/street-design-elements/vertical-speed-control-elements/

Figure 3 - List of design guidance manuals and documents

SAFETY

The following is a summary of safety benefits observed in studies on raised crosswalks in Durham, North Carolina, and Montgomery County, Maryland:[4,5]

- There was an overall reduction in traffic speeds at the treatment sites as compared to the control sites. In North Carolina, the 50th percentile speeds were 4.0 to 12.4 mph lower at the treatment sites than at the control sites (Maryland results were not statistically significant).
- Yielding rates were 47.8% higher compared to the control site at one of the North Carolina locations. However, that site included an overhead flashing beacon in addition to the raised crosswalk that may have contributed to the increase.
- Raised crosswalks improve the "pedestrian environment"; however, the treatments themselves do not guarantee that motorists will slow down or yield for pedestrians.

Another before and after study was performed in Cambridge, Massachusetts, and found the following:

- The percentage of pedestrians who crossed inside the crosswalk, versus outside of the marked crosswalk, increased from 11.5% to 38.3% after installation of the raised crosswalk.
- The percentage of motorists yielding to pedestrians in the crosswalk increased after installation of the raised crosswalk, but the results weren't statistically significant due to the small sample size.

Increase in percentage of pedestrians crossing inside the crosswalk	+26.8%

Figure 4 - Pedestrian crossing in raised crosswalk in Forest Park, Illinois

OPERATIONS

Raised crosswalks improve pedestrian accessibility and travel by elevating the roadway pavement to or near the sidewalk level, thus giving pedestrians a constant crossing grade, which may encourage pedestrian roadway crossings at the crosswalk and discourage jaywalking. Their trapezoidal cross section can also impact vehicular operations by limiting vehicle speeds and at the same time increase pedestrian visibility, thus increasing motorist compliance with lawfully stopping for crossing pedestrians.[6]

Figure 5 - Raised crosswalk on Madison Street in Forest Park, Illinois

Based on review of The Safe Routes to School Guide and the FHWA Pedestrian Safety Guide, the following operational factors should be considered for a raised pedestrian crosswalk:

- Should not be used on sharp curves or steep grades.
- Detectable warnings are required to be placed where the sidewalk intersects the roadway to indicate the beginning of the crosswalk.
- Colors and special paving materials can be used for an urban design effect, further increasing visibility of the crosswalk.
- The use of raised crosswalks is advised for local roads. Their use may not be appropriate on a collector route if the intersection is part of an emergency or transit route. Emergency and transit vehicles may have difficulty traversing the raised crossings, and therefore emergency service and transit agencies should be consulted prior to installation of these facilities.
- Raised crosswalks may cause ponding water and ice patches by disrupting the existing drainage pattern, creating a hazard for both road users and pedestrians.

Delay

The FHWA studies in North Carolina and Maryland, also found the treatments did not have a significant effect on the average waiting times for pedestrians to cross.

Drainage

Raised crosswalks create an elevated point in the road that may obstruct roadway surface water runoff from properly reaching drainage inlets, which may cause undesirable ponding and hinder traffic operations. Several options to provide proper drainage include installing additional inlets, installing raised crosswalks at existing high points, and creating drainage cutouts at the curbside covered by ADA accessible grates.

MAINTENANCE

A raised crosswalk is a passive, self-enforcing traffic calming treatment that requires minimal maintenance beyond routine restriping of pavement markings. A power source is not required unless supplemental warning beacons, LED units (installed at location shown in Figure 5), or rectangular rapid flashing beacons (RRFB) are installed with the pedestrian crossing signage.

Typical Infrastructure to Maintain

- Asphalt or concrete speed table
- Pedestrian crossing signage with push-button activation or passive activation equipment
- Optional warning beacons, LED units, or RRFB installed with signage
- Optional curb bump outs
- Optional textured surface within striped crosswalk

Street Sweeping & Snow Removal

Raised crosswalks are designed with gradual slopes, typically between 2.3% on faster streets to 5.5% on slower streets per section 41-12 of the IDOT BLR Manual, which allows for snow plows to continue operations without lifting plows. However, some research into maintenance procedures around the country found hesitation with using vertical traffic calming measures such as raised crosswalks. The APWA *Design Guidelines for Traffic Calming Measures* states that "snow plowing over vertical traffic calming elements may cause damage either to the snow plow or the street."[7] In order to address this issue, some municipalities raise plow blades at the crossings while others only inventory them and alert plow crews to their locations so they can be prepared to minimize damage to the plow when performing snow removal at the crosswalk.

Figure 6 - Plowed and salted raised crosswalk on Madison Street in Forest Park. Note the shoveled sidewalk approaches.

Utility Cuts and Construction Damage

The installation and operation of a raised crosswalk should not impact underground utilities, aside from when an existing structure inside the crosswalk need to be adjusted to meet the proposed grade. During utility repairs raised crosswalks may be impacted, but IDOT and most municipal utility policies require surfaces and pavement be restored to existing conditions by the entity disrupting the pavement or facility. Utility companies may require additional information or guidance on proper repair of a raised crosswalk, and work should be inspected following repairs.

District One Studies

The following is a summary of findings from four studies performed by IDOT in 2014, for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 1 - Summary of IDOT District 1 Studies, 2014

Study	Summary of Findings
Pedestrian Survey	The raised crosswalk had higher ratings on comfort and safety than the control location. It also received more overall positive comments. In contrast those surveyed regarding the control crosswalk shared significantly more comments regarding shortcomings.
Motorist Compliance and Pedestrian Behavior	55.2% of motorists did not stop for pedestrians at the control crosswalk, as opposed to 30.0% at the raised crosswalk. Average pedestrian wait times for crossing were 0.6 seconds lower at the raised crosswalk location, which is not considered a significant enough change in behavior.
Speed Study	Based on the results of the IDOT District One Speed Study conducted in Forest Park, Illinois, the raised crosswalk at this location was effective at reducing vehicle speeds. The 85th percentile, mean, and median speeds were all 4 to 8 MPH lower at the raised crosswalk versus the control crosswalk.
Crash Analysis	Due to the low number of crashes at the study locations chosen, no crash trends could be determined. Therefore, the crash analysis was indeterminate.

Pedestrian Survey

Pedestrian surveys were conducted at the same crosswalk locations chosen for the pedestrian and motorist behavior study. The purpose of the pedestrian survey was to determine the perceived effectiveness of the raised crosswalk compared to that of the unraised crosswalk at the control site.

Site Conditions

In-person surveys were conducted on July 2, 2014 from 4 to 6 p.m. at the site of the raised crosswalk on Madison Street between Burkhardt Court and Thomas Avenue in Forest Park. The temperature was in the upper 60s with light drizzle throughout the duration of the survey. In-person surveys were also conducted on July 30th, 2014, from 4 to 6 p.m. at the control crosswalk site on Madison Street just west of Beloit Avenue. On that day, the weather was sunny, and the temperature was about 70 degrees

Study Method

A cross sectional study method was chosen to allow for collection of data at a given point in time. The facility and control questions were similar in order to facilitate response comparison. The surveys taken at the facility and control locations were performed on separate days with new respondents to prevent a biased result.

To conduct the surveys, two staff members stood on the sidewalk at opposite ends of the raised crosswalk. Both members were wearing safety vests to be safe and to attract the attention of pedestrians. Staff approached pedestrians and asked them if they would like to take a survey and offered the option of taking the survey in person or online at their own convenience. The online survey was open for two weeks, and the submissions were analyzed to remove any multiple submissions from the same person.

Survey Questions

Pedestrians using the raised crosswalk and the control crosswalk were asked the following questions, shown below in Table 2. The questions asked were adjusted to better reflect aspects of each specific crosswalk studied. The results were aggregated for comparison purposes, and the results are displayed in Figure 7 through Figure 18.

Table 2 - Survey questions and corresponding figure number

Figure #	Questions Asked
7	What is you gender?
8	In what age group do you fall?
9	What best describes why you are out here today?
10	In the past month, about how often have you walked down Madison Street in Forest Park?
11	In the past month, about how often have you driven down Madison Street in Forest Park?
12	Which answer best describes what an Illinois motorist must do when approaching a crosswalk?
13	Are you aware of the raised crosswalk on Madison Street and Burkhardt Court?
14	In the past month, how often have you crossed the road on the crosswalk at Madison Street and Burkhardt Court (or Beloit Avenue)?
15	How safe do you feel when using the raised crosswalk at Madison Street and Burkhardt Court (or Beloit Avenue) during the following times?
16	How safe do you feel when crossing the raised crosswalk at Madison Street and Burkhardt Court (or Beloit Avenue) in Forest Park in the following weather conditions?
17	When driving on Madison Street (if applicable), how visible is the raised crosswalk (or non-raised crosswalk) from a distance of 50 feet in the following weather conditions?
18	Do you have any suggestions or comments regarding crosswalks like the one on Madison Street and Burkhardt Court (or Beloit Avenue) in Forest Park?

Survey Results

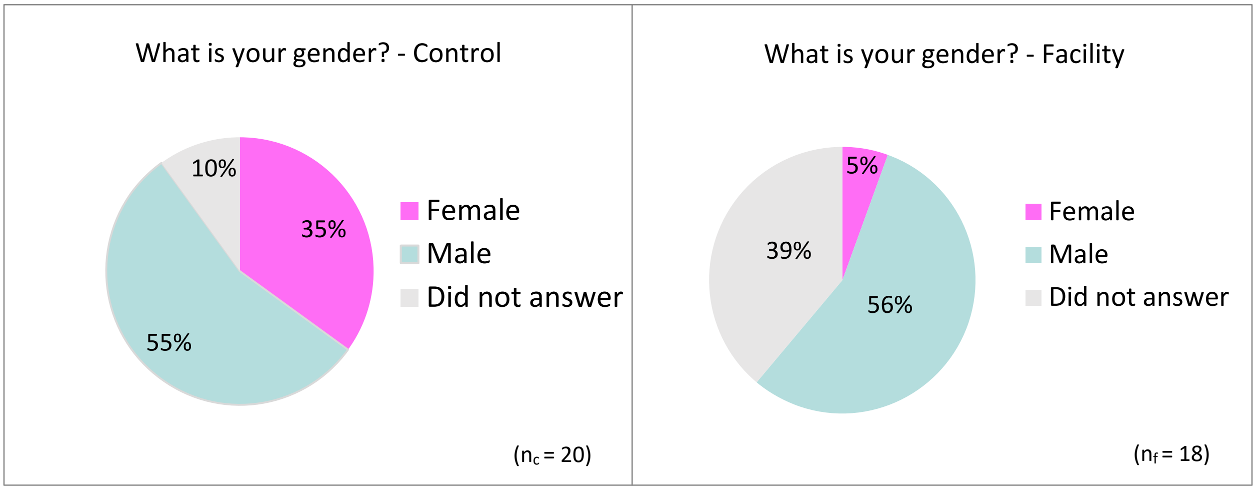


Figure 7 - What is your gender? Results from the control location (left) and raised crosswalk (right).

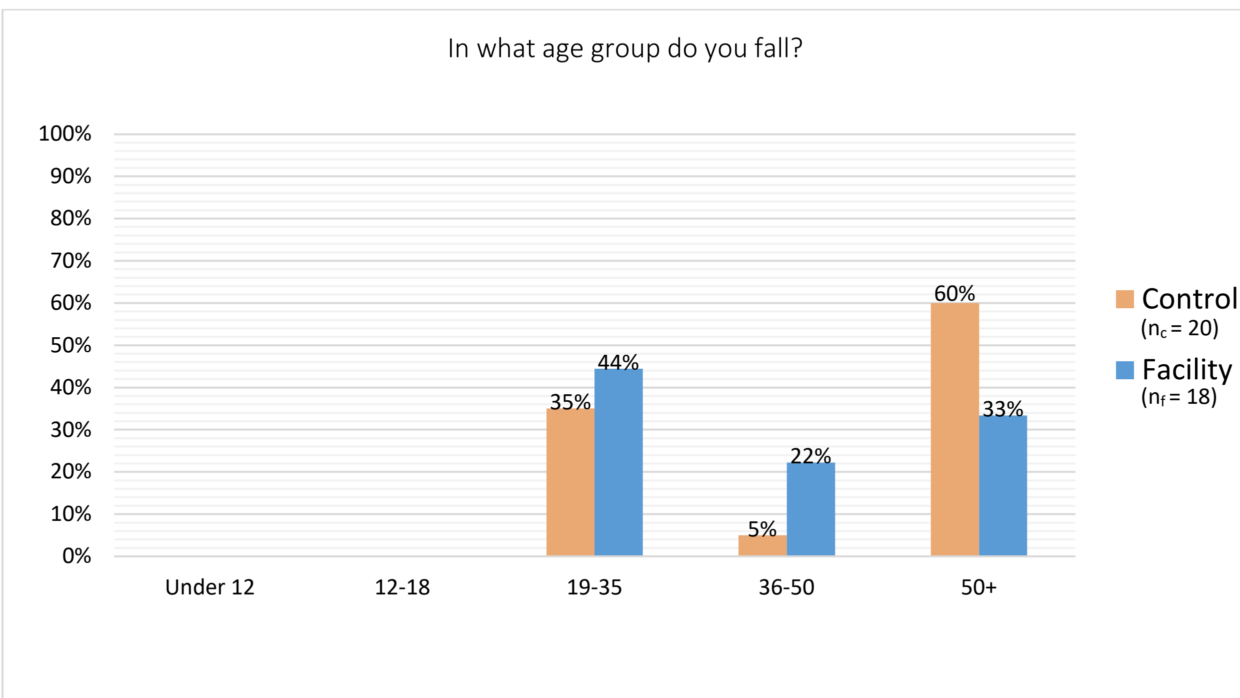


Figure 8 – In what age group do you fall?

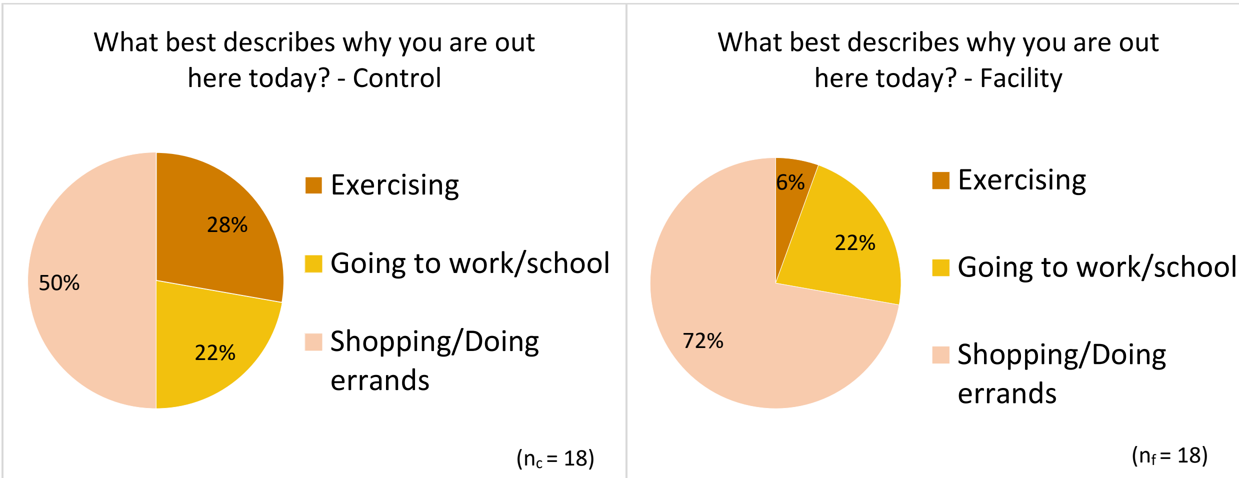


Figure 9 –What best describes why you are out here today? Results from control (left) and the raised crosswalk (right).

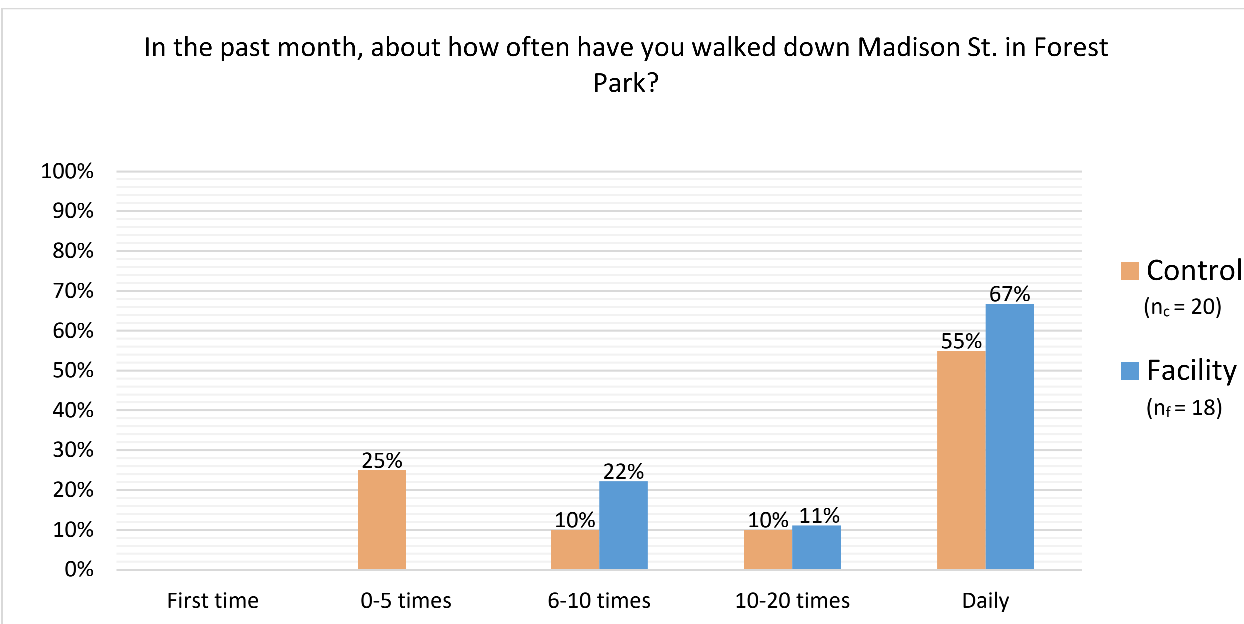


Figure 10 –In the past month, about how often have you walked down Madison Street in Forest Park?

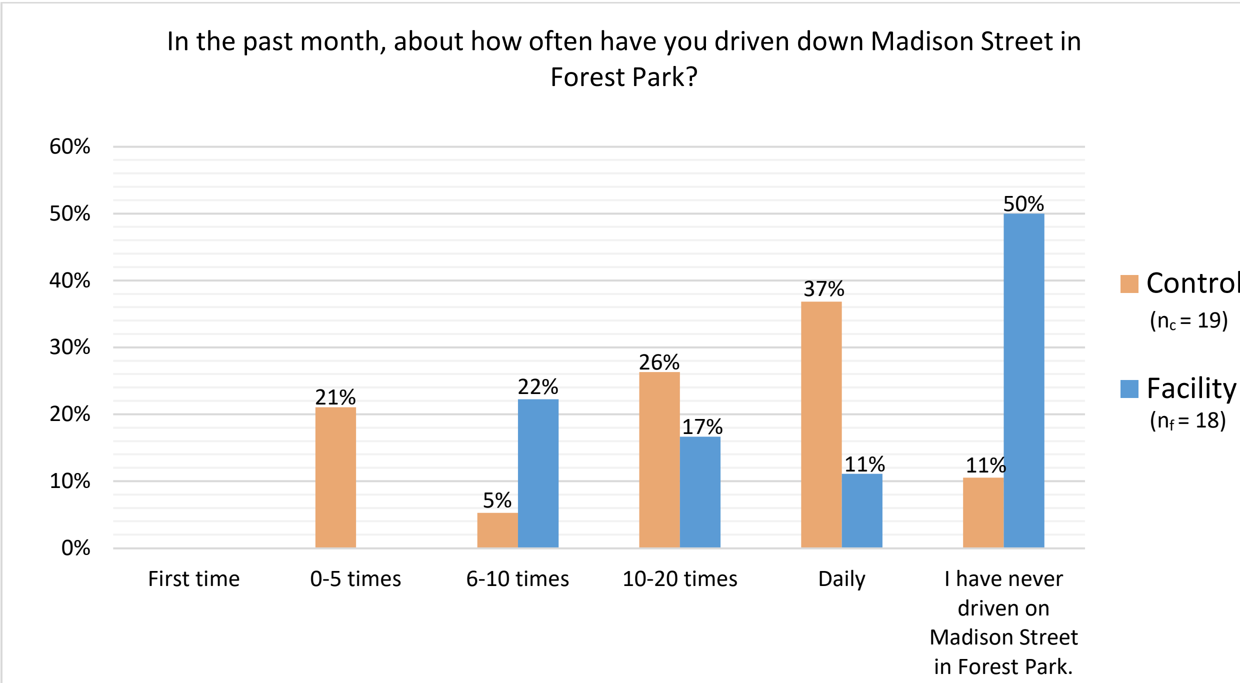


Figure 11 –In the past month, about how often have you driven down Madison Street in Forest Park?

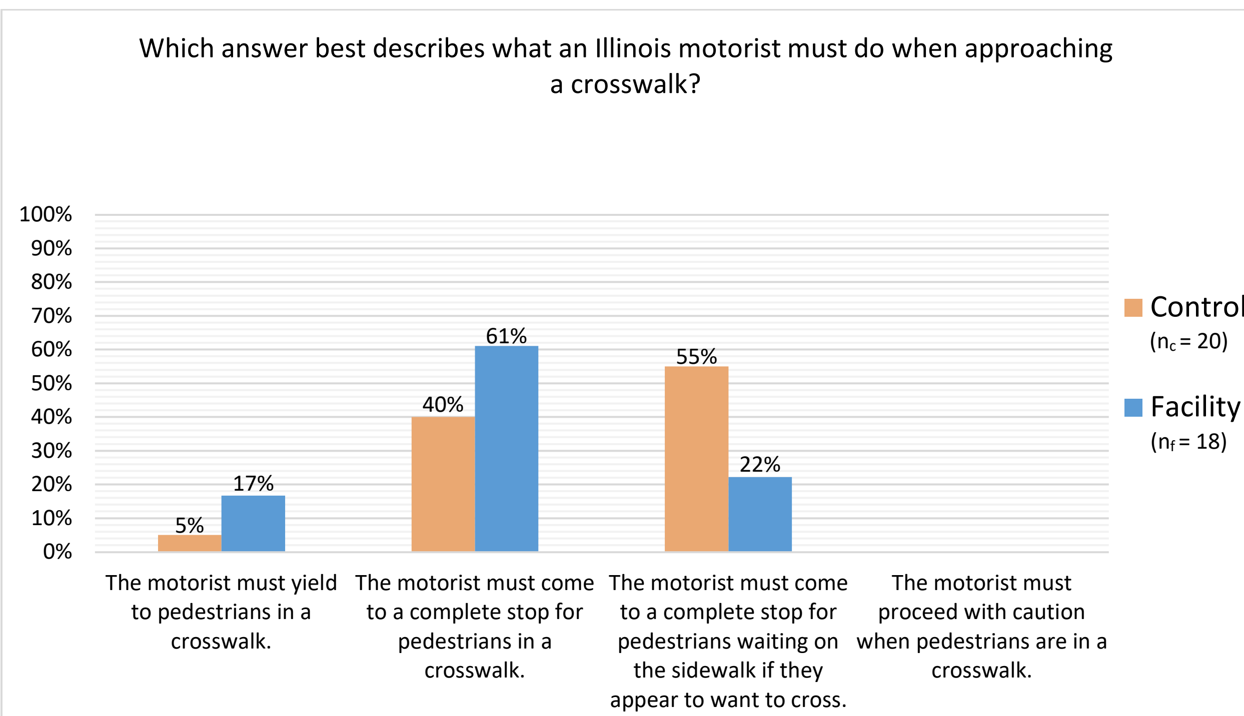


Figure 12 –Which answer best describes what an Illinois motorist must do when approaching a crosswalk?

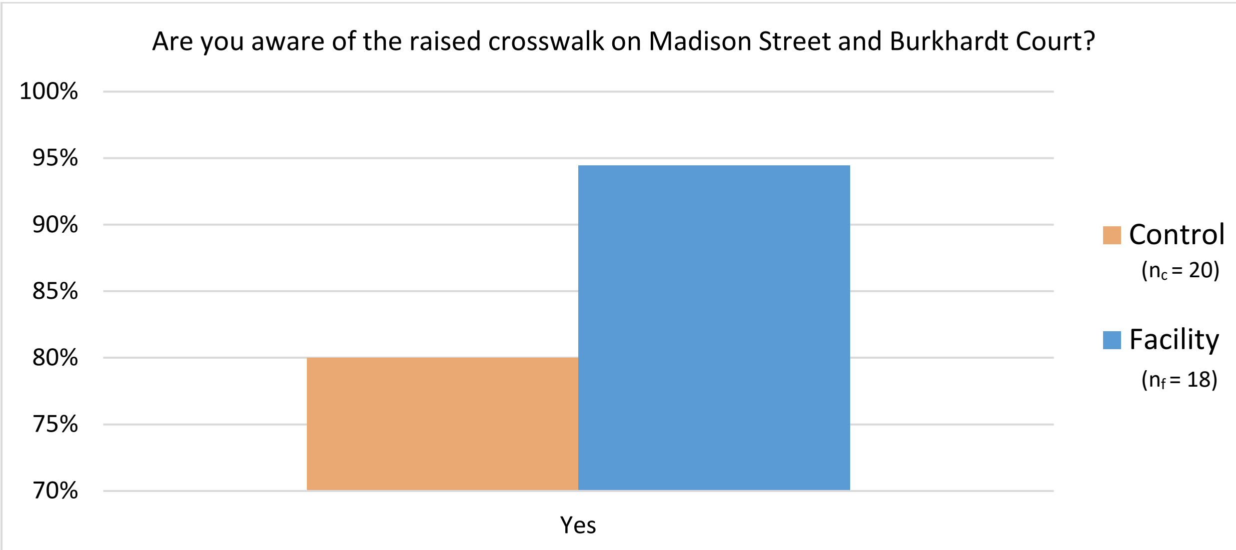


Figure 13 –Are you aware of the raised crosswalk on Madison Street and Burkhardt Court?

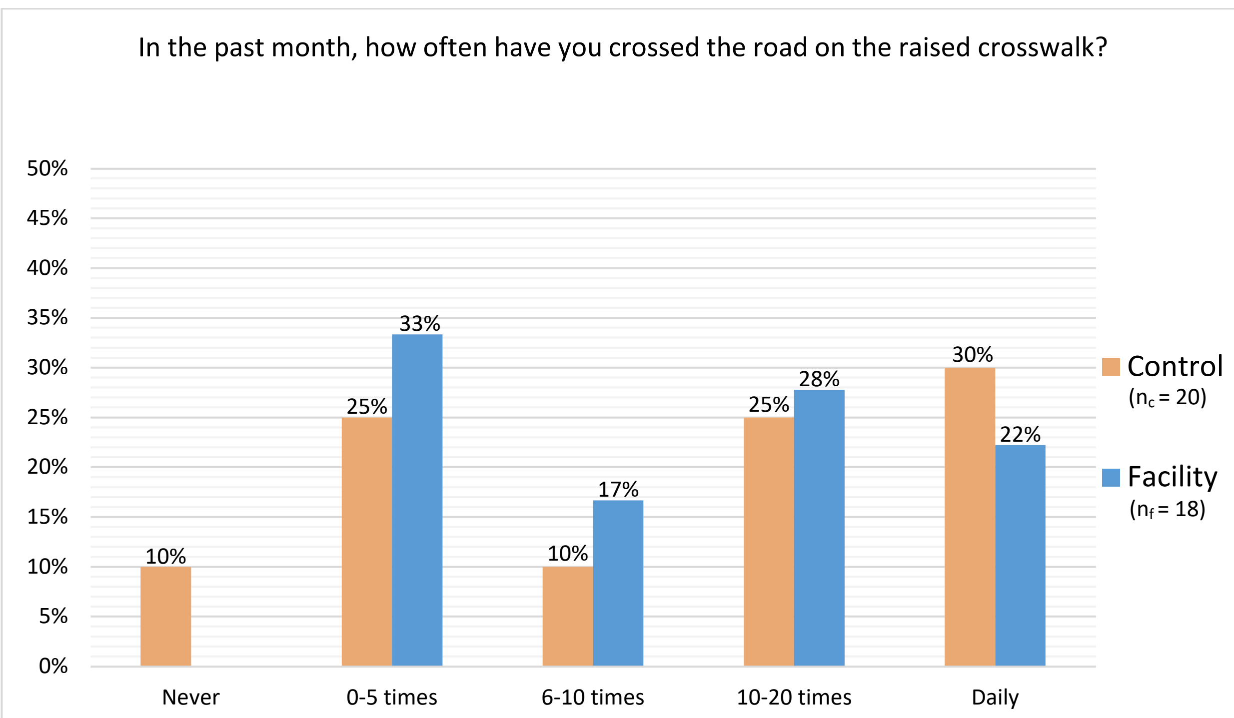


Figure 14 –In the past month, how often have you crossed the road on the raised crosswalk?

For the following questions (Figures 15 through Figure 16), the participant was asked to choose a rating between one and five on how safe they felt when crossing the raised crosswalk with one being completely unsafe and uncomfortable, three being neither safe nor unsafe, and five being completely safe and comfortable. The participant could choose N/A if he/she had no experience with the specific conditions at the crosswalk.

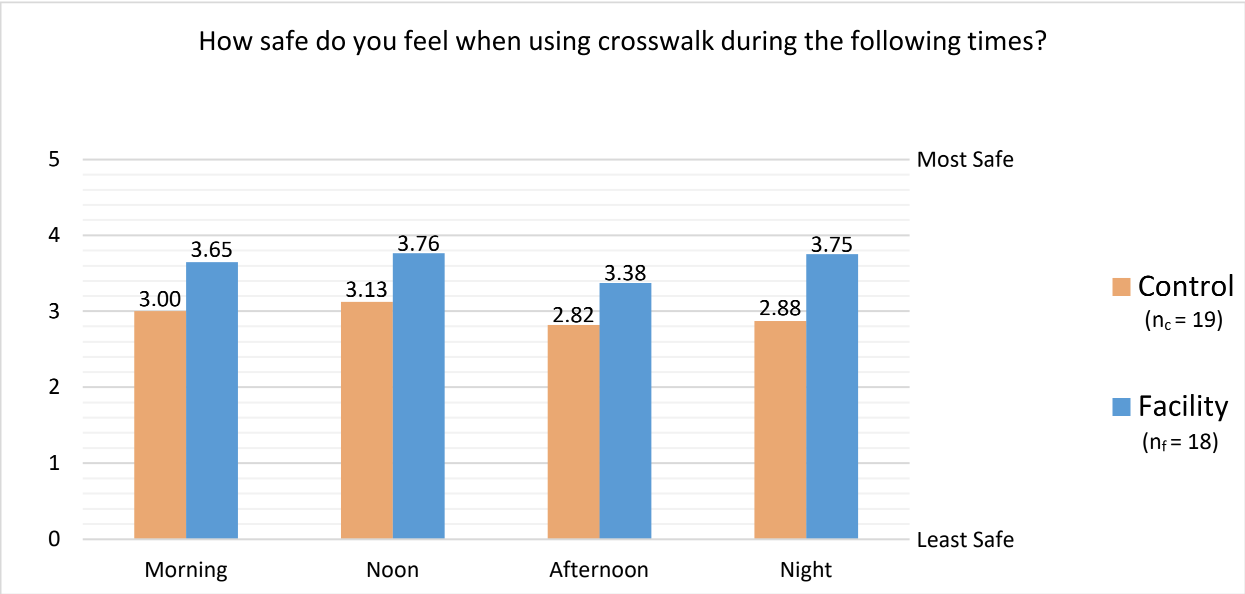


Figure 15 –How safe do you feel when using crosswalk during the following times?

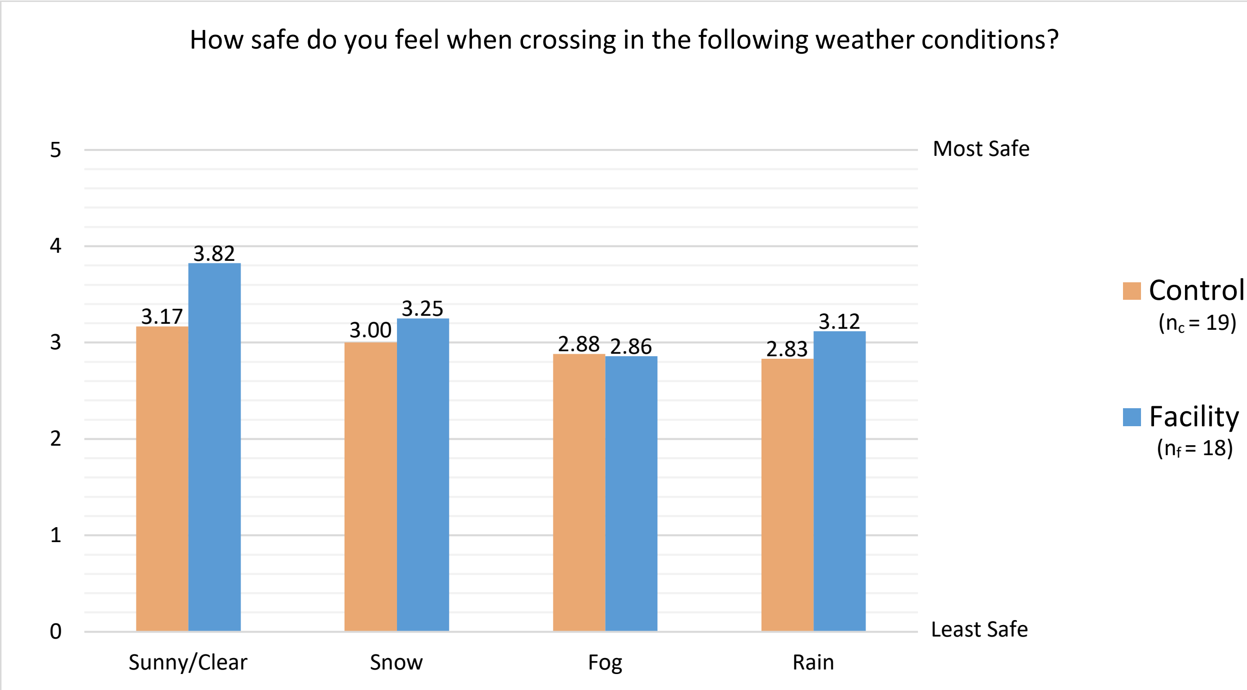


Figure 16 –How safe do you feel when crossing in the following weather conditions?

For Figure 17, the participants were asked to give a rating between one and five regarding their perception of the visibility of the crosswalk with one being that the crosswalk was barely visible and five being that the crosswalk was completely visible from a distance of about 50 feet. The participant could choose N/A if he/she had no experience with the specific conditions at the crosswalk.

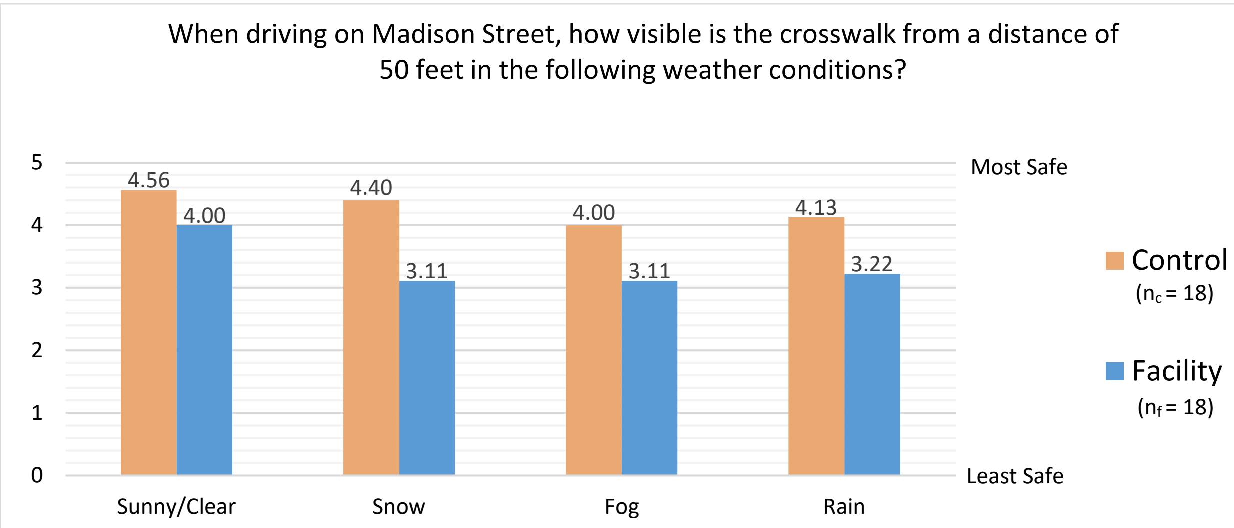


Figure 17 –When driving on Madison Street, how visible is the crosswalk from a distance of 50' in the following weather conditions?

Participants were given the opportunity to voice their open opinions about the two crosswalks. The opinions were categorized and shown below in Figure 18.

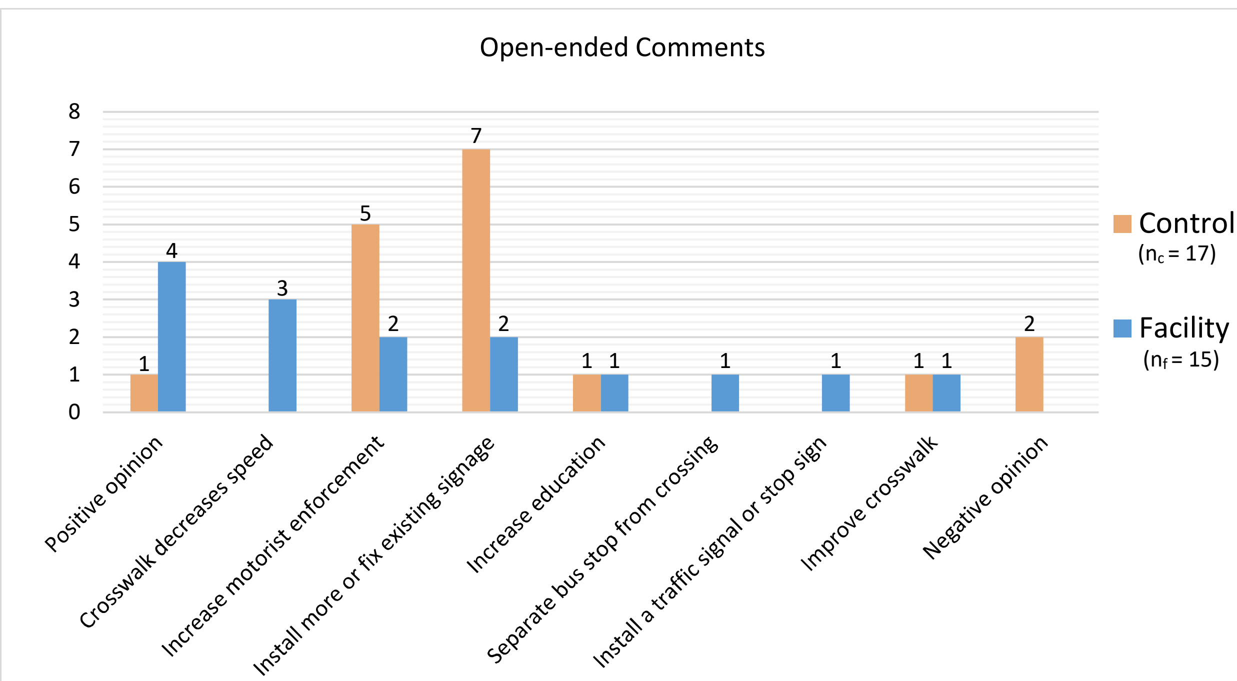


Figure 18 –Do you have any suggestions or comments regarding the crosswalk like the one on Madison Street and Burkhardt Court in Forest Park?

Discussion

Most pedestrians surveyed were male, above the age of 19, shopping or doing errands the day of the survey. At both the facility and control sites, over 50% of participants indicated they walk on Madison Street daily. Participants from both sites reported driving along Madison Street with varying frequency. When asked about the current Illinois law requiring a motorist to stop for pedestrians in a crosswalk, 50% of respondents replied with the correct understanding of the law.

As shown in Figure 15, there was no significant difference in the participants' safety rating of the crosswalk during different times of day other than what was shown as a slight dip in the rating during the afternoon. According to Figure 16, the participants felt slightly safer crossing the raised crosswalk under sunny and clear conditions which, according to Figure 17, is when participants who also drive on Madison Street indicated the raised crosswalk is the most visible when driving. The raised crosswalk location scored higher than the control location in pedestrian comfort and safety during all times of the day and all weather conditions except in fog. Regarding the perception of safety, the highest increase between the raised crosswalk and control locations was reported for nighttime and for sunny/clear conditions. This may indicate the effectiveness of the raised crosswalk in low lighting or the effectiveness of the crosswalk signage and marking. Both the raised crosswalk and control location had pedestrian activated crosswalk signs that may have also contributed to the higher perception of safety reported during nighttime conditions. However, pedestrians surveyed who crossed at the control location reported higher ratings on visibility from the driver's perspective at that crossing than at the raised crosswalk location.

The last question (Figure 18) gave participants the opportunity to voice their opinions about the raised crosswalk. There were responses regarding a desire for a decrease in vehicle speeds at the raised crosswalk location. Several participants mentioned that occasionally police officers enforce the state law regarding vehicles stopping for pedestrians at the crosswalk locations and ticket those who do not comply with the law. Further enforcement measures were suggested as a means of encouraging vehicle compliance with stopping for pedestrians in crosswalks. These included setting up periodic "crosswalk stings," finding motorists for breaking the law requiring a vehicle to stop for a pedestrian and posting of "In-Street Pedestrian Crossing"" signs at the crosswalks. Other participants surveyed expressed concerns about the pushbutton-activated flashing LED signs located at both the raised crosswalk and control locations. They indicated the placement of the pushbutton was inconvenient, pedestrians were not using the pushbuttons, and there seemed to be an uncertainty of the flashing LED operation.

One individual expressed a belief that the raised crosswalk increased jaywalking while another perceived a decrease in jaywalking at this location. A raised crosswalk may encourage pedestrians to cross at the marked crosswalk because of a greater perception of safety and comfort. However, it may also encourage pedestrians to cross outside the crosswalk due to lower vehicle speeds observed at a raised crosswalk location (see the raised crosswalk speed study later in this report).

The raised crosswalk location received more positive comments and no negative comments compared to the control location which received two negative comments. Pedestrians crossing at the control location also expressed a significantly higher number of requests to increase police enforcement and install or fix additional signage. This may indicate pedestrians' concerns with crossing at a non-raised crosswalk.

Conclusion

A total of 38 pedestrians were surveyed for the study. Most participants had a positive opinion about the raised crosswalk; many favored the raised crosswalk over the control crosswalk. The raised crosswalk had a higher average comfort and safety rating than the control crosswalk (3.6 versus 3.0) for all time periods throughout the day and for all weather conditions except fog. The control crosswalk did score higher in visibility than the raised crosswalk (4.3 versus 3.4), but this may have been attributed to other factors specific to the two locations (location with respect to intersection, on-street parking, bump-out geometry). Overall, there were more comments regarding shortcomings with the crosswalk at the control site despite the fact that both locations had the same pedestrian signage and push-button activated lights on the pedestrian crossing signs.

Figure 19 - Raised crosswalk on Madison Street in Forest Park, Illinois

Motorist Compliance and Pedestrian Behavior Study

A pedestrian and motorist behavior study was conducted for the purpose of gaining further information and knowledge about the performance of a raised crosswalk facility in the District One Region. Two crosswalk locations with similar crosswalk features, pavement markings, roadway geometry, and traffic control devices were included in the study: one with a raised crosswalk (facility site) and one with a non-raised crosswalk (control site). An aerial view of the sites is shown in Figure 20.

The raised crosswalk is located on Madison Street between Burkhardt Court and Thomas Avenue at Constitution Court. The control site is a crosswalk with no raised section which is also on Madison Street and located 340 feet west of the raised crosswalk, just west of Beloit Ave.

In addition to the general similarities noted above, each location also had pedestrian warning signs with pushbutton activated LED lights on each side of the crossing and colored/textured pavement within the area of the crosswalk. There was also a bus stop at each location.

Site Conditions

Madison Street is a 3-lane east-west minor arterial with an ADT of 11,700 and a speed limit of 25 mph. The field study for the raised crosswalk was conducted at the Burkhardt Court intersection on July 1, 2014, from 4 to 6 p.m. under partly cloudy skies with temperatures in the lower 80s. The field study for the non-raised crosswalk was conducted at the Beloit Avenue intersection on July 31, 2014, from 4 to 6 p.m. under partly cloudy skies with temperatures in the mid-80s. Madison Street, including the crosswalks and associated traffic control devices, is under the jurisdiction and maintenance of the Village of Forest Park. All devices and markings appeared to be in good condition at the time of the study.

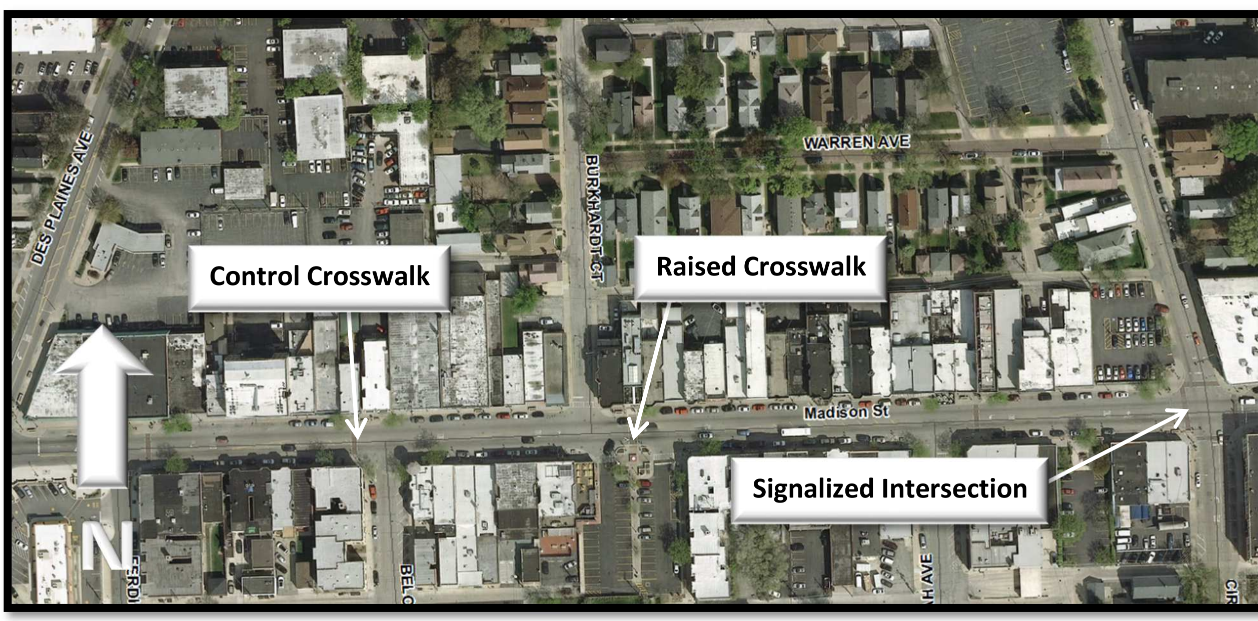


Figure 20—Aerial view of the study location on Madison Street in Forest Park, Illinois.

Study Method

A cross sectional study method was chosen in order to observe behaviors on a given day and compare these behaviors between the two facilities. During the data collection period, staff members observed from an inconspicuous position perpendicular to the raised crosswalk. They were dressed in a manner designed not to draw attention or distract motorists or pedestrians. One staff person collected data on vehicles and pedestrians travelling one direction, and the other focused on those traveling in the opposite direction.

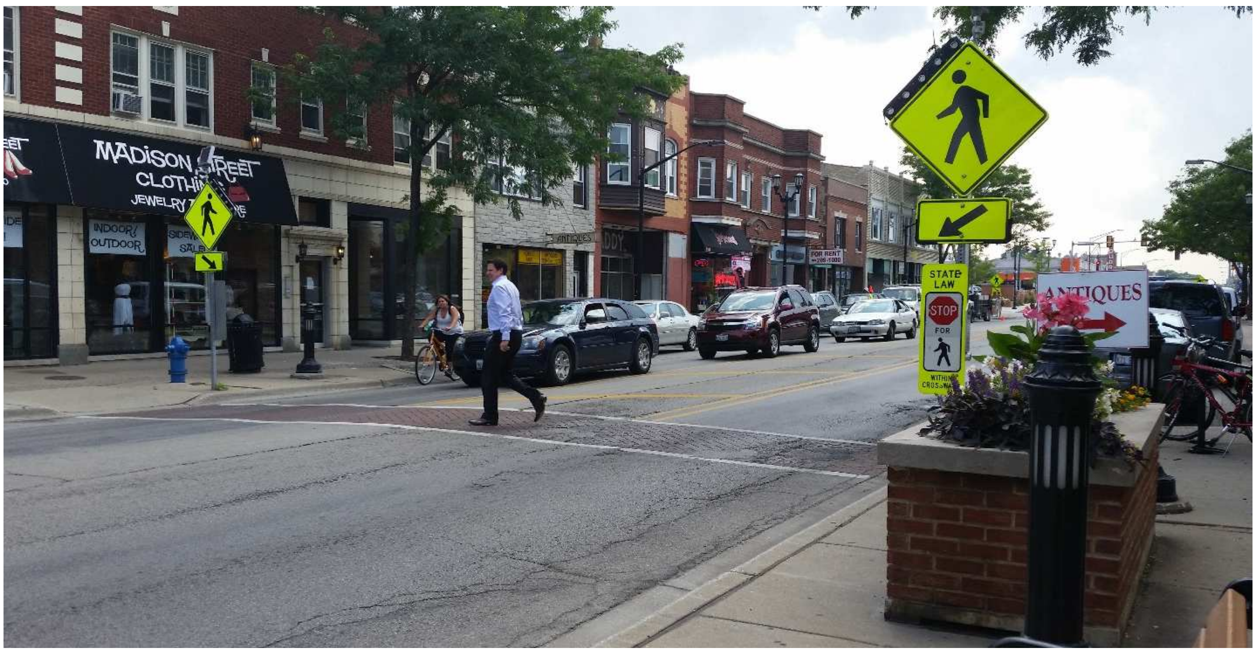


Figure 21 - Control crosswalk on Madison Street in Forest Park, Illinois

Motorist Behavior

Motorist compliance was measured at the lighted crosswalk (facility) and control locations. Motorists were monitored for stopping for crossing pedestrians and if so, how they stopped. Three of the categories includes motorists that stopped or slowed enough for pedestrians to cross: practically stopped (motorists that slowed to between 0 and 3 mph), stopped by traffic, and voluntary full stop. The fourth category, non-stopping, did not stop or allow a pedestrian to cross. The data is summarized in Table 3 and Figure 22. The percentage of non-stopping westbound vehicles was higher than non-stopping eastbound vehicles. A total of 235 vehicles were recorded between the two sites while a pedestrian was either present in the crosswalk or waiting on the curb to cross.

Table 3 - Total vehicles (from both directions). Results from raised crosswalk (left) and control site (right).

Control (n=105)		Facility (n=130)	
Non-Stopping	55.2%	Non-Stopping	30.0%
Practically Stopped	8.6%	Practically Stopped	15.0%
Stopped by Traffic	3.8%	Stopped by Traffic	6.2%
Voluntary Full Stop	32.4%	Voluntary Full Stop	48.0%

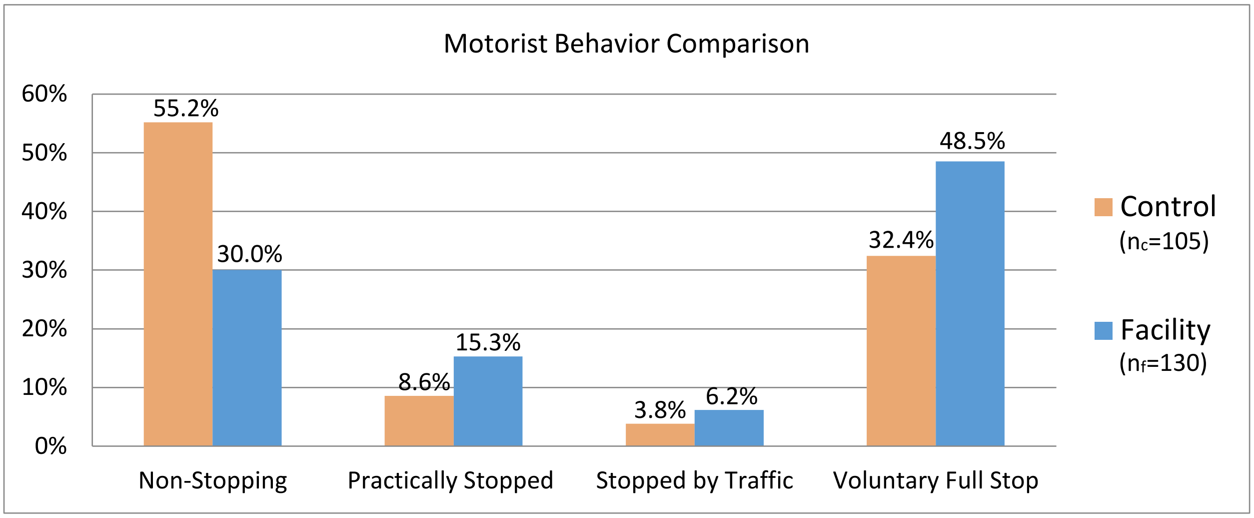


Figure 22 - Motorist Behavior Comparison (does not include the standard error percentages)

Pedestrian Behavior

Of the 107 pedestrians recorded crossing the raised crosswalk on Madison Street between Burkhardt Court and Thomas Avenue, there were 3 people who hesitated when crossing the raised crosswalk and 20 who jaywalked. For northbound pedestrians, the average time spent waiting to cross the road was 0.76 seconds. The average wait time for southbound pedestrians was 3.04 seconds.

There was one southbound pedestrian who waited 26 seconds to cross. However, it was observed that this pedestrian did not appear confident about crossing the road and did not stand at the edge of the sidewalk while waiting to cross. Because of this, motorists did not appear to realize his intention to cross. If this outlier wait time is omitted, then the average southbound wait time was 1.42 seconds.

At the control crosswalk on Madison Street at Beloit Avenue, 83 pedestrians were recorded crossing at the crosswalk. When crossing the road, 14 of the pedestrians hesitated. Staff also recorded three cases where pedestrians ran across the crosswalk, and 14 cases where people crossed the road nearby but outside of the crosswalk. The average wait time for northbound pedestrians who did not activate a flashing LED pedestrian crossing warning sign was 1.50 seconds, and the average for southbound pedestrians was 1.90 seconds.

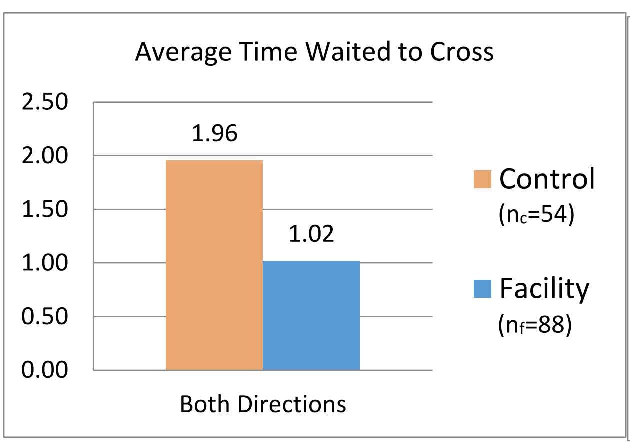


Figure 23 –Average Time Waited to Cross

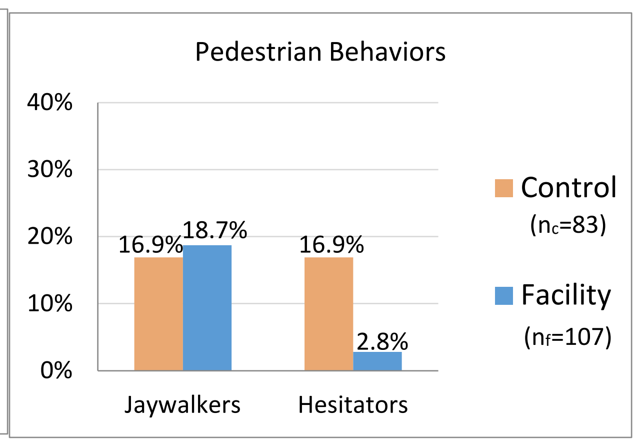


Figure 24 – Pedestrian Behaviors

Discussion

Figure 22 shows the average time that a pedestrian stood at the edge or the beginning of the crosswalk waiting for motorists to stop before beginning to cross the road. Pedestrians at the raised crosswalk waited an average time of 1.1 seconds compared to those who waited 1.7 seconds at the control site. Also significantly fewer pedestrians were observed to hesitate when crossing the raised crosswalk, 16.9% at the control location versus 2.8% at the raised location. A hesitation was defined as the act of stepping into the crosswalk and then stepping back to the sidewalk, the act of stopping in the crosswalk to wait for traffic to clear after beginning to cross, or breaking stride in the middle of crossing.

There were more people who jaywalked or did not cross within the limits of the crosswalk at the intersection with the raised crosswalk than at the control site. Observers also noted few people used the push button to activate the flashing LED pedestrian crossing warning sign at the raised crosswalk location. Although this behavior was not a focus of the study, it is suggested this lack of use could be explained by placement of the push buttons which are not located adjacent to the crosswalk at either the raised crosswalk or control crosswalk sites.

Conclusion

Overall it was concluded that the raised crosswalk was effective at reducing wait times for pedestrians and increasing motorist compliance. These findings are in agreement with the conclusions of existing research.

Speed Study

A speed study was conducted in 2014 along Madison Street in Forest Park, Illinois, at the same crosswalk sites chosen for the pedestrian survey and pedestrian behavior and motorist compliance study. The purpose of the speed study was to determine if vehicle speeds were significantly lower at the raised crosswalk compared to the vehicle speeds at the non-raised crosswalk.

Study Method

Three sets of Jamar pneumatic tubes were placed along Madison Street in Forest Park, Illinois, to collect traffic data for the roadway segment upon which the raised crosswalk is located as shown in the diagram below. The first set of tubes (Tube Set A, Figure 26) was placed just east of the raised crosswalk, the second set was placed 200 feet east of the raised crosswalk at a midblock location (Tube Set B, Figure 27), and the third set was placed 340 feet west of the raised crosswalk and just west of the non-raised crosswalk (Tube Set C, Figure 28).

Madison Street Characteristics

Roadway Classification	Average Daily Traffic	Speed Limit
Minor Arterial	11,700	25 MPH

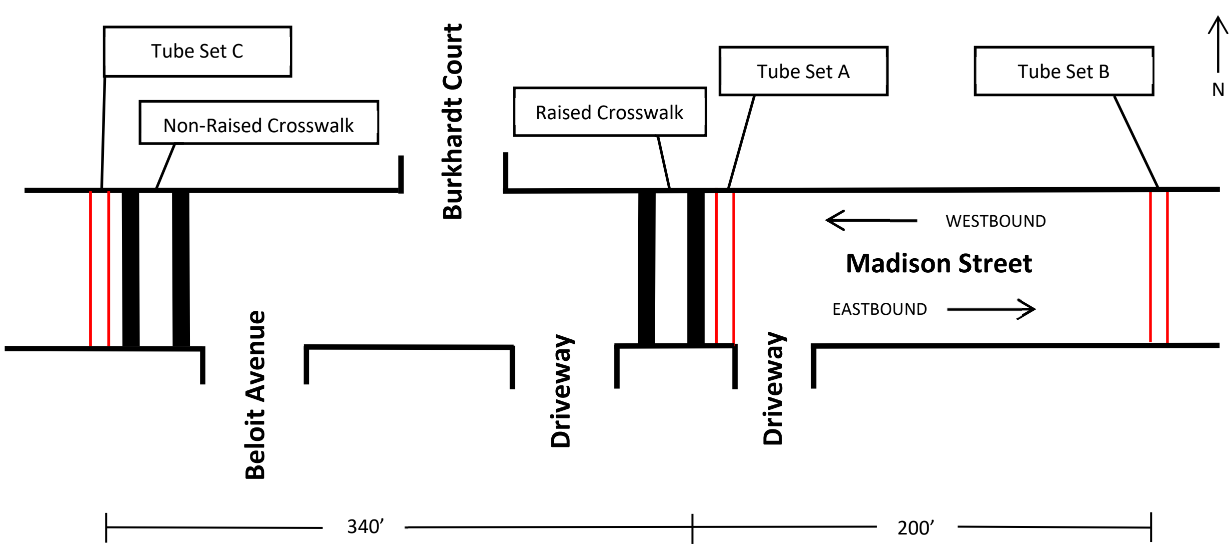


Figure 25 - Layout of data collection points for speed study conducted in July 2014 on Madison Street in Forest Park, Illinois. Madison Street is an east-west minor arterial with an ADT of 11,700 and has a posted speed limit of 25 mph.

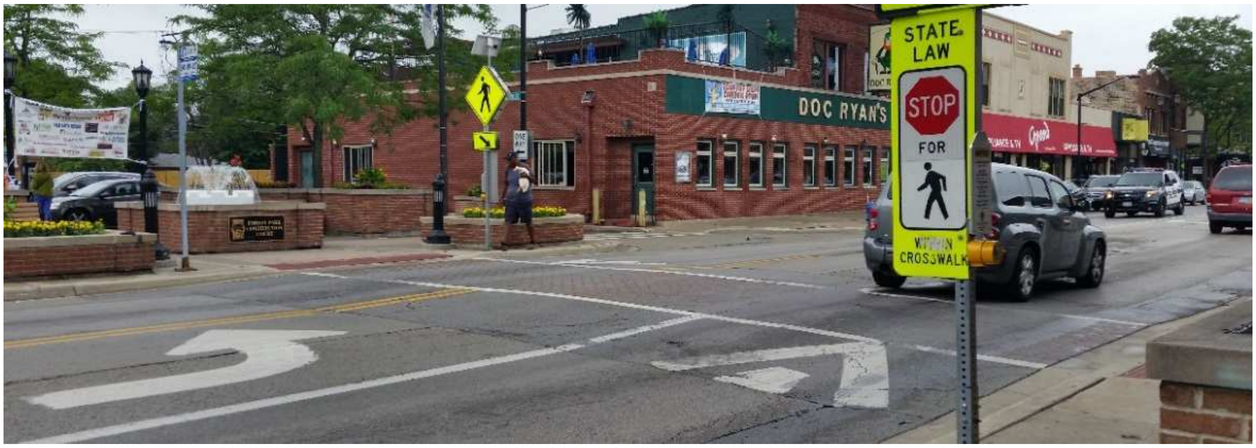


Figure 26 - Raised crosswalk location on Madison Street between Burkhardt Court and Thomas Avenue. Tube Set A is not yet installed.

Figure 27 - Tube Set B location serving as control site and located 200 feet east of the raised crosswalk.

Figure 28 - Tube Set C location serving as control site and located just west of the non-raised crosswalk at Madison Street and Beloit Avenue.

Study Results

Data collected on Thursday, July 10, 2014 from 7:00 AM to 7:00 PM

Table 4 - Speed summaries for all locations

	Tube Set A (Raised Crosswalk)		Tube Set B (Mid-Block Location)		Tube Set C (Non-Raised Crosswalk)	
Traffic Direction	Westbound	Eastbound	Westbound	Eastbound	Westbound	Eastbound
85^{th} Percentile Speed	**19**	**17**	**23**	**24**	**24**	**25**
Mean Speed (MPH)	**14**	**13**	**18**	**18**	**18**	**20**
Median Speed (MPH)	**14**	**12**	**19**	**19**	**19**	**20**
Vehicle Count	3,871	5,596	4,406	5,980	4,225	5,550
Pace Speed (MPH)	10-19	8-17	15-24	15-24	16-25	16-25
% in Pace	72.7	76.3	67.6	66.4	59.5	64.8
Standard Deviation	4.858	4.401	5.665	5.602	N/A	N/A
Peak AM Time	7:30	7:15	8:30	8:15	11:15	7:30
Peak PM Time	6:00	4:00	3:15	3:45	5:30	4:00

Table 5 - Probability that a motorist will exceed the speed limit

Probability that a motorist will exceed the speed limit		
Raised Crosswalk	Tube Set B	Non-Raised Crosswalk
1.01%	6.85%	11.74%

Discussion

Westbound motorists' average speeds were reduced from 18 mph to 14 mph when approaching the raised crosswalk. Eastbound drivers also showed slower speeds at the raised crosswalk, going from averaging 13 mph at the raised crosswalk to 18 mph at a flat mid-block location 200 feet east of the raised crosswalk. This represents an average reduction of 25% between the vehicle speed measured at the raised crosswalk and the vehicle speed measured at Tube Set B for eastbound vehicles. While this is a significant decrease in speeds for vehicles moving away from the raised crosswalk, the percentage of decrease could possibly have been greater if there was not a signalized intersection located 400 feet east of Tube Set B. Because of the signal, traffic queues develop on Madison Street requiring eastbound drivers to decelerate prior to reaching the location of Tube Set B.

Another approach to analyzing the results of the speed study is to compare median vehicle speeds rather than average speeds. According to the *Manual of Transportation Engineers*, the median speed is often a better measure of reference than the average speed because the median is typically less susceptible to outlier observations of very high or low speeds.[8] When analyzing speed changes based on the median, the speed for eastbound vehicles moving away from the raised crosswalk increase from 12 mph at the raised crosswalk (Tube Set A) to 19 mph (36.8% increase) at the mid-block location (Tube Set B), and the westbound vehicle speed drops from 19 mph at the mid-block location (Tube Set B) to 14 mph (26.3% decrease) at the raised crosswalk (Tube Set A.)

The 85th Percentile Speeds, which are typically used for design purposes, are an estimate of the fastest speed driven by reasonable drivers (Manual of Transportation Engineers 2010). On Madison Street, the 85th percentile speeds were 23.4% lower at Tube Set A than at Tube Set B.

Speeds at the non-raised crossing (Tube Set C), in both eastbound and westbound directions, were similar to those measured at the mid-block crossing (Tube Set B). If it can be assumed that the speed at which vehicles approach the raised crosswalk is the same at which they move off the raised crosswalk, then data for westbound vehicles indicates an increase in median vehicle speed between the raised and non-raised crosswalks of 5 mph or a 36% increase in speed. Alternatively, if the assumption above is correct, then data for eastbound vehicles indicates a decrease in median vehicle speed of 7 mph or a 37% decrease in speed.

Conclusion

Based on data measuring vehicles speeds for approximately 4,000 westbound and 6,000 eastbound vehicles, motorists reduced their vehicle speed significantly as they approached the raised crosswalk. The 85th percentile, mean, and median speeds were all 4 to 8 MPH lower at the raised crosswalk location versus the control crosswalk. Therefore, based on the results of the IDOT District One Speed Study conducted in Forest Park, Illinois, in July 2014, the raised crosswalk at this location was effective at reducing vehicle speeds.

Crash Analysis

As part of this Feasibility Study, a crash analysis was performed for the following locations in the District One region of the Illinois Department of Transportation (IDOT):

- Madison Street in Forest Park, Illinois
- Thacker Street in Des Plaines, Illinois
- Stony Island Avenue in Chicago

Only four total crashes were recorded between the three sites between 2005 and 2013, so no crash trends could be determined. There are other raised crosswalks across Illinois; however, only these three sites were chosen for analysis because each shared similar features, street context, or availability of crash data. While the *Highway Safety Manual* doesn't indicate any crash modification factors for the installation of a raised pedestrian crossing, it does "conclude that raised pedestrian crosswalks have an overall positive effect on crash occurrence because they are designed to reduce vehicle operating speeds. However, the magnitude of the crash effect is not certain at this time".[9]

Many cities or counties have multiple raised crosswalks, however, only one from each city (aside from Chicago) was listed for reference.

Table 6 – Examples of Raised Crosswalk locations in the USA, with locations in District One highlighted

Country	City/County	State	Intersection	Install Year
Canada	Vancouver	British Columbia	E. 45th Ave and Killarney St	2012
USA	Tucson	AZ	Elm St and Wilson Ave	Unknown
USA	Alameda County	CA	Willow Ave and Willow Ct	2007
USA	El Cerrito	CA	Lincoln Ave and Richmond St	2010
USA	Fort Bragg	CA	Harold St and Pine Ave	2012
USA	Kern County	CA	Norwalk St and 20th Ave	Unknown
USA	Los Altos	CA	N. El Monte Ave and S. Clark Ave	2012
USA	Pomona	CA	S. University Dr and Camphor Ln	2011
USA	Poway	CA	12509 Oak Knoll Rd	2010
USA	San Diego County	CA	Montgomery Ave and Westminster Dr	Unknown
USA	San Francisco	CA	Newcomb Ave and Phelps St	2011
USA	Santa Cruz	CA	La Fonda Ave and Holway Dr	2013
USA	South Windsor	CT	Arnold Way adjacent to Orchard Hill School	2013
USA	West Palm Beach	FL	Northwood Rd, Spruce Ave to Broadway	Unknown
USA	Tucker	GA	Livsey Rd and Livsey Woods Dr	2009
USA	**Chicago**	**IL**	**1100 E 57th St**	**Unknown**
USA	**Chicago**	**IL**	**N. Lincoln Ave and W. Lawrence Ave**	**Unknown**
USA	**Chicago**	**IL**	**5809 S. Stony Island**	**Unknown**
USA	**Des Plaines**	**IL**	**Thacker St and S. Cora St**	**2011**
USA	**East St. Louis**	**IL**	**1000 N. 15th St**	**2013**
USA	**Forest Park**	**IL**	**Madison St and Burkhardt Ct**	**2012**
USA	Iowa City	IA	Newton Rd	2008
USA	Cambridge	MA	Berkshire St and Hardwick St	2007
USA	Northampton	MA	Jackson St and Barrett St	2009
USA	Ann Arbor	MI	Canterbury Rd and Shrewsbury	Unknown
USA	Minneapolis	MN	E. River Pkwy	Unknown
USA	Sparks	NV	Victorian Ave from Pyramid Way and 10th St	2005
USA	Raleigh	NC	Dan Allen Dr and North Carolina State University	Unknown
USA	Portland	OR	SE 55 Ave and Hawthorne Ave	Unknown
USA	Snohomish	WA	67th Ave SE and Puget Park Dr	2007
USA	Vancouver	WA	McLoughlin Blvd and Daniels St	Unknown

[1] NYCDOT. 2015. *Traffic Calming Design Guidelines.* Accessed February 25, 2015. http://www.nyc.gov/html/dot/html/pedestrians/traffic-calming.shtml#raisedcrossings

[2] NYCDOT. 2013. *Raised Crosswalks.* "Engineering Instruction." Accessed February 25, 2015. https://www.dot.ny.gov/programs/completestreets/repository/ei_13-018_raised%20crosswalks.pdf

[3] Bushell, Max A., Bryan W. Poole, Charles V. Zegeer, Daniel A Rodriguez. 2013. *Costs for Pedestrian and Bicyclist Infrastructure Improvements*. University of North Carolina Highway Safety Research Center. http://www.pedbikeinfo.org/cms/downloads/Countermeasure%20Costs_Report_Nov2013.pdf

[4] Federal Highway Administration (FHWA). 2001. *The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior*. By Herman F. Huang and Michael J. Cynecki. Accessed August 19, 2014. https://nacto.org/wp-content/uploads/2015/04/effects_traffic_calming_on_ped_motorist_behavior_huang.pdf

[5] Federal Highway Administration (FHWA). 2013. *Evaluation of Pedestrian-Related Roadway Measures: A Summary of Available Research.* Report DTFP61-11-H-00024. Report by Jill Mead, Charlie Zegeer, Max Bushell. http://www.pedbikeinfo.org/data/library/details.cfm?id=4872 (link inactive), or https://trid.trb.org/view/1284787

[6] Pedestrian and Bicycle Information Center, and National Highway Traffic Safety Administration. "Raised Pedestrian Crosswalks." *SRTS Guide*. Safe Routes to School Guide, n.d. Web. 09 Mar. 2015. http://guide.saferoutesinfo.org/engineering/raised_pedestrian_crosswalks.cfm

[7] American Public Works Association (APWA). 2006. *North American Design Guidelines for Traffic Calming Measures.*
http://www2.apwa.net/documents/email/designguidelines/Design%20Guidelines%20for%20Traffic%20Calming%20Measures(metric).doc
http://www3.apwa.net/Resources/Reporter/Articles/2006/7/Traffic-Calming-Design-Guidelines

[8] - Institute of Transportation Engineers (ITE). 2010. *Manual of Transportation Engineering Studies.* 2nd Edition. By Schroeder, Bastian J., Christopher M. Cunningham, Daniel J. Findley, Joseph E. Hummer, Robert S. Foyle. Publication No. TB-012A.

[9] American Association of State Highway and Transportation Officials. "13A.9.1.2. Install Raised Pedestrian Crosswalks." *Highway Safety Manual*. 1st ed. Vol. 3. Washington, D.C.: American Association of State Highway and Transportation Officials, 2010. 13-68. Print.

Curb Bump Outs

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation


STATE LAW
STOP
HERE
FOR

A curb bump out (also referred to as a curb extension or curb radius reduction) extends the curb line and sidewalk, typically into an existing parking lane, resulting in a visually and physically narrower roadway. Bump outs increase pedestrian visibility for approaching motorists, and decrease pedestrian crossing distance and roadway exposure time. By narrowing the perceived roadway, bump outs may also reduce motorist speeds. Bump outs also encourage slower turning speeds by tightening intersection curb radii that may be overdesigned.

Figure 1 - Curb bump out extending into a parking lane on Central Street in Evanston, Illinois

Features

Bump outs typically extend the curb into an existing parking lane, and extend the sidewalk toward and closer to the vehicle travel lanes. They are typically outlined by curb, but can also be demarcated with lower cost, interim materials such as temporary curbs, bollards, planters, or striping (NACTO). Some have a recessed area for bioswales. Others, mainly in urban environments, are filled with concrete or asphalt and are used for placement of benches, trashcans, bike racks, potted plants, and other street furniture. They may also require removal of some on-street parking to accommodate.

Generally, the Institute of Transportation Engineers recommends using the smallest practical curb radius to accommodate the vehicles that frequent the route, even if that means the largest design vehicle expected may occasionally encroach on opposing lanes. AASHTO also does not restrict designs that “allow for an occasional large truck to turn by swinging wide and encroaching on other traffic lanes” if the design does not disrupt traffic significantly.[1]

$

$13,000
Average cost per extension
(2013)

Costs

Bump outs may require a fire hydrant, utility pole, or controller box to be relocated, incurring some additional costs. Bump outs that capture storm water can also increase cost. The average bump out costs $13,000, but costs can vary from as low as $1,070 to as high as $41,170.[2] Based on the average cost, a four-leg intersection with bump outs at all 4 corners would cost approximately $52,000 (4 x $13,000).

Design Guidance

FHWA	MUTCD Section 3b.23 http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm
Illinois Department of Transportation	BDE Manual: Section 36-2.01 http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Design-and-Environment/Illinois%20BDE%20Manual.pdf
Illinois Department of Transportation	BLRS Manual: Sections 34-1.04, 34-2 http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Local-Roads-and-Streets/Local%20Roads%20and%20Streets%20Manual.pdf
AASHTO	A Policy on Geometric Design of Highways and Streets (6th Edition Sections : Sections 2.1, 3.3.6, 9.6) https://store.transportation.org/Item/CollectionDetail?ID=180
AASHTO	Guide for the Development of Bicycle Facilities Section 4.12.6 https://store.transportation.org/Item/CollectionDetail?ID=116
AASHTO	Guide for the Planning, Design, and Operation of Pedestrian Facilities - Sections 2.6.2 and 3.3.2 https://store.transportation.org/Item/CollectionDetail?ID=131
ite	Intersection Design Guidelines http://www.ite.org/css/online/DWUT10.html
NACTO	Urban Street Design Guide Curb Extensions http://nacto.org/publication/urban-street-design-guide/street-design-elements/curb-extensions/

Figure 2 - List of design guidance manuals and documents

SAFETY

Curb bump outs are intended to make pedestrians more visible to approaching motorists, thus increasing pedestrian safety. Bump outs also reduce pedestrian crossing distance which reduces their exposure to traffic while increasing comfort. Adjustments to facility geometry and demarcation can discourage or prevent motorists from parking too close to the intersection and crosswalk and thereby obstructing sight distances. Bump outs can also narrow the roadway, potentially reducing motorist speeds.

"Larger curb radii typically result in high-speed turning movements by motorists," but when a bump out is installed at an intersection, an excessively large curb radii can be reduced. Smaller radii encourage motorists to slow down while making turns and reduces the most common type of pedestrian crash.[3] Guidance by AASHTO also dictates design speeds of 15 mph for curb radii of 50 feet or less.[4] Smaller curb radii also decreases the crossing distance; AASHTO also reports that for every 10 feet of increased curb radius, crossing distance increases by an additional 10 to 15 feet.

The Oregon Department of Transportation performed a case study on motorist and pedestrian behaviors at an intersection in Albany, Oregon.[5] The crosswalk was on a two-lane roadway with a bump out on only one side of the street. The cross-sectional study found that when a pedestrian attempted to cross from the bump out side, the average number of vehicles that passed after a pedestrian arrived at the curb decreased by 42.7% on the near side lane and 33.9% at the far side lane, compared to pedestrians that arrived on the non-bump out side.

Reduction in number of vehicles in the **near-side** lane that passed before a pedestrian crossed	42.7%
Reduction in number of vehicles in the **far-side** lane that passed before a pedestrian crossed	33.9%

Furthermore, studies on midblock bump outs found motorist speeds were reduced by 4% if two lanes were maintained or 14% if two lanes were reduced to one lane and both directions must share the lane.[6] Another study in New Zealand examined the effectiveness of various roadway widths at the narrowest point. Two-lane roadways that narrowed down to approximately 20 feet did not see any change in motorist speed. At openings of approximately 16.5 feet, 40% of motorists slowed down for opposing motorists.[7]

Bump outs may have negative safety impacts. Pedestrians may become complacent and develop a false sense of security when crossing. Also, large vehicles may encroach on the curb during turns. Additionally, engineers should consider bicyclists when designing bump outs. "Bicyclists prefer not to have the roadway narrow into the path of a motorist".[6] Bump outs should not extended into bicycle lanes. Depending on roadway width, bump outs may prohibit the placement of future bicycle lanes. On shared streets or instances where the bicycle lane and motorist lane merge and there is inadequate room for both a motorist lane and bicycle lane, alternative features such as raised crosswalks should be installed to encourage motorists to yield to bicyclists and allow them to travel through first while still providing a comfortable pedestrian crossing. A separate path through or around the bump out may also be provided specifically for bicyclists although this may prohibit its use as a pedestrian crossing tool.

OPERATIONS

Generally, intersection curb extensions do not cause travel delays or affect operations because they are typically not designed to extend into the travelled way.

However, because bump outs narrow the total width of the road, motorist speeds may decrease. Some bump outs installed at midblock locations may cause delays depending on traffic volumes or if lanes are reduced. As mentioned in the safety portion of this report, curb bump outs reduce turning speeds because of a tighter curb radii. The requirement to accommodate large trucks and tractor trailers is often used as justification for large curb radii, but in many urban settings it is often possible to use smaller turning radii and allow large vehicles to encroach into opposing lanes when completing a turn. Set back stop bars may be used to accommodate these encroaching turns. A regulation promoting the use of small delivery trucks in areas of high pedestrian traffic is one alternative that may alleviate hardship to local business due to restrictions imposed on large trucks and using smaller radii.

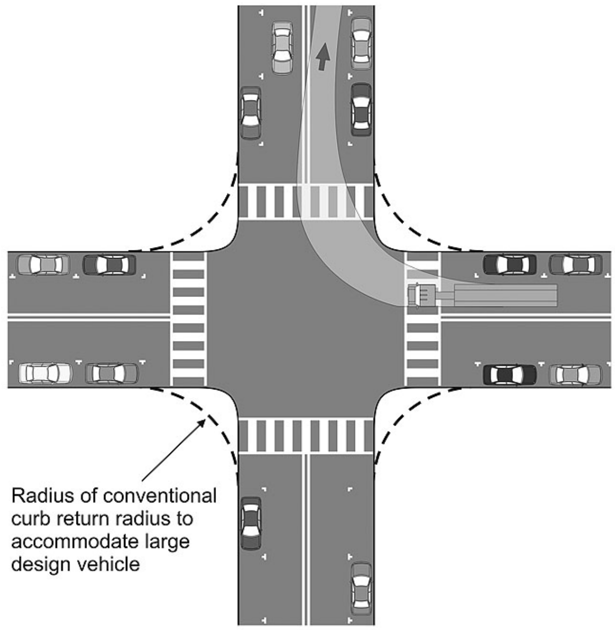


Figure 3 - www.ite.org/css/online/DWUT10.html

Clifford Chai, Dr. Glen Koorey, and Pr. Alan Nicholson investigated the effect of decreasing roadway width at a midblock location via bump outs.[7] Their findings are published in their report "The Effectiveness of Two-Way Street Calming Pinch-Points." Their study took place in 2011 in Christchurch, New Zealand and looked at three locations with differing bump outs. At the first location (a two-lane, two-way street with a bump out and opening of 20 feet wide) they studied the interaction between two cars simultaneously approaching the reduction from opposite directions. Here they found motorists' speeds were not affected by the bump outs. The next site was another two-lane, two-way street but it was reduced to 16.5 feet at a midblock bump out. Again they looked at the interaction between two motorists simultaneously approaching the reduction from opposite directions and found approximately 40% of motorists reduced their speed, 20% of motorists avoided sharing the space with the oncoming motorist and opted to wait until it was clear before proceeding. At the last study site (a one-lane, one-way street where the midblock width was reduced to about 15 feet) they studied the interaction between bicyclists and motorists when approaching the reduction at the same time. Their study found either the motorists or bicyclist gave way and waited nearly 60% of the time, around 35% of the time the bicyclist and motorist shared the narrowing, and 8% of the time the bicyclists (mostly younger children) avoided the narrowing and used a bypass instead.

Bump outs can be also be placed at bus stops, where they are usually called bus bulbs. An example is shown in Figure 4. A bus bulb improves bus travel times by eliminating lost time busses encounter while waiting to reenter traffic. The presence of a bus bulb also creates additional space for bus shelters and benches. By installing a bump out/bus bulb, pedestrian flow remains undisturbed because it allows pedestrians to move out of the main sidewalk area so that normal flow can resume. In the study done for TCRP Report 65, it is stated that the average flow of pedestrians traveling along the sidewalk adjacent to the bus stop improved by approximately 11%.[8]

Bump outs can also effect pedestrian crossing operations. A 7 foot bump out in Chicago can reduce pedestrians crossing time by 2-3 seconds.[9] Decreasing pedestrian crossing distance and time will also improve signal timing and motorist operations.[3]

Finally, bump outs are a context sensitive facility. As always, effects on traffic speed and delay should be considered in tandem with the reverse safety effects of slower traffic. "Adequate radii for vehicle operations should be balanced against the needs of pedestrians", according to AASHTO.[1]

Figure 4 - A rendering of a proposed bus bulb in Chicago as part of Chicago's LoopLink project. Image courtesy of CDOT. Reprinted with permission.

MAINTENANCE

Curb bump outs are passive, self-enforcing facilities that require minimal routine maintenance. Some curb bump outs may have optional planters and other vegetation that may require landscape upkeep. Curb extensions may require the relocation of a fire hydrant in order to maintain appropriate curbside access. Utility relocations are also a possible consideration if the bump out is being installed over an existing manhole or other existing utilities.

Typical Infrastructure to Maintain

- Concrete or asphalt curb
- Optional raised crosswalk facility
- Optional landscaping
- Optional "urban furniture" such as benches, trash receptacles, and bike racks

Street Sweeping & Snow Removal

Bump outs may require extra visibility tools to aid snow plowing operations. If a bump out is not properly marked and there is a heavy snowfall, a snow plow driver may not know the bump out is there and consequently strike the curb extension with the plow. Not only could this seriously compromise the facility but it could also injure the plow drivers and others using the roadway.

Drainage

Bump outs should be installed to allow water to drain away from the curb, otherwise the bump out may require inlets be installed and maintained.[10] Bump outs have the option of being offset from the street to avoid affecting existing drainage. A one to two foot gap can be placed between the existing flow line and the bump out to keep the existing drainage plan in place. If the bump outs are separate from the original street return then routine gutter clearing may be necessary to maintain drainage.

Figure 5 - Curb bump out on Central Avenue in Evanston, Illinois.

District One Studies

The following is a summary of findings from four studies performed by IDOT in 2014, for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 1 - Summary of IDOT District One Studies

Study	Summary of Findings
Pedestrian Survey	There were a total of 38 online survey responses at the facility location only. Overall feedback was 60% negative and only 3% positive (the remaining 37% unanswered). Participants gave various reasons as to why the curb bump outs were not as effective as intended.
Motorist Compliance and Pedestrian Behavior	Sample sizes from this study were low, so it is not feasible to draw conclusions on bump outs and their impact on motorists and pedestrians

Pedestrian Survey

An in-person and online survey was conducted to gain insight on pedestrian and motorist usage and opinions of the curb bump outs on Central Street at Hastings Avenue in Evanston, IL. The location is next to a park and school. Online submissions were allowed from November 21st to November 26th, 2014.

Site Conditions

In-person surveys were conducted on November 21, 2014 from 4 to 6 p.m. at the site of the curb bump out on Central Street at Hastings Avenue. Central Street is a two-lane roadway with an ADT of 11,100 and a 30 mph speed limit at the site of the bump out, decreasing to 25 mph two blocks east of the study site. The temperature was in the upper 60s with light drizzle throughout the duration of the survey. In-person surveys were also conducted at the control crosswalk site on Gross Point Road and Thayer Street in Evanston.

Survey Method

To conduct the surveys, two staff members stood on the sidewalk at opposite ends of the crosswalk. Both members were wearing safety vests to be safe and to attract the attention of pedestrians. Staff approached pedestrians and asked them if they would like to take a survey and offered the option of taking the survey in person or online at their own convenience.

The in person survey received zero responses. The online survey was active and available for one week and received 38 responses. Not all participants responded to every question. The individual response IP addresses were checked to eliminate duplicate submissions. No residents completed an in-person survey or online survey at the control location.

Survey Questions

The questions asked in the survey are listed in Table 1. The responses and their corresponding graphs are shown in the results section of this report. The original paper survey form is attached in Appendix A.

Table 2- Survey questions and corresponding figure numbers

Figure #	Question Asked
Figure 6	What is your gender?
Figure 7	In what age group do you fall?
Figure 8	What best describes why you are out here today?
Figure 9	As a pedestrian, in the past month about how often have you crossed Central Street at Hastings Avenue in Evanston?
Figure 10	As a motorist, in the past month about how often have you driven down Central Street past Hastings Avenue in Evanston?
Figure 11	Which answer best describes what an Illinois motorist must do when approaching a crosswalk?
Figure 12	How safe do you feel when crossing Central Street at Hastings Avenue in Evanston? 1 being completely unsafe and uncomfortable, 3 being neither safe nor unsafe, and 5 being completely safe and comfortable.
Figure 13	When driving past Central Street and Hastings Avenue in Evanston (if applicable), how visible is the crosswalk from 50 feet away? 1 being barely visible and 5 being completely visible.
Figure 14	Do you have any suggestions or comments regarding crosswalk bump outs like the one crossing Central Street at Hastings Avenue?

Survey Results

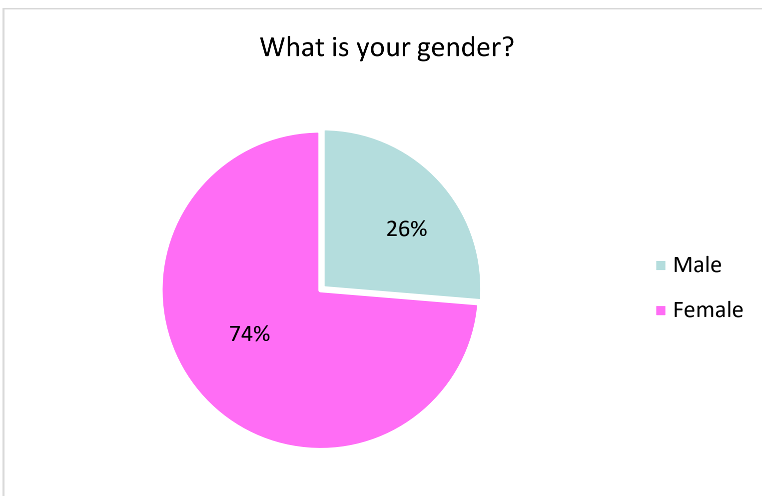


Figure 6 - What is your gender?

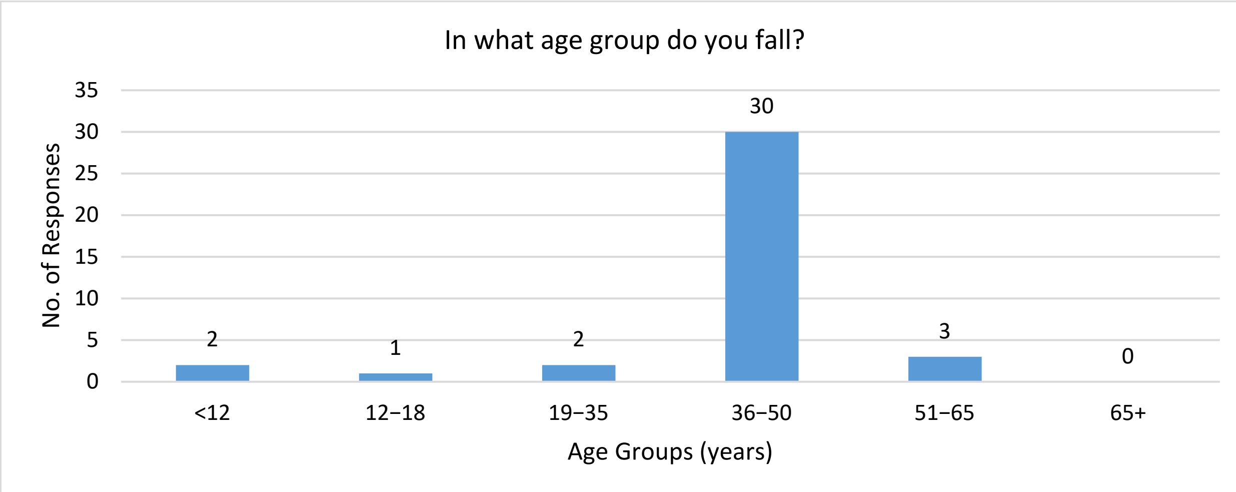


Figure 7 - In what age group do you fall?

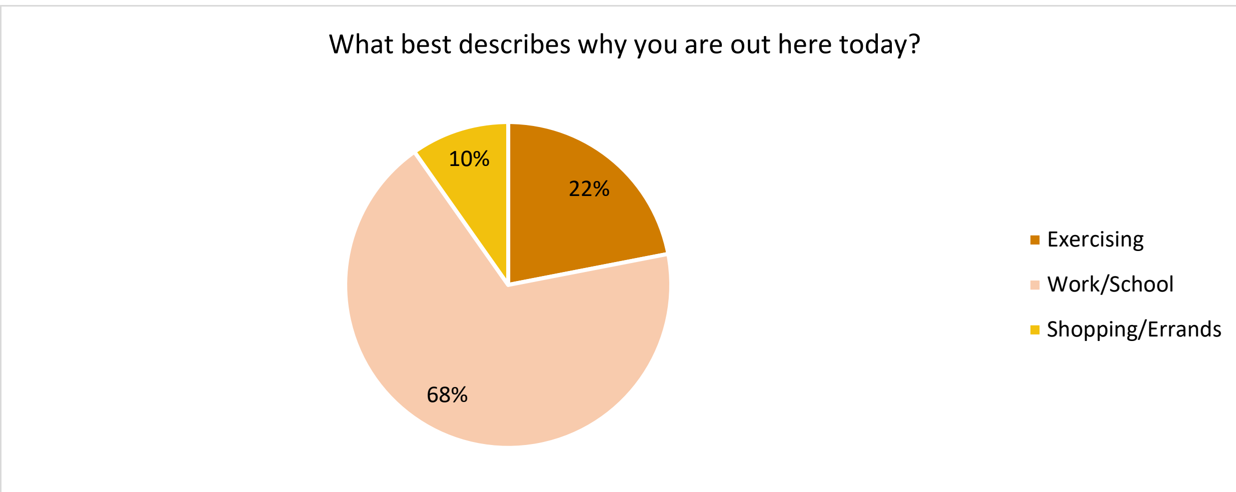


Figure 8 - What best describes why you are out here today?

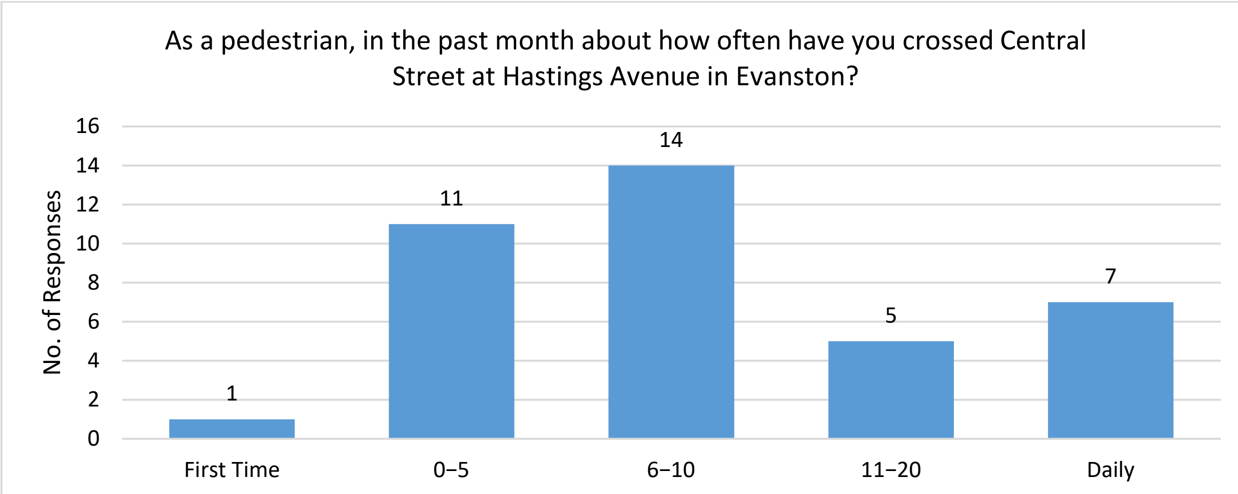


Figure 9 - As a pedestrian, in the past month about how often have you crossed Central Street at Hastings Avenue in Evanston?

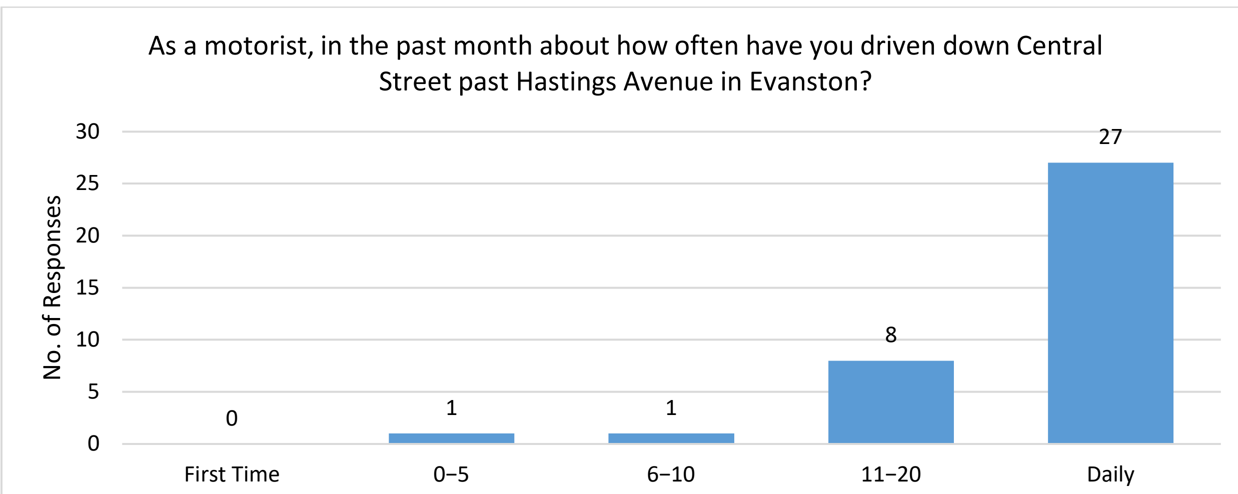


Figure 10 - As a motorist, in the past month about how often have you driven down Central Street past Hastings Avenue in Evanston?

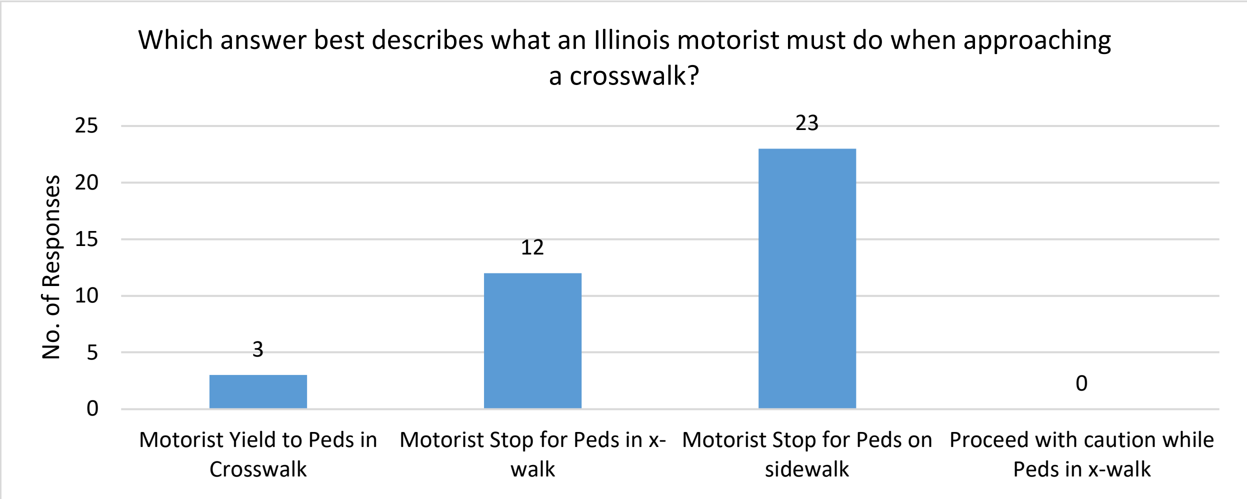


Figure 11 - Which answer best describes what an Illinois motorist must do when approaching a crosswalk?

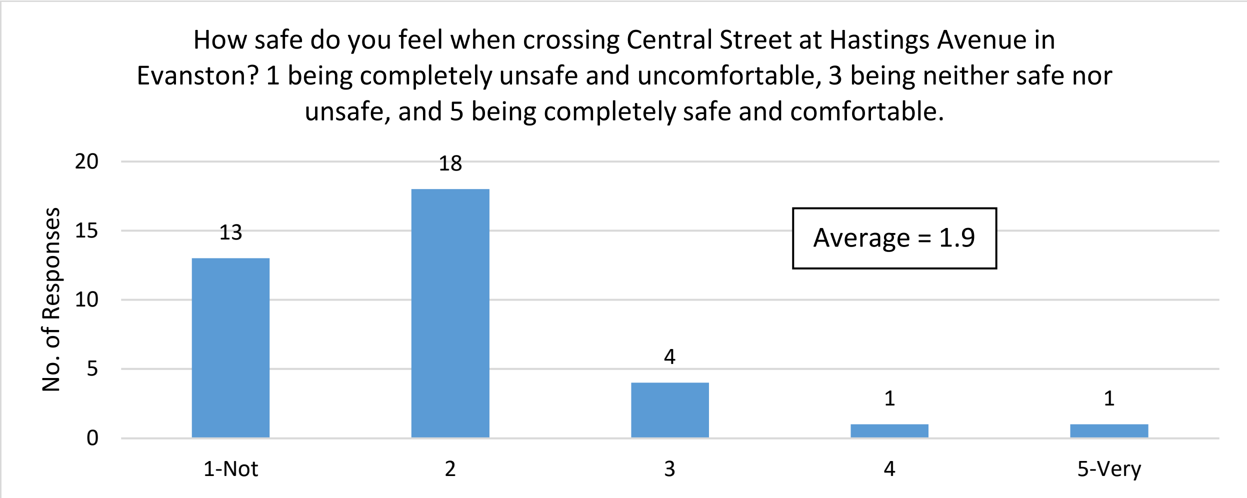


Figure 12 - How safe do you feel when crossing Central Street at Hastings Avenue in Evanston? 1 being completely unsafe and uncomfortable, 3 being neither safe nor unsafe, and 5 being completely safe and comfortable.

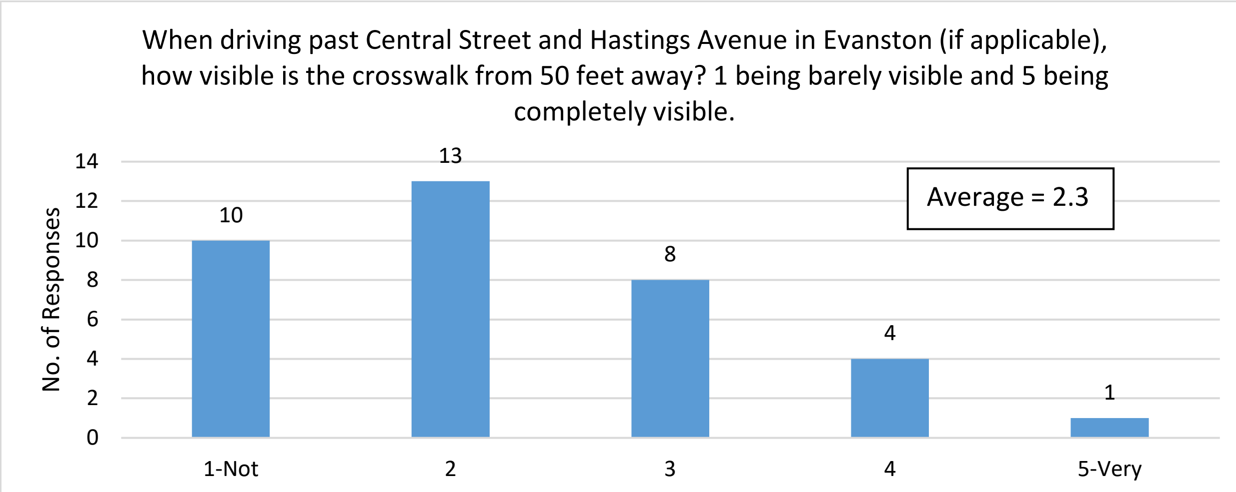


Figure 13 - When driving past Central Street and Hastings Avenue in Evanston (if applicable), how visible is the crosswalk from 50 feet away? 1 being barely visible and 5 being completely visible.

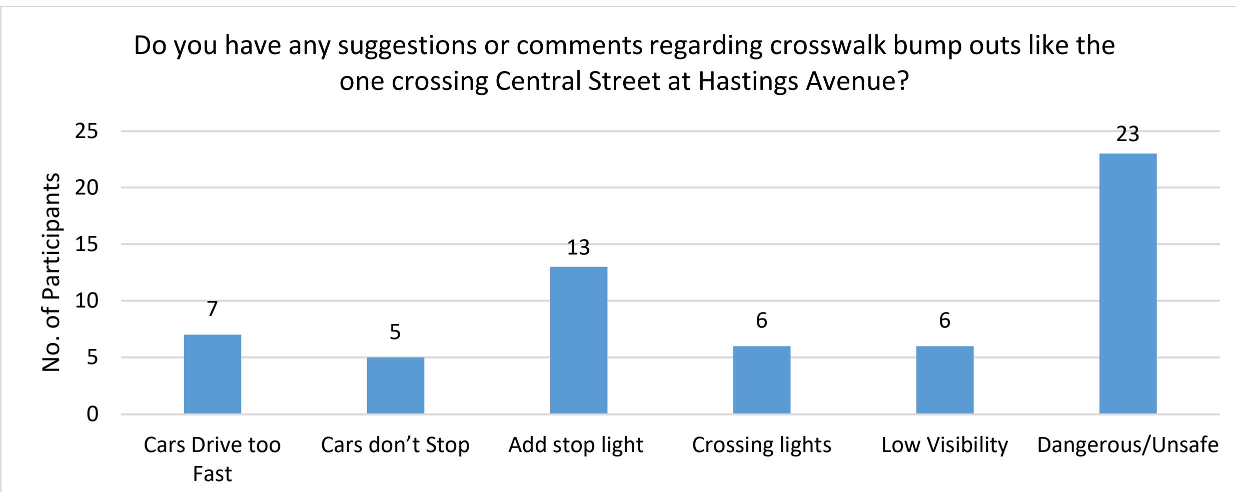


Figure 14 - Do you have any suggestions or comments regarding crosswalk bump outs like the one crossing Central Street at Hastings Avenue?

Discussion

The majority of the survey participants was female and fell within the age range of 36 – 50 years of age. During the survey, 68% of the participants were traveling to work or school, while 22% were exercising, and 10% were running errands. The majority of participants surveyed only crossed Central Street at this location 0-10 times in the past month, but drove down the street daily. When asked about the current Illinois law requiring a motorist to stop for pedestrians in a crosswalk, 60% of respondents replied with the correct understanding of the law.

Out of the 38 pedestrians, 6 responded that the cross walk was somewhat (3) to very (5) safe, while 84% felt that this crossing is a 1-2, indicating that the majority of pedestrians do not feel comfortable crossing. The average rating was 1.89. Similarly, 82% of respondents that mentioned they drive tended to think the crosswalk wasn't visible from 50 feet away; they were "somewhat" to "not at all" able to see the crosswalk when approaching. The average rating for visibility was 2.3. In the open-ended question, most respondents mentioned the bump outs were ineffective, dangerous or unsafe. Many also requested improvements such as a stop light. The low ratings on comfort and visibility, and the many negative comments may be an attempt by the residents to encourage a stoplight or improvements to the crosswalk. This is despite notifications on the survey that the results of the survey will not affect any outcome at this particular location and was meant to gather information on the effectiveness of bump outs only.

Conclusion

There were a total of 38 online survey responses at the facility location only. No responses were received at the control site. Not all participants responded to every question asked. Overall, feedback was 60% negative and only 3% positive (the remaining 37% unanswered). Participants gave various reasons as to why the curb bump outs were not as effective as intended.

The morning and afternoon activity was comprised of students, parents, and adults going to work or exercising. Many complained that due to low visibility and vehicles driving too fast, them and/or their children have almost been hit. Participants noted that visibility at this location becomes an even bigger issue in the fall when the sun makes the visibility almost impossible.

Some respondents gave positive responses about the bump out but that it needed to be enhanced. For example, installing a stop light or lighted crosswalk could improve the crosswalks visibility. They also stated that the bump outs do not extend into the roadway far enough, allowing through motorists to pass queued, left turning motorists..

Motorist Compliance and Pedestrian Behavior Study

A pedestrian and motorist behavior study was conducted for the purpose of gaining further information and knowledge about the performance of a curb bump out facility in the District One Region. Two crosswalk locations with similar crosswalk features, pavement markings, roadway geometry, and traffic control devices were included in the study: one with a curb bump out (facility site) and one with a conventional crosswalk (control site).

The curb bump out was located on Central Street at Hastings Avenue. The control crosswalk, without a curb bump out was on Gross Point Road and Thayer Street in Evanston.

Figure 15 - Bump out at Central Street and Hastings Avenue in Evanston, Illinois

Site Conditions

The bump out facility behaviors were monitored on November 10th, 2014 from 3 to 5 pm. Central Street is a two-lane roadway with an ADT of 11,100 (2014) and a 30 mph speed limit at the site of the bump out, decreasing to 25 mph two blocks east of the study site. The temperature at the time of the study was 55 degrees and cloudy. The control crosswalk behaviors were monitored on November 20th, 2014 from 3:00 to 5:00 pm. Gross Point Road has an ADT of 7,400 vehicles per day at this location, and the temperature at this time was 27 degrees and cloudy.

Study Method

A cross sectional study was conducted to compare a crosswalk with curb bump outs with a similar crosswalk without the bump outs (a control site). For both studies, the staff members dressed in normal street clothes and were positioned in an inconspicuous spot near the crosswalks.

Motorist Behavior

Figure 18 shows the behaviors of the motorists when pedestrians were present and waiting to cross the road at the crosswalk. The figure includes both the facility and the control locations. Three of the categories includes motorists that stopped or slowed enough for pedestrians to cross: practically stopped (motorists that slowed to between 0 and 3 mph), stopped by traffic, and voluntary full stop. The fourth category, non-stopping, did not stop or allow a pedestrian to cross. A total of 13 vehicles were recorded at the bump out location. At the control site, 7 motorists were observed.

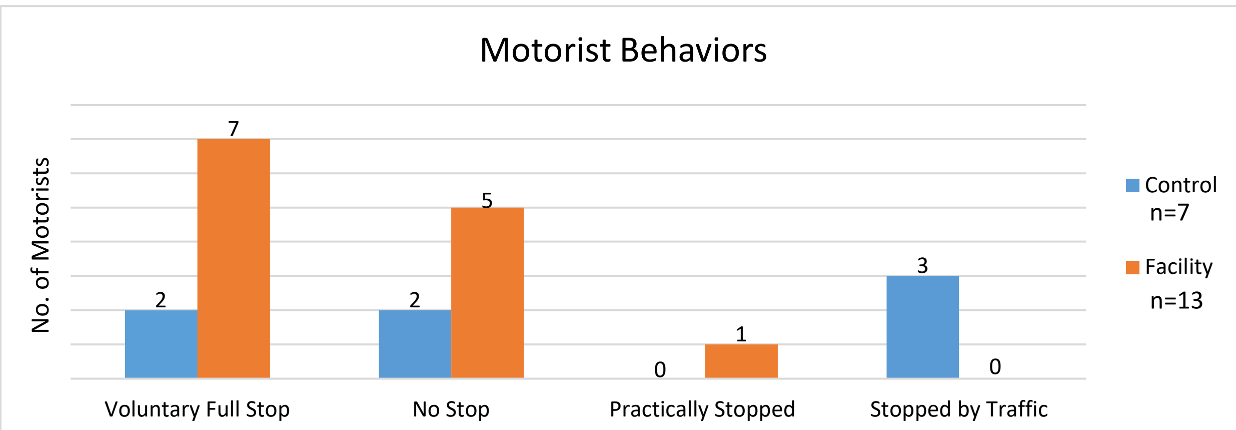


Figure 16 - Motorist Behaviors at bump out location versus a control site.

Conclusion

The site with the bump outs had only 8 pedestrians; however, none of those pedestrians jaywalked, whereas at the control location 3 out of the 30 pedestrians jawalked. While no pedestrians jaywalked at the bump out intersection, 3 out of the 5 hesitated when crossing the road, whereas only 4 of the 30 pedestrians hesitated at the control location. Overall, pedestrian and motorist counts were low so it is not feasible to draw a strong conclusion on bump outs and their impact on motorists and pedestrians.

Below are some of the locations in the United States in which bump outs were located. Many of these cities have more than one bump out; however, only one from each city (except for Chicago) was listed in the table for conciseness.

Table 3 – Examples of curb bump outs in the USA

Country	City/County	State	Intersection
USA	San Francisco	CA	7th Avenue and Irving Street
USA	San Bernadino	CA	Multiple locations
USA	Encinitas	CA	Multiple locations
USA	Cotati	CA	Old Redmond Highway
USA	Davis	CA	C Street near Farmers Market
USA	Del Mar	CA	Multiple locations
USA	Laguna Beach	CA	Multiple locations
USA	Buena Vista	CO	South Main
USA	Del Ray Beach	FL	Multiple locations
USA	West Palm Beach	FL	Multiple locations
USA	**Chicago**	**IL**	**3100 North Lake Shore Drive**
USA	**Chicago**	**IL**	**2350 West Berwyn Avenue**
USA	**Oak Lawn**	**IL**	**(US 20) 95th Street and Hamlin Avenue**
USA	**Urbana**	**IL**	**Florida and Philo**
USA	South Bend	IN	Eddy Street Commons
USA	Indianapolis	IN	Multiple locations
USA	Arlington	MA	Mass. Avenue at Wyman Street
USA	Birmingham	MI	Multiple locations
USA	Waconia	MN	Walnut and First Street
USA	Rochester	MN	1st Avenue SW and 2nd Street SW.
USA	St. Louis	MO	4th Street and Spruce Street
USA	Littleton	NH	Pleasant Street and Main Street
USA	Keene	NH	Multiple locations
USA	New York	NY	Mulry Square
USA	Columbus	OH	New Bond Street
USA	Kingston	ON	Hudson Drive and Pimlico Place
USA	Toronto	ON	Fairford Avenue and Rhodes Avenue
USA	Portland	OR	SE Harold Street
USA	Erie	PA	West 12th and State Street
USA	Philadelphia	PA	3100-3300 West Queen Lane
USA	Anderson	SC	Downtown Anderson
USA	Alexandria	VA	Washington Street and Pendleton Street

USA	Seattle	WA	Multiple locations
USA	Milwaukee	WI	East Chicago Street and Nnorth Milwaukee Street
USA	Madison	WI	Multiple locations

[1] American Association of State Highway & Transportation Officials (AASHTO). *A Policy on Geometric Design of Highways and Streets.* 6th Edition. 2011.

[2] Bushell, Max A., Bryan W. Poole, Charles V. Zegeer, Daniel A Rodriguez. 2013. *Costs for Pedestrian and Bicyclist Infrastructure Improvements*. University of North Carolina Highway Safety Research Center.

[3] Safe Routes to School Guide. *Reduced Corner Radii.* http://guide.saferoutesinfo.org/engineering/reduced_corner_radii.cfm

[4] Institute of Transportation Engineers (ITE). *Traffic Calming: State of the Practice.* ITE and FHWA. August 1999. http://www.industrializedcyclist.com/trafficcalming.pdf

[5] Johnson, Randall S. *Pedestrian Safety Impacts of Curb Extensions: A Case Study.* Oregon Department of Transportation. FHWA Report No. FHWA-0R-DF-06-01. http://nacto.org/docs/usdg/pedestrian_safety_impacts_of_curb_extensions_randal.pdf

[6] Institute of Transportation Engineers (ITE). *Traffic Calming Measures – Choker*. Accessed October 16, 2015. http://library.ite.org/pub/2a11c074-ee6e-d5d1-1d7a-b2c383f66596

[7] Chai, Clifford, Dr. Glen Koorey, Prof Alan Nicholson. The Effectiveness of Two-Way Street Calming Pinch-Points. IPENZ Transportation Group Conference. Auckland. March 2011. http://nacto.org/docs/usdg/two_way_street_calming_pinchpoints_chai.pdf

[8] K. Fitzpatrick, K. Hall, S. Farnsworth, M. Finley. *TCRP Report 65 – Evaluation of Bus Bulbs.* NACTO. Accessed November 2014. http://nacto.org/docs/usdg/tcrprpt65_fitzpatrick.pdf

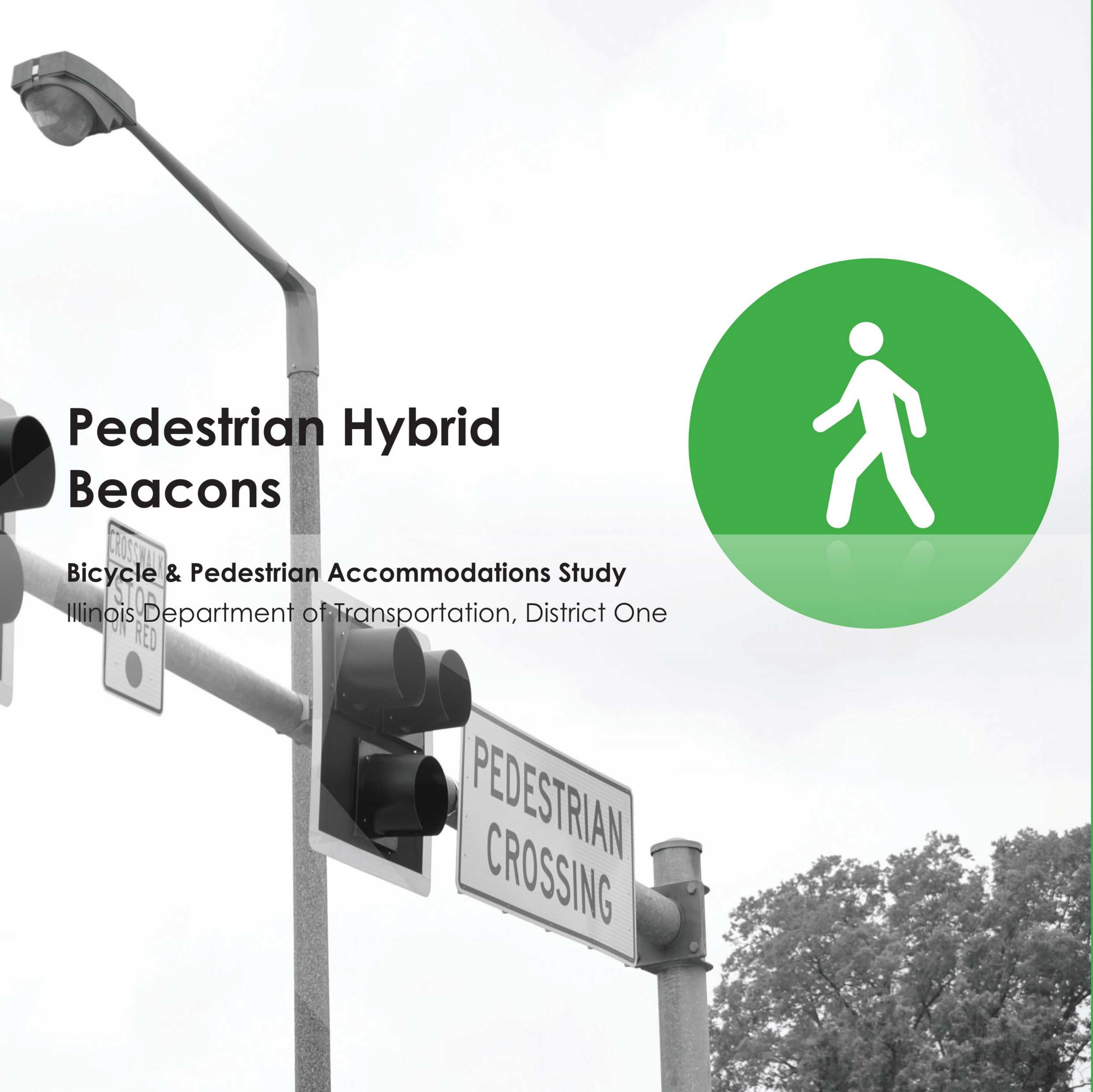
[9] *Tools for Safer Streets Guide.* City of Chicago, Chicago Department of Transportation. Accessed October 2014. http://www.cityofchicago.org/content/dam/city/depts/cdot/street/general/ToolsforSaferStreetsGuide.pdf

[10] Institute of Transportation Engineers (ITE). *Intersection Design Guidelines.* Accessed November 2014. http://www.ite.org/css/online/DWUT10.html (link broken)

Pedestrian Hybrid Beacons

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One



Illinois Department of Transportation


PEDESTRIAN
CROSSING

Pedestrian hybrid beacons (PHBs) were designed by engineers in Arizona to aid pedestrians in crossing streets and raise motorist awareness. One type of PHB is a crossing device known as a High-Intensity Activated crosswalk (HAWK) signal. PHBs remain dormant until they are activated by a pedestrian. Once activated, the PHB has a sequence of five displays indicating what the motorist or pedestrian must do. Motorists are not obligated to stop unless the signal is activated by a pedestrian. PHBs are an FHWA approved device with application, design and operation governed by Chapter 4F of the 2009 MUTCD.[1] They can be installed midblock or at an intersection. Although the MUTCD suggests a separation of 100 feet from side streets and driveways, current research indicates no negative safety or operational effects of PHBs at an intersection.

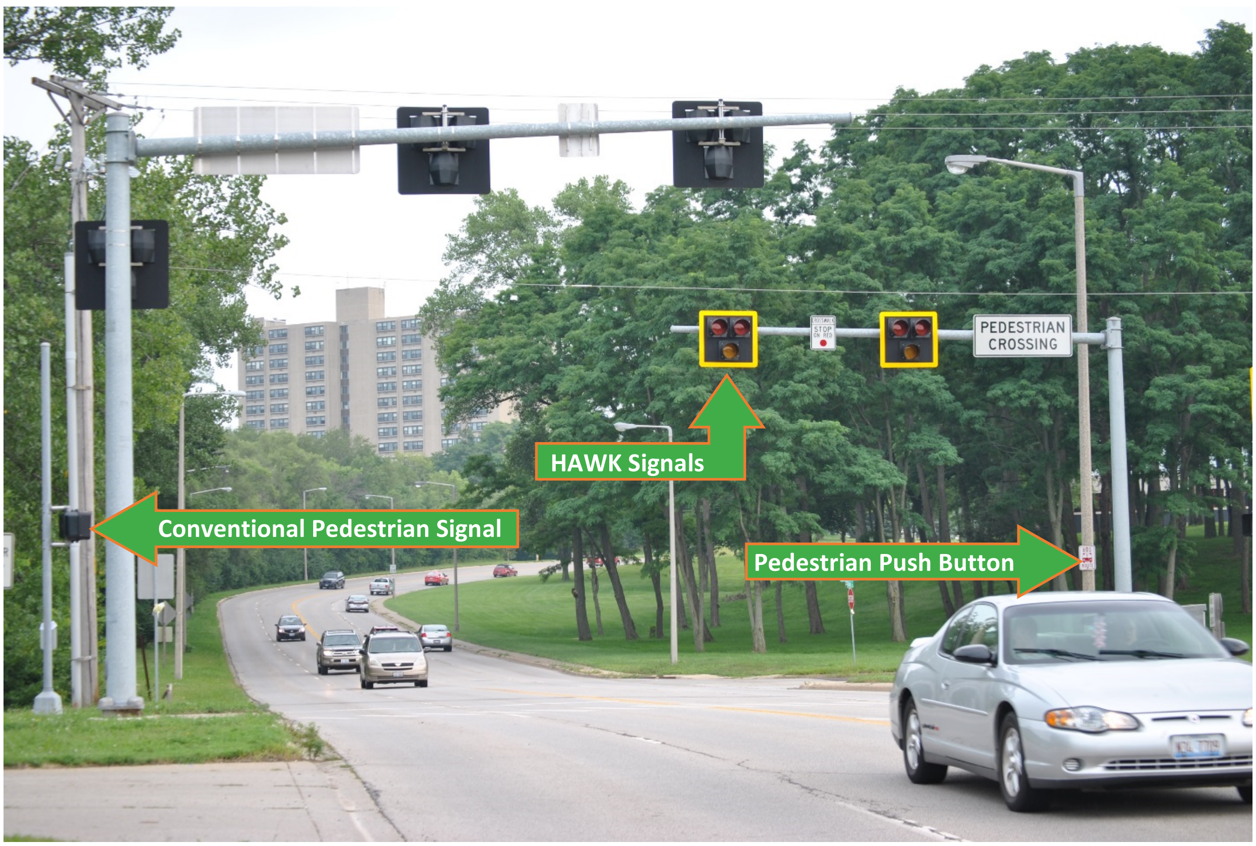


Figure 1 - HAWK Signal on Parkway Drive near Stadium Drive in Pekin, IL.

PHBs prevent crashes and reduce injury severity at pedestrian crossings by increasing motorist awareness and stopping rates. According to the FHWA Pedestrian Hybrid Beacon Guide, a collection of recommendations and case studies by the Federal Highway Association, PHB sites "experienced an 83% reduction in the pedestrian crash rate after installation."[2]

Features

After the pedestrian activates the signal, the pedestrian follows instructions from a conventional pedestrian signal on the opposite end of the crossing, while the approaching motorists will see several displays illuminated on the PHB signal as shown in Figure 2. PHBs can also be used in conjunction with a median refuge island for a two-phase crossing. A location in Scottsdale utilized this method across a 6-lane roadway with an ADT of 47,000. For more detailed information on the features of the PHB signal, please see the FHWA Pedestrian Hybrid Beacon Guide.

Displays

1. The signal is dark until activated by a pedestrian waiting to cross.
2. Once activated, the bottom light will flash yellow. This indicates to motorists that the light is about to turn red and a pedestrian is about to use the crosswalk. The pedestrians will see the red hand, "do not cross" symbol.
3. The PHB signal's bottom light then turns solid yellow similar to a normal traffic signal, instructing motorists to slow down and prepare to stop at the line.
4. The PHB signal's two top lights then turn red, and its bottom yellow light turns off, indicating that the motorists must come to a complete stop at the line so that pedestrians may cross. The pedestrians will now see the walk indication on the pedestrian signal and may proceed.
5. At the end of the pedestrian clearance interval, the PHB signal's top two lights will begin alternating flashing red. This is an indication to motorists that they may proceed if pedestrians are clear. Arriving pedestrians will see the flashing hand on the pedestrian signal indicating they should not begin their crossing.
6. The signal finally returns to a dark state, indicating that motorists may proceed as normal.

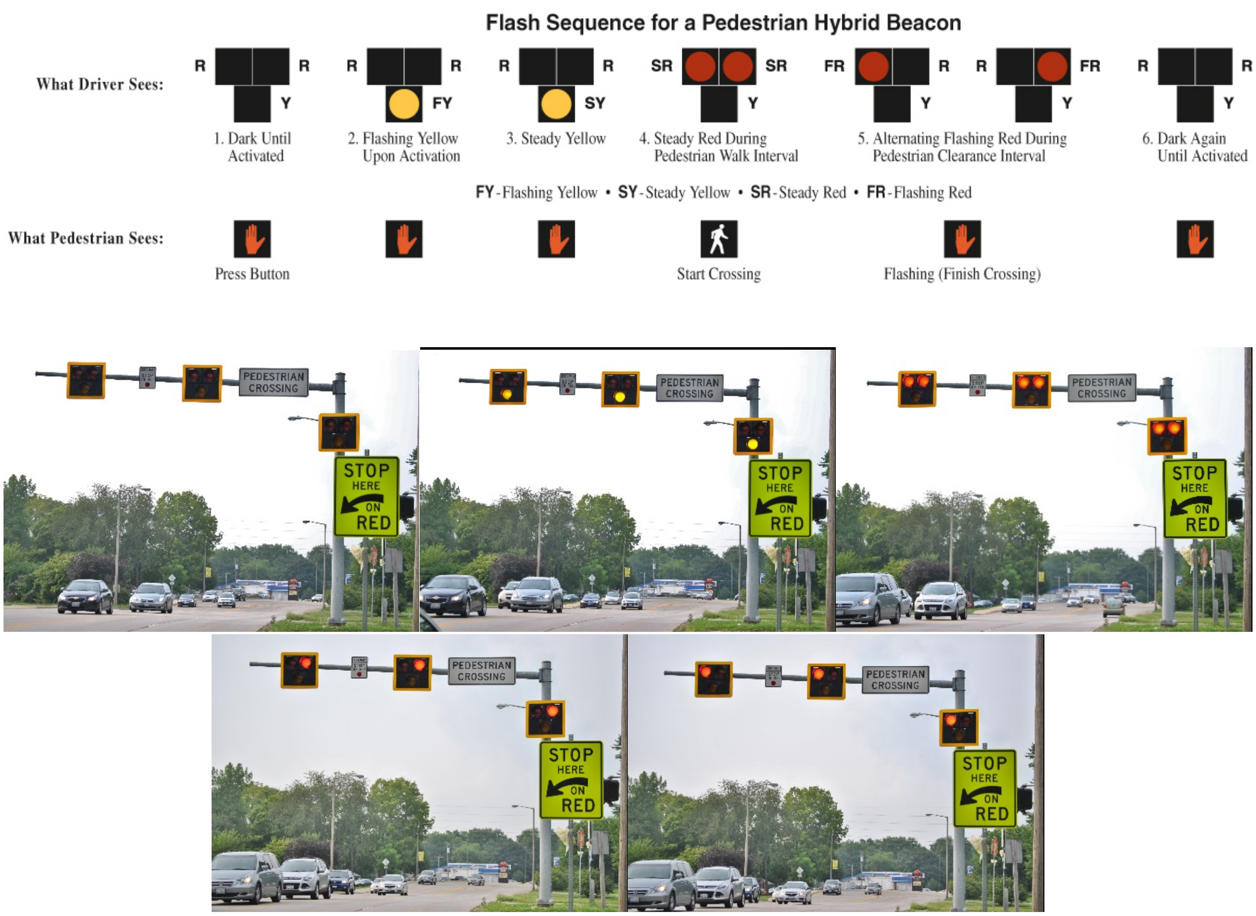


Figure 2 - Stages of PHB signal. Top image from Figure 4F-3 "Sequence for a Pedestrian Hybrid Beacon" in the 2009 MUTCD. Bottom images from a PHB in Pekin, Illinois.

Warrants

These signals are typically installed at mid-block crosswalks on busy arterial roads, but can be appropriate at other locations as well. The MUTCD bases a crossings need for a PHB signal on 4 variables: total pedestrian crossings per hour, vehicle speeds, roadway width, and vehicles per hour. According to the MUTCD, "a pedestrian hybrid beacon may be considered for installation to facilitate pedestrian crossings at a location that does not meet traffic signal warrants (see Chapter 4C), or at a location that meets traffic signal warrants under Sections 4C.05 and/or 4C.06 but a decision is made to not install a traffic control signal." The MUTCD also states that PHB signals should be installed if gaps in traffic are not long enough to allow pedestrians to cross, vehicle speeds are too high for pedestrians to cross, or if the amount of time pedestrians must wait to cross safely is excessive.

Figure 3 and Figure 4 show where PHB signals are appropriate for installation. The graphs' curves are based on 85^{th} percentile speeds, length of crosswalk, crossing pedestrians per hour, and the total number of vehicles per hour from both approaches. The MUTCD states, "the need for a pedestrian hybrid beacon should be considered if the engineering study finds that the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding total of all pedestrians crossing the major street for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve (in either figure below) for the length of the crosswalk."

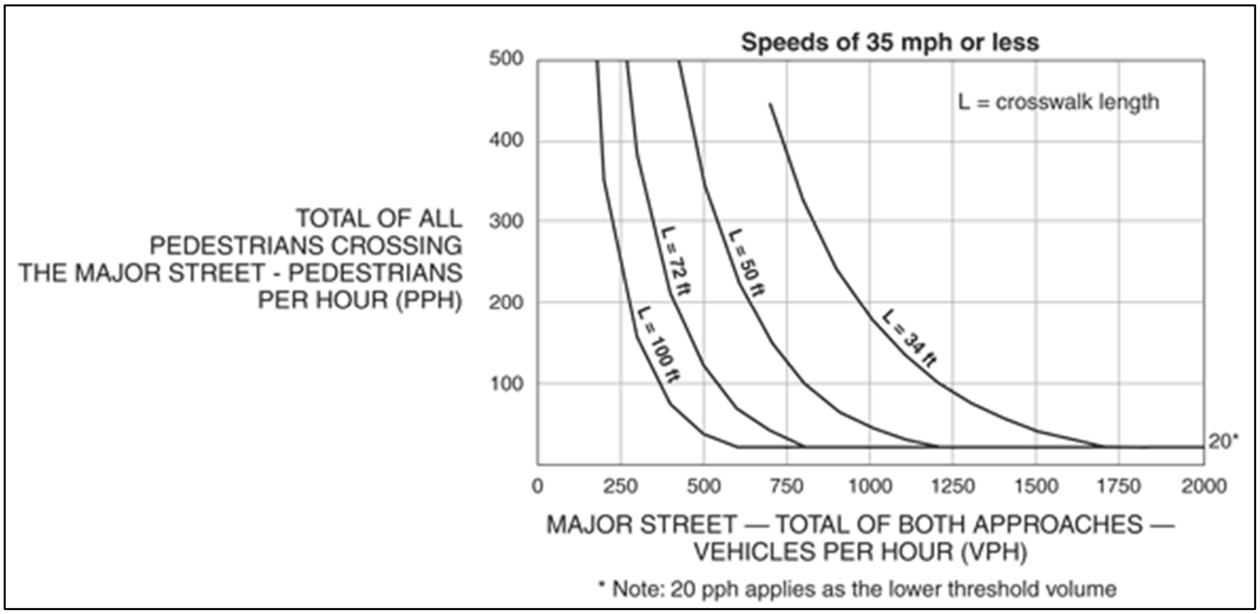


Figure 3 - "Figure 4F-1. Guidelines for the Installation of Pedestrian Hybrid Beacons on Low-Speed Roadways", MUTCD 2009

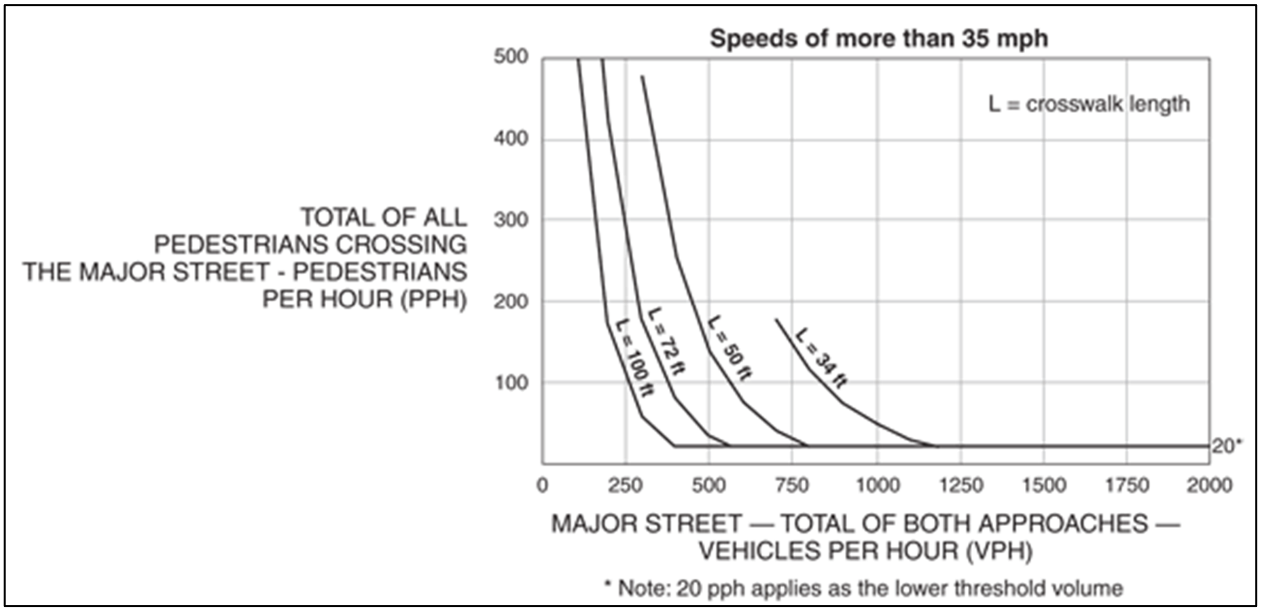


Figure 4 - "Figure 4F-2. Guidelines for the Installation of Pedestrian Hybrid Beacons on High-Speed Roadways", MUTCD 2009

Education and Enforcement

Signage which delegate instructions such as, "STOP ON FLASHING RED THEN PROCEED WHEN CLEAR", "CROSSWALK", and "PEDESTRIAN CROSSING", are installed at intersections with PHB signals. MUTCD Sign R10-23 is required at all PHB locations (Figure 5). In addition to the signage, many cities have provided residents with "how-to" brochures that explain what the signals are and how to use to them. Some cities have also visited local schools that use PHB signals to explain the facility to students and faculty. The City of Champaign in Illinois created a brochure to explain their new signal.[3]

Figure 5 - R10-23 sign, "Crosswalk, Stop on Red"

Costs

According to Bushell et al, "[PHBs] are typically more expensive to implement and maintain than some devices, but less expensive than full traffic signals."[4] Between 9 different installations, Bushell et al found the cost of installation to range between $21,440 and $128,660 with the average cost to be $57,680.

$

$57,680

Average cost

(2013)

Design Guidance

FHWA	FHWA Pedestrian Hybrid Beacon Guide http://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa14014/fhwasa14014.pdf
FHWA	MUTCD Chapter 4F – Pedestrian Hybrid Beacons http://mutcd.fhwa.dot.gov/pdfs/2009/part4.pdf
Illinois Department of Transportation	IDOT BLR - 42-3.02(i) Bike Paths/Highway Crossings http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Local-Roads-and-Streets/Local%20Roads%20and%20Streets%20Manual.pdf
TRB	TRB NCHRP Report 562 & TCRP Report 112 – Appendix A-O http://nacto.org/wp-content/uploads/2010/08/NCHRP-562-Improving-Pedestrian-Safety-at-Unsignalized-Crossings.pdf
NACTO	Urban Bikeway Design Guide http://nacto.org/publication/urban-bikeway-design-guide/bicycle-signals/hybrid-beacon-for-bike-route-crossing-of-major-street/

Figure 6 - List of design guidance manuals and documents

SAFETY

Tucson, Arizona is one of the forefront cities in implementation of PHB signals. To date, they have installed over 90 PHB signals at locations with high frequencies of pedestrian crashes, including those near schools and shopping areas. The FHWA conducted a study on 21 of these PHB signals to determine their "safety effectiveness".[2] In their study they found the PHB signals created:

- A 29% reduction in total crashes, which is statistically significant at the 95% confidence level.
- A 69% reduction in pedestrian crashes, which is statistically significant at the 95% confidence level.
- A 15% reduction in severe crashes, although not statistically significant at the 95% confidence level.

Reduction in pedestrian crashes after installation of PHBs	69%

A joint NCHRP and Transit Cooperative Research Program (TCRP) report examined various solutions to improve pedestrian safety at unsignalized intersections, PHBs being one of them.[5] They found high motorist yielding rates across three research events: stages crossings, general population crossings, and literature review. The PHB exhibited an average of 97% motorist compliance for the staged crossings, 99% compliance for the general population, and 93% average compliance across the NCHRP's review of existing literature. Furthermore, "the number of lanes did not affect performance." [6]

Motorist Compliance at PHBs	93-99%

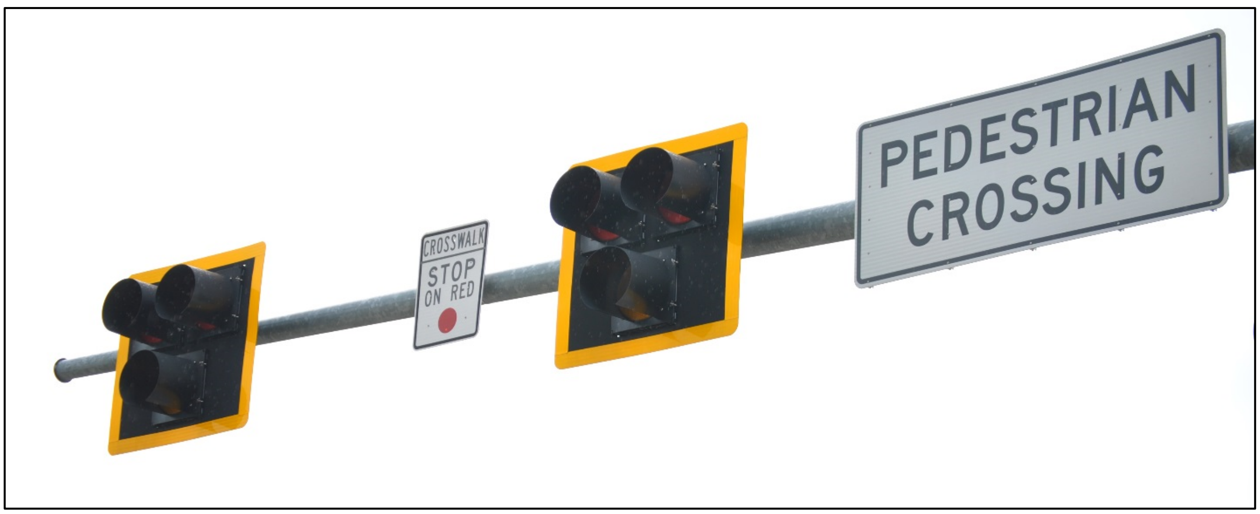


Figure 7 - PHB Signal in Pekin, Illinois.

The University of Nevada Las Vegas conducted a study titled "Effects on compliance of a PHB signal in Las Vegas". In their study they found jaywalking, near-misses/crashes, total pedestrian crossing time, and average number of motorists not yielding to the pedestrians to be significantly reduced after a PHB signal was installed on Sahara Avenue in Las Vegas, Nevada.[7] Sahara Avenue is an eight lane divided roadway with a posted speed limit of 45 mph and a curb to curb length of 118 feet. Near-misses and crash events over the same time period before and after installation resulted in an 84% decrease.

A study commissioned by the D.C. DOT found a 97% compliance rate of motorists yielding for pedestrians at the PHB.[8] The study was performed 11 months after the installation of a signal at a crossing of a minor street and a major street. Additionally, the researchers did not observe any adverse effects on pedestrian crossing behaviors during the study. Furthermore, the researchers did not observe any problems with motorists turning from the side street. “Motorists who turned onto [the major street from the side street] took advantage of stopped traffic on the [major street] but generally yielded to pedestrians using the crosswalk.” DCDOT also found 39.4% of pedestrians did not activate the signal which lead to decreased yielding (73.7% of conflicts occurred when pedestrians did not activate the signal), however the researchers noted that poor utilization may have been due to frequent gaps in traffic that allow some pedestrians to cross without the assistance of the signal.

PHB signals also reduce jaywalking by encouraging pedestrians to cross inside the crosswalk. The study in Las Vegas, Nevada found a statistically significant decrease in daily jaywalking events of 24.4%, immediately before and after installation. The Las Vegas NCHRP report also examined the general effect that a red signal, whether it’s on a PHB, half-signal or midblock conventional traffic signal, had on jaywalking. The researchers found that between 90-95% of the pedestrians crossed within 10 feet of the crosswalk.

Roundabouts

PHBs are a useful tool for roundabouts, especially for non-handicapped and sighted pedestrians. When not in use, PHBs maintain the free flowing benefit of roundabouts. A study in Oakland County, Michigan specifically observed blind pedestrians crossing at roundabouts. The study found a decrease in interventions after installation of a PHB. Interventions are instances where the blind pedestrian’s assistant was required to intervene to prevent a potentially dangerous crossing.[9] Interventions decreased “from 7.7% and 9.6% at the three-lane entry and exits, respectively, to 0.0% and 0.8%.” At two-lane, [each direction] roundabouts, the intervention rate decreased from 8.7% and 1.9% for entry and exits, respectively, to 1.7% and 0.0%. Another NCHRP study also observed similar results with intervention rates of 2.4% before installation and 0.0% after installation of a PHB in Golden, Colorado.[10]

The Oakland County study also compared expected collisions with actual collisions before and after installation of a PHB at a roundabout.[9] The researchers found motorist-motorist crashes were reduced by 31% although it was not statistically significant due to a small sample size. Regardless, the researchers conclude “the safety analysis suggests that the treatment installation had no significant adverse effect on [motorist crashes], and may in fact have contributed to making the roundabouts safer.”

OPERATIONS

A PHB signal is put in place to assist pedestrians crossing a roadway at an unsignalized location with a marked crosswalk. If no traffic control device was in place prior to the installation of a PHB signal, traffic operations may be delayed. If the PHB signal is replacing an existing facility, such as a stop sign, it may improve traffic operations if vehicles were being forced to stop without pedestrians present. PHB signals may also reduce pedestrian wait times on streets with heavy traffic volumes by giving pedestrians a designated time to cross the roadway and increasing motorist stop compliance.

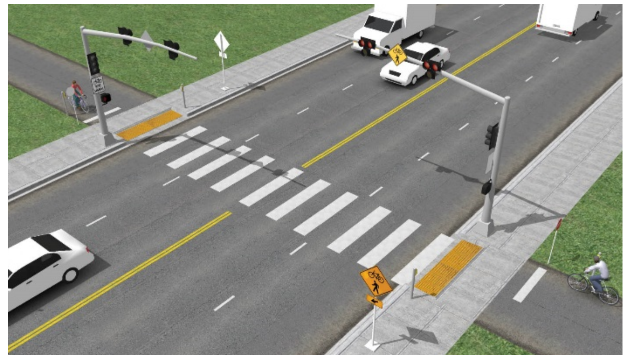


Figure 8 - Example of a PHB and a midblock shared use path crossing. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.

PHBs were designed as a compromise between a conventional traffic signal and an unsignalized crosswalk. Whereas a conventional signal requires traffic to stop for the entire duration of the walk signal, the PHB allows motorists to proceed once the pedestrian is clear. Therefore, PHBs perform better operationally than a conventional traffic signal. A study by the Kansas Department of Transportation found the average excessive delay to motorists was 0.94 seconds at the PHB, which was statistically less than the 10.1 seconds at a signalized midblock crossing.[11] Another study examining, various options to improve operations at unsignalized crosswalks with enhancements also found similar reductions in delay with PHBs. At all levels of traffic flow and number of lanes, the PHB delay was always half of what was experienced at conventional, pedestrian activated signals.[12] Operational benefits may take time to occur. DCDOT observed that some motorists did not understand they may proceed on flashing red after making a complete stop and waiting for pedestrians to clear.[8]

DCDOT also observed that while the PHB was not coordinated with other signals, no operational issues were witnessed at the intersection, further upstream, or downstream. At two lane roundabouts, Oakland County observed a statistically significant increase in queue lengths with the queue length prior to PHB installation being one vehicle across both lanes and the post-installation queue length being 2.1 vehicles across both lanes.[9] The researchers note this may be problematic on the exit lanes but the Oakland design had a 30 foot offset for the stop bar and the circulating lanes; enough storage to accommodate the increased queue. The average time-in-queue also increased, from 0.5 seconds to 2.3 seconds in the exit leg, which still results in a LOS of A according to HCM. The entry leg results for time-in-queue were not significant. At three lane roundabouts, queues were “generally higher which can be attributed to higher traffic volumes.” The average queue increased from 2.4 vehicles to 4.6 vehicles after installation, which is still contained within the 30 feet queue storage for three lanes. Average time-in-queue increased from 0.5 to 2.3, and was statistically significant, and results in an LOS of A/B (times-in-queue on the exit leg were identical for the two lane and three lane roundabouts according to the study). The entry leg results were not significant.

PHBs at **Two** Lane Roundabouts:	
Increase in queue length	1.1 vehicles
Time-in-queue increase	1.8 seconds
LOS after installation of PHB	A
PHBs at **Three** Lane Roundabouts:	
Increase in queue length	2.2 vehicles
Time-in-queue increase	1.8 seconds
LOS after installation of PHB	A/B

Regarding pedestrians, the Oakland study measured the effect on crossing delay before and after the installation of PHBs at two lane and three lane roundabouts. Delay is defined as the time from when a pedestrian arrived at the crosswalk and when the pedestrian began the crossing. "Installing the PHB significantly decreased delay for blind participants at a two lane roundabout from 17.1 to 11.3 seconds per leg. The PHB resulted in an apparent increase in delay for sighted participants from 7.9 to 8.9 seconds, but this increase was not statistically significant [only two sighted pedestrians participated in the before and after study]. Note that these numbers include the steady and flashing yellow phases of the PHB "warm-up". At three lane roundabouts, delay for blind participants decreased from 21.2 seconds to 12.9 seconds per leg. The effects of the PHB on sighted participants at three lane roundabouts was not statistically significant. Operational effects of PHBs at roundabouts may vary depending on the site specific motorist and pedestrian volumes. However, the Oakland County values are provided as a case study.

MAINTENANCE

According to Bushell, "[PHBs] are more expensive to maintain than some devices, [like RRFBs, curb bump outs, or other crosswalk enhancements] but less expensive than full traffic signals."[4] While not as extensive, PHB signals have essentially the same maintenance requirements as conventional traffic signals. They require attention during power outages and occasional bulb replacements. Maintenance crews should use caution when taking PHB signals out of service for maintenance; adequate maintenance of traffic is required and extra attention should be paid to pedestrians crossing the roadway. PHB signals require push activation from crossing pedestrians so regular checks should be done to ensure the activation button is in working condition.

Figure 9 - PHB Signal in Pekin, Illinois.

District One Studies

The following is a summary of findings performed by IDOT District One in 2014, for the purpose of providing research and data for this feasibility study. The study location was in IDOT's District Four in the City of Pekin. Details of each study are included in this report.

Table 1- Summary of IDOT District 1 studies , 2014

Study	Summary of Findings
Pedestrian Survey	There was a total of 13 survey participants. The majority of the participants felt safe crossing the road at the PHB signal and made no suggestions to make the facility better. A few participants did state they didn't activate the PHB signal because it stopped traffic operations for an excessive amount of time.
Motorist Compliance and Pedestrian Behavior	Of the 28 bicyclists/pedestrians that crossed the road, zero jaywalked but only 43% of users activated the PHB signal. Those who activated the signal didn't wait at all to cross the road, while those who did not activate the PHB signal had an average wait time of 1.5 seconds. Thirty-nine motorists were observed approaching the crosswalk while the PHB signal was activated and a pedestrian was waiting to cross; 72% of these motorists complied by stopping before the crosswalk, while the remaining 28% did not stop or practically stopped.

Pedestrian Survey

A survey was conducted in Pekin, Illinois to gain insight on pedestrians' experiences with a PHB signal. There were a total of 13 participants.

Site Conditions

In-person surveys were conducted on Wednesday August 6th, 2014 from 4 to 6 p.m. at the site of the PHB signal at the intersection of Parkway Drive and the Pekin Park District Trail, a shared used path used by pedestrians and bicyclists. The temperature was in the 70s with light rain throughout the duration of the day.

Survey Method

Two surveyors were positioned on both ends of the trail at the intersection. Both surveyors had survey forms to record in-person responses onsite. They also handed out a postcard that included a link to an online survey, however, the online survey received no responses in the 2 weeks it was available.

Survey Questions

The questions asked and their corresponding figure numbers are listed in Table 1.

Table 2 - Survey questions and corresponding figure number

Figure #	Question Asked
9	What is your gender?
10	In what age group do you fall?
11	What best describes why you were on the Pekin Park District Trail?
12	In the past month, how often have you walked down Parkway Drive in Pekin?
13	In the past month, how often have you driven down Parkway Drive in Pekin?
14	Which answer best describes what an Illinois motorist must do when approaching a crosswalk?
15	Are you aware of the HAWK (which stands for High-Intensity Activated Crosswalk) and what it's intended for on Parkway Drive near Stadium Drive in Pekin?
16	In the past, how often have you used the crosswalk on Parkway Drive near Stadium Drive in Pekin?
17	How safe do you feel when using the HAWK signal to cross the crosswalk on Parkway Drive near Stadium Drive in Pekin during the following times? 1 being completely unsafe and uncomfortable, 3 being neither safe nor uncomfortable, and 5 being completely safe and comfortable.
18	How safe do you feel when using the HAWK signal to cross the crosswalk on Parkway Drive near Stadium Drive in Pekin during the following weather conditions? 1 being completely unsafe and uncomfortable, 3 being neither safe nor uncomfortable, and 5 being completely safe and comfortable.
19	When driving on Parkway Drive (if applicable), how visible is the crosswalk from a distance of 50 feet in the following times of the day? (Choose one for each row. Choose N/A if you have no experience with these conditions at the crosswalk)
20	When driving on Parkway Drive (if applicable), how visible is the crosswalk from a distance of 50 feet in the following weather conditions? (Choose one for each row. Choose N/A if you have no experience with these conditions at the crosswalk)
21	Do you have any suggestions or comments regarding the HAWK signal or others like it?

Results

The following charts were created based off the recorded survey data.

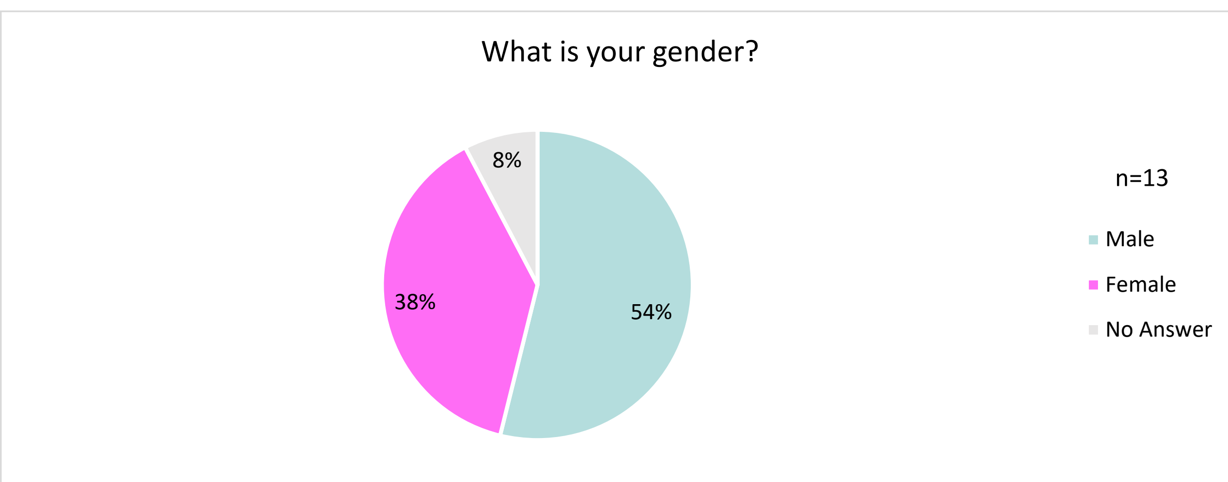


Figure 10- What is your gender?

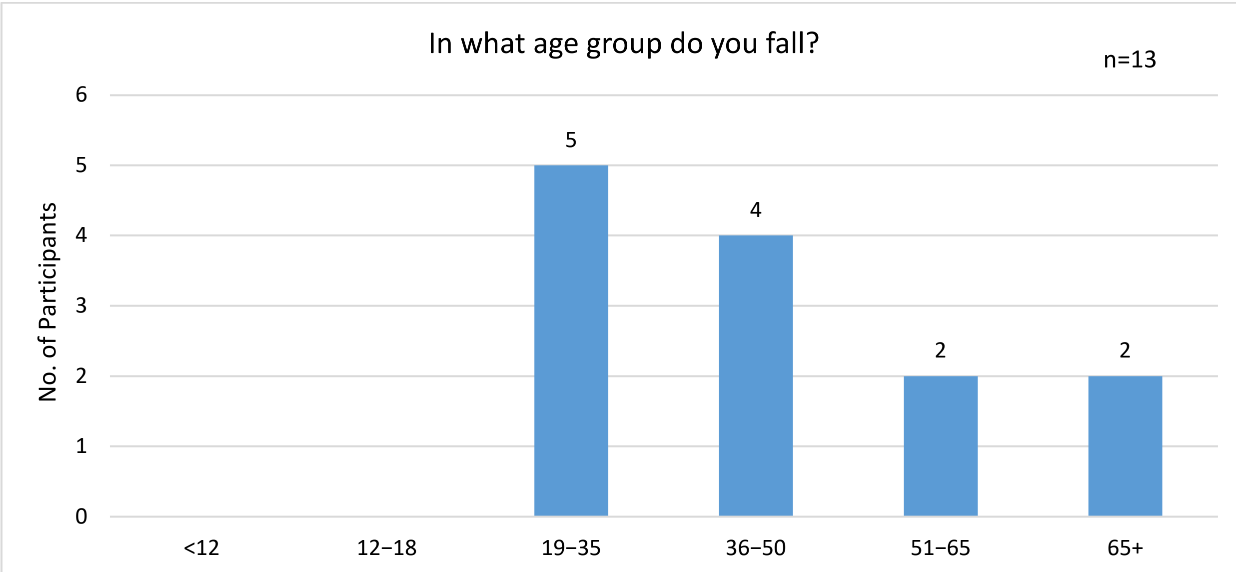


Figure 11 - What age group do you fall in?

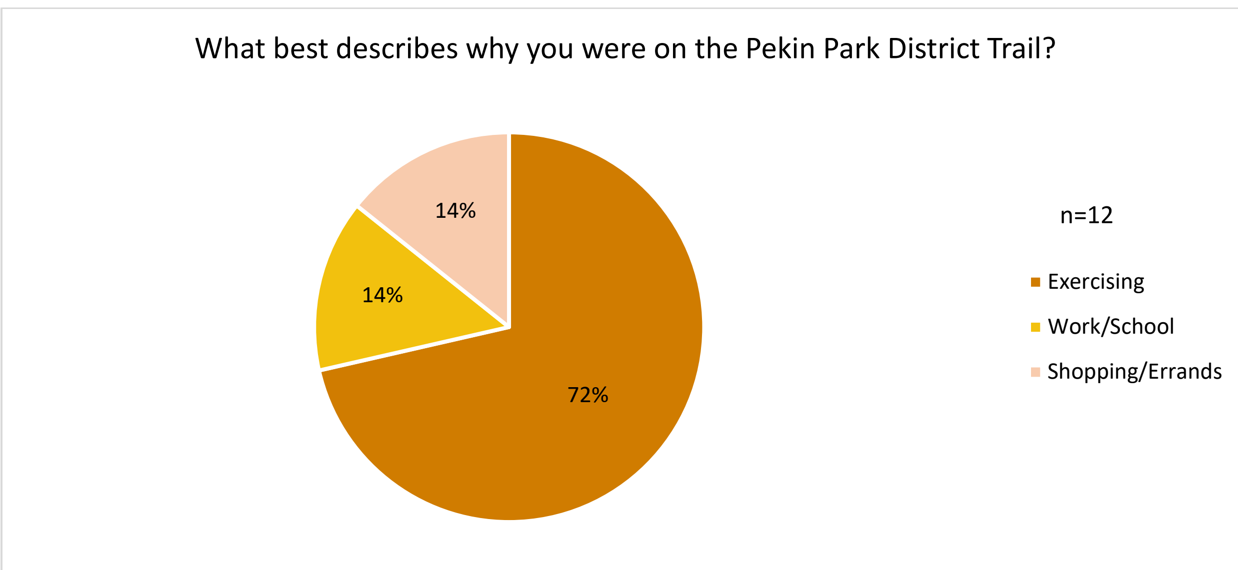


Figure 12 - What best describes why you were on the Pekin Park District Trail?

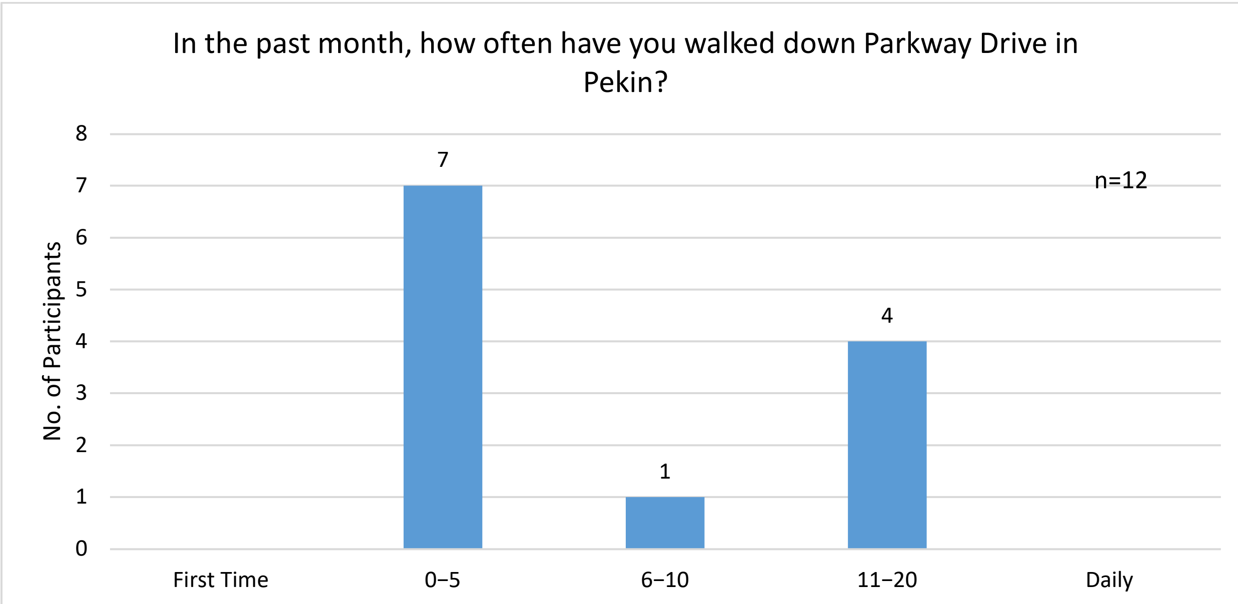


Figure 13 - In the past month, how often have you walked down Parkway Drive in Pekin?

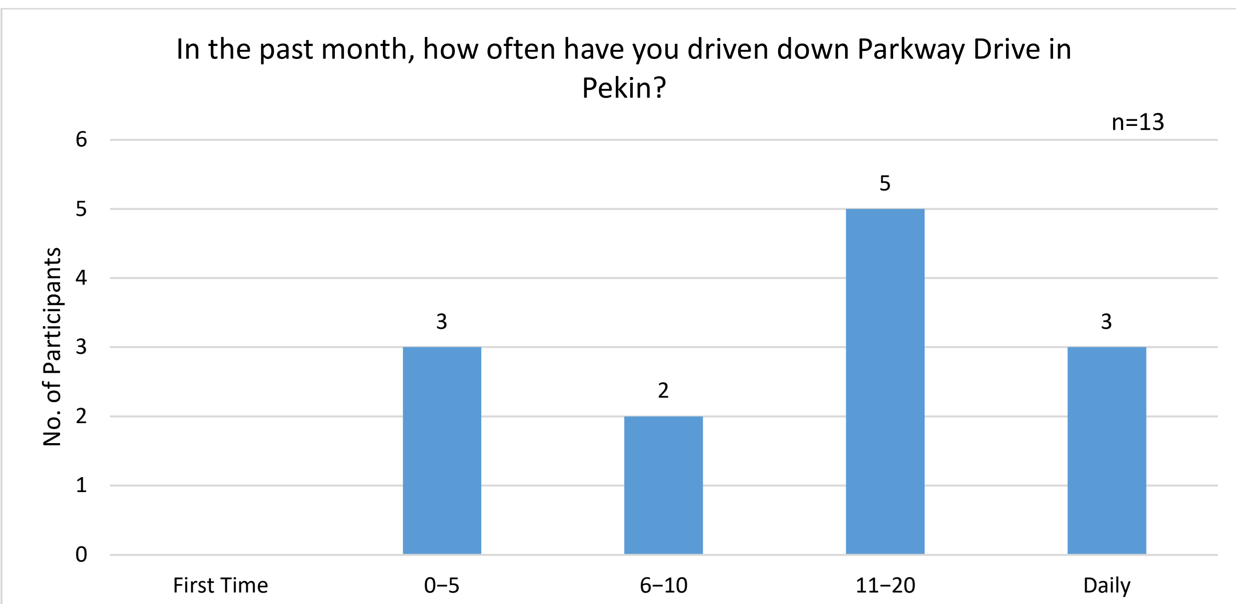


Figure 14 - In the past month, how often have you driven down Parkway Drive in Pekin?

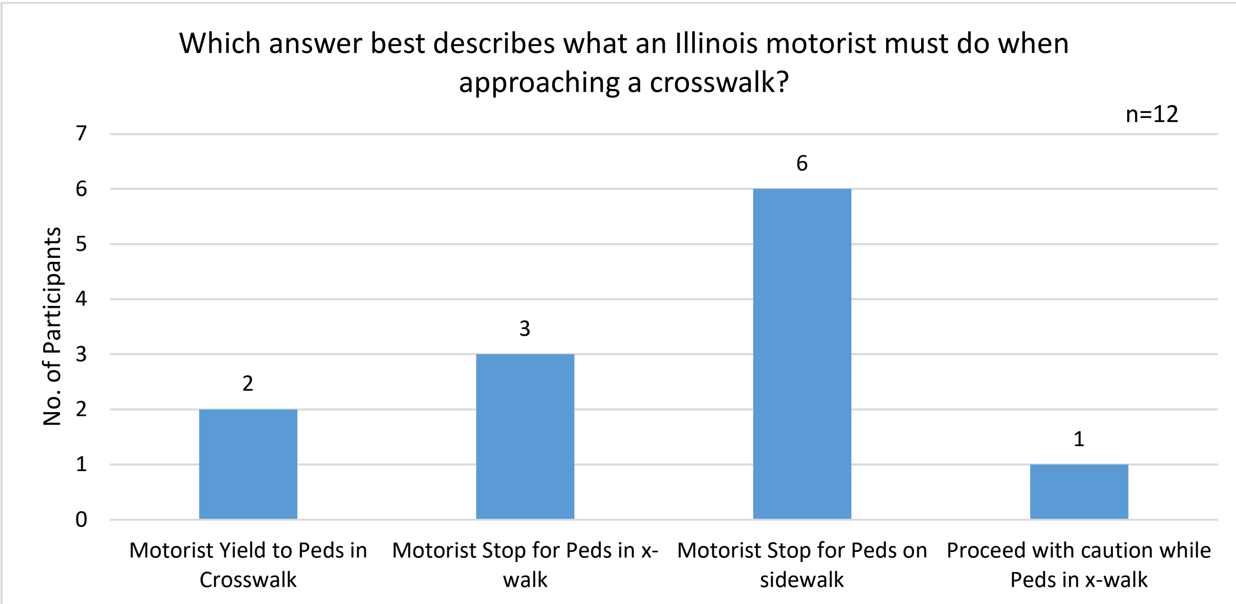


Figure 15 - Which answer best describes what an Illinois motorist must do when approaching a crosswalk?

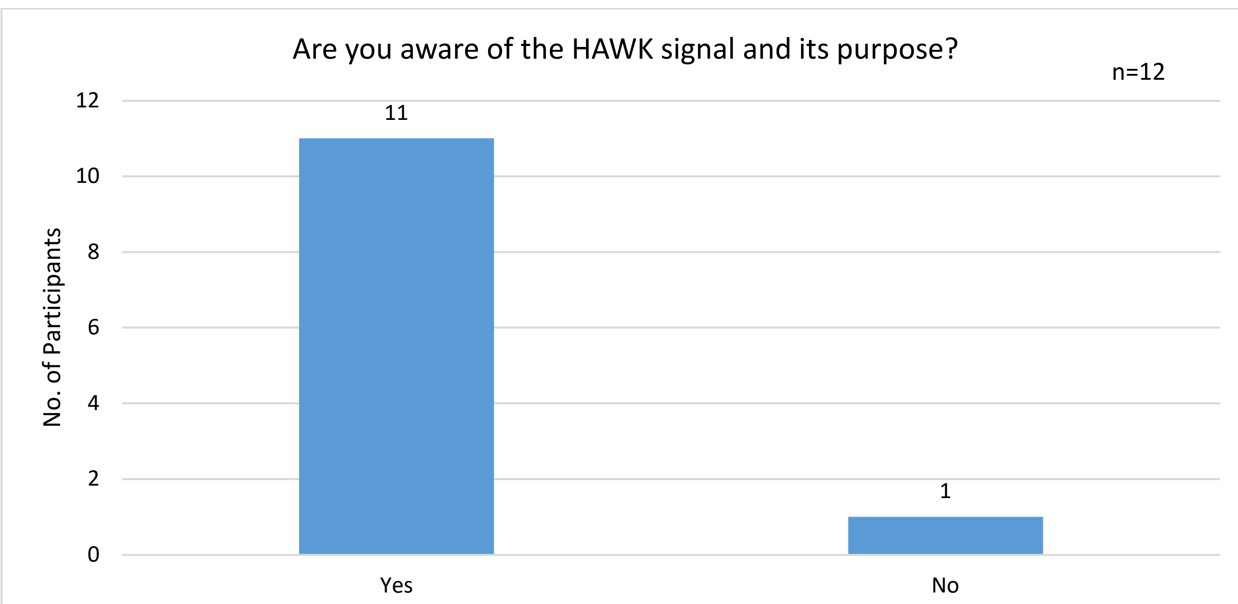


Figure 16 - Are you aware of the HAWK (which stands for High-Intensity Activated Crosswalk) and what it's intended for on Parkway Drive near Stadium Drive in Pekin?

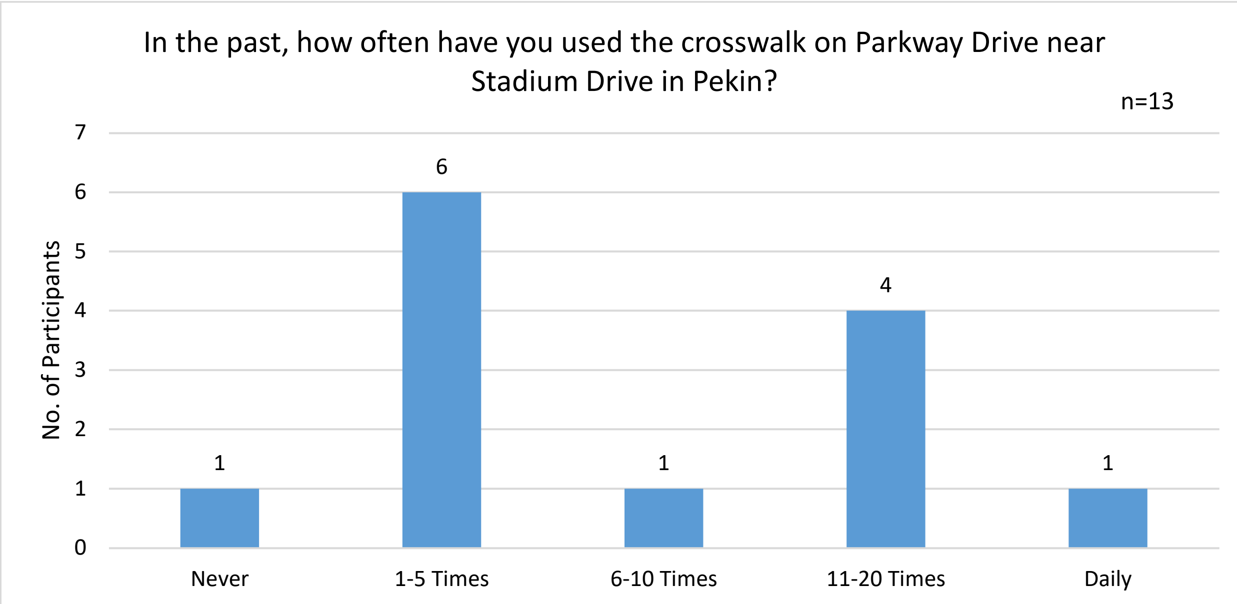


Figure 17 - In the past, how often have you used the crosswalk on Parkway Drive near Stadium Drive in Pekin?

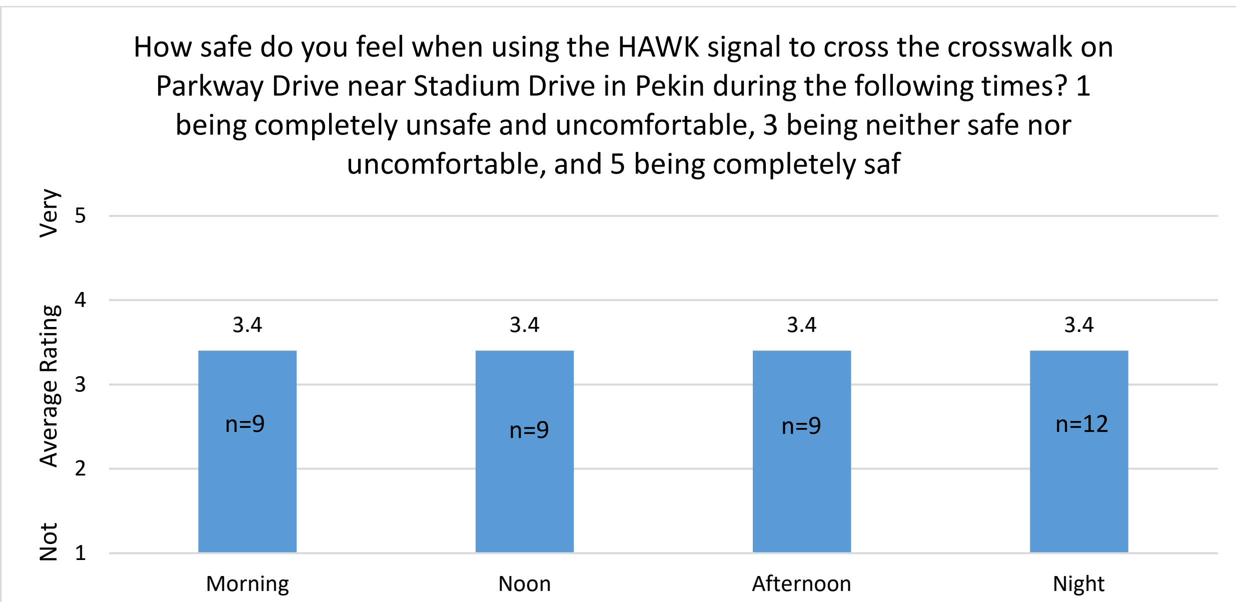


Figure 18 - How safe do you feel when using the HAWK signal to cross the crosswalk on Parkway Drive near Stadium Drive in Pekin during the following times? 1 being completely unsafe and uncomfortable, 3 being neither safe nor uncomfortable, and 5 being completely safe and comfortable.

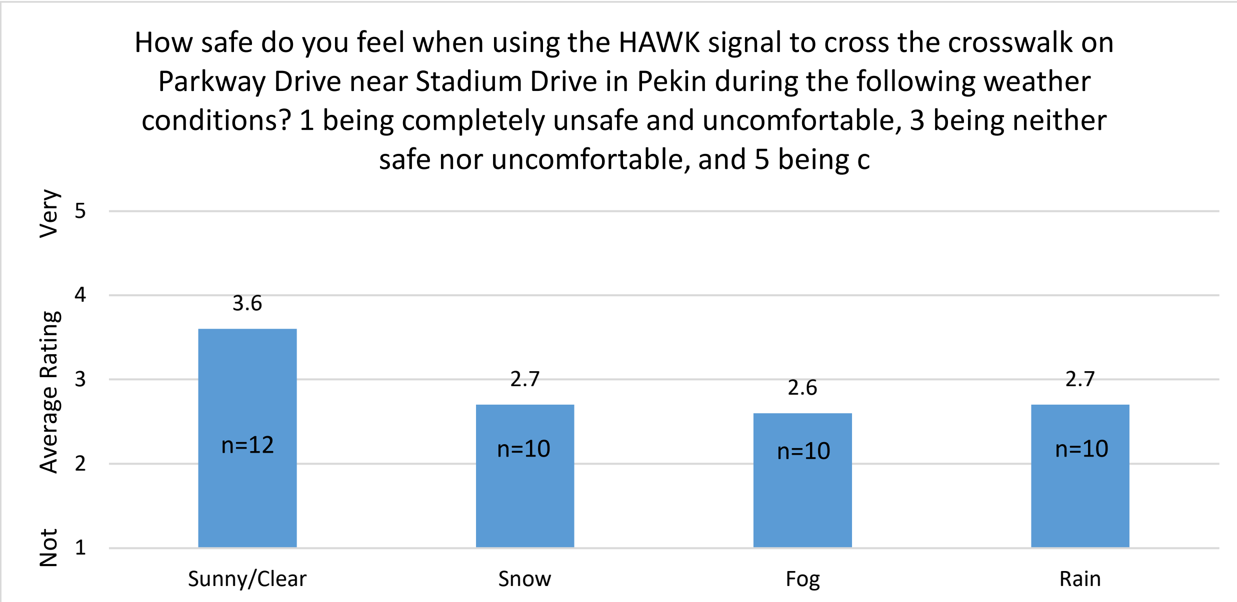


Figure 19 - How safe do you feel when using the HAWK signal to cross the crosswalk on Parkway Drive near Stadium Drive in Pekin during the following weather conditions? 1 being completely unsafe and uncomfortable, 3 being neither safe nor uncomfortable, and 5 being completely safe and comfortable.

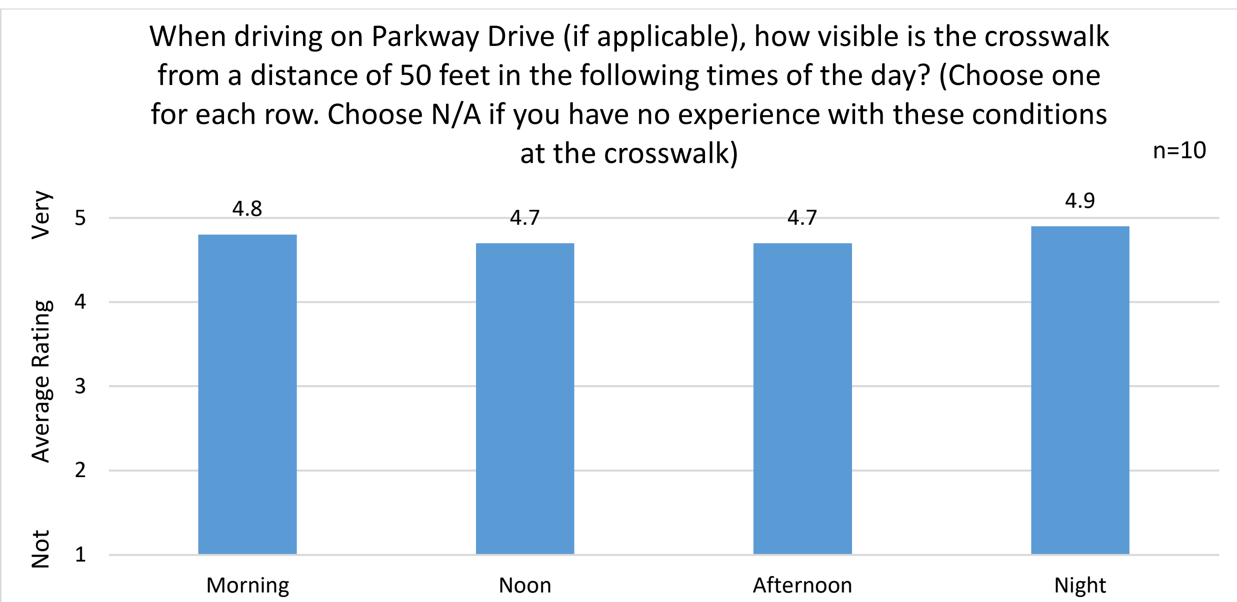


Figure 20 - When driving on Parkway Drive (if applicable), how visible is the crosswalk from a distance of 50 feet in the following times of the day? (Choose one for each row. Choose N/A if you have no experience with these conditions at the crosswalk)

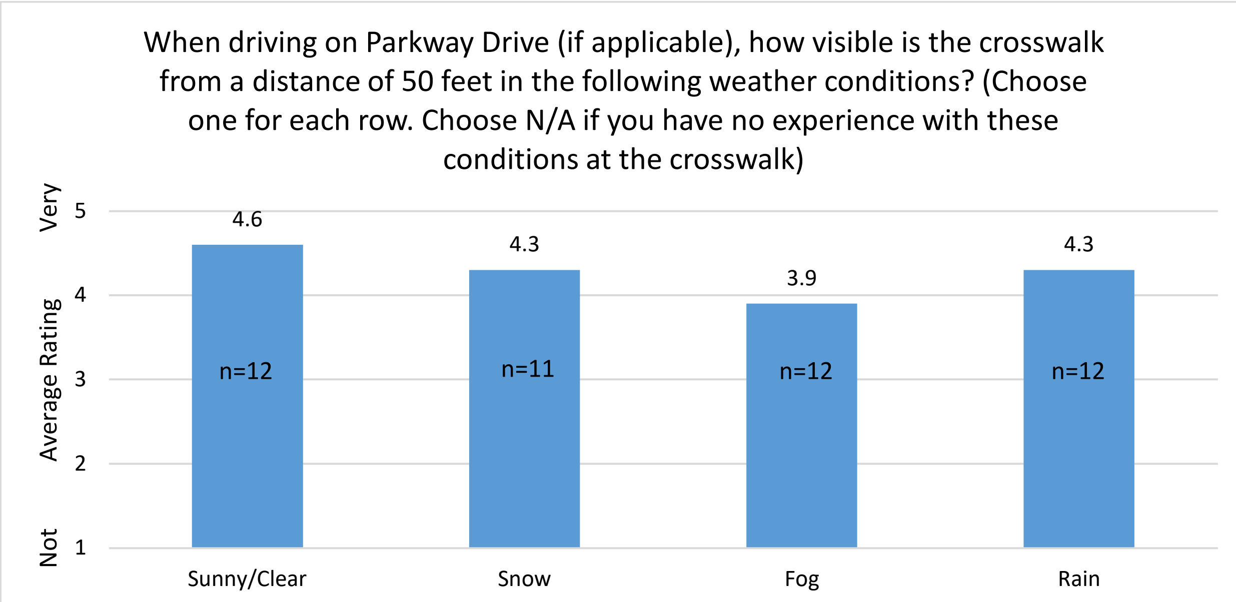


Figure 21 - When driving on Parkway Drive (if applicable), how visible is the crosswalk from a distance of 50 feet in the following weather conditions? (Choose one for each row. Choose N/A if you have no experience with these conditions at the crosswalk)

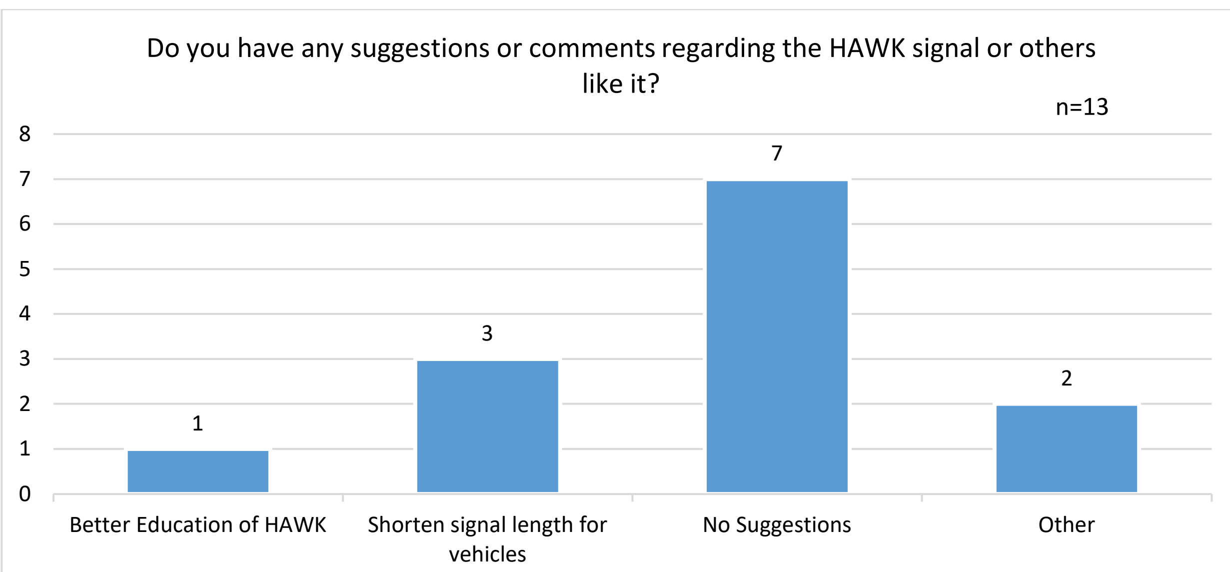


Figure 22 - Do you have any suggestions or comments regarding the HAWK signal or others like it?

Discussion

This survey had a small sample size, 13, and in some instances participants skipped a question or did not answer it fully. This may be due to only 11 of the 13 having experience using the PHB signal. The majority of pedestrians gave a high rating for their perceived safety crossing at the PHB signal, but there was one participant who responded with a “1 - not at all comfortable”, which lowered the overall average rating. Furthermore, HAWK was used in the survey but IDOT has subsequently changed to using the FHWA term: pedestrian hybrid beacon.

There was a wide range of responses when asked how Illinois motorists should react when approaching a crosswalk containing a PHB while a pedestrian is present. The most popular response, from 46% of participants, was that motorists must come to a complete stop for a pedestrian on the sidewalk waiting to cross the road. Participants reported high visibility during all times of the day.

Conclusion

There was a total of 13 survey participants. Not all questions applied directly to each participant, so not all participants responded to the every question asked.

The majority of the participants felt safe crossing the road at the PHB signal and had no suggestions to make the facility better. Of the six participants who had advice on the PHB signal, three of them stated that the signal timing was excessive; they stated the signal delayed vehicles longer than the time needed for a pedestrian to cross the intersection. One participant even admitted to not activating the PHB signal because it left vehicles waiting too long and they felt uncomfortable. The majority of participants felt safe (meaning they rated their comfort level at least a 3 out of 5) when using the facility during various times and weather conditions.

Motorist Compliance and Pedestrian Behavior Study

A pedestrian, bicyclist, and motorist behavior study was completed for the PHB signal installed by the City of Pekin, Illinois in 2010.

Site Conditions

The signal is located at a crosswalk that is signed and marked for pedestrians and bicyclists where the Pekin Park District Trail, a shared use path, crosses Parkway Drive, just south of the entrance to Coal Miners Park and approximately 150’ north of the intersection with Stadium Drive. Parkway Drive is a 4-lane minor arterial roadway with an ADT of 16,900 and a posted speed limit of 35 mph. The study was conducted on August 5, 2014 during the afternoon peak traffic hours of 4 to 6 p.m., and weather conditions were 80 degrees and cloudy.

Study Method

A spot study was conducted to observe the usage of the PHB signal and crosswalk by pedestrians/bicyclists crossing Parkway Drive, and to observe motorist compliance with the signal. Two staff members were positioned along the side of the road at the PHB signalized crosswalk. One evaluator observed motorist compliance with the PHB signal, noting if motorists stopped when pedestrians/bicyclists were present and had activated the PHB signal. The other evaluator observed whether pedestrians/bicyclists used the crosswalk and PHB signal or jaywalked.

Figure 23 - PHB signal along Parkway Drive in Pekin, Illinois

Pedestrian and Bicyclist Behavior

During the two hour study period, 10 pedestrians and 18 bicyclists were observed crossing Parkway Drive at the study location. The pedestrian/bicyclist usage and behavior data collected was compiled and summarized below.

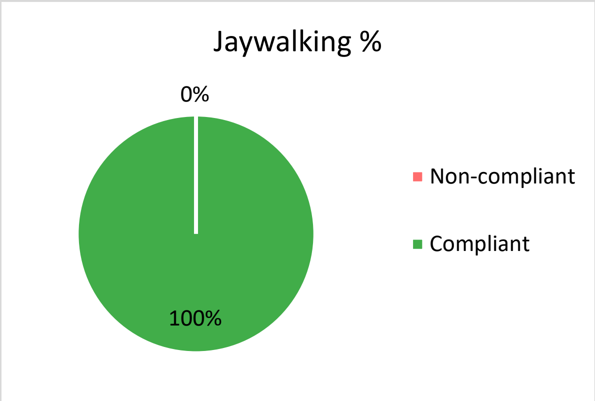


Figure 24 - Jaywalking by pedestrians & bicyclist

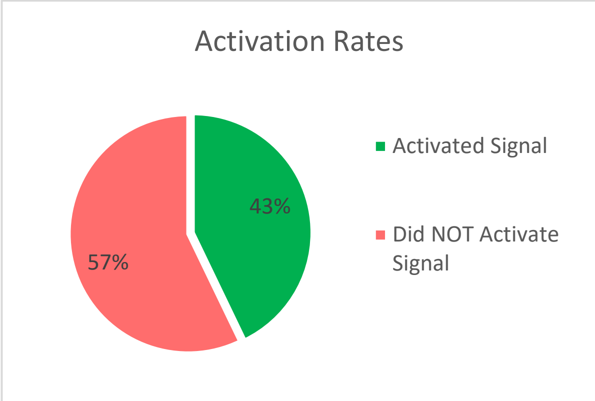


Figure 25 - Signal activation % by pedestrians & bicyclists

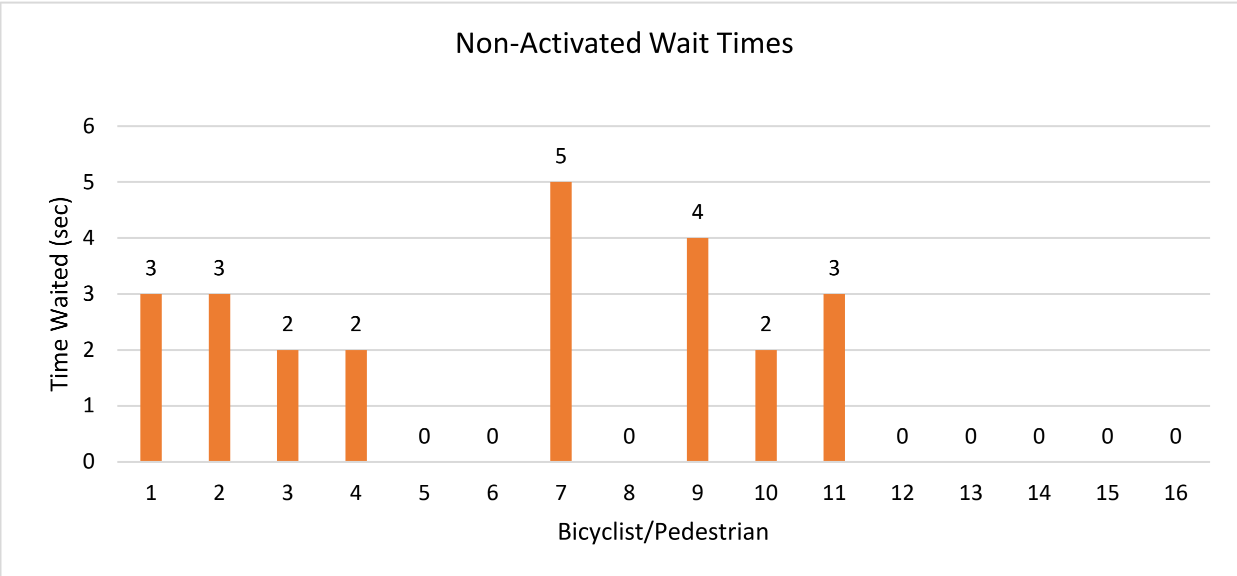


Figure 26 - The amount of time (seconds) that 16 separate bicyclists or pedestrians waited to cross the road when not activating the PHB signal.

As shown in Figure 24, none of the 28 pedestrian/bicyclists jaywalked, meaning all crossed at the crosswalk (regardless of whether or not they activated the PHB signal). More than half, 16 out of the 28 pedestrians/bicyclists did not activate the PHB signal before crossing Parkway Drive. Figure 26 shows the time in seconds that each person who did not activate the PHB signal waited to cross after arriving at the Parkway Drive crosswalk. They had an average wait time of 1.5 seconds. The other 12 pedestrians/bicyclist who activated the signal waited to cross until they received the walk indication from the conventional pedestrian signal. Once they received this signal all 12 were all able to cross immediately.

Motorist Behavior

Figure 27 shows motorist behavior and compliance when the PHB signal was illuminated solid double red. Three of the categories include motorists that stopped or slowed enough for pedestrians to cross: practically stopped (motorists that slowed to between 0 and 3 mph), stopped by traffic, and voluntary full stop. The fourth category, non-stopping, accounted for vehicles that did not stop or allow a pedestrian to cross. During the 2 hour study period, 35 motorists were observed approaching the crosswalk while the signal was displaying two steady circular red signal indications during the pedestrian walk interval and pedestrians/bicyclists were crossing. There were 29 motorists who came to a full stop, three

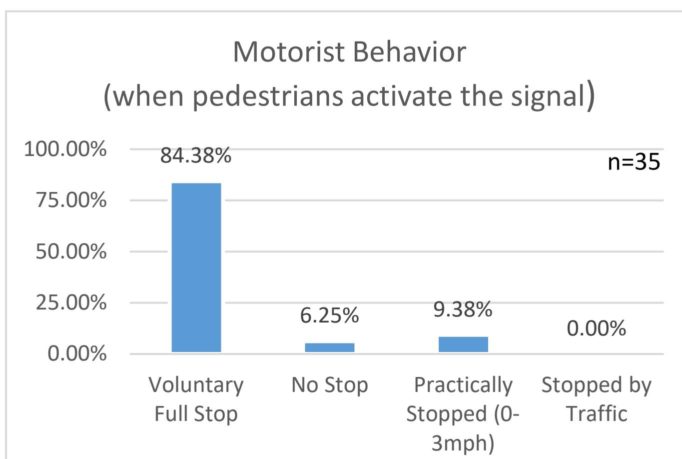


Figure 27 - Motorist behaviors approaching crosswalk while the HAWK signal was illuminated solid double red.

motorists who did not stop, and three motorists who slowed down significantly to the extent that it was considered "practically stopped".

Discussion

The 100% rate for pedestrian/bicyclist crossing at the crosswalk suggests that the installation of the PHB signal is successful in preventing jaywalking, although it is unsure what the rate of jaywalking was prior to the presence of the PHB signal.

The motorist results reflect a significant percentage of stopping motorists, 83%. 9% of motorists did not stop for pedestrians or bicyclists.

Pedestrian wait times when not activating the PHB signal were lower than pedestrians who activated the signal when you factor in the time those who activated the signal had to wait to receive the walk indication. According to the survey results, taken prior to the behavior study, some pedestrians said they refrained from activating the PHB signal because it stops vehicular traffic for too long. The observers also looked for hesitating pedestrians, who almost crossed but were stopped by oncoming traffic not stopping, however there were none.

Conclusion

Of the 28 bicyclists/pedestrians, zero jaywalked but only 43% of users activated the signal. The large non-activation rate could be explained through the survey results in which people described the activation time being too long for motorists. Another possibility could be pedestrians chose not to activate the signal because there was minimal to no traffic with adequate gaps. During the two hour period, those who did not activate the PHB signal had an average wait time of 1.5 seconds.

Thirty-two motorists were observed approaching the crosswalk while the PHB signal was activated and a pedestrian was waiting to cross; 94% of these motorists complied by stopping for users crossing at the crosswalk, while the remaining 6% did not stop.

As of May 16, 2014, there were 187 PHB signals in twenty-four states of the United States, including two in Illinois, five in Indiana, and two in Wisconsin. Many cities or counties have multiple PHB signals, however, only one from each city was listed for reference. There may be other locations with raised crosswalks that are not listed.

Table 3 - PHB Signal Inventory

Country	City	State	# of Signals	Example Intersection/Street	First Installation Year
USA	Juneau	AK	1	Glacier Hwy	2012
USA	Phoenix	AZ	6	Indian School Rd	2009
USA	Scottsdale	AZ	4	Pima Rd & Dixileta Dr	2011
USA	Sun City West	AZ	3	Granite Valley Dr & Mantor Ln	2013
USA	Tempe	AZ	2	Western Canal Trail on Rural Rd	2004
USA	Tucson	AZ	98	W Ajo Way	2000
USA	Yucaipa	CA	1	Oak Glen Rd & 2nd St	2009
USA	Boulder	CO	1	Regent Dr	2011
USA	Centennial	CO	1	S Holly St	2013
USA	Golden	CO	1	S Golden Rd & Johnson Rd	Temporary
USA	Lakewood	CO	1	Union Blvd	2014
USA	Washington	DC	1	Connecticut Ave & Northampton St	2013
USA	Newark	DE	1	Route 72 & S Chapel St	2010
USA	Austell	GA	1	Six Flags Dr	2012
USA	DeKalb County	GA	4	Candler Rd & S DeKalb Mall	2013
USA	Cedar Rapids	IA	2	C Ave NE	2012
USA	Des Moines	IA	1	Grand Ave & Polk Blvd	2013
USA	Ada County	ID	35	Cole Rd & Ustick Rd	2008
USA	**Bolingbrook**	**IL**	**1**	**Lily Cache Ln east of Lindsey Ln**	
USA	**Champaign**	**IL**	**1**	**Bradley Ave & Redwood Dr**	**2009**
USA	**Oak Park**	**IL**	**1**	**Chicago Ave & Harvey Ave**	**2016**
USA	**Pekin**	**IL**	**1**	**Parkway Dr & Stadium Dr**	**2010**
USA	Bloomington	IN	2	19th St & Dunn St	2012
USA	Fort Wayne	IN	2	Covington Rd & Eggeman Rd	2010
USA	South Bend	IN	1	Twyckenham Dr & Vaness St	2013
USA	Rockville	MD	1	Gude Dr	2010
USA	Ann Arbor	MI	1	W Huron St & Chapin St	2010
USA	Oakland County	MI	1	W Maple Rd & Drake Rd	2009
USA	St. Cloud	MN	1	1st St S & 12th Ave	2009
USA	Billings	MT	1	4th Ave N & N 20th St	2013
USA	Westfield	NJ	1	Central Ave & Cambridge Rd	2012
USA	Las Vegas	NV	1	E Sahara Ave &S 15th St	2012

USA	Klamath Falls	OR	1	Klamath Falls-Malin Highway & Portland St	2012
USA	Portland	OR		SE 41st Ave & E Burnside St	2006
USA	Providence	RI	1	Elmwood Ave & Daboll St	2011
USA	Dallas	TX	1	McKinney Ave	2013
USA	Salt Lake City	UT	4	1300 East & Yale Ave	2010
USA	Alexandria	VA	1	Van Dorn St	2008
USA	Grafton	WI	1	13th Ave & W-60 Trunk	2010
USA	Neenah	WI	1	North Commercial St at the Fox River	2010

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Rectangular Rapid Flashing Beacons

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation


PUSH
BUTTON TO
TURN ON
WARNING
LIGHTS

A rectangular rapid flashing beacon, or RRFB, is a pedestrian-activated warning beacon designed to aid pedestrians in crossing streets and is an innovative alternative to traditional flashing beacons. These beacons are installed in conjunction with and to supplement standard pedestrian or school crossing signs located at a marked crosswalk. They can be installed at midblock or uncontrolled intersections and at roundabouts, and can be mounted overhead and on the median to supplement roadside mounts. They have been installed around the country on both two lane and multilane roadways, and in areas with heavy pedestrian and school traffic. When activated, the LED lights will flash rapidly in an irregular, alternating pattern, alerting motorists to pedestrians attempting to cross the street. RRFBs have increased motorist yielding rates at every location studied.

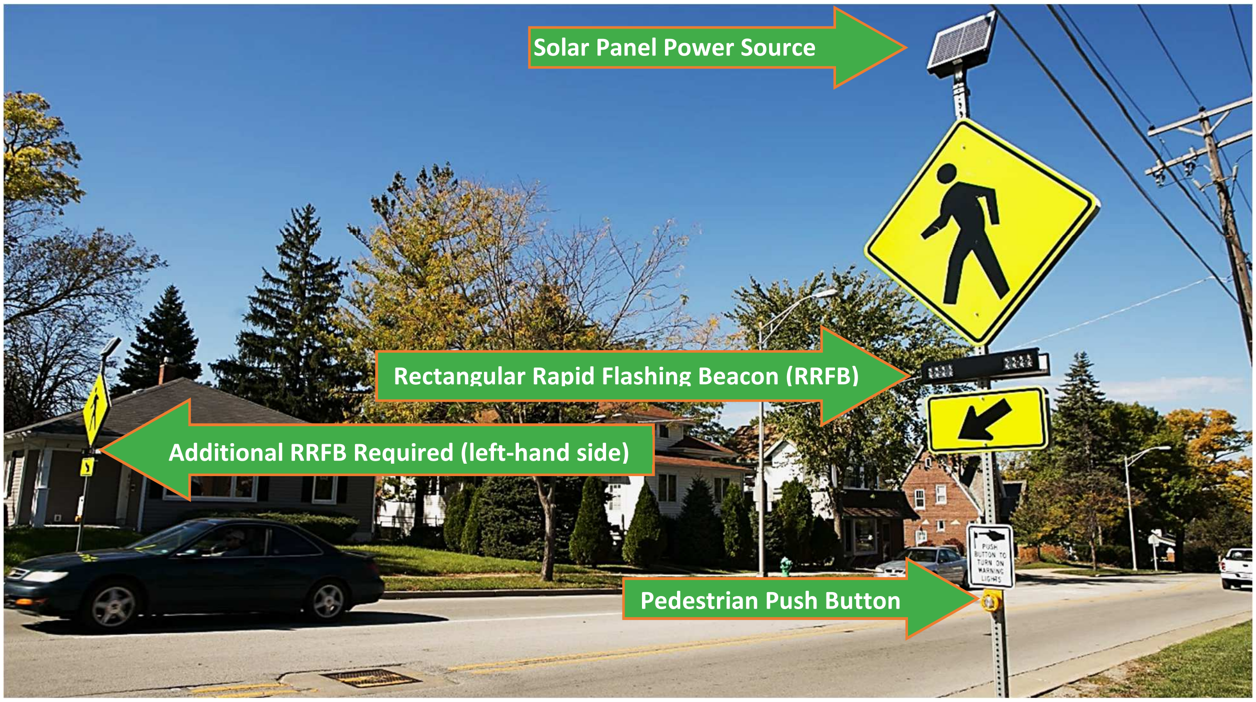


Figure 1 - RRFB on State Street at Logan Street in Lemont, Illinois.

RRFBs have MUTCD interim approval by the FHWA, requiring jurisdictions to submit a written request to the FHWA for approval prior to installation. States may request interim approval for all jurisdictions in that state. Because the MUTCD is concerned about overuse decreasing effectiveness over time, the previous interim approval limited use "to locations with the most critical safety concerns, such as pedestrian and school crosswalks across uncontrolled approaches."[1] As of mid-2018 Illinois has also established a statewide interim approval that will allow for implementation of RRFBs at locations where they are found to be appropriate.

Research by the FHWA and others has shown RRFBs are successful at significantly increasing motorist yielding rates and distances on 2 and 3 lane roadways, and also on multilane roadways with posted speeds up to 40 mph. However, caution should be exercised when utilizing RRFBs on multilane roads, especially those with higher speeds and traffic volumes, given concerns with traffic obscuring an approaching motorist's view of the roadside RRFBs and crossing pedestrians at an existing installation on an IDOT route. To improve visibility along multilane roads, the MUTCD interim approval does allow for additional overhead and median placement of the RRFBs with additional crosswalk warning signage, as well as advance placement where sight distance approaching the crosswalk is inadequate. Also, further crosswalk enhancements can be considered; see the crosswalks enhancements facility report for more information. In particular, median refuge islands should be considered to allow for pedestrians to cross one half of the roadway at a time. More expensive treatment options should be used on high-speed, high-volume roadways such as pedestrian hybrid beacons, traffic signals, or grade separation, where costs may be justified in areas of frequent pedestrian or bicycle crossings such as shared use trails.

Ultimately, RRFBs are "not a substitute for good crosswalk placement and design"[2] and are simply an additional tool available to District engineers in enhancing the effectiveness of crosswalks.

Features

- RRFB mounting consisting of two rectangular yellow indications aligned horizontally
- RRFB mounting placed between the crossing warning sign and the arrow plaque
- Located on both the left and right-hand sides of the roadway
- Can be used to supplement pedestrian, trail, or school crossing signs
- Push button actuation or passive detection (see pedestrian signal heads)
- Flash duration based on MUTCD procedures for pedestrian signals
- Independent solar power source
- Long-lasting LED lights
- Wireless communication with other beacons

Figure 2 - Features of the RRFB. From left to right: pedestrian activated push button, RRFB, and solar panel.

Costs

RRFBs are a low cost crosswalk enhancement relative to the safety benefits achieved. The average cost of an RRFB is $22,250 according to Bushell et al., but can be considerably lower or higher depending on the addition of overhead, median, or advance RRFB mountings, and the type and features of pedestrian activation and detection devices.

$ | $22,250 Average cost (2013)

Design Guidance

FHWA	Interim Approval (IA-21) - Optional Use of RRFBs https://mutcd.fhwa.dot.gov/resources/interim_approval/ia21/index.htm
FHWA	Interpretation Letter 4-376(I) - RRFB Overhead Mounting https://mutcd.fhwa.dot.gov/resources/interpretations/4_376.htm
FHWA	Pedestrian and Bicyclist Information Center http://pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=53
ite	Unsignalized Intersection Improvement Guide – RRFB http://toolkits.ite.org/uiig/
NACTO	Urban Bikeway Design Guide http://nacto.org/publication/urban-bikeway-design-guide/bicycle-signals/active-warning-beacon-for-bike-route-at-unsignalized-intersection/

Figure 3 - List of design guidance manuals and documents

SAFETY

Several studies have been performed on RRFBs to determine their effectiveness at increasing motorist yield rates, which are defined as the percentage of motorists that yield to crossing pedestrians. The FHWA Office of Transportation Operations "has reviewed the available data and considers the RRFB to be highly successful for the applications tested (uncontrolled crosswalks). The RRFB offers significant potential safety and cost benefits because it achieves very high rates of compliance at a very low relative cost in comparison to other more restrictive devices that provide comparable results, such as full midblock signalization."[1] A detailed study was performed by the FHWA in three cities: St Petersburg, Florida; Mundelein, Illinois; and Washington D.C.[3]

Yielding Rates

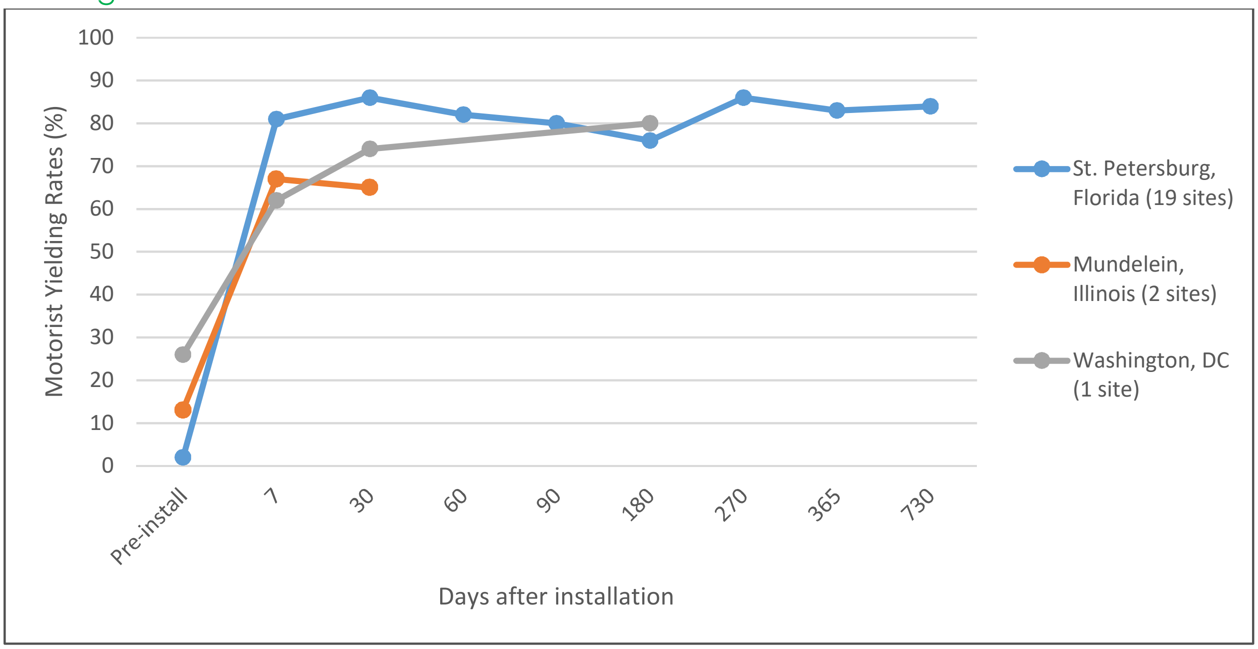


Figure 4 - Effect of RRFBs on motorist yielding rates over time.

The FHWA study examined the locations several times after installation, with up to two years after installation at the Florida sites. All 19 Florida RRFB locations showed little decline, if any, in effectiveness after two years as shown in Figure 4. Washington DC was also measured after half a year and effectiveness was maintained and even increased slightly. The speed limit at most sites was 35mph with a max of 40 mph. Most sites had four lanes of traffic with ADTs between 5,000 and 19,000 vehicles per day (Washington DC, an outlier in terms of traffic, had the highest ADT at 30,000 vehicles per day). Out of the 22 sites, seven had medians and 15 did not.

RRFBs significantly increase yielding that is sustained over time

Angled lights further increase yielding by 17%

Additional RRFBs in the median further increase yielding by 6.6%

Nighttime yielding is comparable to daytime

Figure 5 - FHWA RRFB research highlights

Since the study has been published in 2010, St. Petersburg installed additional RRFBs on higher volume, higher speed locations with ADTs between 24,000 and 31,000 vehicles per day and posted speeds of 35-40 mph. Of the six sites studied at these higher limit locations, two had medians and five did not. Preliminary results from these additional locations indicate all sites have experienced yield rates over 75%.[2] The 85th percentile speeds recorded at these sites were 43-48mph, yet a 75% yielding rate was still achieved with zero crashes reported. Due to the preliminary nature of the observations, more detailed yielding rates are not available yet.

FHWA examined several other features and design options of RRFBs in the study:

- LED's that were angled toward approaching motorists, a feature of some RRFB models, produced an average yielding rate of 89% versus 72% for parallel lights.
- Two-beacon systems (one on either side of the roadway) and four-beacon systems (two additional RRFBs installed in the median refuge island) produced different results. The average yielding rate before all installations was 18.2%. The two-beacon system experienced an 81.2% yielding and the four-beacon system experienced slightly higher yielding at 87.8%.
- Nighttime yielding was 2.1% lower at the two-beacon system site and 9.9% higher at the four-beacon system site compared to daytime yielding rates at the same location, 30 days after installation.

Additional Studies

Other studies also showed improved yielding rates. A study in Calgary, Alberta found motorist yielding increases by an average of 15% after the installation of RRFBs at six sites, reaching nearly 100% compliance in the majority of cases.[4] A study conducted by the University of North Carolina found that motorist yielding went from 2% before the installation of a group of RRFBs in St. Petersburg, FL to 54% after (this study is separate from the FHWA study).[5] The yielding rate includes instances when the RRFBs were activated.

A study by Western Michigan University in South Lyon and Ann Arbor, Michigan compared motorist yield rates when the signal was activated versus non-activated. The first site was a two lane road that saw motorist yielding rates increase from 10% when the signal was not activated to 66% when the signal was activated.[6] The second site, which crossed a two lane road with a median refuge island, saw motorist yielding rates increase from 45% when the signal was not activated to 82% when the signal was activated. The third site, which crossed a four lane road, saw motorist yielding rates increase from 9% when the signal was not activated to 84% when the signal was activated.

Roundabouts

The Western Michigan study also compared motorist yield rates for pedestrians when the signal was activated versus non-activated at roundabout entrances. The first entrance where pedestrians crossed a four lane road with a median refuge island (crossing two lanes in each direction) observed motorist yielding rates increase from 30% when the signal was not activated to 89% when the signal was activated.[6] The second entrance where pedestrians crossed a six lane road with a median refuge island (crossing three lanes in each direction) observed motorist yielding rates increase from 9% when the signal was not activated to 55% when the signal was activated. The study also found comparable results with pedestrian hybrid beacons (PHBs) at the two lane entrance but RRFBs had lower yielding rates than PHBs at the three lane entrance.

Figure 6 – One lane roundabout in Lincolnshire, Illinois

Another Michigan study examined the same roundabout with blind participants and measured "interventions" by study aides. An intervention is any event where the "instructor physically stopped the pedestrian from continuing to cross because of safety concerns." The RRFB reduced entrance interventions from 7.5% to 0.0% and from 23.8% to 16.4% on the exit leg. The researchers still consider the 16.4% rate to be high. The high intervention rates on the exit leg may be attributable to high vehicle speeds, concern for rear-end collisions, and the site specific narrowing of the road further downstream, after exiting the roundabout. In comparison, a pedestrian hybrid beacon resulted in a 1.1% intervention rate at a similar roundabout.

OPERATIONS

RRFBs have minimal effect on motorist operations and improve pedestrian operations by reducing wait times to cross. Similar to PHBs, RRFBs are a compromise between a conventional traffic signal and an unsignalized crosswalk. Whereas a conventional signal may operate on a timed schedule, requiring lengthy stops and lost time by motorists, RRFB's allow motorists to proceed once the pedestrian has crossed their half of the roadway.

Figure 7 - RRFB on Monroe Street in Chicago, between Millennium Park and the Art Institute of Chicago.

Roundabout Motorist Queue

At a two lane roundabout, Oakland County observed only minor increases in motorist queue length. When sighted pedestrians crossed, queue lengths increased from an average of 0.7 to 0.9 vehicles in the entry leg and 0.1 to 0.2 vehicles in the exit leg. When blind pedestrians were crossing, queue lengths increased from 3.1 to 3.4 vehicles and 0.1 to 1.4 vehicles, for entry and exit legs respectively. Similar low increases were observed at the three lane roundabout.

Roundabout Pedestrian Delay

At the two lane roundabout, delay for blind pedestrians was reduced slightly but the result was not statistically significant. Delay for sighted pedestrians was reduced from 15.9 to 5.7 seconds at the entry leg and 13.9 to 7.3 seconds at the exit leg, although the researchers cautioned about the results as only one of the participants returned for the after study. More significantly, the study also examined yield utilization, where a pedestrian notices and utilizes a gap in traffic or yield situation and starts their crossing. Blind pedestrians are especially challenged here because they may miss, fail to detect, or are uncomfortable crossing in front of presumably stopped motorists. Yield utilization for blind pedestrians increased from about 39% for both entry and exit legs to 79.8% and 75.2% for entry and exit, respectively. Yield utilization also increased for sighted pedestrians but at a lower level of significance. However, it further shows that blind pedestrians are still hesitant to cross at roundabouts, even if the RRFB aids in crossing.

At three lane roundabouts, delay for blind and sighted pedestrians was above 45 seconds for the combined entry/exit legs, which is an LOS of F for pedestrians. The researchers note an LOS of F encourages high risk taking by pedestrians. The RRFB significantly decreased the entry leg delay for blind participants, and appeared to decrease delay for sighted participants although statistical significance was not reported. Yield utilization for blind pedestrians increased from about 40-45% for both entry and exit legs to 76.3% and 69.2% for entry and exit, respectively, although this was not statistically significant. Yield utilization also increased for sighted pedestrians but at a lower level of significance.

RRFBs at **Two** Lane Roundabouts:

- Motorist entry queue → Minor increase
- Pedestrian yield utilization → Improved

RRFBs at **Three** Lane Roundabouts:

- Motorist entry queue → Minor increase
- Pedestrian yield utilization → Improved

Travel Time

Figure 8 - Pedestrian push button for activation of RRFB in Lemont, Illinois.

One study, conducted by Western Michigan University, examined vehicular speeds with and without the presence of an RRFB. While speeding can be a safety issue, especially in the context of this study, it is included in the operations analysis sections due to the travel time component. The study did not take place at a pedestrian crossing, but rather a RRFB was mounted to an existing roadside 35 MPH speed limit sign on Lake Street in Mundelein, Illinois. The observers first recorded vehicle speeds without the presence of an RRFB. During the second phase, the RRFB was activated when vehicles 200-300 feet away traveled at speeds above 41 MPH; their speed was then recorded 100 feet after they passed the RRFB. The study found that, with the installation of the RRFB, the percentage of vehicles traveling above 41 MPH decreased by 20% with the presence of the RRFB (VanWagner, Van Houten and Betts 2011).[7]

MAINTENANCE

RRFBs require infrequent maintenance. Critical maintenance issues that can arise include replacement (infrequent) of LED bulbs, repair of solar panel malfunctions, and repair or replacement if the facility is struck by a vehicle. All RRFB installations use LEDs which have long life expectancies. Traffic Safety Corp., a manufacturer of RRFBs, describes the facility as requiring "no maintenance", while Carmanah, another manufacturer, says the facility requires "no scheduled maintenance for up to five years".

Figure 9 - RRFB at crossing in Lemont, Illinois

They are extremely cost effective to operate as well. "The RRFBs achieve significant cost savings as they are solar powered and use a wireless connection for communication between the terminals."[4] Passive detection equipment may require additional maintenance but most RRFB installations use simple push button actuators, commonly used for traditional pedestrian signals.

District One Studies

The following is a summary of findings from a survey performed by IDOT in 2014, for the purpose of providing research and data for this feasibility study.

Table 1 - Summary of IDOT District 1 Studies, 2014

Study	Summary of Findings
Pedestrian Survey	Most responses reflected a desire to add further enhancements to the RRFB facility. Many participants wanted more warning for, and clearer expectations of, motorists at the crosswalks, so that enforcement can be facilitated.

Pedestrian Survey

A survey was conducted to determine the effectiveness of the rectangular rapid flashing beacons. Both online and in-person surveys were offered to participants.

Site Conditions

In-person studies were conducted at the RRFB on State Street at Logan Street in Lemont, IL on the morning of Sunday, October 26th, 2014. State Street is a locally maintained road that has an ADT of 1620, a speed limit of 25 mph, and a classification of major collector. The temperature was 37 degrees and it was mostly sunny.

Figure 10 - Survey location on State Street at Logan Street in Lemont, Illinois.

Survey Method

Two staff members stood on the sidewalk on opposite sides of State Street near the RRFBs. Both members were wearing safety vests for safety purposes and to attract the attention of pedestrians walking on the sidewalk. The staff approached pedestrians asking them if they would like to take a survey and then gave them the option of taking the survey in person or online at their convenience. The online survey was open for one month and IP addresses were analyzed to avoid multiple submissions from the same person.

Survey Questions

Participants were asked questions listed in Table 2.

Table 2 - Survey questions and corresponding figure number.

Figure #	Questions Asked
11	What is your gender?
12	What best describes why you are out here today?
13	In which age group do you fall?
14	In the past month, about how often have you used the Rectangular Rapid Flashing Beacon (RRFB) on State and Logan in Lemont?
15	In the past month, about how often have you driven down State Street in Lemont?
16	Which answer best describes what an Illinois motorist must do when approaching a crosswalk?
17	How safe do you feel when crossing the street using the Rectangular Rapid Flashing Beacon like the one on State Street and Logan in Lemont during the following times? (1 being completely unsafe and uncomfortable, 3 being neither safe nor unsafe, 5 being completely safe and comfortable. Choose N/A if you have no experience with these conditions at the crosswalk).
18	How safe do you feel when crossing the street using the RRFB on State at Logan in Lemont in the following weather conditions? (1 being completely unsafe and uncomfortable, 3 being neither safe nor unsafe, 5 being completely safe and comfortable. Choose N/A if you have no experience with these conditions at the crosswalk).
19	When driving on State Street in Lemont (if applicable) how visible is the crosswalk during the following times? (1 being barely visible, 5 being completely visible from about 50 feet. Choose N/A if you have no experience with these times at the crosswalk).
20	When driving on State Street in Lemont (if applicable) how visible is the crosswalk during these weather conditions? (1 being barely visible, 5 being completely visible from about 50 feet. Choose N/A if you have no experience with these conditions at the crosswalk).
21	Do you have any suggestions or comments regarding crosswalks like the one crossing State Street?

Results

The following charts illustrate the results of the survey. A total of 18 surveys were completed for the facility location (10 in-person and 8 online). Not all respondents answered every question.

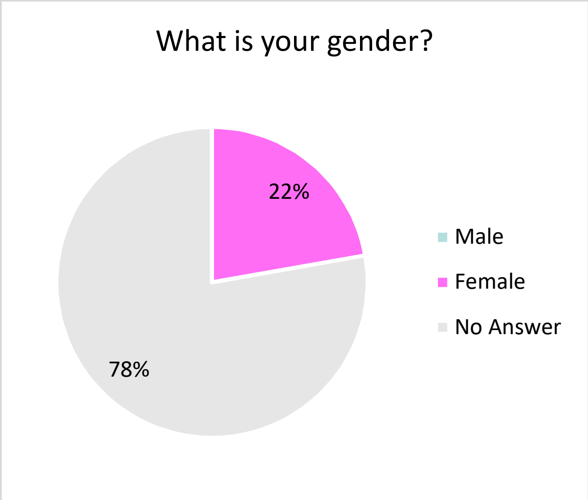


Figure 11 - What is your gender?

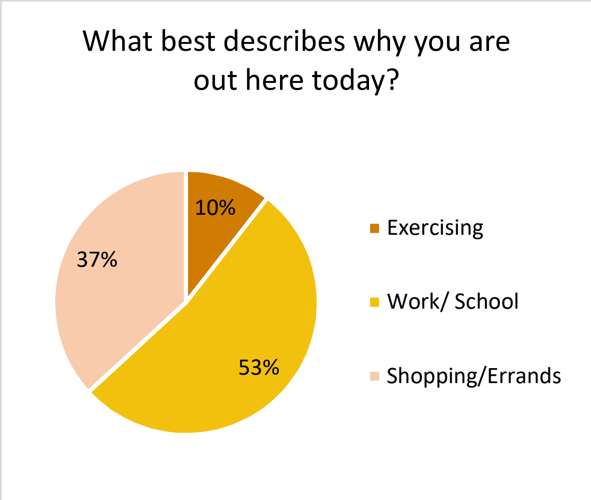


Figure 12 - What best describes why you are out here today?

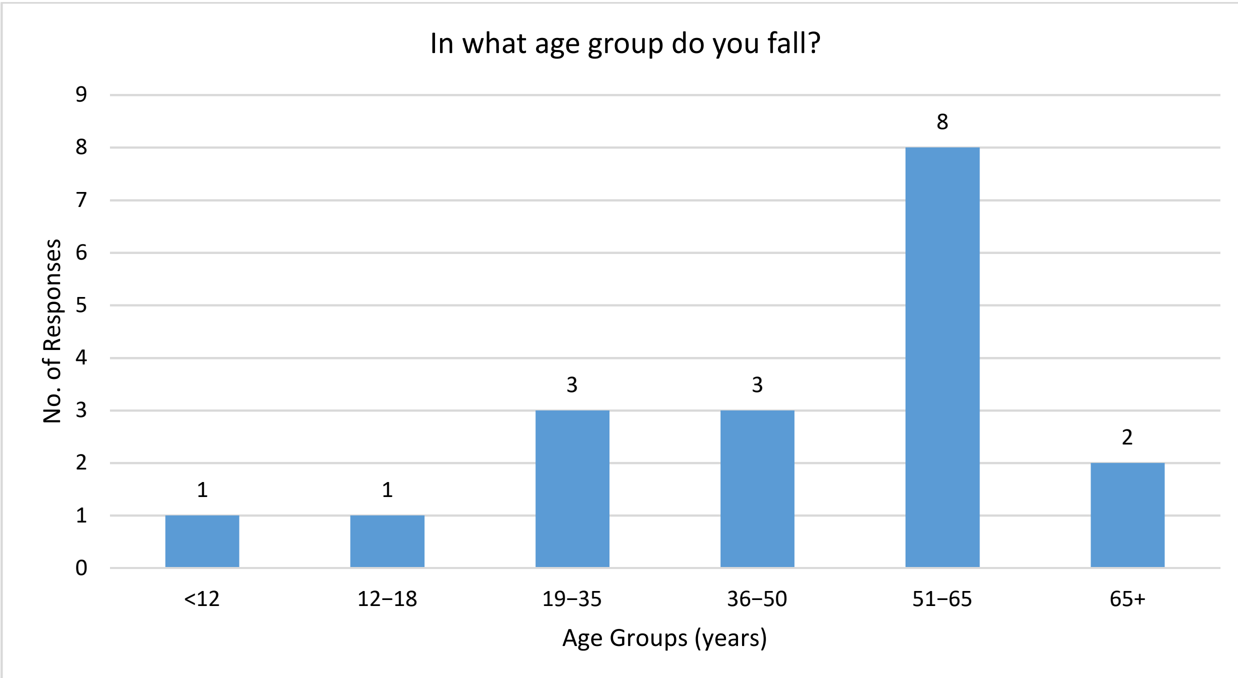


Figure 13 - In what age group do you fall?

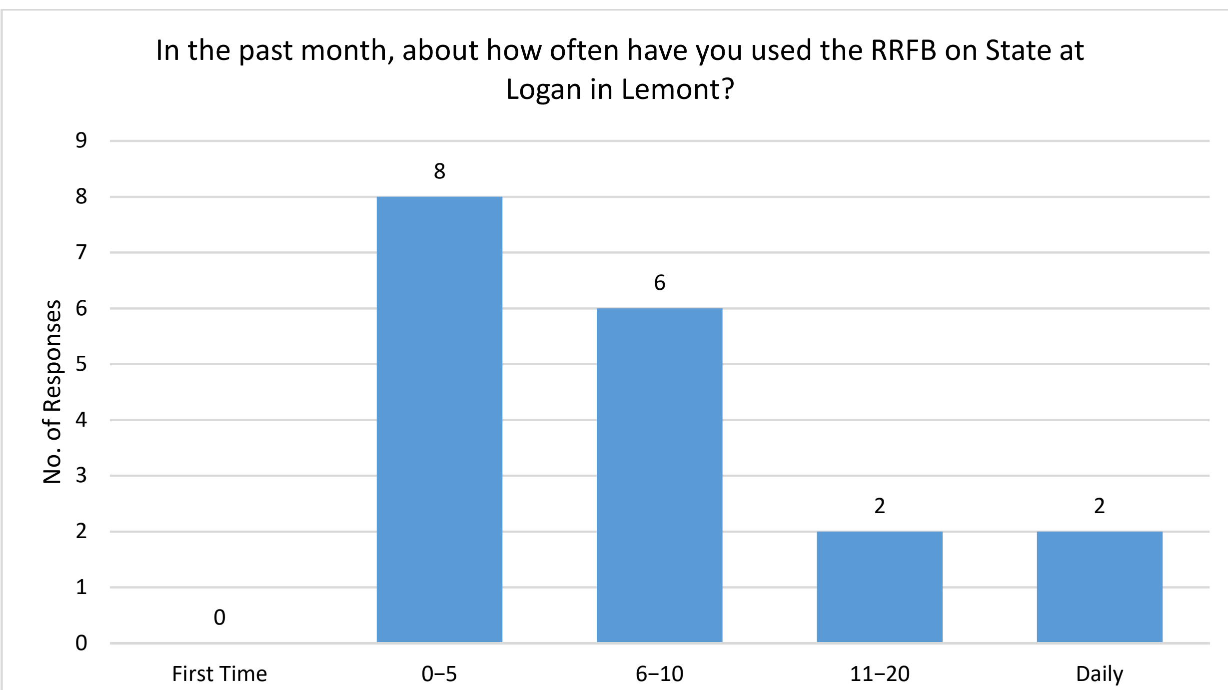


Figure 14 - In the past month, about how often have you crossed at this crosswalk?

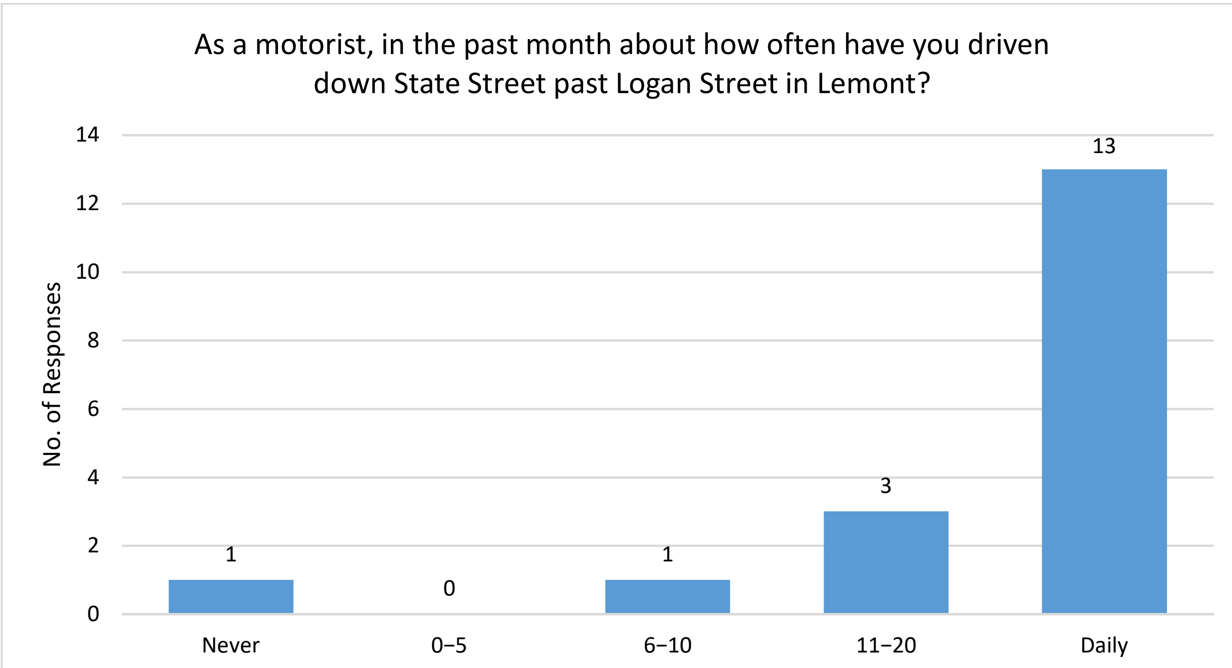


Figure 15 - As a motorist, in the past month, about how often have you driven down this street?

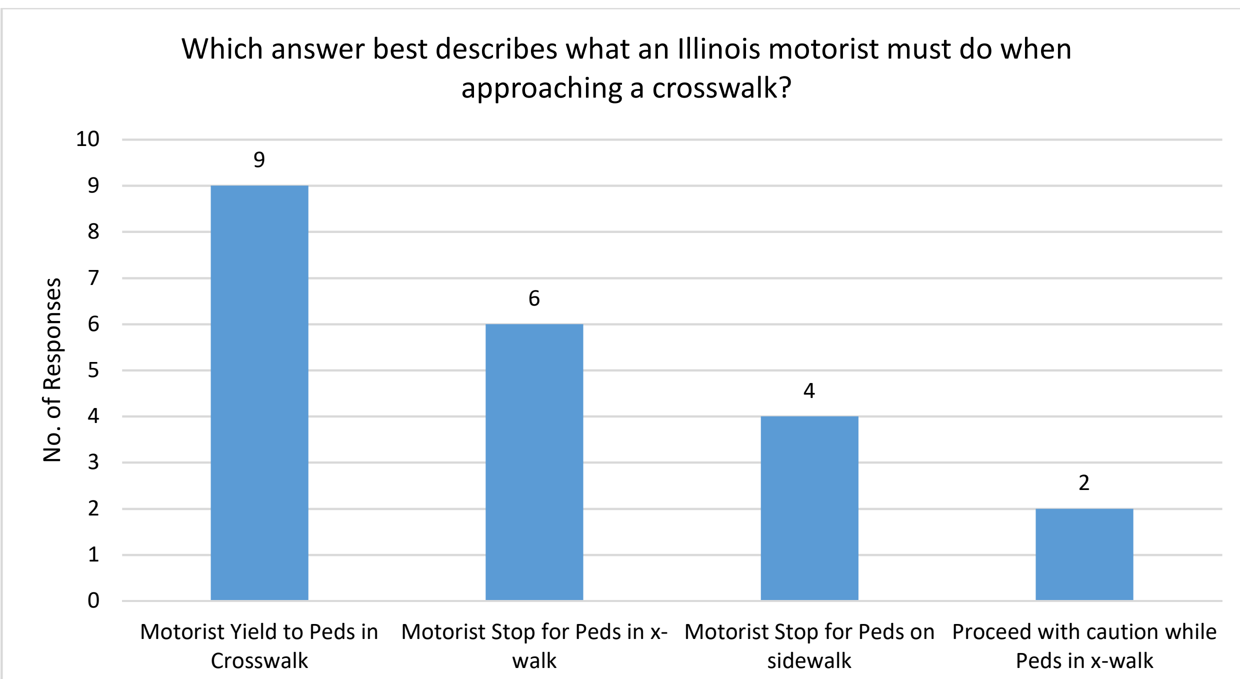


Figure 16 - Which answer best describes what an Illinois motorist must do when approaching a crosswalk?

For Figure 17 and Figure 18, the participant was asked to choose a rating between 1 and 5 on how safe they felt when crossing at these locations in certain conditions, 1 being completely unsafe, 3 being neither safe nor unsafe, and 5 being completely safe. The participant could choose N/A if he/she had no experience crossing under the asked condition.

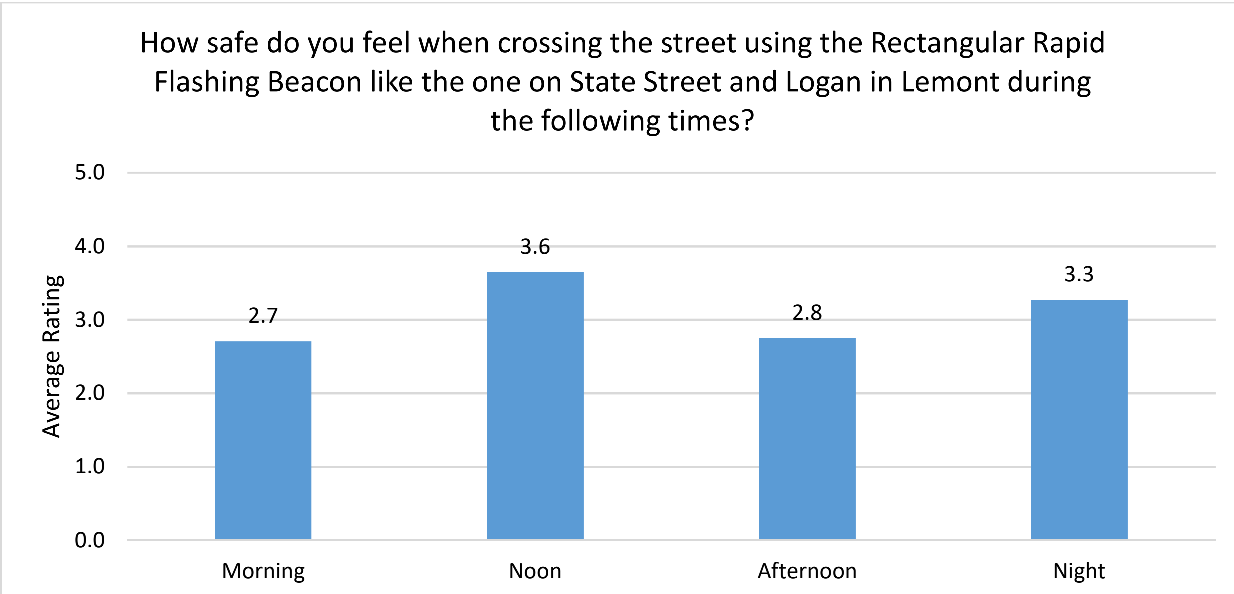


Figure 17 - Level of safety at various times of the day.

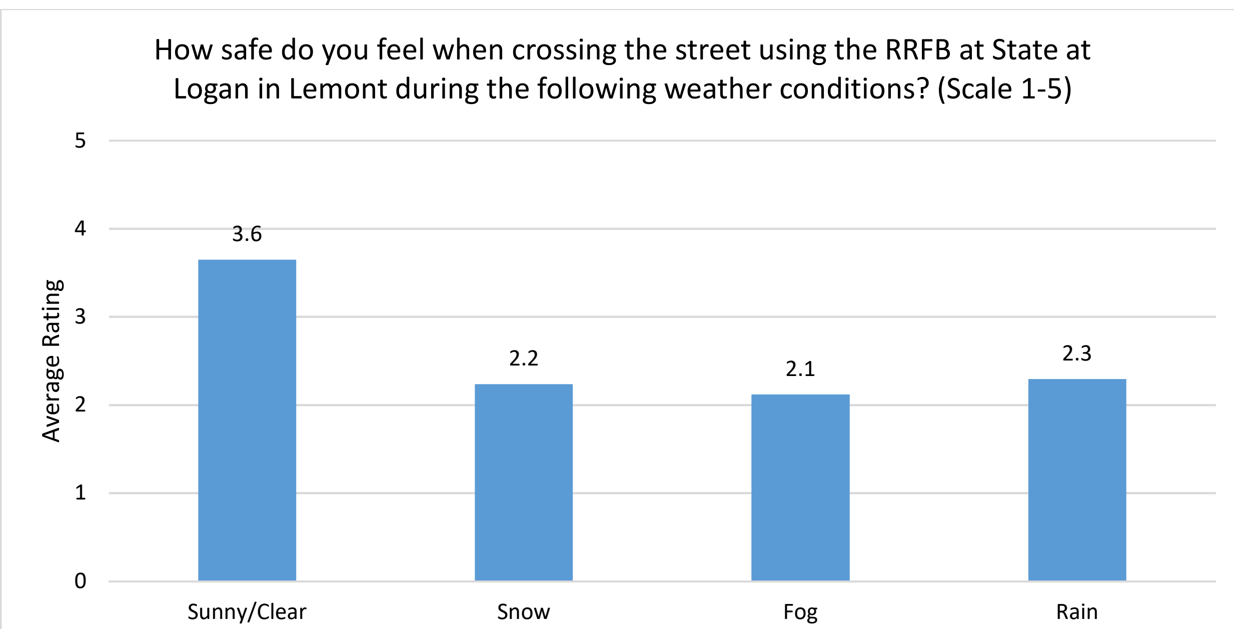


Figure 18 - Level of safety during various weather conditions.

For Figure 19 and Figure 20, the participants were asked to give a rating between 1 and 5 about the visibility of the crosswalk from 50 feet away, 1 being that the crosswalk was not visible, and 5 being that the crosswalk was clearly visible. The participant could choose N/A if they had no experience viewing the crosswalk from 50 feet away under the asked condition.

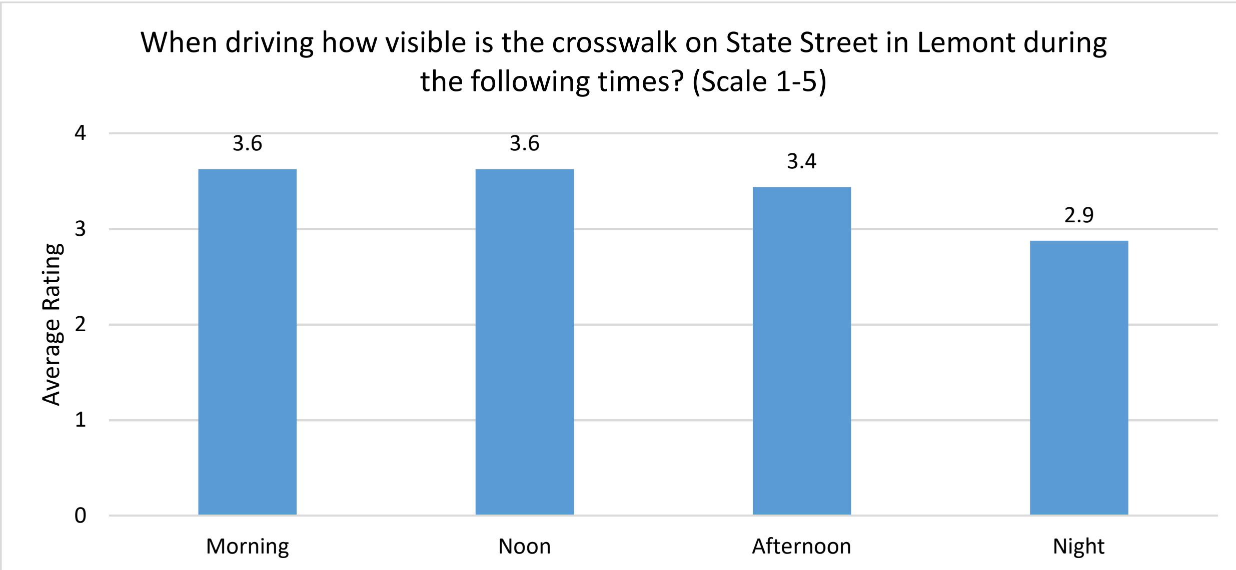


Figure 19 - When driving how visible is the crosswalk during the following times? (Scale 1-5)

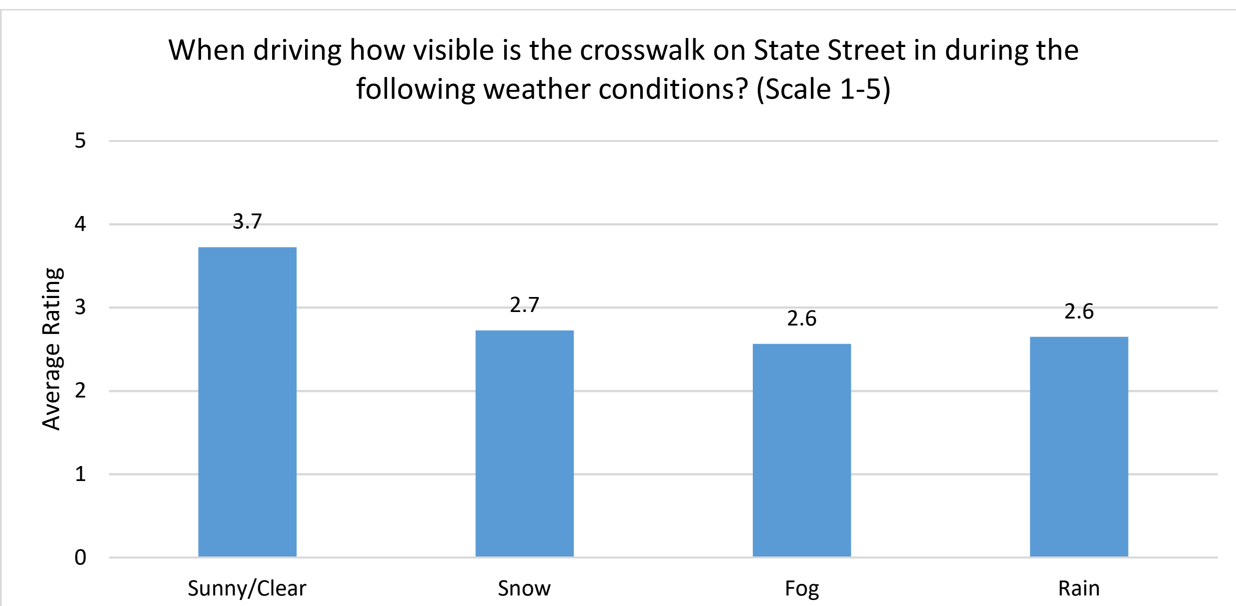


Figure 20 - Level of visibility during various weather conditions at each location.

Figure 21 was an open-ended response question. Participants were given the opportunity to voice their opinions about the different crosswalks. The opinions were broken off into different relevant categories and shown in the charts below.

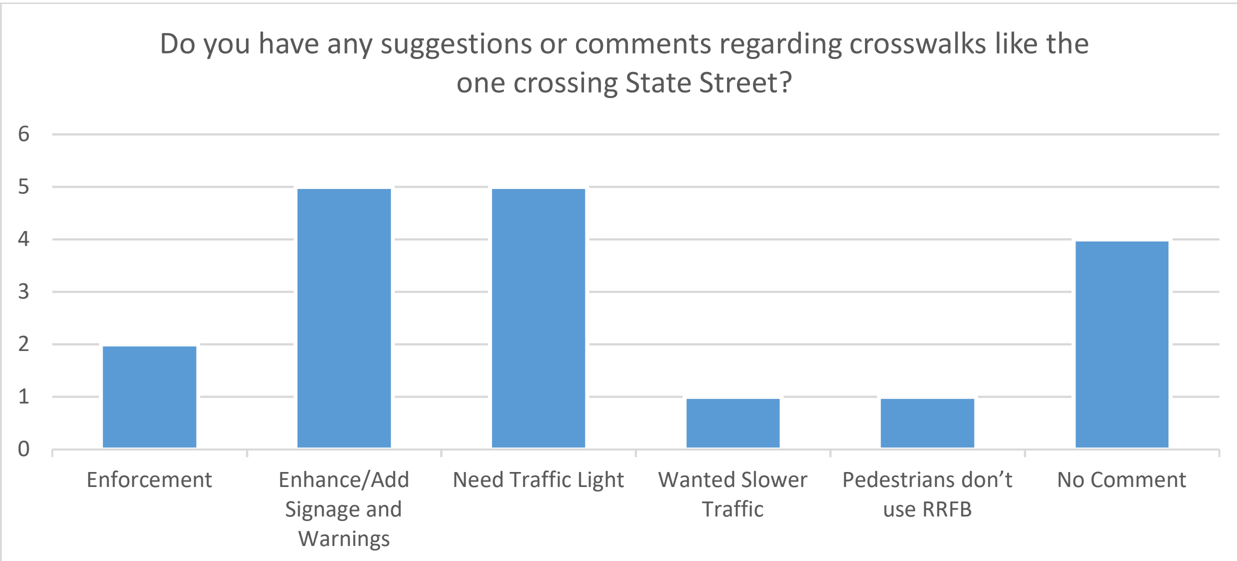


Figure 21 - Do you have any suggestions or comments regarding crosswalks like the one crossing State Street?

Discussion

One issue with the survey was that participants did not answer every question even when the question was applicable to them. For instance, gender was only recorded for 4 of the 18 participants. Responses may also be skewed due to non-familiarity with the facility. As seen in Figure 14 & Figure 15, it appears that most participants did not frequent the area regularly on foot but many drove down this portion of State Street daily.
Figure 17 shows a slight difference in the participants' safety rating of each crosswalk during different times of day.

The last question, Figure 21, gave the participants the opportunity to voice their opinions. Most responses reflected a desire to add further enhancements. Many participants wanted more warning of the crosswalk and clearer expectations of drivers at the crosswalks, so that enforcement can be made easier.

Conclusion

There were a total of 18 people who took the survey. The crosswalk location had an average safety level rating of 3.1 out of 5.0 for various times throughout the day and an average rating of 2.55 for various weather conditions. The most prominent comments included adding additional enhancements or upgrading the facility to a full traffic signal.

RRFB installations are widespread across North America. Table 3 lists some of the cities and counties around the USA with RRFB facilities.

Table 3 – Examples of RRFB locations in the USA, with locations in District One and Illinois shown in bold text.

Country	City/County	State	Intersection	Install Year
USA	Phoenix	AZ	E. Danbury Rd. and N. 40th St.	Unknown
USA	Coachella	CA	Unknown	Unknown
USA	Fort Collins	CO	Unknown	Unknown
USA	Washington D.C.	DC	Unknown	Unknown
USA	St. Petersburg	FL	5th Ave. and 64th St.	Unknown
USA	Atlanta	GA	10th St. west of Peachtree St. NE	2013
USA	Honolulu	HI	Unknown	Unknown
USA	Ada County	ID	State St. and 2nd St.	Unknown
USA	**Batavia**	**IL**	**Unknown**	**Unknown**
USA	**Buffalo Grove**	**IL**	**Unknown**	**Unknown**
USA	**Burr Ridge**	**IL**	**County Line Rd. and 60th St./Sedgley Rd.**	**Unknown**
USA	**Chicago**	**IL**	**5859 S. Stony Island Ave.**	**Unknown**
USA	**Chicago**	**IL**	**Monroe Dr. between Michigan Ave. and Columbus Dr.**	**Unknown**
USA	**Chicago**	**IL**	**Clybourn Ave. and Ogden Ave.**	**Unknown**
USA	**Crystal Lake**	**IL**	**S. Main St. and Three Oaks Recreation Drive**	**2015**
USA	**Danville**	**IL**	**Unknown**	**Unknown**
USA	**Des Plaines**	**IL**	**Algonquin Rd. and 5th Ave.**	**2013**
USA	**DuPage County**	**IL**	**Unknown**	**Unknown**
USA	**Kane County**	**IL**	**Bliss Rd. and Virgil L. Gilman Trail** **Kirk Rd. and Illinois Prairie Path**	**FHWA Approved – Pending Installation**
USA	**Lake County**	**IL**	**Unknown**	**Unknown**
USA	**Lincolnwood**	**IL**	**Unknown**	**Unknown**
USA	**McHenry County**	**IL**	**Unknown**	**Unknown**
USA	**Mount Prospect**	**IL**	**Busse Rd. and Lonnquist Blvd.**	**2014**
USA	**Mundelein**	**IL**	**Hawley St. and Atwater Dr.**	**2008-2009**
USA	**Mundelein**	**IL**	**Midlothian Rd. and Kilarny Pass Rd.**	**2007-2012**
USA	**Olympia Fields**	**IL**	**Unknown**	**Unknown**
USA	**Oswego**	**IL**	**Washington St. and Main St.**	**2009-2012**
USA	**Springfield**	**IL**	**Miller St. just west of 1st St.**	**Unknown**
USA	**Urbana**	**IL**	**Springfield Ave. and Grainger Library**	**Unknown**
USA	**Westmont**	**IL**	**Cass Ave. and Quincy St.**	**2014**
USA	Indianapolis	IN	Unknown	Unknown
USA	Olathe	KS	E. Orleans Dr. and Heritage Elementary School	2010

USA	Lexington	KY	Unknown	Unknown
USA	Rockville	MD	Unknown	Unknown
USA	Detroit	MI	Davison St. and Holmur Ave.	Unknown
USA	Alberta Lea	MN	Unknown	Unknown
USA	Concord	NH	Unknown	Unknown
USA	Rio Rancho	NM	King Blvd. NE south of Zia St.	2013
USA	Las Vegas	NV	Unknown	Unknown
USA	Brookhaven	NY	Unknown	Unknown
USA	Columbus	OH	E Weber Rd. in front of Indianola School	2013
USA	Hillsboro	OR	SE 44th Ave. and SE Tualatin Valley Hwy.	2013
USA	Rapid City	SD	Unknown	Unknown
USA	Abilene	TX	N 10th St. and Jefferson Ave.	2013
USA	Orem	UT	W. 1000 S. and S. 800 W.	Unknown
USA	Norfolk	VA	Powhatan Ave. and the Maglev Track	2014
USA	Burlington	VT	Unknown	Unknown
USA	Mill Creek	WA	Mill Creek Blvd. and 161st St. SE	2012
USA	Milwaukee	WI	Kilbourne Ave. and Market St.	Unknown

[1] Federal Highway Administration (FHWA). *Interim Approval 21 - Rectangular Rapid Flashing Beacons at Corsswalks.* Manual on Uniform Traffic Control Devices. 2018. https://mutcd.fhwa.dot.gov/resources/interim_approval/ia21/index.htm

[2] Cynecki, Mike. *Countermeasure Strategies for Pedestrian Safety: Rectangular Rapid Flashing Beacons.* Pedestrian and Bicycle Information Center. November 2015. http://www.pedbikeinfo.org/pdf/Webinar_PSAP_110515.pdf

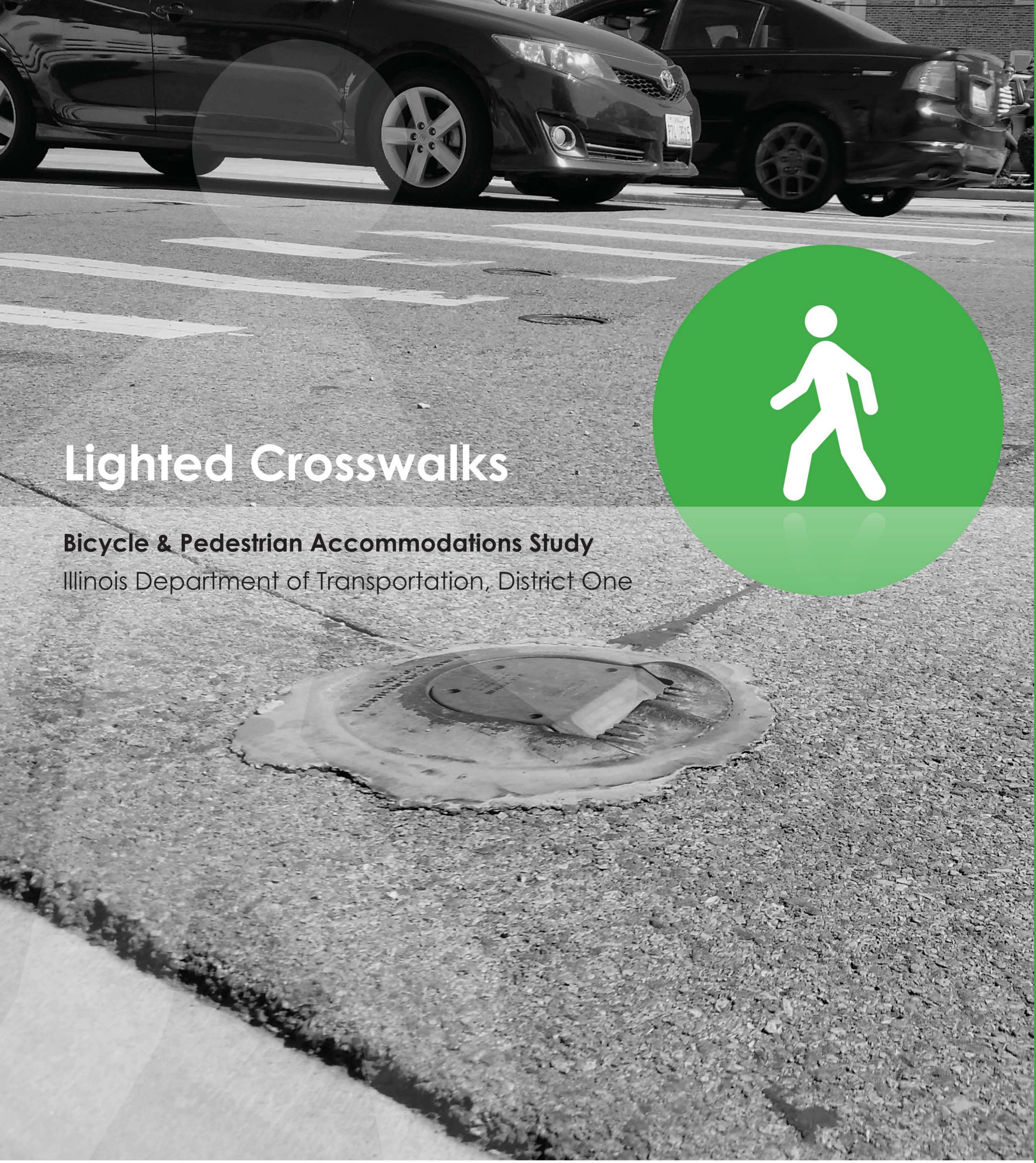
[3] Federal Highway Administration (FHWA). *Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks.* FHWA-HRT.10-043-. Washington D.C. 2010. http://www.fhwa.dot.gov/publications/research/safety/pedbike/10043/index.cfm

[4] Domarad, Joanna, Pat Grisak and John Bolger. 2013. *Improving Crosswalk Safety: Rectangular Rapid Flashing Beacon (RRFB) Trial in Calgary.* Calgary, AB: City of Calgary Transportation Department. http://trid.trb.org/view.aspx?id=1263306

[5] Hunter, William W., Raghavan Srinivasan and Carol A. Martell. 2009. *Evaluation of the Rectangular Rapid Flash Beacon at a Pinellas Trail Crossing in St. Petersburg, Florida.* FDOT Contract BA784. Tallahassee, FL: Florida Department of Transportation. http://nacto.org/case-study/rectangular-rapid-flash-beacon-rfb-at-the-pinellas-trail-crossing-in-st-petersburg-florida/

[6] Van Houten, Ron, John LaPlante, Tim Gustafson. *Evaluating Pedestrian Safety Improvements: Final Report*. Western Michigan University & T.Y. Lin International. Kalamazoo, MI. December 2012 http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC-1585_408249_7.pdf.

[7] VanWagner, Michelle, Ron Van Houten and Brian Betts. "The Effects of a Rectangular Rapid-Flashing Beacon on Vehicle Speed." *Journal of Applied Behavior Analysis* 44, no. 3 (Fall): 629-633. 2011. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3177346/



Lighted Crosswalks

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

Lighted crosswalks are signed and marked crosswalks that include flashing yellow lights embedded into the pavement along both sides of the crosswalk. The MUTCD refers to the embedded lights as in-roadway warning lights (IRWLs), and allows their use only at uncontrolled crosswalks.[1] IRWLs alert motorists to crossing pedestrians and to slow down and/or prepare to stop. They are especially effective at night and during fog, rain, or snow, but are difficult to see during the day and thus should supplement, not replace, traditional pavement markings. They can be manually activated by a pedestrian pushing a button before crossing the street, or passively activated by detecting pedestrians as they approach the crosswalk. Currently, IRWLs are not installed based on any standardized warrants but rather on engineering judgment, although it is noted that IDOT provides guidance on installation in the Illinois Supplement to the MUTCD. Many installations around the country were installed based on crash history and experience.

Figure 1– Lighted crosswalk with pedestrian warning beacon on Roosevelt Road (IDOT) at Lombard Avenue in Oak Park, Illinois. View is from south side of Roosevelt Road looking easterly.

Features

IRWLs feature flashing LED yellow lights in a durable plastic or metal casing level with or slightly above the road surface. The lights are solar powered or wired to a power source. The duration of the flashing lights is set to give pedestrians ample time cross the road. According to Section 4N.01 of the Manual on Uniform Traffic Control Devices (MUTCD) "in-roadway lights shall not exceed a height of ¾ inch above the roadway surface" and "shall be flashed and shall not be steadily illuminated." Typically, unidirectional lights are used on both sides of the crosswalk visible only to approaching motorists, however there is a bidirectional option that allows the lights to be visible to crossing pedestrians.

Figure 2 - Unidirectional in-roadway warning lights on Roosevelt Road (IDOT) at Lombard Avenue in Oak Park, Illinois

Warrants

A study completed by Katz, Okitsu & Associate for the city of Fountain Valley, CA, and another study by Whitlock & Weinberger Transportation, Inc. for the State of California Office of Traffic Safety and the FHWA UNC Highway Safety Research Center, proposed several warrants for installation of IRWLs.[2,3] These can be used in conjunction with engineering judgment as a baseline for determining warrants in District One.

- Lighted crosswalks should only be used at uncontrolled crosswalks (current MUTCD standard).
- 85th percentile speeds should be 45 mph or less.
- Primary roadway ADT should be between 5,000 and 30,000.
- Stopping sight distance should be 400 feet for speeds less than 35 mph, 500 feet for speeds between 35 mph and 40 mph, and 600 feet for speeds between 40 mph and 45 mph.
- Pedestrian volumes should be a minimum of 100 pedestrians per day (current IDOT guidance is 40 pedestrians during each of any two hours).
- There must be no marked crosswalks or controlled intersections within 250 feet in advance of or following the crosswalk.
- Lights may be installed on a street with a minimum of three lanes.
- Other treatments have also been considered (current IDOT guidance defines application of standard signing and pavement marking prior to considering IRWLs).

Costs

According to a cost compilation study by the UNC Highway Research Center, the average cost for the installation of a lighted crosswalk is $17,620, although lower costs of $15,000 were obtained after repeated installations.[4,5] Other installation costs were found to range between $6,480 and $40,000. This facility can be expensive to maintain and should only be considered for installation after first considering other options.

$ **$17,620**

Average cost

(2013)

Figure 3 - A lighted crosswalk in the winter on Roosevelt Road (IDOT) at Lombard Avenue in Oak Park, Illinois. View is from the south side of Roosevelt Road looking northwesterly.

Figure 4 - A lighted crosswalk at night in Clovis, California. Image by James Sinclair, reprinted with permission. https://stopandmove.com/2013/06/one-year-later-clovis-crosswalk-sti.html/

Design Guidance

Section 4N.02 in the MUTCD states that lighted crosswalks:

- Shall only be installed at marked crosswalks, but not at crosswalks controlled by YIELD signs, STOP signs, or traffic control signals.
- Shall be installed along both sides of the crosswalk for the entire length.
- Shall be activated either passively or actively; they cannot operate continuously.
- Shall display a flashing yellow light at a specific rate when activated.
- Shall be installed in the area outside the edges of the crosswalk and 10 feet from the outside edge of the crosswalk.
- They shall face away from the crosswalk if unidirectional, or shall face away from and across the crosswalk if bidirectional.
- If used on one-lane, one-way roadways, a minimum of two in-roadway warning lights shall be installed on the approach side of the crosswalk. If used on two-lane roadways, a minimum of three in-roadway warning lights shall be installed along both sides of the crosswalk. If used on roadways with more than two lanes, a minimum of one in-roadway warning light per lane shall be installed along both sides of the crosswalk.
- On one-way streets, in-roadway warning lights may be omitted on the departure side of the crosswalk.
- Based on engineering judgment, the in-roadway warning lights on the departure side of the crosswalk on the left side of a median may be omitted.
- Unidirectional in-roadway warning lights installed at crosswalk locations may have an optional, additional yellow light indication in each unit that is visible to pedestrians in the crosswalk to indicate to pedestrians in the crosswalk that the in-roadway warning lights are in fact flashing as they cross the street. These yellow lights may flash with and at the same flash rate as the light module on the pedestrian crossing sign. Where the period of operation is sufficient only for crossing from a curb or shoulder to a median of sufficient width for pedestrians to wait, median-mounted pedestrian actuators shall be provided.

The Illinois Supplement to the MUTCD also states:

- Shall display minimum one flashing yellow warning beacon with minimum one pedestrian crossing warning sign, flashing at same time and rate as IRWLs, with option to use flashing LED units within border of pedestrian crossing sign in lieu of warning beacon.
- Shall display "PUSH BUTTON TO TURN ON WARNING LIGHTS" sign mounted above pushbutton.
- Recommend engineering judgment shows evidence of safety problem not alleviated by standard signing and marking prior to installing IRWLs, along with determination that IRWLs will not compromise safety at nearby intersections.
- Recommend presence of minimum 40 pedestrian crossings and 200 vehicles during each of two peak pedestrian usage hours in a given day prior to installation.

FHWA	Manual on Uniform Traffic Control Devices (MUTCD) – Chapter 4N. In-Roadway Lights. 2009 Edition, Revisions 1 & 2, May 2012 http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm
Illinois Department of Transportation	Illinois Supplement to the MUTCD – Chapter 4N. In-Roadway Lights 2009 edition, Revision 1, June 2014 http://idot.illinois.gov/Assets/uploads/files/Transportation-System/Manuals-Guides-&-Handbooks/Highways/Operations/2009%20ILMUTCD%20-

Figure 5 – List of design guidance manuals

SAFETY

Most studies across the USA showed an improvement in various measures of safety. The studies measured the crosswalk's impact on vehicle compliance, vehicle speeds, and pedestrian activation rates.

Motorist Behaviors

The City of San Rafael, California installed IRWLs at a crosswalk where pedestrian safety was of particular concern. IRWLs had recently obtained FHWA approval at the time of installation, so a before and after study was conducted to determine their effectiveness, including measurement of motorist reaction and pedestrian activation. Only 48% of pedestrians activated the flashing lights, however the number of motorists who yielded to pedestrians increased by 15%.[6]

A comparison of other studies completed in the U.S. found vehicle yielding rates increased at most but not all lighted crosswalk locations as shown in Table 1.[7] Some of the studies also examined speeds before and after at differing locations approaching the sidewalk. Thomas cautions that "methodologies and definitions varied from study to study making comparisons of the outcome measures across studies infeasible… yielding rates [and] speed effects should not be compared across studies. It is important to note that San Jose performed their study during the nighttime hours and observed even greater increases in yielding rates, supporting the benefit of IRWLs during dark or even low visibility conditions.

Table 1 - Changes in yielding rates before and after installation of a lighted crosswalk from various studies compiled by Thomas, Libby J.

Location	Change in Yielding Rates	Study Period (months)	Time of Day
San Jose, CA	+38%	6	Day
San Jose, CA	+71%	6	Night
Gainesville, FL	+12%	2	Day
Lakeland, FL	-6%	3-4	Day
Honolulu, HI	+30%	2	Day
Cedar Rapids, IA	+15%	6	Day
Henderson, NV	+37%	Unknown	Day

Another study looked at various sites across California and Washington, with both daytime and higher nighttime increases in yielding rates. It is noted that several of these studies were short term and Thomas cautions that longer term studies need to be performed to observe if these yielding rates are sustained over time. For example, one study in San Jose found the percentage of yielding drivers increased one month after installation but then decreased 6 months later.[5]

Some studies examined IRWL installations on multi-lane roads. Those reviewed by Thomas found "inconsistent results on whether IRWLs improve (motorist) yielding to pedestrians in the middle of crossing or approaching a second travel lane." However, an Israeli study found increases in motorist yielding rates after IRWL installation were much higher for pedestrians in the middle of a crossing (70%) versus at the beginning of a crossing (35%).

A 2003 study by Van Derlofske et al. found the mean speed decreased as vehicles approached IRWLs.[7] In another report, Van Derlofske et al. also found approach speeds initially decreased, but follow-up studies eventually showed an increase.[8] Two years later the change in approach speed was 2.5 mph higher with a pedestrian present than the speed before installation. A 2006 Las Vegas study by Karkee et al. found a statistically significant reduction in mean driver speed of 4.7 mph when pedestrians were crossing or waiting to cross.[9] The Cedar Rapids, IA study, reviewed by Thomas, also observed speeds increasing: mean spot speeds increased 1.4 mph with pedestrians present and 0.8 mph without pedestrians present and 85th percentile speeds increased 1.3 mph with pedestrians present but remained the same without pedestrians present after installation of the lighted crosswalk. However, the Honolulu study observed mean speeds decreasing by 25% and 85th percentile speeds by 14% (actual speed changes were not provided).

Pedestrian Behaviors

A study in Orlando interviewed pedestrians on lighted crosswalk issues. Only 23% of respondents in that study indicated they relied on IRWLs to encourage drivers to stop, and only 33% of the respondents observed pedestrians activating the lights when crossing. Another study interviewed pedestrians before and after IRWL installation and found pedestrians did not feel safer with the IRWLs, although the sample size was small. Of the survey respondents from San Jose, 65% found IRWLs effective.[5] Of users surveyed in San Francisco, 50% found them “very helpful” with 73% believing drivers were yielding more frequently.[10]

One study witnessed a decrease in jaywalkers (from 16% to 8%), indicating increased use of the lighted crosswalk compared to the previously in-place traditional crosswalk. Regarding crossing times, one study found no change at two observation sites. One location witnessed 75% of crossing pedestrians activating the IRWLs. Previous studies in San Rafael and Orlando found activation rates of 48% and 33%, respectively. A potential solution to the low activation rates is conversion to passive activation. The City of San Jose, CA uses bollards with infrared beams which detect when a person passes, and automatically activates the IRWLs. San Francisco also uses passive detection and found that infrared bollard detectors worked better than the microwave detection systems.[10]

IRWL Removal

An important finding from Thomas’ review was that several communities had removed their IRWLs in favor of alternate crosswalk enhancements for various reasons. Santa Rosa, CA removed their IRWLs based on maintenance concerns and sustained visibility of the lights over time and replaced them with overhead flashing lights. A location in Honolulu, HI had IRWLs replaced with a traffic signal after determination that the IRWL treatment was insufficient to address concerns of an elderly and child population nearby. Boulder, CO replaced their IRWLs in favor of pedestrian-activated, sign-mounted flashing lights, “State Law” signing, and raised crossings at right-turn bypass islands.[7] The Village of Westmont, IL in District One has also removed their one installation of IRWLs, installed in 2005 and removed in 2014, due to extensive maintenance costs.[11]

Figure 6 - Pedestrian activated button on Roosevelt Road (IDOT) at Lombard Avenue in Oak Park, Illinois. View is from south side of Roosevelt Road looking easterly.

Conclusion

Most national lighted crosswalk locations that were studied saw a modest increase in motorist yielding rates with higher increases noted during nighttime observations, a slight decrease in vehicle speeds, and low user activation rates. These results are similar to studies performed in District One and detailed in the District One Studies section in this report. Studies on their impact to crashes are minimal to non-existent. One study in San Francisco, however, did examine 5 years of before and after crash data and found that IRWLs had no impact on crashes.[10]

Since the lights are embedded in the pavement, they can be affected by adverse weather conditions as shown in Figure 7. They may also be difficult to see in the daytime, further decreasing their effectiveness. They are most effective at night and/or during limited visibility conditions. Another visibility issue with the IRWLs is that the lights are usually only visible to the first motorist approaching the crossing, an issue not seen with post or overhead mounted warning light systems.[12] Therefore, IRWLs may be best suited for low traffic roadways in District One, as their effectiveness seems to be modest at medium to high traffic roadways. While there may be concerns over an increase in rear-end crashes, one study did not find a quantifiable increase to justify that concern (detailed background data was not provided).[2] If IRWLs are used, it is recommended that bidirectional light fixtures be installed to also alert pedestrians that the lights are activated. Otherwise, single directional lights are not visible to pedestrians in the crosswalk.[13,14] The 2009 MUTCD allows for bidirectional lights.

Figure 7 – In-roadway warning light during dry and sunny conditions, on Roosevelt Road (IDOT) in Oak Park, Illinois

Figure 8 – In-roadway warning light during winter conditions, covered in road grime and salt, on Roosevelt Road (IDOT) in Oak Park, Illinois

OPERATIONS

The 2009 MUTCD states that IRWLs shall be activated either passively or actively; they cannot operate continuously. The crosswalk operates as a normal crosswalk at all other times, only causing traffic delays when a pedestrian is crossing. Regardless, the lights serve to increase compliance by motorists who are legally obligated to stop whenever a pedestrian is present, whether IRWLs are installed or not. Therefore, IRWL's should not affect motorist traffic operations.

Pedestrian volumes may increase with the sustained use of IRWLs or other enhancements or facilities due to the reduction in wait times and increased comfort experienced at IRWLs. See the District One Studies below for anecdotal evidence of these trends.

Figure 9 – Crosswalk with in-roadway warning lights on Roosevelt Road (IDOT) at Lombard Avenue in Oak Park, Illinois. View is from the south side of Roosevelt Road looking northerly.

MAINTENANCE

Maintenance is a primary concern for IRWLs due to the wear they receive from traffic and snow plowing operations given their location on the road surface within the travel lanes. Thus, material selection and product choice are an important factor in IRWL installations. Alloy and iron products typically last up to five years, versus plastic products that may only last for two to three years.[15] Wiring installation and placement is similar to embedded detector loops along with associated maintenance (see Figure 10). Snow removal is a major concern for areas with frequent snowfall given potential damage to IRWLs from snow plow blades. IRWLs have been installed in locations that experience heavier snowfall than Illinois, such as Alaska and Washington, however Alaska has replaced IRWLs due to snow plow damage. Although the MUTCD allows a maximum IRWL height of ¾ inch above the roadway surface, flush-mounted or plow-ready lights are recommended for areas with frequent snow fall.

Figure 10 - IRWLs and cable routing on Roosevelt Road (IDOT) at Lombard Avenue in Oak Park, Illinois

Figure 11 – Flush mounted IRWLs during the winter on Roosevelt Road (IDOT) in Oak Park, Illinois

There are two light activation options: push-button or passive actuation. Infra-red beams or other non-pad detection equipment should be utilized if passive detection equipment is chosen. Maintenance may be more intensive and costly with the passive actuation, compared to push button actuation. However, passive detection may be preferable due to low push button activation rates witnessed in IDOT District One studies where 27% of pedestrians did not activate the IRWL. Refer to the District One Studies section in this report for more information on activation rates. If pads are used, snow should be kept clear of the detection area to avoid false activation. Snow should also be kept clear in the vicinity of pedestrian activation buttons which may make access difficult for pedestrians and especially users with disabilities (see Figure 11).

During a study in San Rafael, California, other maintenance issues were discovered with the lighting system including moisture penetration in the fixtures, minor vandalism, and problems with street cleaning operations. Corrective actions were taken by the City of San Rafael and the manufacturer to address these issues.[6] However, other communities decided to remove their IRWLs due to maintenance issues. The City of Santa Rosa, CA removed their lighted crosswalks over concerns of maintenance and sustained visibility of the lights over time, and subsequently replaced them with overhead flashing lights. Boulder, CO replaced their IRWLs in favor of pedestrian-activated, sign-mounted flashing lights, "State Law" signing, and raised crossings at right-turn bypass islands.[7] San Francisco had issues with one of their two IRWL locations constantly malfunctioning. NYCDOT chose not to install them based on maintenance costs, anticipating the need to purchase additional street sweeping and snow removal equipment to accommodate the embedded lights.[5] However, newer IRWL options seem to forgo this requirement due to upgrades in lights and flusher installations. In IDOT's District One, the Pedestrian Safety Engineer noted that although a safety study hasn't been done at the facility in Oak Park, it does not stand out as being any better or worse than standard crossings nearby. However, there are issues and/or concerns over leaves or snow obstructing the lights during the fall and winter periods and distracting drivers from focusing on the pedestrians crossing; IDOT expressed concerns over motorists potentially focusing their attention on the lights rather than pedestrians entering the crosswalk from the periphery of their vision.

The Village of Westmont, also in District One, had previously installed Smart Stud System brand IRWLs in 2005 at a cost of approximately $65,000 (which also included some sidewalk and brick paver installation) but removed them due to maintenance costs. Westmont was spending approximately $8,000 every year to replace more than 50% of the system due to discontinued lights. These maintenance costs included replacement parts, installation and MOT. The Village removed the lights in 2014.

Figure 12 - Difficult to access pedestrian activation button in Chicago

Typical Infrastructure to Maintain

- Embedded lights
- Use LED bulbs, otherwise bulbs may burn out within 3-4 years
- Equipment quality: iron, alloy, plastic, etc. (alloy and iron products last the longest, up to 5 years)
- In-pavement wiring
- Push-buttons
- Flashing beacons with pedestrian warning signs (required by the Illinois Supplement to the MUTCD)
- Passive detection pads require snow clearing on the sidewalk to avoid false calls
- Lights may interfere with video and ultrasonic systems

Figure 13 – In-roadway warning lights during the winter on Roosevelt Road (IDOT) in Oak Park, Illinois

Conclusion

In-roadway warning light systems have been in use since 2012 along Roosevelt Road in Oak Park, Illinois under IDOT jurisdiction in District One, and no particular issues were identified by the municipalities responsible for maintenance of the three facilities along Roosevelt Road. If IRWLs are chosen for a crosswalk, snow plowing operations may hasten the need for maintenance or replacement. The lights and push buttons should be periodically checked to ensure they are operating correctly.

District One Studies

The following is a summary of findings from four studies performed by IDOT in 2014 for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 2- Summary of IDOT District 1 Studies, 2014

Study	Summary of Findings
Pedestrian Survey	The lighted crosswalk received only slightly higher ratings overall on comfort and safety than the control location; however, it should be noted that the lighted crosswalk scored slightly lower for inclement weather conditions, contrary to what was expected. The lighted crosswalk received some positive opinions but received more opinions regarding suggestions for improvements.
Motorist and Pedestrian Behavior Study	The lighted crosswalk had an average 5.5 second lower pedestrian wait time when the lights were activated compared to the control location and encouraged 40% less jaywalking. Motorist stopping compliance rates were also higher, with 24% compliance at the lighted crosswalk versus 6% at the control location.
Speed Study	Based on the results of the IDOT District One Speed Study conducted in Oak Park, Illinois, the lighted crosswalk at this location had minimal impact on vehicle speeds.
Pedestrian Crash Analysis	Three IRWLs were installed in 2012 along Roosevelt Road (IDOT) in Oak Park. A total of three pedestrian crashes occurred at these locations during years 2008 through 2014, with two crashes occurring prior to installation. Therefore, data is too limited to determine crash trends and the crash analysis was indeterminate. However, of note is a rear-end crash in 2014 when a motorist stopped for a pedestrian in the lighted crosswalk resulting in an A-injury to the motorist. The pedestrian was unharmed.

Pedestrian Survey

Pedestrian surveys were conducted at the same crosswalk locations chosen for the motorist and pedestrian behavior study and speed study. The purpose of the surveys was to compare and contrast pedestrians' perceptions of the lighted crosswalk versus a similar non-lighted crosswalk.

Site Conditions

The in-person facility surveys for the lighted crosswalk location were conducted on July 17, 2014 from 4 pm to 6 pm at the intersection of Roosevelt Road and Lombard Avenue in Oak Park, Illinois, under sunny and clear conditions with temperatures in the lower 70s. Lombard Avenue was stop-sign controlled. For the control crosswalk, the in-person surveys were conducted on August 19, 2014 from 4 pm to 6 pm at the intersection of Roosevelt Road and Monitor Avenue in Oak Park, under mostly sunny conditions with a temperature of 82°F. Monitor Avenue was stop-sign controlled.

Figure 14 – Survey site at Roosevelt and Lombard Avenue in Oak Park, Illinois

Study Method

A cross sectional study was conducted to determine the effectiveness of a crosswalk with in-roadway warning lights (IRWLs) compared with a similar neighboring crosswalk without IRWLs. The questions asked at both the facility and control sites were kept as similar as possible to facilitate comparison of the results.

Staff members conducting the in-person surveys stood at opposite ends of the crosswalk at both the facility and the control sites. Staff wore safety vests for safety purposes and to attract the attention of pedestrians. Staff approached the pedestrians and asked them if they would like to take a survey. The pedestrians were given the option of performing the survey in person or online at their convenience. The online survey was open for 2 weeks, and the IP addresses of submissions were monitored to avoid multiple submissions from the same person.

Survey Questions

The participants at the facility site and control site were given similar surveys for comparison purposes. Participants at both sites were asked questions shown below in Table 4, corresponding to Figures 13 through 24. Additional questions were asked specific to the particular crosswalk being studied. The participants at the facility site were asked questions regarding the lighted crosswalk, and participants at the control site were asked questions about the traditional crosswalk and also if they were aware of the lighted crosswalk.

Table 3- Survey questions corresponding to the following figures

Figure #	Questions Asked
13	What is your gender?
14	In what age group do you fall?
15	What best describes why you are out here today?
16	In the past month, about how often have you walked down Roosevelt Road in Oak Park?
17	In the past month, about how often have you driven down Roosevelt Road in Oak Park?

18	Which answer best describes what an Illinois motorist must do when approaching a crosswalk?
19	Are you aware of the in-pavement flashing crosswalk lights on Roosevelt Road and Lombard Avenue?
20	In the past month, how often have you walked across Roosevelt Road at the lighted crosswalk at Lombard Avenue (or crosswalk at Monitor Avenue)?
21	How safe do you feel when using the lighted crosswalk at Roosevelt Road and Lombard Avenue (or crosswalk at Monitor Avenue) during the following times?
22	How safe do you feel when crossing the lighted crosswalk at Roosevelt Road and Lombard Avenue (or crosswalk at Monitor Avenue) in the following weather conditions?
23	When driving on Roosevelt Road (if applicable), how visible are the flashing lights at Lombard Avenue (or crosswalk at Monitor Avenue) from a distance of 50 feet in the following weather conditions?
24	Do you have any suggestions or comments regarding lighted crosswalks (or crosswalks) like the one on Roosevelt Road and Lombard Avenue (or Monitor Avenue) in Oak Park?

Survey Results

For the facility site, a total of 22 paper surveys were completed and one online submission was received. For the control site, 11 paper surveys were completed and zero online submissions were received.

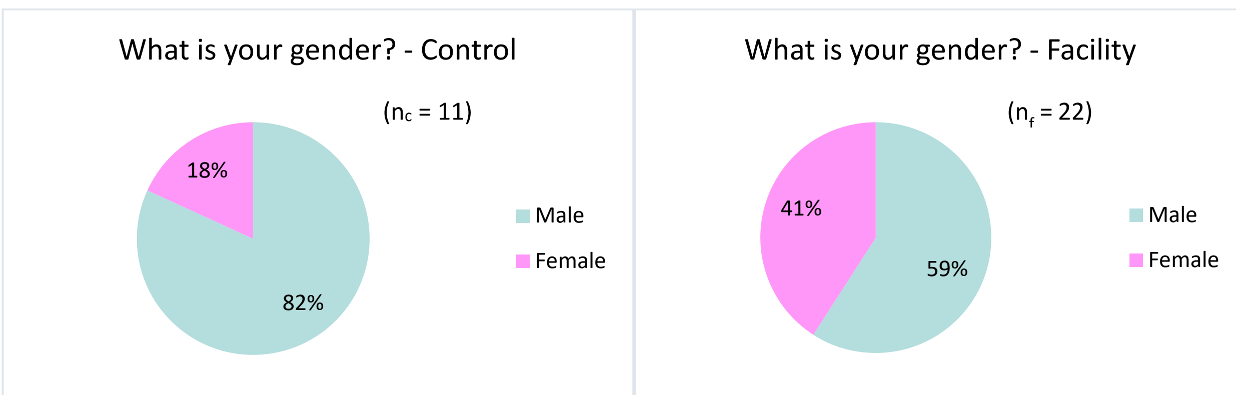


Figure 15 – What is your gender? Results from the control location (left) and lighted crosswalk (right).

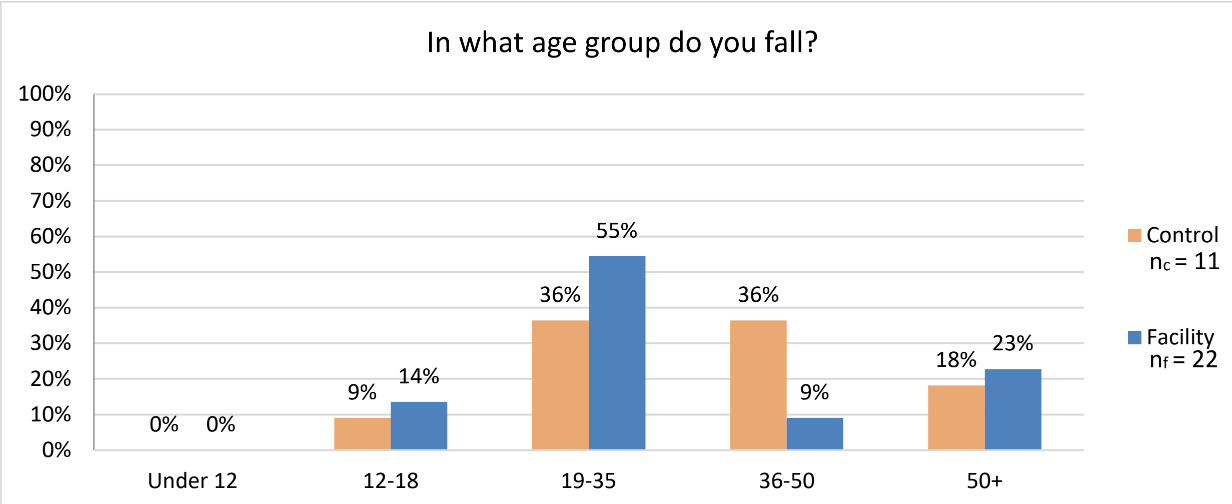
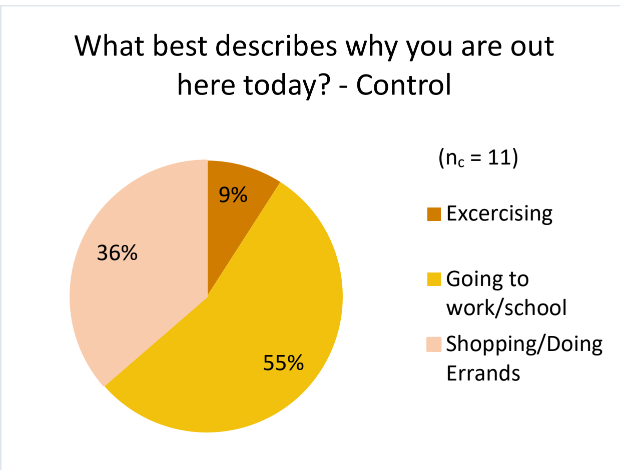


Figure 16 – What age group do you fall in?



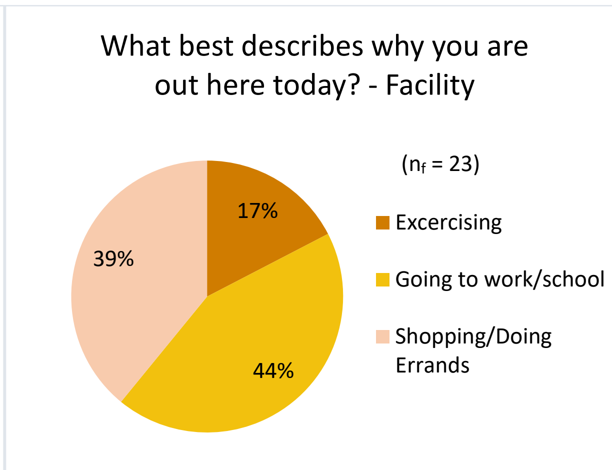


Figure 17 – What best describes why you are out here today? Results from the control location (left) and lighted crosswalk (right).

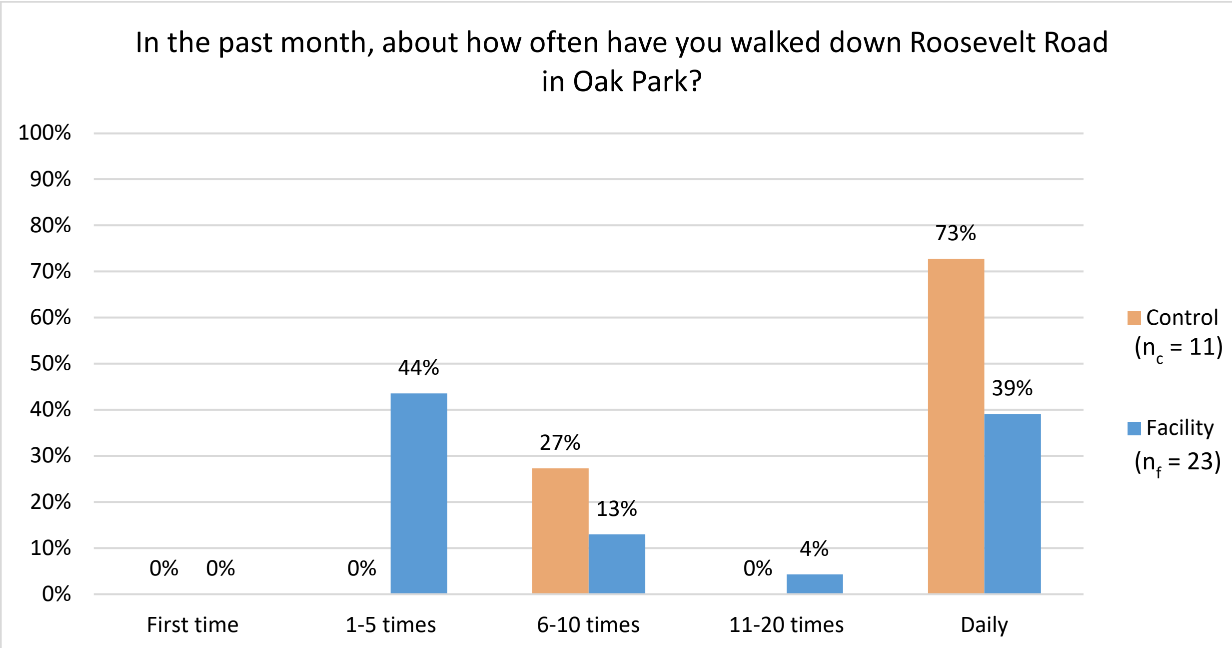


Figure 18 – In the past month, about how often have you walked down Roosevelt Road in Oak Park?

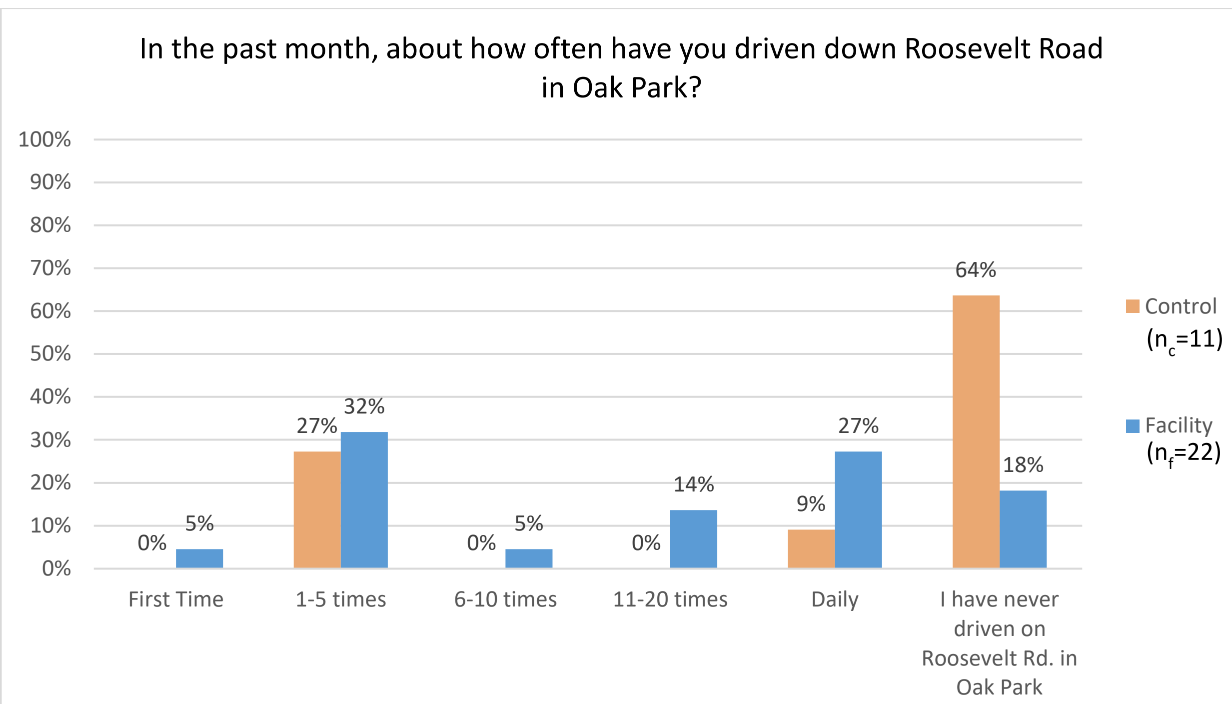


Figure 19 - In the past month, about how often have you driven down Roosevelt Road in Oak Park?

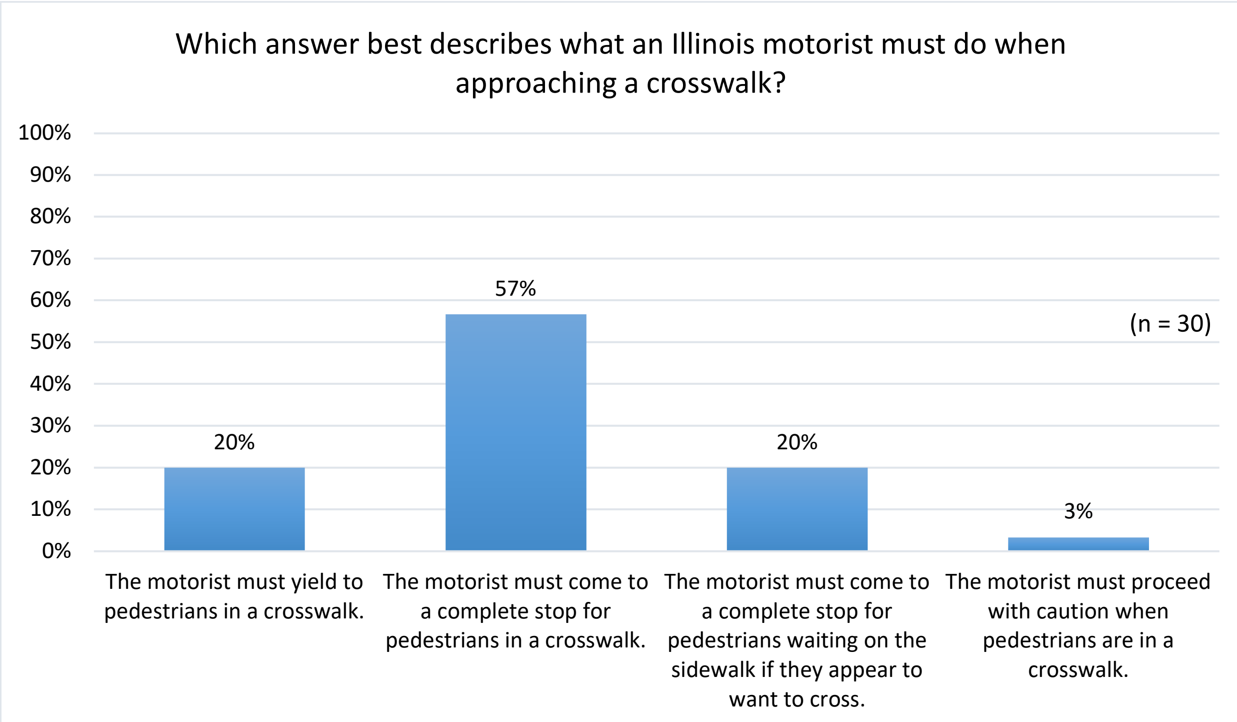


Figure 20 - Which answer best describes what an Illinois motorist must do when approaching a crosswalk? Compiled responses from control and facility locations.

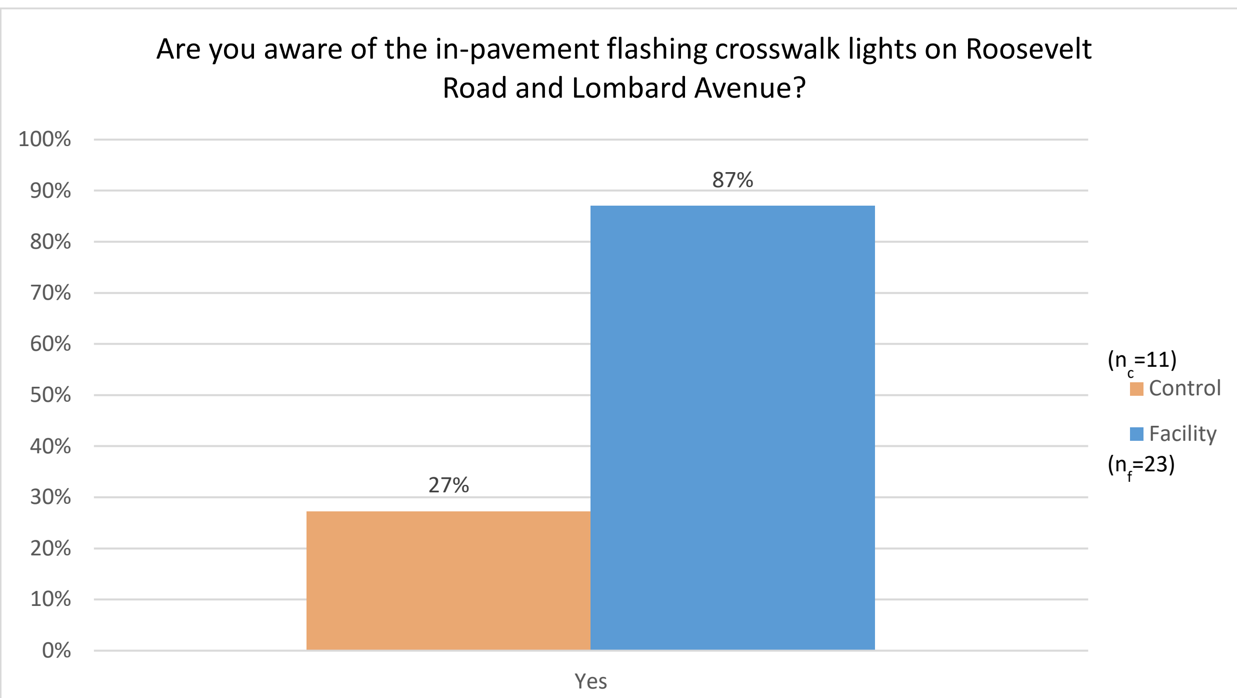


Figure 21 - Are you aware of the in-pavement flashing crosswalk lights on Roosevelt Road and Lombard Avenue?

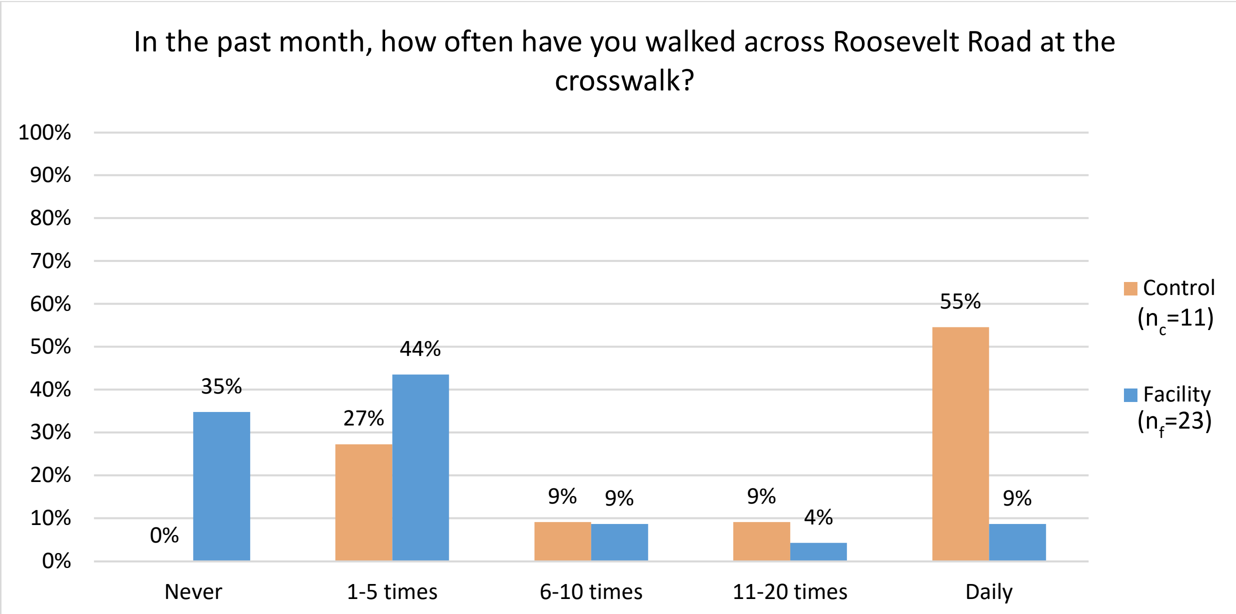


Figure 22 - In the past month, how often have you walked across Roosevelt Road at the crosswalk?

For the following questions (Figure 23 and Figure 24), the participant was asked to choose a rating between 1 and 5 on how safe they felt when crossing at the lighted crosswalk, 1 being completely unsafe and uncomfortable, 3 being neither safe nor unsafe, and 5 being completely safe and comfortable. The participant could choose N/A if he/she had no experience with the specific conditions at the crosswalk.

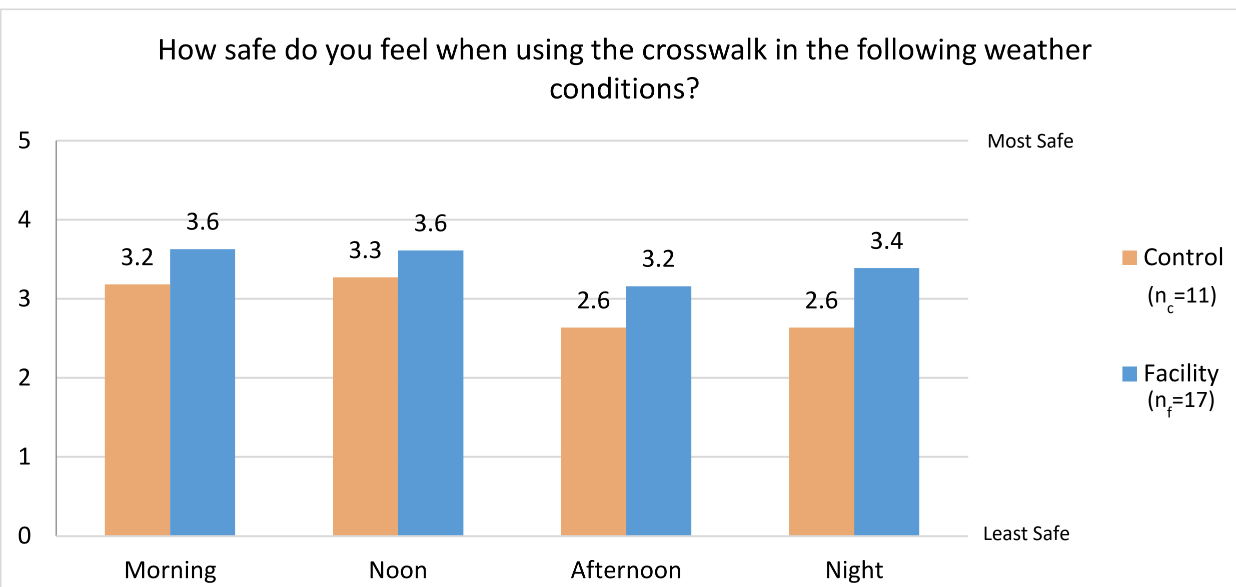


Figure 23 - How safe do you feel when using the crosswalk during the following times?

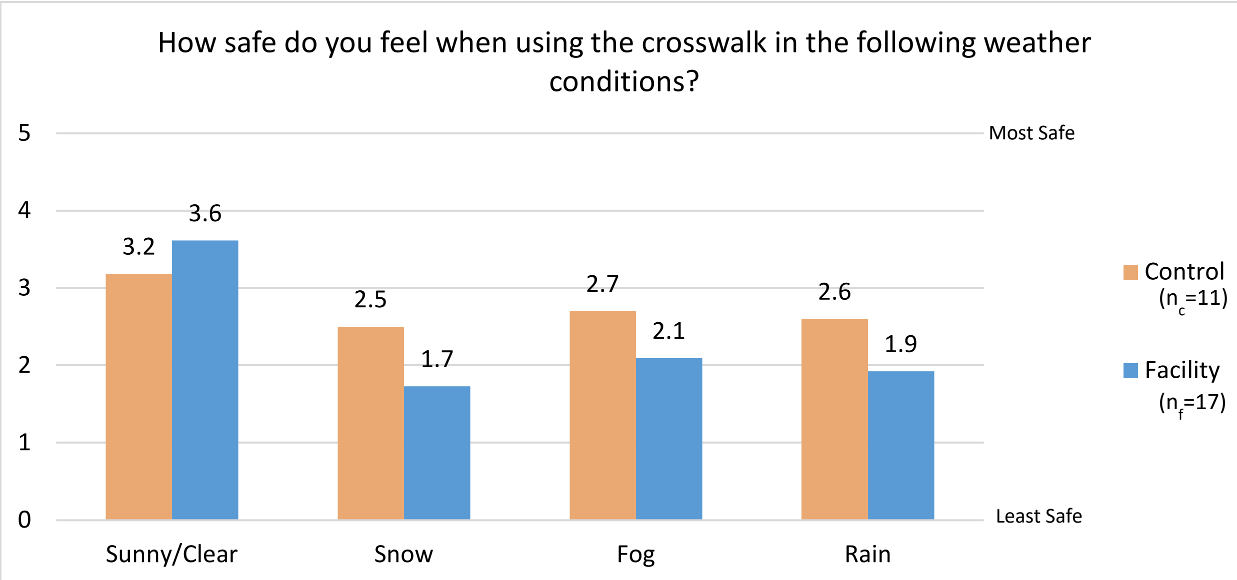


Figure 24 - How safe do you feel when using the crosswalk in the following weather conditions?

For Figure 25, the participants were asked to give a rating between 1 and 5 about the visibility of the crosswalk, 1 being that the crosswalk was barely visible and 5 being that the crosswalk was completely visible from a distance of about 50 feet. The participant could choose N/A if he/she had no experience with the specific conditions at the crosswalk.

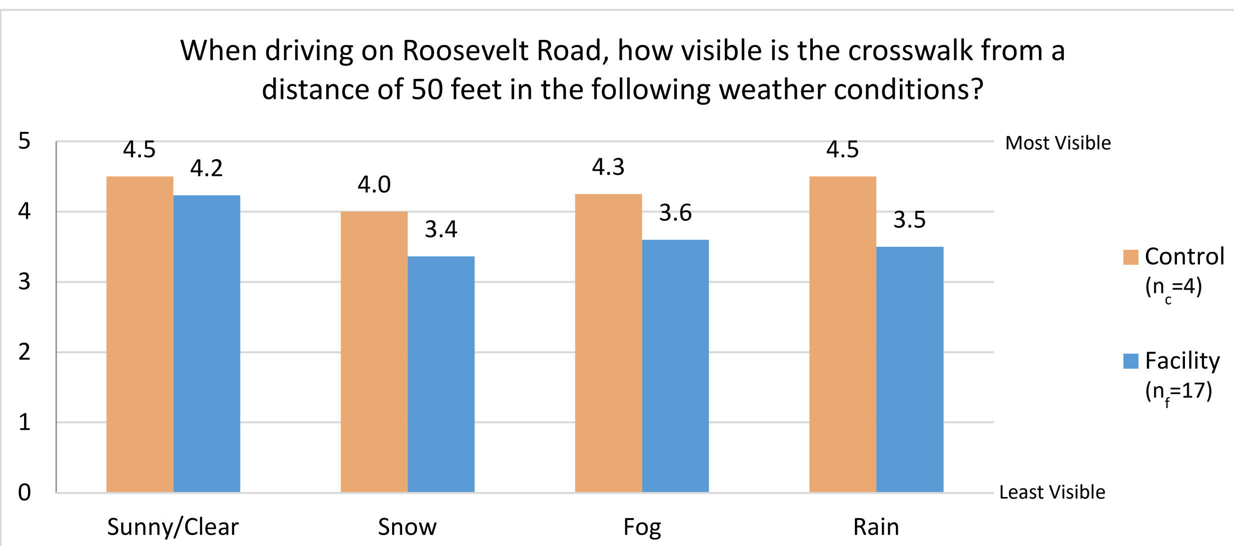


Figure 25 - When driving on Roosevelt Road, how visible is the crosswalk from a distance of 50 feet in the following weather conditions?

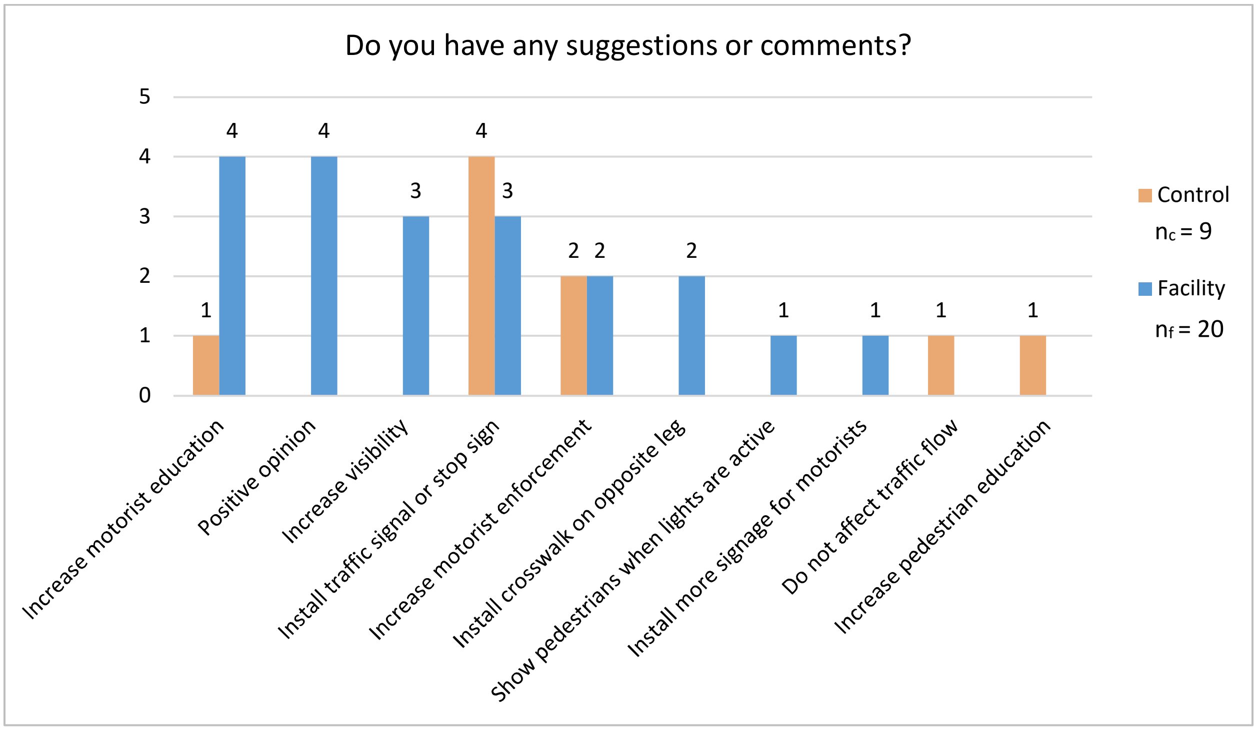


Figure 26 - Do you have any suggestions or comments?

Discussion

Most participants were male and between 19 to 35 years old. The majority of participants were going to work or school. More pedestrians crossed daily at the control crosswalk compared to the facility crosswalk, where typical frequencies were one to five crossings a week. Of the participants surveyed, 55% responded with the correct understanding of Illinois state crosswalk law, while 45% responded incorrectly. 13% of participants at the facility site were unaware of the lighted crosswalk treatment.

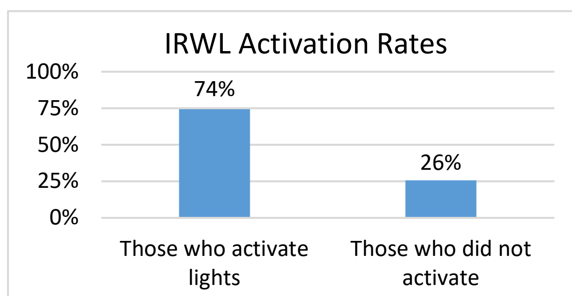


Figure 27 - Pedestrian activation rates at lighted crosswalk

The questions regarding pedestrian comfort and feelings of safety had the most similar responses between the facility and control sites. The lighted crosswalk received slightly higher scores than the traditional crosswalk when comparing different times of the day as well as during sunny and clear weather conditions. During snow, fog, or rain, however, the traditional crosswalk scored slightly better. The traditional crosswalk also scored slightly better in terms of visibility for a motorist at a distance of 50’ from the crosswalk. It should be noted that questions were only asked of pedestrians walking along or crossing Roosevelt, with a significant portion stating they have not driven on Roosevelt Road, and a separate survey of motorists was not performed. Regardless, these results are unexpected given IRWLs are supposed to increase crosswalk visibility when activated, especially during night time conditions and inclement weather. Results may be explained by the low activation rates. As shown in Figure 25, the crosswalk is not activated more than 20% of the time, resulting in a crosswalk that functions like a traditional striped crosswalk.

The final open-ended question, asking for comments on the lighted and traditional crosswalks, received mixed responses. The two most popular responses at the lighted crosswalk either considered the crosswalk a positive facility or suggested a desire for increased motorist education. The two next most popular comments mentioned increasing crosswalk visibility or installing a traffic signal or stop sign, pointing to inadequacies in the current treatment. The most popular comment at the control site was to install a traffic signal or stop sign.

It is important to note that the data was limited; only nine pedestrians participated in the survey at the control crosswalk versus 23 at the lighted crosswalk. Furthermore, the questions asking about comfort and feelings of safety during various times and weather conditions may have been too tedious for an in-person survey. Most responses for conditions other than sunny or daytime received similar ratings from the same person, diluting the average ratings. Furthermore, the survey took place during sunny and daylight conditions. Results may have been different if the data was collected at night or during inclement weather.

Conclusion

Overall, 31 people participated in the surveys in person or online. Based on the surveys, the effectiveness of lighted crosswalks at increasing pedestrian comfort and feelings of safety is minimal during daylight and sunny conditions. The survey results do not support the benefit of lighted crosswalks at night or inclement weather, a primary reason for their installation. Furthermore, feelings of safety and activation rates at lighted crosswalks are lower in comparison to other facilities studied by IDOT District One.

Motorist and Pedestrian Behavior Study

Site Conditions

The motorist and pedestrian behavior field study for the lighted crosswalk along Roosevelt Road at the intersection with Lombard Avenue in Oak Park was conducted on July 16, 2014 from 4 pm to 6 pm, under sunny conditions with temperatures in the upper 60's. The same field studies were conducted at a control crosswalk along Roosevelt Road at Monitor Avenue on August 14, 2013 from 4 pm to 6 pm, also under sunny conditions with temperatures in the upper 60's. It is noted that Roosevelt Road at both intersections is under IDOT jurisdiction and local maintenance, and all traffic control devices required for the lighted crosswalk were in place in accordance with the ILMUTCD and in good condition.

Study Method

A cross sectional study was conducted to compare a crosswalk with in-roadway warning lights (IRWLs) with a similar crosswalk without IRWLs (a control site).

Three staff members observed from an inconspicuous spot perpendicular to the lighted crosswalk. The staff members were dressed normally (no safety vest) so that they did not alter motorist behavior. Two staff members recorded the actions of pedestrians crossing the roadway including wait times in the Pedestrian Behavior Field Sheet; one person observed pedestrians crossing southbound and walking eastbound and the other observed pedestrians crossing northbound and walking westbound. The other staff member recorded the actions of motorists when a pedestrian waited to cross the roadway in the Motorist Behavior Field Sheet. The sheets were switched every 15 minutes.

Motorist Behavior

Motorist compliance was measured at the lighted crosswalk (facility) and control locations. Motorists were monitored for stopping for crossing pedestrians and if so, how they stopped. Three of the categories includes motorists that stopped or slowed enough for pedestrians to cross: practically stopped (motorists that slowed to between 0 and 3 mph), stopped by traffic, and voluntary full stop. The fourth category, non-stopping, did not stop or allow a pedestrian to cross. There were a total of 137 vehicles recorded at the lighted crosswalk and 41 at the control when a pedestrian was present. Both the facility and control locations saw high non-compliance rates (above 70%). The facility location saw modest improvement over the control location with 18% more motorists stopping at the crosswalk when a pedestrian was waiting to cross, as shown in Figure 28.

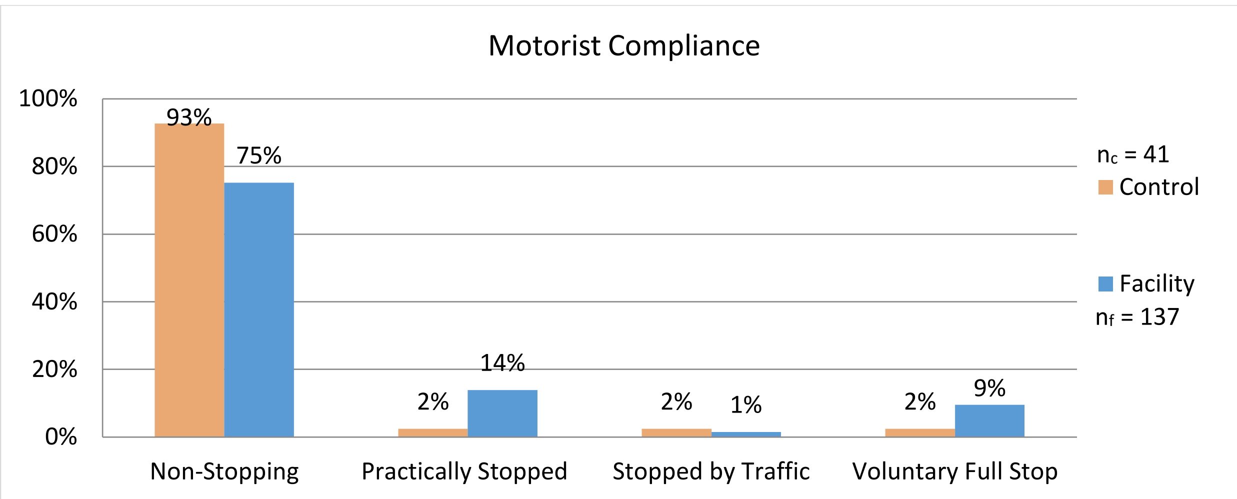


Figure 28 - Motorist behavior comparison, control versus lighted crosswalk locations

Pedestrian Behavior

There was a total of 51 pedestrians recorded crossing at Lombard Avenue (facility) and nine crossing at Monitor Avenue (control). At Lombard Avenue, seven pedestrians hesitated when crossing during IRWL activation and 14 jaywalked. Hesitation scenarios include pedestrians who step out onto the crosswalk and then step back onto the sidewalk, those that stop in the crosswalk waiting for traffic to clear, and those who broke stride in the middle of crossing.

Wait times were also recorded. Wait times were measured from the moment they stop on the sidewalk edge to the moment they enter the crosswalk and start their crossing. The average wait times are shown in Figure 27. It is important to note that wait times did not include jaywalkers so the average wait time at the control facility is only based on three pedestrians. Those that activated the IRWLs had wait times less than those that did not activate the lights. They also had wait times less than the control location. The highest wait times were 27 and 22 seconds for two pedestrians who did not activate the lights.

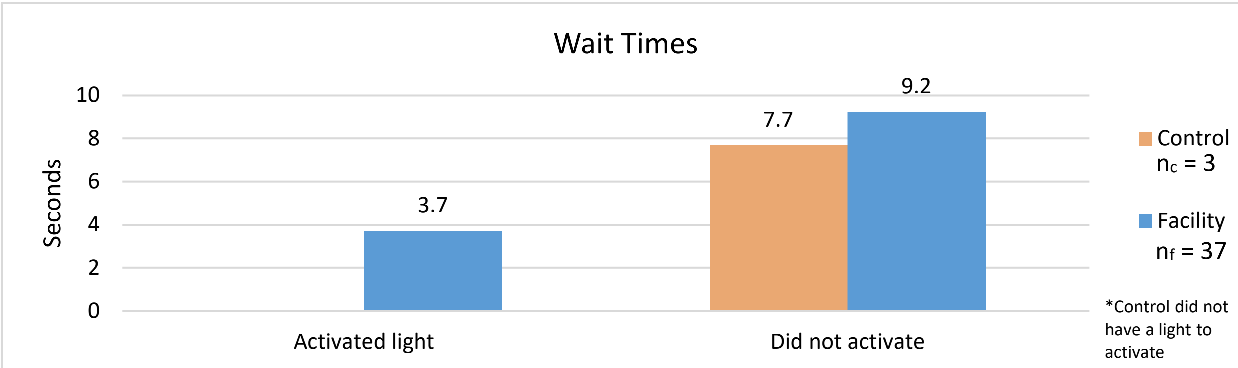


Figure 29 - Wait times for pedestrians entering the crosswalks

As shown in Figure 31 and Figure 30, the facility location experienced less jaywalkers compared to the control location, with 74% of pedestrians observed activating the IRWLs before crossing.

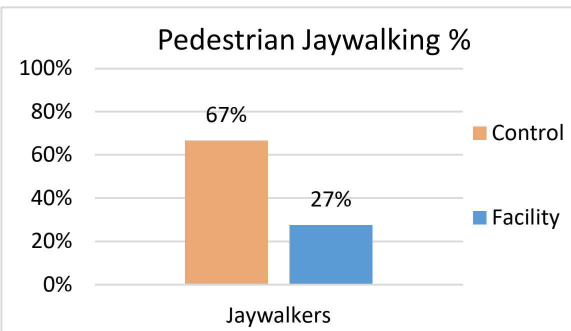


Figure 30- Pedestrian jaywalking percentages

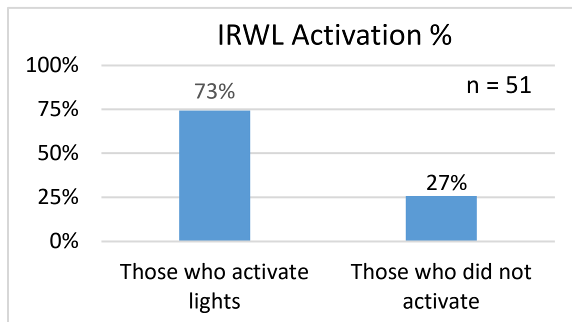


Figure 31- IRWL activation percentage

Discussion

Motorist stopping compliance with IRWLs was observed to be low, especially in comparison to locations with other crosswalk facilities such as raised crosswalks, rectangular rapid flashing beacons, or HAWK signals. However, compliance rates were slightly better at the lighted crosswalk compared to the control crosswalk, indicating the IRWLs had some effect on motorist behavior. This correlates with observed pedestrian wait times at the lighted crosswalk which decreased from 9.2 to 3.7 seconds when the IRWLs were activated. The lighted crosswalk also experienced 40% fewer jaywalkers, possibly due to pedestrian familiarity with higher motorist stopping rates and lower pedestrian wait times, making the lighted crosswalk a more attractive option for pedestrians. Observation of pedestrian crossing behavior at the lighted crosswalk revealed most pedestrians waited prior to entering the crosswalk, apparently expecting vehicles to not stop, but only two pedestrians hesitated before crossing the roadway.

Conclusion

Overall, the lighted crosswalk displayed slightly better results than the control location, lessening pedestrian wait times by approximately 5.5 seconds, increasing motorist stopping compliance rates, and encouraging 40% less jaywalking. The improvements were minimal, especially when comparing to other midblock crosswalk treatments.

The lighted crosswalk appeared to be less effective at increasing vehicle compliance and pedestrian comfort compared to other pedestrian safety enhancements. The lighted crosswalk observed along Roosevelt Road (IDOT) at Lombard Avenue in Oak Park, Illinois saw a vehicle stopping rate of 25%, compared to 7% at the control site. While the lighted crosswalk improved stopping rates, the rates are much lower than other, more effective, pedestrian crossing enhancements such as the raised crosswalk. It should be noted that all signing, marking and signalization at the Roosevelt/Lombard intersection met requirements for lighted crosswalks as set forth in the MUTCD and the Illinois Supplement to the MUTCD. More studies should be completed as additional IRWLs are installed to better evaluate the facility.

Speed Study

A speed study was conducted in 2014 along Roosevelt Road (IDOT) in Oak Park, Illinois, at the same crosswalk site chosen for the pedestrian survey and the motorist compliance and pedestrian behavior study. The purpose of the speed study was to determine if vehicle speeds were significantly lower at the lighted crosswalk compared to the vehicle speeds at a standard crosswalk.

Study Method

Two sets of pneumatic tubes were placed on Roosevelt Road in Oak Park, Illinois to collect traffic speed data near the lighted crosswalk at the Lombard Avenue intersection. One set of tubes (Set A) was installed adjacent to the lighted crosswalk, and the other set of tubes (Set B) was placed at a midblock location 470 feet east of the lighted crosswalk, as shown in Figure 31. Two weeks later, a similar study was conducted at a control location on Roosevelt Road approximately half of a mile east of the lighted crosswalk location, with tubes placed adjacent to the control crosswalk as shown in Figure 32. The control location's intersection and crosswalk properties were similar to the Lombard Avenue location, the difference being the absence of a lighted crosswalk.

Figure 32- In-roadway warning lights on Roosevelt Road at Lombard Avenue intersection in Oak Park, Illinois

Roosevelt Road Characteristics

Roadway Classification	Average Daily Traffic	Speed Limit
Other Principal Arterial	19,300	30 MPH

Facility Location

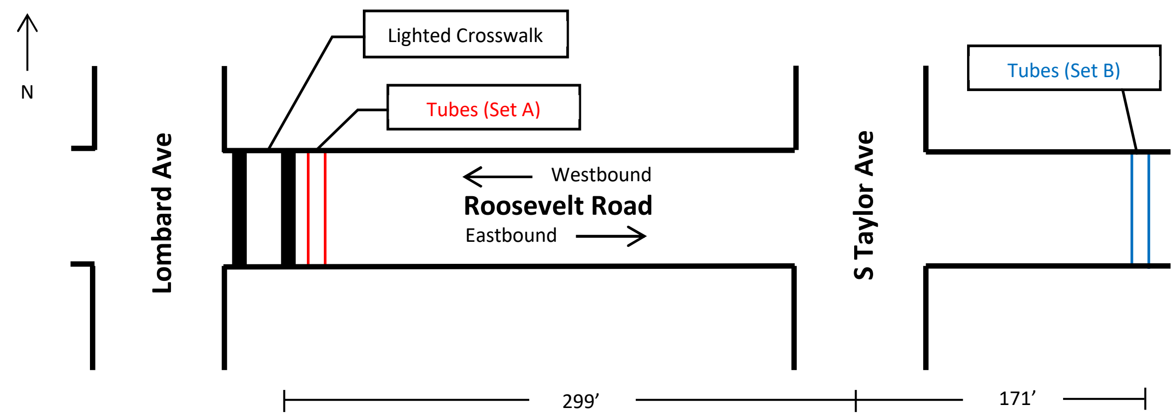


Figure 31 - Study location layout. Roosevelt Road at the study location has an ADT of 19,300 and a speed limit of 30 mph.

Control Location

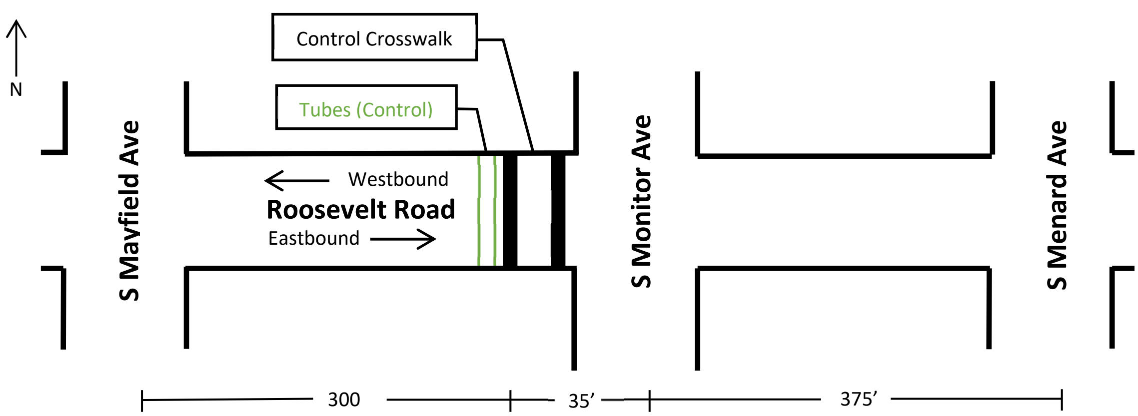


Figure 33- Control location layout. Roosevelt Road at the study location has an ADT of 19,300 and a speed limit of 30 mph.

Study Results

Table 5- Roosevelt Road speed data

	Lighted Crosswalk – Collected on 7/17/14 from 7AM-7PM		Midblock – Collected on 7/17/14 from 7AM-7PM		Control Location – Collected from 8/15/14 at 7AM to 8/17/14 at 7PM	
Traffic Direction	Westbound	Eastbound	Westbound	Eastbound	Westbound	Eastbound
85th % (MPH)	29	30	32	30	30	30
Mean (MPH)	23	25	27	24	25	23
Median (MPH)	24	26	27	25	26	25
Vehicle Count	6,595	6,519	6,512	6,980	21,505	17,727

Table 6 - Probability of vehicles exceeding the speed limit on Roosevelt Road

	At Lighted Crosswalk (Set A)	Midblock (Set B)	At Control Crosswalk
Probability of Exceeding 30 MPH Speed Limit	16%	21%	20%

Discussion

The 85th percentile speed, mean speed, median speed, and pace at the lighted crosswalk are similar to the values at the midblock location and control crosswalk. The probabilities that motorists will exceed the speed limit differ slightly between the three locations due to minimal differences in means and standard deviations.

Conclusion

The lighted crosswalk had minimal impact on vehicle speeds when compared with vehicle speeds at the midblock and control locations. It should be noted that the speed data collected was over a continuous period of time and does not differentiate between when the lighted crosswalk was active and non-active, so it is possible that vehicle speeds may have decreased while the lighted crosswalk was active. However according to research, speed studies performed previously at lighted crosswalk locations witnessed only a slight decrease in vehicle speeds.

Future studies should utilize a radar gun and staged crossings. The observer should record motorist speeds while another staff member attempts to cross, therefore allowing for a large sample size and control over the experiment. This will allow for speed measurements only at times when a pedestrian is present and the lighted crosswalk is activated, isolating the effectiveness of the lights at reducing motorist speed.

Several states in the USA have installed lighted crosswalks; most installations are located in California, where the facility was developed. The first lighted crosswalk was installed in Santa Rosa, California in the mid 1990's, followed by an installation in the state of Washington in the late 1990's.[7] Lighted crosswalk installations grew nationwide after their approval from the FHWA and incorporation into the MUTCD in 2003.

Table 7 - Examples of Lighted Crosswalk locations in the USA, with locations in District One shown in bold text

Country	City/County	State	Intersection	Installation Year
USA	Fairbanks	AK		Unknown
USA	Marana	AZ		2006
USA	Tucson	AZ	First St. and Mountain Ave.	2010
USA	Lynwood	CA		Unknown
USA	Fairfield	CA	Union Ave. and Texas St.	2007
USA	Alameda County	CA	San Pablo Ave. and 43rd St.	2012*
USA	Belmont	CA	Ralston Ave. and Elmer St.	2010
USA	Danville	CA	Hartz Ave. and E Prospect Ave.	Unknown
USA	Glendale	CA	W. Laurel St. and Brand Blvd.	2013*
USA	Humboldt County	CA	West Ave. and Tydd St.	Unknown
USA	Kern County	CA	Norwalk St. and 20th Ave.	Unknown
USA	Kings County	CA	7th Ave. and Orange St.	2010
USA	Petaluma	CA	Washington St. and Edith St.	2014
USA	Pleasanton	CA	Santa Rita Rd. and Francisco St.	2013
USA	San Bernardino	CA	9th St. and Cunningham St.	Unknown
USA	San Clemente	CA	El Camino Real and Avenida Cabrillo	2013
USA	San Mateo County	CA	Valparaiso Ave. and Hoover St.	2010
USA	Sonoma County	CA	Healdsburg Ave. And Plaza St.	Unknown
USA	Stanislaus County	CA	Central Ave. and Academy Pl.	2008
USA	Sunnyvale	CA	Bernardo Ave. and Ayala Dr.	2008
USA	Sutter County	CA		Unknown
USA	San Rafael	CA	Civic Center Dr. and Vera Schultz Dr.	2003
USA	Los Angeles County	CA	Alhambra Rd. and 2nd St.	2010
USA	Honolulu	HI	Kapalama Post Office – N. King St.	2010
USA	**Oak Park**	**IL**	**Roosevelt Rd. (IDOT) and Home Ave. Roosevelt Rd. (IDOT) and Lombard Ave. Roosevelt Rd. (IDOT) and Gunderson Ave.**	**2012**
USA	Denville	NJ	Savage Rd. and Franklin Rd.	2000
USA	East Hampton	NY	Montauk Hwy. and Huntting Ln.	2012
USA	Dallas	TX	Cedar Springs and Reagan St.	2012
USA	Charlottesville	VA		Unknown
USA	Kirkland	WA		1997

* These installation dates are an estimate based on the best available information during the study period.

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[10] Federal Highway Administration (FHWA). 2008. *San Francisco PedSafe Phase II – Final Implementation Report and Executive Summary.* Report prepared by San Francisco Municipal Transportation Agency and University of California Traffic Safety Center. http://safety.fhwa.dot.gov/ped_bike/tools_solve/ped_scdproj/sf/pedsafety_sf.pdf

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Signal Phasing

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation


PUSH BUTTON
TO CROSS
START CROSSING
Watch For
Turning Cars
DON'T START
Finish Crossing
If Started
FLASHING
STEADY
PEDESTRIANS
SHOULD NOT BE
IN CROSSWALK

Table 1 - List of types of pedestrian signal phasing

Facility	Report Location
Exclusive Pedestrian Phase • Barnes Dance	In this facility report
Leading Pedestrian Intervals	In this facility report

Signal phasing is defined as the right-of-way, yellow change, and red clearance intervals in a cycle that are assigned to an independent traffic movement or combination of movements.[1] Typical signal phasing for pedestrians is concurrent with one or more vehicle phases, resulting in potential conflicts between crossing pedestrians and turning motorists. Two phasing options that can reduce these conflicts by separating pedestrian and vehicle movements are exclusive pedestrian phases and leading pedestrian intervals (LPIs).

Exclusive Pedestrian Phase

An exclusive pedestrian phase stops traffic in all directions so that pedestrians may cross through the intersection in any direction, including diagonally in a variance referred to as a Barnes Dance or pedestrian scramble. It is installed to provide added safety for pedestrians by prohibiting vehicular movement during the entire phase, eliminating all conflicts.[2] Exclusive pedestrian phases can be implemented at intersections having any number of legs or intersection angles.

Figure 1 - Barnes Dance at Jackson Boulevard and State Street in Chicago

Exclusive pedestrian phase crossings can effectively be used at locations where turning vehicles conflict with very high pedestrian volumes and when pedestrian crossing distances are short.[3] However, adding an exclusive pedestrian phase crossing has a direct trade-off of increasing pedestrian safety while decreasing motorist operations, and to a smaller extent, motorist safety as well. Pedestrian operations may decrease as well depending on how the signal is phased and applied.

Features

Common characteristics of an exclusive pedestrian phase crossing include the following:

- One phase that stops traffic in all directions, allowing pedestrians to cross the intersection at all legs, in all directions including diagonally.
- Pedestrian signals to notify pedestrians of the allowed crossing movements.
- Accessible pedestrian signals that provide information in non-visual formats, such as audible tones, speech messages, and vibrating surfaces.
- No turn on red signs for vehicular traffic.
- Signing, pavement marking, and pedestrian signals that indicate diagonal pedestrian crossings are allowed.

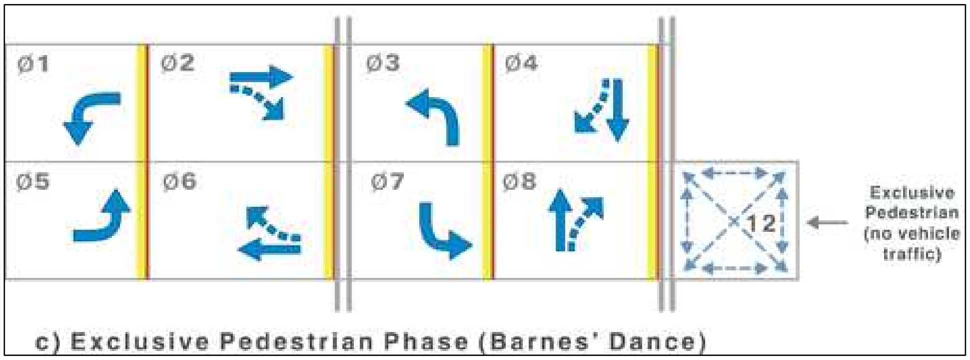


Figure 2 - Signal phasing for an exclusive pedestrian phase. Image: FHWA

Figure 3 - Barnes Dance at Jackson Boulevard and State Street in Chicago

Figure 4 - Barnes Dance at Green Street and Goodwin Avenue in Urbana, Illinois

Figure 5 - Intersection at 55th Street and Plainfield Road, a skewed intersection in Countryside, Illinois that has an exclusive pedestrian phase.

Crosswalk Markings

Crosswalk markings for an exclusive pedestrian phase crossing are similar to the markings at a standard crosswalk, with the exception of the additional diagonal markings for a Barnes Dance which are optional but useful for alerting pedestrians to the diagonal crossing option. "When an exclusive pedestrian phase crossing is used, crosswalk markings should be located so that the curb ramps are within the extension of the crosswalk markings."[1]

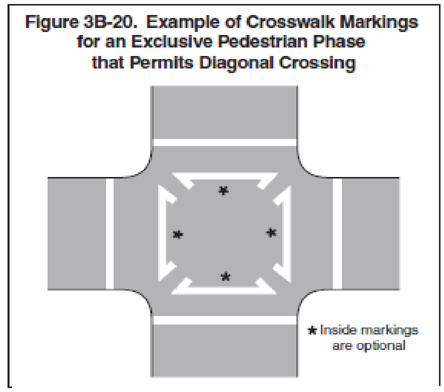


Figure 6 - Diagonal crosswalk markings for an exclusive pedestrian phase.

Signage

The addition of standard pedestrian/motorist regulatory signs can be important in defining crosswalk locations, providing warning in advance of a crosswalk, and reminding motorists to lawfully stop for crossing pedestrians. No turn on red signs (R10-11) should be considered for an exclusive pedestrian phase, according to Section 2B.54 of the MUTCD.

Figure 7 – Sign posted at a Barnes Dance indicating OK for pedestrians to cross diagonally.

Signalization

Signal cycles should be kept fairly short to minimize pedestrian delay, but wider intersections may require longer cycle lengths. Speed and volume of motor vehicles should be considered in signal timing calculations and decisions. Additional pedestrian signal heads can be added that face the diagonal pedestrian crossing movements.

Warrants

Based on review of The Safe Routes to School Guide and the Pedestrian Safety Guide, an exclusive pedestrian phase crossing should be considered at locations with high pedestrian volumes and low vehicle speeds and volumes.[4]

Costs

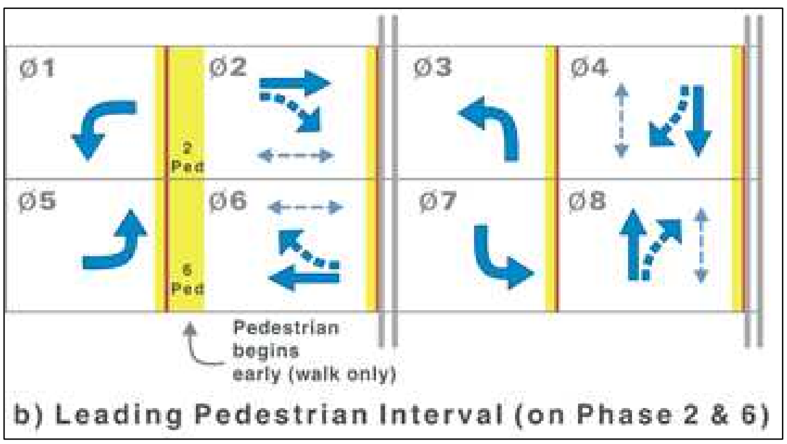
Barnes dance installations are relatively inexpensive as they use traditional striping and pedestrian signals. The pedestrian signals are often installed on existing poles and mast arms. Typical material upgrades are thermoplastic striping, no turn on red and diagonal crossing signage, and additional pedestrian signal heads facing the diagonal pedestrian crossing directions. All of these materials can be implemented for $5000 to $15,000 on average based on cost research by Bushell et. al. and the FHWA and based on 2012 dollars.[5,6] The cost of implementing the exclusive pedestrian phase only can be less, given work required is limited to changing the phasing and timing within the existing controller box.

$ | $5,000-15,000
Barnes Dance or All-Red Crossings

Leading Pedestrian Intervals (LPI)

Leading pedestrian intervals provide pedestrians a WALK signal before vehicle turning movements are allowed.[2] LPI's are most useful at intersections with high pedestrian volumes where motorists have difficulty finding gaps to turn during the green interval and at locations where pedestrian-vehicle conflicts are significant. An LPI "typically gives pedestrians a 3-7 second head start when entering an intersection with a corresponding green signal in the same direction of travel."[7] Intervals of up to 10 seconds may be appropriate when pedestrian volumes are high or crossing distance is long. Additionally, LPIs "should be at least 3 seconds in duration and should be timed to allow pedestrians to cross at least one lane of traffic."[1] Curb bump outs may also be installed at intersections to increase the effectiveness of the leading pedestrian phase.[7]

Lagging pedestrian intervals can also be used. They are similar to leading pedestrian intervals except that the interval starts several seconds after the parallel vehicle movement phase begins. Lagging pedestrian intervals are most useful at intersections with a high right-turning vehicle volume, where an exclusive right-turn lane is present, or when the two intersecting roads handle one-way traffic.[2]



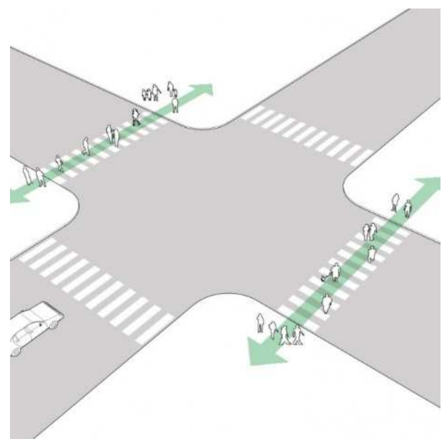


Figure 8 – Left: Signal phasing for leading pedestrian intervals. Image: FHWA 2015. Right: Leading pedestrian interval, depicting pedestrian crossing movements prior to parallel vehicular movements. Image from Urban Bikeway Design Guide, by NACTO. Copyright © 2014 National Association of City

Warrants

In order to maximize the safety and operation at intersections, a leading pedestrian interval best works at locations with the following features:[8]

- Any intersection where drivers make left turns without the need to yield to oncoming traffic (T-intersections for example).
- High presence of visibility issues
- Documented pedestrian safety issues
- High volume of pedestrian traffic
- High rate of documented collisions
- Near elementary schools
- Near a high level of activity by elderly residents.

Costs

The average cost for implementing an LPI is minimal as typically only signal timing and phase changes are required within the traffic controller box. According to Fayish, LPIs are a cost-effective strategy of reducing crashes due to the low cost, even if safety benefits are also minimal.[9]

$ <$1,000 Leading Ped Interval

Design Guidance

FHWA	Manual on Uniform Traffic Control Devices (MUTCD) Chapter 2B, Sections 2B.54, 3B.18, 4E.06 http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm
FHWA	Traffic Signal Timing Manual. Office of Operations. Section 4.5 - Pedestrian Phasing http://ops.fhwa.dot.gov/publications/fhwahop08024/index.htm
FHWA	FHWA Signalized Intersections Informational Guide. Section 9.1.5 – Modify Pedestrian Signal Phasing http://safety.fhwa.dot.gov/intersection/conventional/signalized/fhwasa13027/
Illinois Department of Transportation	IDOT BDE Section 57-4.11 - Traffic Signal Timing http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Design-and-Environment/Illinois%20BDE%20Manual.pdf
Illinois Department of Transportation	IDOT BLR Section 41-5.03 - Older Pedestrians http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Local-Roads-and-Streets/Local%20Roads%20and%20Streets%20Manual.pdf
AASHTO	Guide for the Planning, Design, and Operation of Pedestrian Facilities – Section 4.1.1 https://bookstore.transportation.org/item_details.aspx?id=119
ite	Designing Walkable Urban Thoroughfares: A Context Sensitive Approach - Chapter 10 - Intersection Design http://library.ite.org/pub/e1cff43c-2354-d714-51d9-d82b39d4dbad
NACTO	Urban Street Design Guide - Leading Pedestrian Interval http://nacto.org/publication/urban-street-design-guide/intersection-design-elements/traffic-signals/leading-pedestrian-interval/

Figure 9 - List of design guidance manuals and documents

SAFETY

Signal phasing, either through exclusive pedestrian crossings or leading pedestrian intervals, have positive safety benefits for pedestrians.

Figure 10 - Pedestrian walking outside the crosswalk due to a stopped motorist encroaching on the intersection. Located at the intersection of 55th Street and Plainfield Road in Countryside, Illinois that has an exclusive pedestrian phase.

Exclusive Pedestrian Phase Crossings

As mentioned earlier, exclusive pedestrians phase crossings eliminate the conflict between pedestrians and motorists by providing a pedestrian only phase that stops motorist traffic in all directions and that prohibit right turns on red. Pedestrians may cross through the intersection in any direction during the phase. Although recommended, if right turns on red are not restricted, then pedestrian and motorist conflicts still exist. [10]

There have been a number of studies examining the effectiveness of the exclusive pedestrian phase. Most of those studies researched the effectiveness of the Barnes Dance, where pedestrians are allowed and encouraged to cross the intersection diagonally through the use of pavement markings and signage. However, the data and findings from the Barnes Dance studies can still be useful and applicable to exclusive pedestrian phase crossings that do not incorporate the diagonal crosswalks. If diagonal crosswalks are used, adequate time should be given for pedestrians to complete the diagonal crossing during the exclusive phase. Slower moving pedestrians, especially elderly pedestrians, may become trapped in the intersection during the next signal phase if inadequate crossing times are provided.

Overall, the study results were generally positive, especially in regards to improving the safety of vulnerable road users such as pedestrians, which is the intended goal of the exclusive pedestrian phase. Impacts to pedestrian and vehicular crashes varied as explained in the studies below.

Public Involvement

A study in San Francisco by the San Francisco Municipal Transportation Agency and the University of California conducted a post-installation pedestrian intercept survey on Stockton Street. "Among over 150 respondents, 69.5% said they felt safer with the pedestrian scramble (Barnes Dance) phase in use. A strong majority favored the phasing change, with 72% saying they liked it 'very much.'"[11]

Conflicts & Crashes

CMF = 0.49

A study submitted to the 2012 TRB annual meeting and conducted in New York City showed that pedestrian crashes decreased by approximately 51% when an exclusive phase pedestrian crossing, Barnes Dance, was present, compared to decreasing by only approximately 9% when no treatment was present (CMF = 0.49).[12,13] Multiple vehicle crashes increased by 10% when a Barnes Dance was present, compared to decreasing by 12% when no treatment was present (the researchers did not elaborate on why vehicle crashes increased and they included the no-treatment change as a control). Thus it could be concluded from this study that adding a Barnes Dance has a direct trade-off of increasing pedestrian safety while decreasing motorist safety. The researchers suggest diverting traffic away from the Barnes Dance in areas with high traffic speeds and large volumes of pedestrians. Another study conducted at the Barnes Dance in Oakland, California, has shown that an exclusive pedestrian phase crossing may reduce vehicle-pedestrian crashes by as much as 50%.[14] FHWA also claims a crash reduction factor of 34% for Barnes Dances (CMF = 0.66) (This CRF was cited in an FHWA report but the source could not be found nor verified).[15]

Pedestrian Crashes w/Barnes Dance	-51%
Pedestrian Crashes w/o Barnes Dance	-9%
Vehicle Crashes w/Barnes Dance	10%
Vehicle Crashes w/o Barnes Dance	-12%

The San Francisco study mentioned earlier found the "total number of vehicle/pedestrian conflicts observed at Stockton Street Barnes Dance intersections decreased from 7.0% to 1.1%.[11] However, the proportion of pedestrians running or aborting their crossing increased at each intersection, in total from 5.3% to 11.2%." Crashes were also analyzed in the study but were too low for a rigorous statistical analysis. A FHWA PedSafe study in California found "auto/pedestrian collisions [decreased] by as much as 63% for the six intersections that maintained the pedestrian phase.[16] Data has suggested unequivocally that this project was a success. Further, overall collision in the Business Triangle were reduced by 20%."

Pedestrian Behavior

Another study by Eck & Illuri and West Virginia University was conducted at four signalized intersections in Morgantown, West Virginia that examined pedestrian behaviors, motorist delay and other operational effects of exclusive pedestrian phases. The researchers observed low activation rates of the Barnes Dance, although activation rates increased as traffic volumes, speed, and turning complexity increased.[17] For example, one of the intersections witnessed only 15% of the pedestrians activating the pushbutton for the exclusive phase which the researchers attribute to the short crossing distance. At another intersection with a longer crossing distance and high turning movement complexity, about 50% of pedestrians activated the pushbutton, indicating the exclusive phase may be unnecessary at low volume, low speed intersections. They also observed low usage of the diagonal crossing with only 4% or less of pedestrians crossing diagonally during the exclusive pedestrian phase. If the cycle length is 75

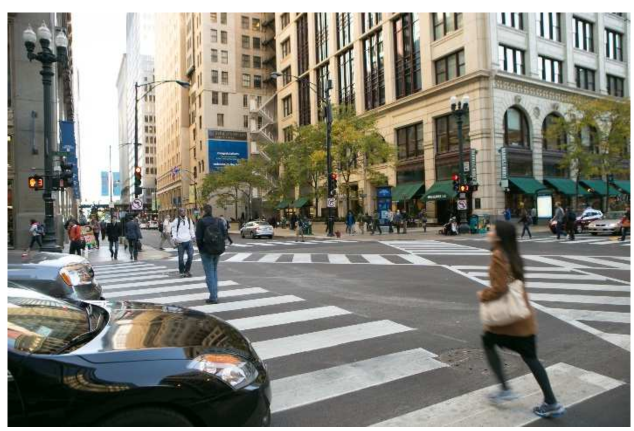


Figure 11 - Motorists encroaching on a crosswalk at the Barnes Dance at Jackson Boulevard and State Street in Chicago

seconds or greater, "pedestrian compliance with the pedestrian indication is negligible unless there are factors such as wide streets, high traffic volumes or complex turning movements that make it more difficult for pedestrians to cross during a gap in traffic or with the traffic signal." Therefore, the researchers conclude exclusive pedestrian phases should only be used in certain contexts.

Regarding compliance, one study suggests exclusive pedestrian phasing results suggests may have negative safety impacts for pedestrians. Barnes Dances "may potentially increase the risk for pedestrians by causing an increase in the red-walking frequency since the proportion of total cycle time allotted to pedestrians to cross an intersection decreases under the scramble system."[14] As stated in the overall findings, pedestrians weigh the potential hazard of crossing against how long they have to wait or the distance they need to cross. If the wait time is perceived as too long, some pedestrians may cross against the light. Another study by Kattan, Acharjee, and Tay found not only did Barnes Dance "timing implementation significantly reduced pedestrian/vehicle conflicts, but that it also led to a decrease in pedestrian compliance at the intersection" (exact compliance rates were not provided in the PBIC summary).[18,19] The previously mentioned Oakland study found post-installation pedestrian violations increased from 12 violations to 15 per every three minute interval (pedestrian violations were not defined in the study).

Visually Impaired Individuals

Exclusive pedestrian phases present challenges for visually impaired individuals because of the lack of traffic cues. Pedestrians with visual impairments depend to some extent on the audible cues created by moving traffic. During exclusive phases, all traffic is stopped and those individuals may have trouble navigating the intersection. The Virginia study recommends the use of accessible pedestrian signals (APS) to assist visually impaired individuals at exclusive phase intersections, even though APS did not have a significant effect on total pedestrian behavior.

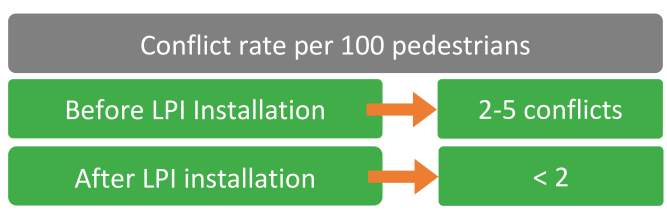
Leading Pedestrian Intervals (LPI)

The use of leading pedestrian intervals enhances the visibility of pedestrians in the intersection, reinforces pedestrian's right-of-way over turning motorists within the intersection, and reduces conflict between pedestrians and turning vehicles,[7] all of which contribute to reduced crashes and increased pedestrian safety. Also as mentioned earlier in the cost discussion, according to Fayish, LPIs are a cost-effective strategy of reducing crashes due to the low cost, even if safety benefits are also minimal.

Conflicts & Crashes

CMF = 0.63

PBIC highlighted a study by Fayish and Gross that calculated a CMF of 0.63 for LPIs.[20,21] Another before and after comparison group study conducted at ten signalized intersections in State College, Pennsylvania calculated a 58.7% reduction in pedestrian-vehicle crashes.[9] A study was conducted at three signalized intersections in downtown St. Petersburg, Florida. A leading pedestrian interval was created for each intersection which had an average pedestrian crossing rate of 60 pedestrians/hour. PBIC's summary of the study states that for pedestrians departing during the start of the WALK interval, "the sites averaged between two and three conflicts per 100 pedestrians, with some periods having up to five conflicts per 100 pedestrians. After the LPI was installed, 34 of the 41 sessions had no conflicts, and no session had more than two conflicts per 100 pedestrians."



PBIC summarized several studies regarding the safety of LPIs.[24] One by Van Houten, Retting, and Farmer concluded that the "introduction of a three-second LPI reduced conflicts between pedestrians and turning vehicles as well as reduced the incidence of pedestrians yielding the right-of-way to turning vehicles.[22] They also concluded that the signal phasing made it easier for pedestrians to cross the street. Another study in New York City by King, found the

LPI decreased collision occurrence and severity, especially at intersections with heavy turning volumes.[23] That study examined five years of before and five years of after data. A study in Anaheim, California by Hubbard, Bullock, and Thai stated that some benefits of LPIs do not necessarily carry over to suburban environments since they found mixed results regarding conflicts after the introduction of an LPI. See the PBIC research report for more detailed information.

Behavior & Compliance

Pedestrians also modified their behavior in the St. Petersburg study; the percentage of pedestrians yielding to vehicles declined, and pedestrians crossed more lanes during the 3 second leading pedestrian interval the longer the intervention was in effect, which PBIC claims can be attributed to "regular users discerning the presence of the LPI and modifying their behavior to utilize it to the fullest extent possible."[24]

At a study in Miami, Florida, Pecheux, Bauer, and McLeod found an increase in the percentage of left-turning motorists yielding to pedestrians in the crosswalk after installation of the LPI, with increases of 18% and 9% at two separate sites, (no change was recorded with right-turning motorists).[19,25] This study also found an increase in the percentage of pedestrians who crossed during the first four seconds, similar to the St. Petersburg study, with increases of 31% and 21% at the two study sites. The San Francisco found LPIs resulted in a decrease of motorists turning in front of pedestrians from 6.2% to 4%.[11] The study found LPIs one of the six most effective countermeasures out of the 13 studied.

OPERATIONS

Exclusive Pedestrian Phase Crossings

An exclusive pedestrian phase dedicates an additional phase for the exclusive use of all pedestrians, and is configured such that no vehicular movements are served concurrently with pedestrian traffic.[2] During this phase, pedestrians can cross the intersection in any direction, including diagonally at a Barnes Dance. Operations of an exclusive pedestrian phase crossing is dependent on signal timing which can be determined by the traffic volumes, traffic movements, and roadway geometry, including the length of the diagonal.[26] Exclusive pedestrian phase crossings may increase motorist delay and pedestrian wait times. However, to minimize delays, MDOT recommends limiting exclusive pedestrian phases to intersections with higher pedestrian volumes than motorist volumes, and where a significant portion of pedestrians would make a diagonal crossing (if considering Barnes Dances).[27] MDOT points out that the "increase in motorist delay may be balanced by a decrease in pedestrian delay" (depending on how the phases are arranged). There was also concerns in San Francisco about the effect of an exclusive pedestrian phase on transit lines. San Francisco found travel time, boarding times, and signal delay all were impacted negatively when an exclusive phase was implemented and instead preferred transit signal priority in this one instance.[11] The exclusive phase was removed. Furthermore, the San Francisco study highlighted the difficulties with "modeling and optimizing traffic flows during peak activity periods because there is so much friction from double parkers, parking maneuvers, bus maneuvers, and jaywalkers (plus a very distracting visual environment)," factors that are present in areas where Barnes Dances work best such as dense downtown streets. With that in mind, the following studies attempt to quantify the operational effects of the exclusive pedestrian phase.

Figure 12 - Pedestrians utilizing the exclusive pedestrian signal phase at a Barnes Dance located at the intersection of State Street and Jackson Boulevard in Chicago

Figure 13 - Motorist operations while pedestrian is waiting for the exclusive pedestrian signal phase at the Barnes Dance along Green Street at the intersection with Goodwin Avenue in Urbana, Illinois

A "before" and "after" study was conducted by the University of California, Berkley, using guidelines for the installation of Barnes Dances (all red traffic phase) in China Town in Oakland, California, at the intersection of 8th Street and Webster Street." The study concluded that Barnes Dance signals are "beneficial only when both the pedestrian and vehicular volumes are better than LOS C." The study defines pedestrian LOS C as space that is "sufficient for normal walking speeds and for bypassing other pedestrians in primarily unidirectional streams. Reverse direction crossing movements can cause minor conflicts and speeds and flowrates are somewhat lower. According to the study, vehicle LOS C means the "ability to pass or change lanes is not assured. Most experienced motorists are comfortable, and posted speed is maintained, but roads are close to capacity. This is often the target LOS for urban highways." Furthermore, "If the volumes on approach arms are below LOS C, then a conventional system is better off. Beyond the prescribed threshold (vehicle and pedestrian volumes at LOS C), [Barnes Dance] signal performs much better than the conventional system. At these criteria, [Barnes Dance] signals are able to considerably reduce the travel time, delays and number of stops at the intersection. This in turn helps to increase the overall pedestrian and vehicle speeds at the intersection and to reduce the extent of blocking-back."[28]

A major study was conducted in 1987 by the Federal Highway Administration in Beverly Hills, California. Capacity analysis was conducted to determine the LOS of each intersection before and after implementation of the exclusive phase. All but two of the intersections experienced a change in the LOS that was still acceptable. The two intersections with a failing LOS were removed and the remaining six were still in use as of 2012.[16]

Motorist speeds actually increased in the San Francisco study on the side streets, which the authors contribute to decreased delays due to lagging pedestrians.[11] Speeds on the main street increased 44% northbound and 40% southbound. Turning vehicle delays decreased by 79% and delay caused by pedestrians decreased to near zero seconds. In the Morgantown, Virginia study, the low volumes of crossing pedestrians and low usage rates of the exclusive phase, when activated, resulted in lost time at many intersections.[17] There were no crossing pedestrians during approximately 75% of the exclusive pedestrian phases partly due to some pedestrians having already completed their crossing by jumping the signal. The researchers recommend additional study to determine the exact amount of increased delay caused by exclusive phases compared to the predicted safety benefits as well as careful scrutiny on where to install exclusive phases

Pedestrian Delay

As mentioned briefly in the safety section, pedestrian wait times may increase with the installation of an exclusive phase, depending on if only exclusive phases are used (and no concurrent phases in between), or if both concurrent and exclusive phases are used. Pedestrian wait times may become so great that some pedestrians may jaywalk and cross against the signal, leading to unused, lost time during the exclusive phase (in addition to the negated safety benefits of the phase). On the other hand, the exclusive phase needs to have a longer crossing time than concurrent phases due to the longer distance within the diagonal crossing.

Leading Pedestrian Intervals (LPI)

A leading pedestrian interval is implemented by adjusting the signal timing to provide a WALK display of 3-7 seconds prior to the vehicle green display for that direction of travel. Overall, LPIs have similar operational considerations as exclusive pedestrian phases with the exception that the concurrent motorist phase is allowed to proceed after a shorter wait time, typically only three seconds. Allowing pedestrians a head start in the crosswalk has minimal effect on turning motorists given that they would normally have to wait for the pedestrian to clear their half of the roadway to proceed.

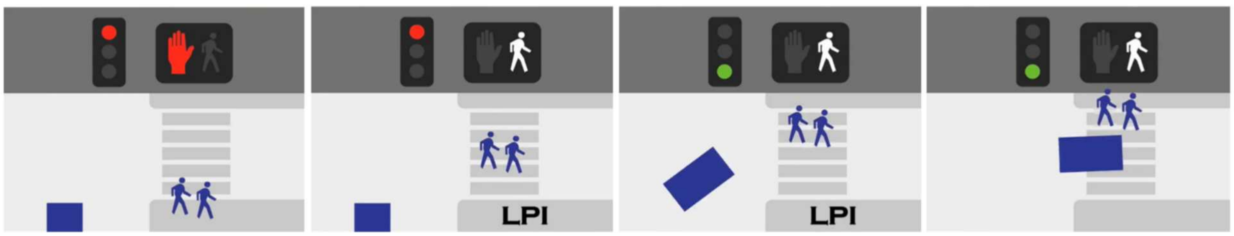


Figure 14 - Stages of LPI progression. Reprinted with permission: www.streetfilms.org

MAINTENANCE

Maintenance of signal phasing and timing is a part of any routine traffic signal maintenance program. The monitoring of signal timing for exclusive pedestrian phasing or leading and lagging pedestrian intervals should be conducted on a continuous basis with regular timing updates, field inspections, continuous maintenance of traffic signal systems, and communications identifying problems or issues. Adjustments to phasing and timing can be based on vehicular and pedestrian volumes, time of day, intersection geometry, and crossing distances.

For the Barnes Dance, the diagonal crosswalk markings require special attention to debris removal, snow removal, and restriping of pavement markings. Maintenance of signs are also important because of the novelty of the facility. If signs are unreadable, pedestrians will not feel confident using the diagonal walk, and motorists might not comply with right turn on red restrictions. Unlike traditional crossings, users might not be familiar with this facility, thus making clarity of pavement markings and signs essential to its effectiveness.

Figure 15 - Partially snow-covered crosswalks at the Barnes Dance at State Street and Jackson Boulevard in Chicago. The diagonal crosswalk markings have worn out and are not noticeable in the photo.

Street Sweeping & Snow Removal

Since a Barnes Dance typically includes crosswalks on all intersection legs as well as diagonally through the intersection, keeping the pavement markings clear of debris and snow is important to maintaining the usefulness of the facility. Faded pavement markings contribute to confusion at the intersection. For instance, pedestrians may not feel confident crossing diagonally if the pavement markings have faded. Furthermore, like traditional intersection crossings, ramps and sidewalks should be kept clear of snow and plows should avoid pushing snow off of the roadway onto the adjacent sidewalks. Figure 15 shows a Barnes Dance intersection with faded diagonal markings and snow obstructing any remaining markings. No pedestrians were witnessed using the diagonal portion during the exclusive phase as a result. However, when the intersection was restriped and clear of snow, staff observed many pedestrians using the diagonal crossing. Snow removal from exclusive pedestrian phase crossings can be done with traditional snow plows.

Utility Cuts and Construction Damage

Although rare, utility relocation may be required at exclusive pedestrian phase crossing locations. Most existing crosswalks do not contain manholes or other utility access points, and do not impact underground utility lines. During utility repairs exclusive pedestrian phase crossings may be impacted, but IDOT and most municipal utility policies require restoration to existing conditions by the utility owners. Utility companies may require additional information or guidance on proper repair, and work should be inspected following replacement.

District One Studies

The following is a summary of findings from three studies performed by IDOT in 2014, for the purpose of providing research and data for this feasibility study. Details of each of the studies are included in this report.

Table 2 - Summary of IDOT District One Studies, 2014

Study	Summary of Findings
Pedestrian Survey (Barnes Dance)	Overall, the responses from the surveys indicated that most pedestrians felt safer and more comfortable using a Barnes Dance with an exclusive pedestrian phase crossing (84.4%), and had an overall positive opinion.
Motorist Compliance and Pedestrian Behavior (Barnes Dance)	Pedestrian behavior was recorded at the Barnes Dance, with only 5.6% of pedestrians either leaving the curb before the beginning of the exclusive pedestrian phase, walking outside the pavement markings, or walking after the end of the exclusive pedestrian phase. Only 35.4% of pedestrians crossed through the intersection diagonally. Motorist non-compliance was also recorded with only 3.4% of motorists driving through the yellow signal, and less than 1% of motorists driving through the red signal.
Crash Analysis	A crash analysis was performed at the following locations in District One and in District Four: State Street and Jackson Boulevard in Chicago and Green Street and 6th Street in Urbana, Illinois. Ten total crashes were recorded at the two sites between 2005 and 2013. At the intersection in Urbana, there was no crash data available before the implementation of the exclusive pedestrian phase crossing. At the intersection in Chicago, there was no crash data available after the implementation of the exclusive pedestrian phase crossing. Therefore, no crash trends could be determined.

Pedestrian Survey – Barnes Dance

Pedestrian surveys for the Barnes Dance were conducted at the same intersection chosen for the motorist compliance and pedestrian behavior study. The purpose of the pedestrian survey was to determine the perceived effectiveness of the Barnes Dance facility.

Site Conditions

The in-person surveys for the study location were conducted on September 3, 2014 from 11:00 a.m. to 1:00 p.m. at the Barnes Dance along Green Street at the intersection with Goodwin Avenue in Urbana, Illinois. Green Street is a two-way east-west minor arterial with an ADT of 11,200 (west of Goodwin Avenue) and 5,400 (east of Goodwin Avenue) and a speed limit of 25 mph at the facility location. Goodwin Avenue is a two-way north-south major collector with an ADT of 5,000 (north of Green Street) and 5,700 (south of Green Street) and a speed limit of 25 mph at the facility location. During the survey, the weather condition was sunny with a temperature of 81°. Online surveys were open and available for a two week period.

Survey Method Two staff members stood at opposite corners of the intersection. Both staff members were wearing safety vests for safety purposes and to attract the attention of pedestrians. The staff member would approach pedestrians asking them if they would like to take a survey. They were given the option of taking the survey in person or online at their convenience. The online survey was open for two weeks, and the submissions were analyzed to remove any multiple submissions from the same person.

Survey Questions

Participants were asked the questions listed below in Table 3.

Table 3 - Survey questions and corresponding figure numbers

Figure #	Questions Asked
16	What is your gender?
17	In what age group do you fall?
18	What best describes why you are out here today?
19	In the past month, about how often have you used this crossing as a pedestrian?
20	In the past month, about how often have you driven through this intersection as a motorist?
21	Which answer best describes what an Illinois motorist must do when approaching a crosswalk?
22	Are you aware that diagonal pedestrian crossings are allowed at the intersection of Green Street and Goodwin Avenue?
23	Do you feel this intersection is easy to understand?
24	How safe and comfortable do you feel when using this exclusive phase pedestrian crossing at the intersection of Green Street and Goodwin Avenue?
25	Do you have any suggestions or comments regarding diagonal pedestrian crossings like this one?

Survey Results

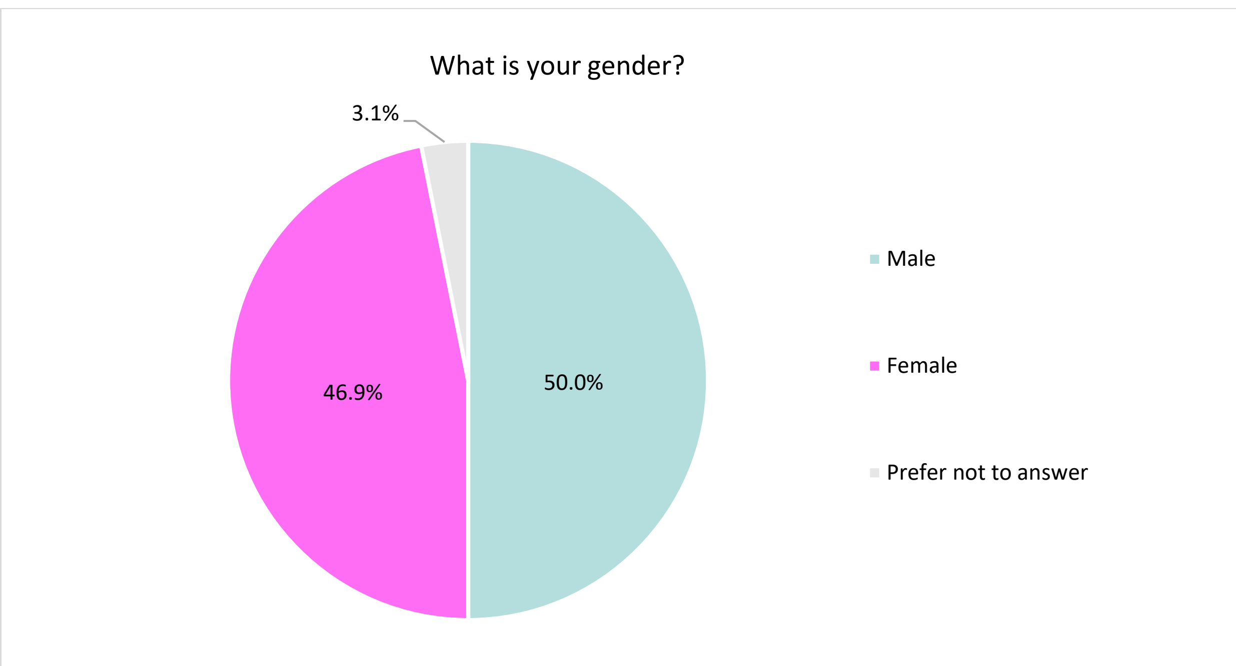


Figure 16 - What is your gender?

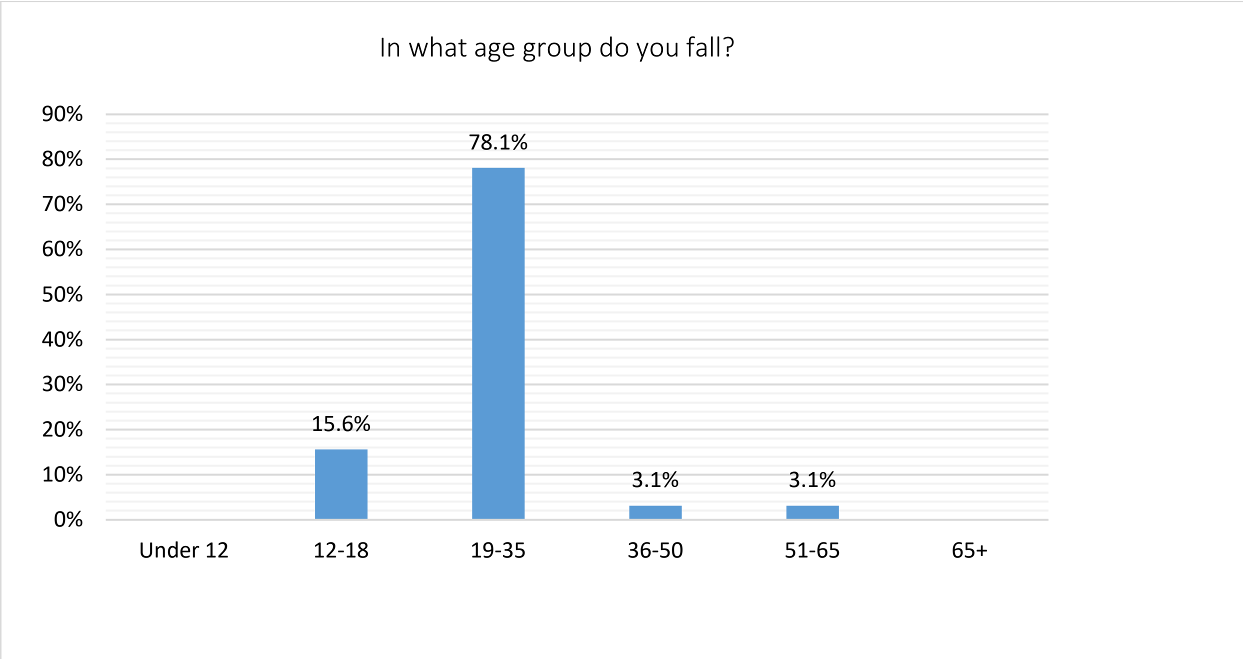


Figure 17 – In what age group do you fall?

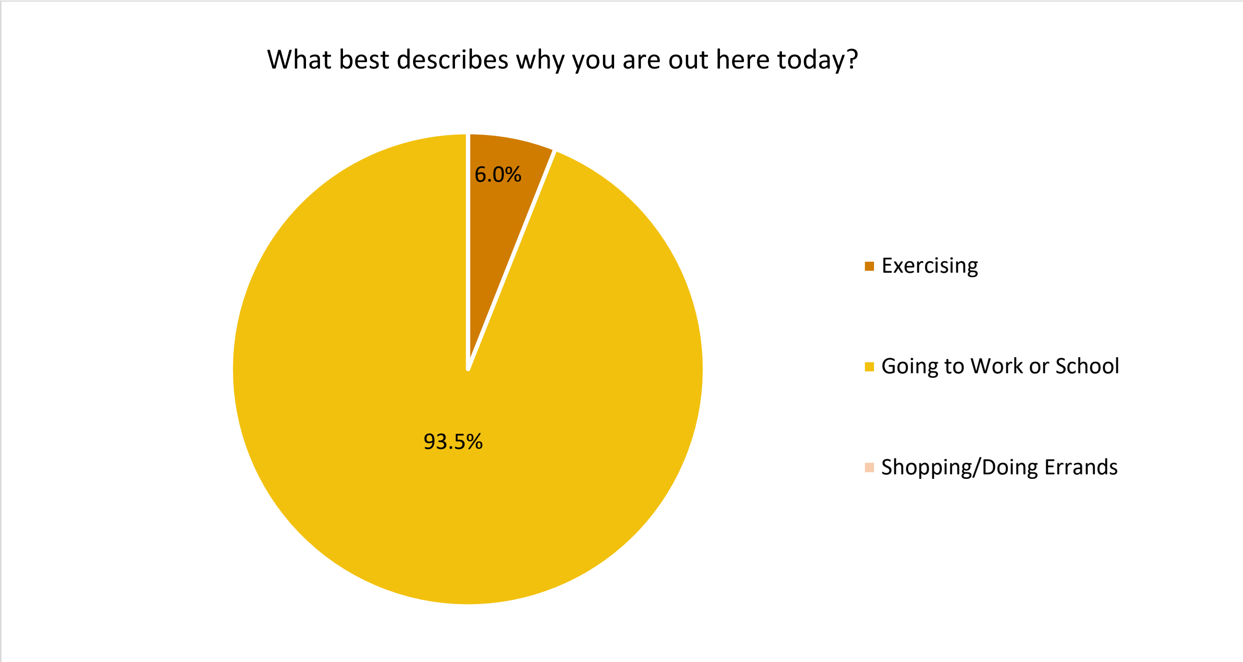


Figure 18 - What best describes why you are out here today?

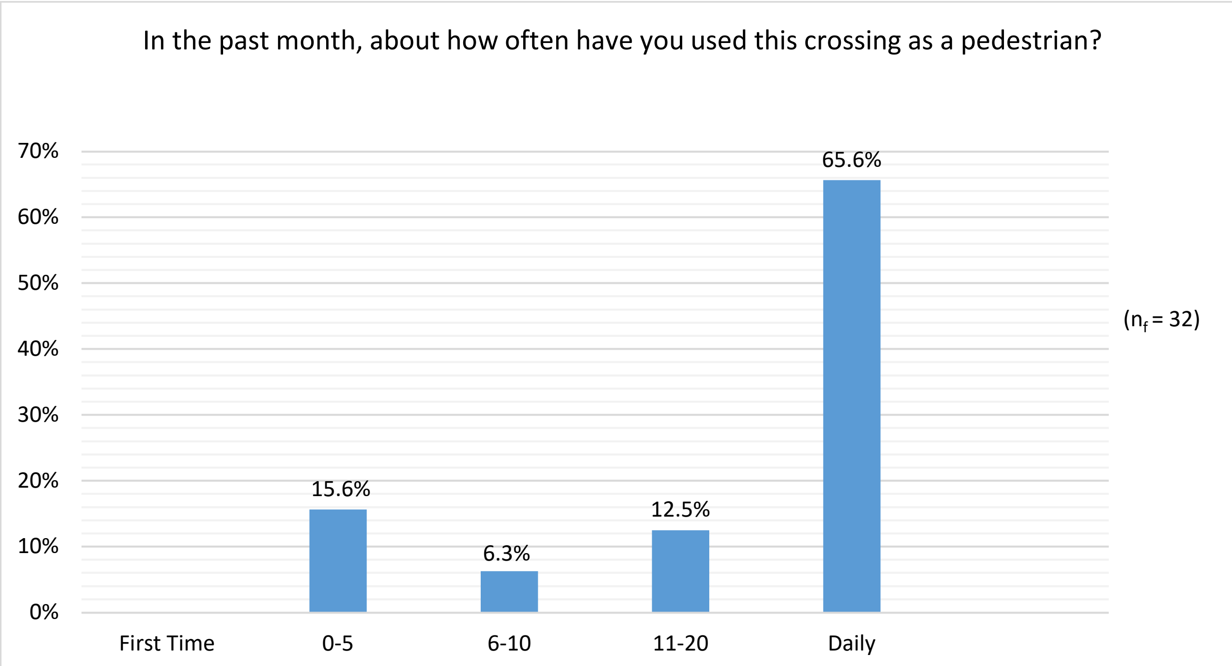


Figure 19 - In the past month, about how often have you used this crossing as a pedestrian?

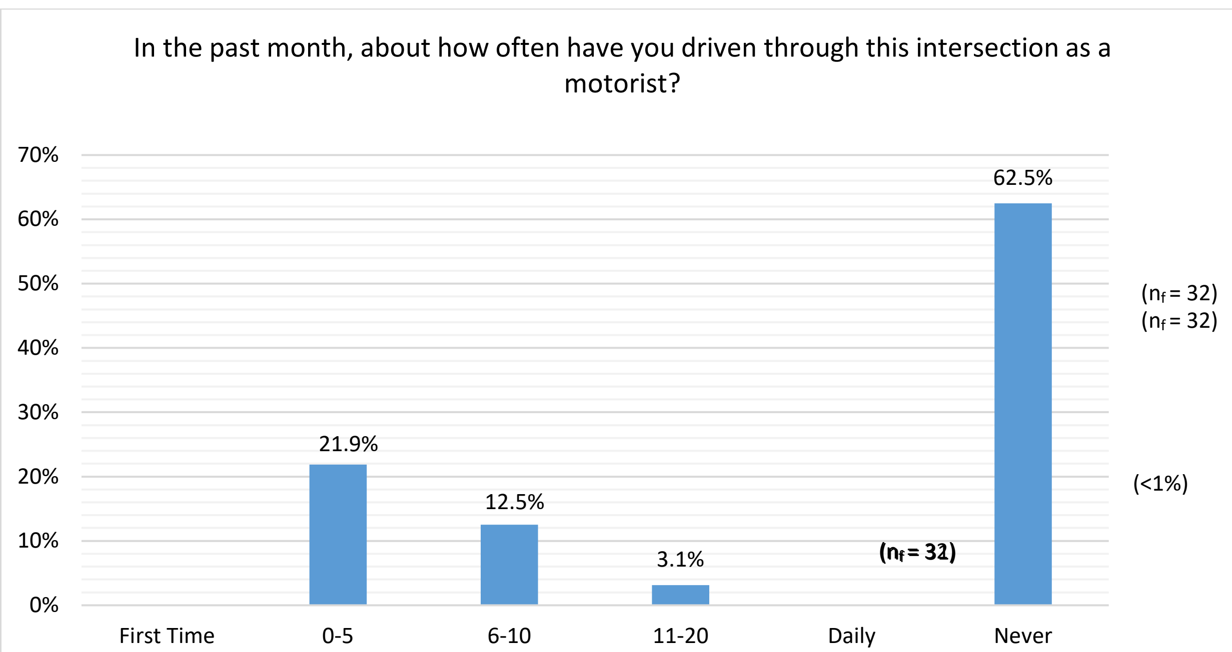


Figure 20 - In the past month, about how often have you driven thought this intersection as a motorist?

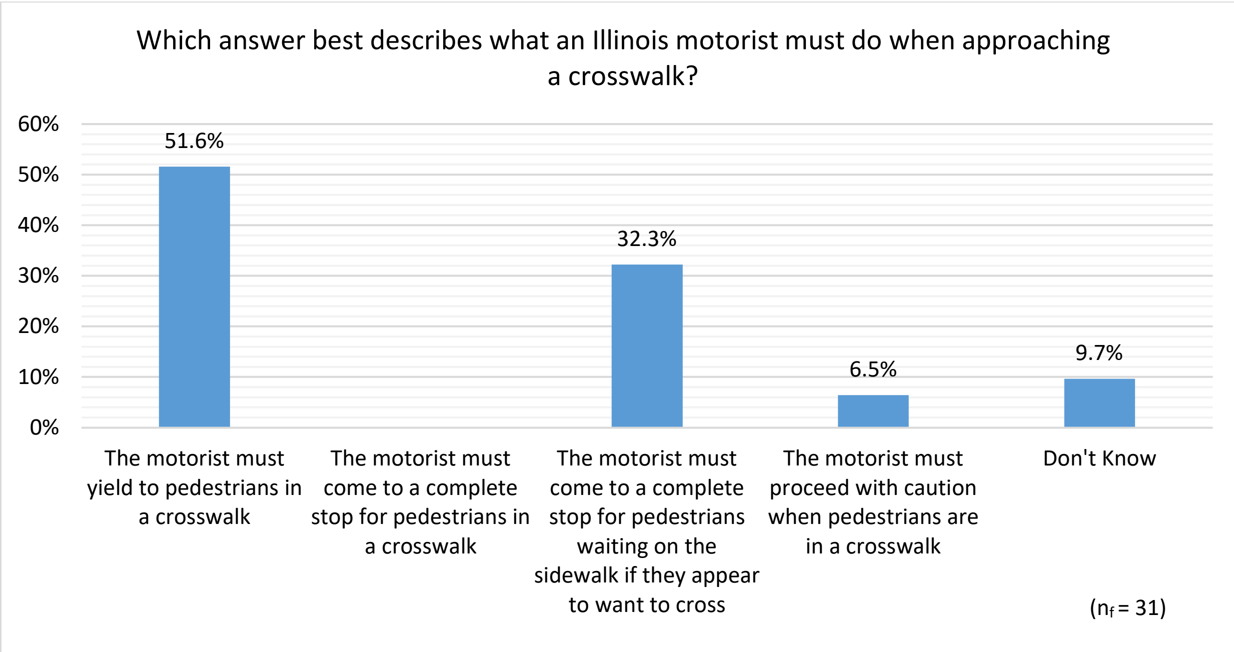


Figure 21 - Which answer best describes what an Illinois motorist must do when approaching a crosswalk?

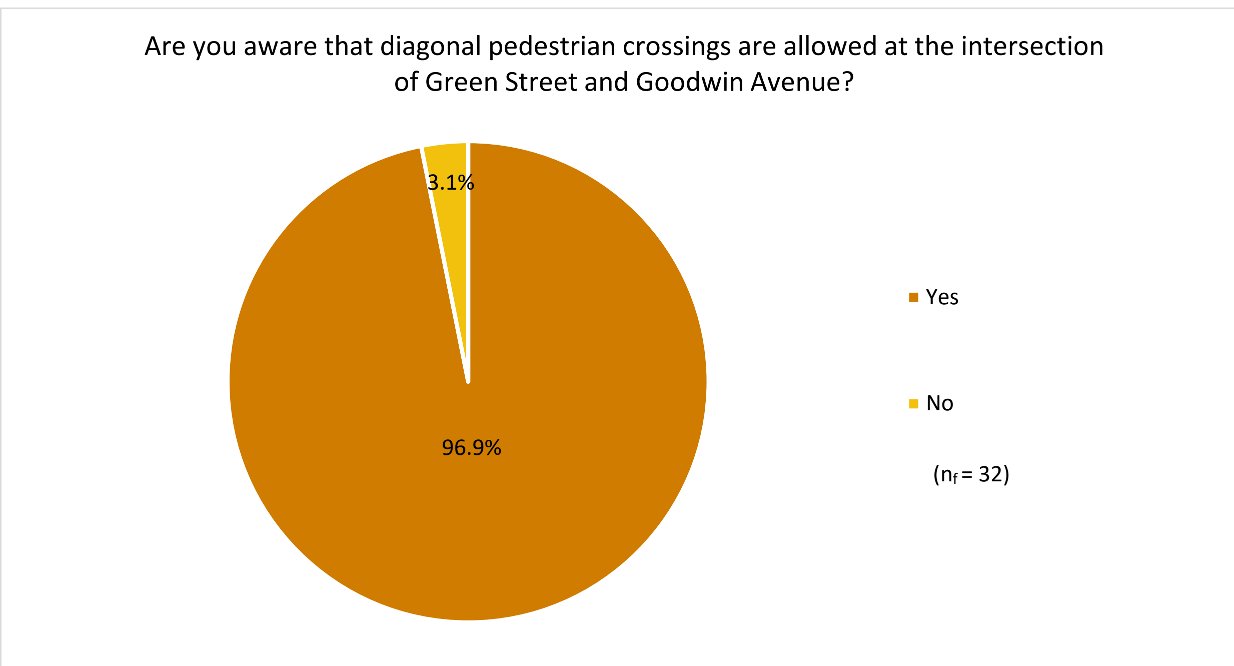


Figure 22 - Are you aware that diagonal pedestrian crossings are allowed at the intersection of Green Street and Goodwin Avenue?

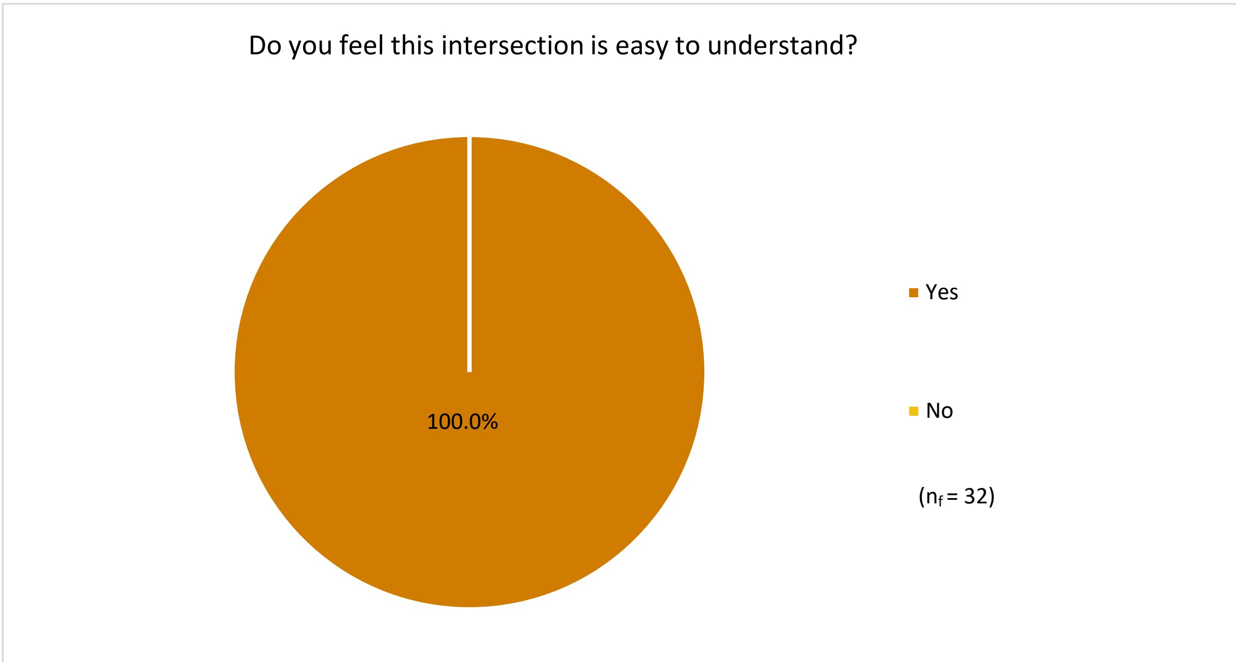


Figure 23 - Do you feel this intersection is easy to understand?

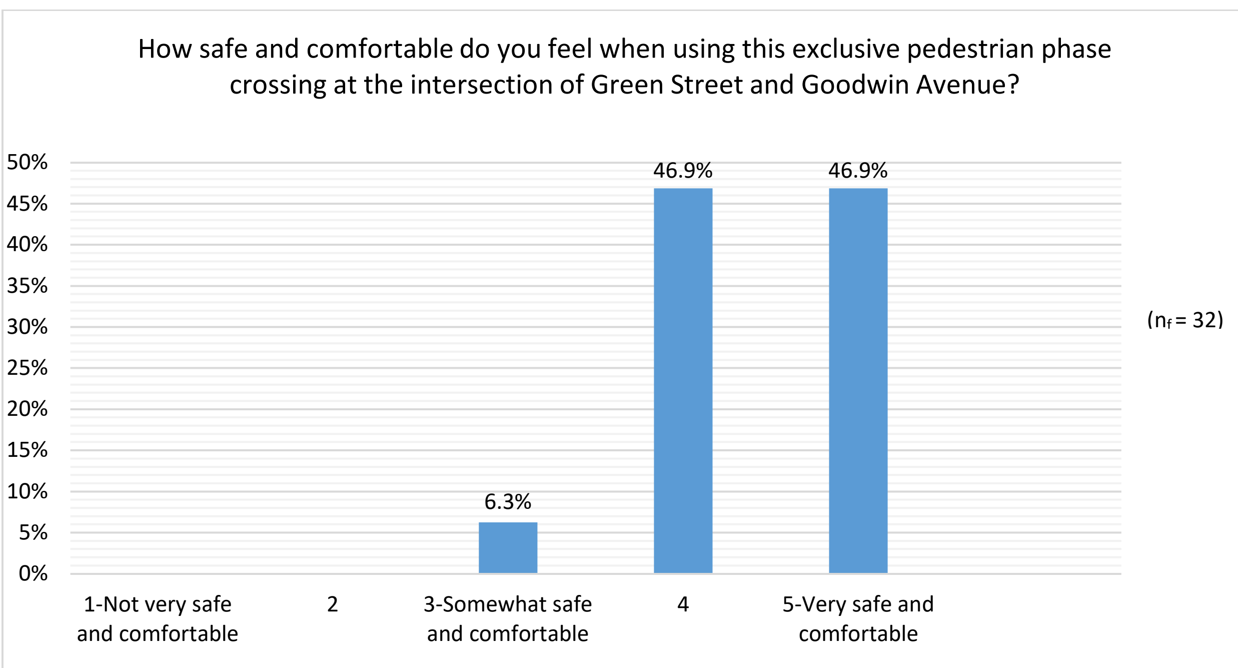


Figure 24 - How safe and comfortable do you feel when using this exclusive pedestrian phase crossing along Green Street at intersection with Goodwin Avenue in Urbana, Illinois, on a scale of 1-5 (1-not very, 3-somewhat, 5-very)?

Participants were given the opportunity to voice their opinions about the diagonal pedestrian crossings. The opinions were categorized and shown below in Figure 25.

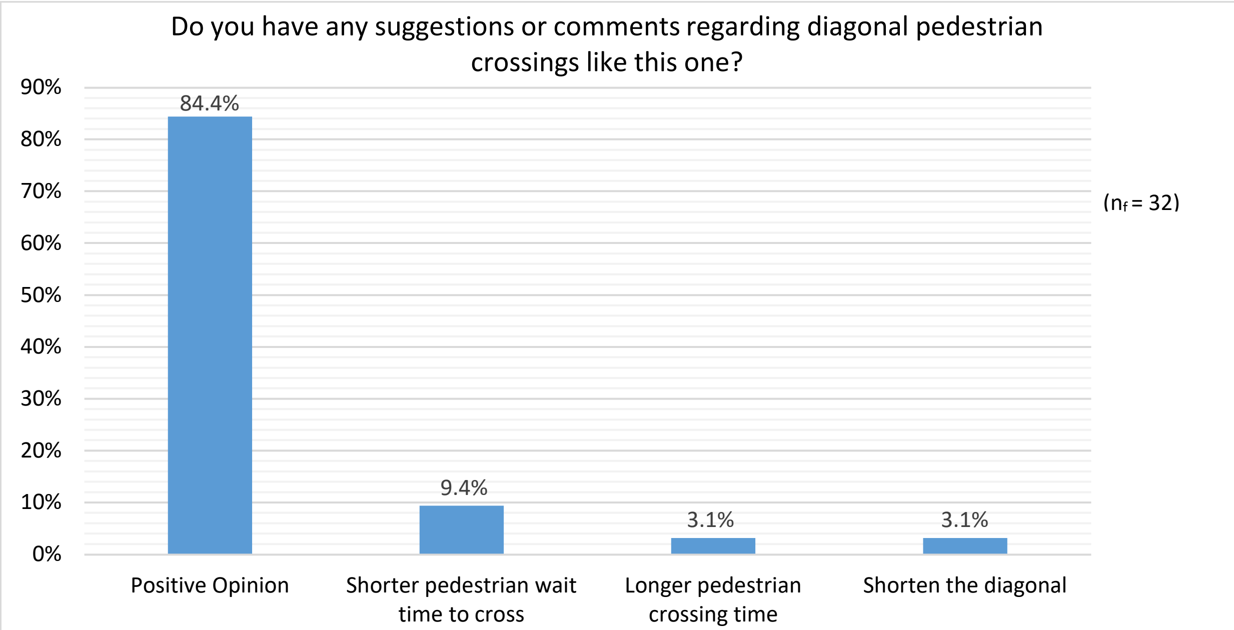


Figure 25 - Do you have any suggestions or comments regarding diagonal pedestrian crossings like this one?

Discussion

For the Barnes Dance in Urbana, Illinois, 27 paper surveys were completed and five online surveys were completed. The majority of participants said they were "Going to work or school", which is consistent with the intersection's location in a heavily populated pedestrian commuter area near the University of Illinois. It appears that most participants frequent the area regularly as pedestrians, not as motorists, with 60% of the participants using the facility daily as a pedestrian. Only one participant was not aware that she could cross diagonally at the Barnes Dance. However, this individual may have never walked or driven through this intersection. All of the participants surveyed felt that this intersection was easy to understand, and the majority of the participants using this facility gave a safety rating indicating that they felt very safe and comfortable, or somewhere in between somewhat safe and comfortable and very safe and comfortable.

When participants were asked what an Illinois motorist must do when approaching a crosswalk, approximately half answered "the motorist must yield to pedestrians in a crosswalk." This response was incorrect and followed previous Illinois Law before it was revised four years ago. Approximately one third of the participants answered "the motorist must come to a complete stop for pedestrians waiting on the sidewalk if they appear to want to cross". This response was also an incorrect response according to Illinois law. Overall, none of the participants knew what Illinois motorists must do when approaching a crosswalk. Illinois law states that the motorist must come to a complete stop for pedestrians in a crosswalk.[29]

Participants were given the opportunity to voice their opinions on the Barnes Dance. Of the participants surveyed, 27 of the participants' responses were positive feelings towards the Barnes Dance, with a few suggestions on how improvements could be made. Several participants mentioned that they would like to have shorter pedestrian wait times to cross the street, one participant would like longer pedestrian crossing times to cross the street, and one participant's response was omitted, since shortening the diagonal can't be accomplished.

Conclusion

The surveys indicated that the majority of pedestrians felt safe and comfortable when using the Barnes Dance crossing and had a positive opinion regarding the diagonal crossings.

Motorist Compliance and Pedestrian Behavior Study – Barnes Dance

A pedestrian and motorist behavior study was conducted for the purpose of gaining further information and knowledge about the performance of the Barnes Dance exclusive pedestrian phase crossing. This study compares a corridor with a Barnes Dance facility already in-place against results from existing studies. The Barnes Dance is located at the intersection of Green Street and Goodwin Avenue in Urbana, Illinois, and was the same location chosen for the pedestrian survey.

Site Conditions

The motorist behavior field study was conducted on September 3, 2014 from 4:00 p.m. to 6:00 p.m. Green Street is a two-way east-west minor arterial with an ADT of 11,200 (west of Goodwin Avenue) and 5,400 (east of Goodwin Avenue) and a speed limit of 25 mph. Goodwin Avenue is a two-way north-south major collector with an ADT of 5,000 (north of Green Street) and 5,700 (south of Green Street) and a speed limit of 25 mph. During the survey, the weather condition was mostly sunny with temperatures in the lower 70's. The crosswalk surface and pavement markings appeared to be in good condition.

The pedestrian behavior field study was conducted on September 3, 2014 from 7:30 p.m. to 9:30 p.m. During the survey, the weather condition was mostly sunny with temperatures in the lower 80's. The crosswalk surface and pavement markings appeared to be in good condition.

Study Method

A spot study was performed at the study location. During the data collection period, the staff members positioned themselves in inconspicuous locations, at the northeast and southwest corners of the intersection, where they had a clear field of vision in all directions. They were dressed in a manner designed not to draw attention or distract motorists or pedestrians. For this study, one staff member focused on vehicle counts, pedestrian counts, and noncompliance, in one direction, while the other staff member focused on vehicle counts, pedestrian counts, and noncompliance in the opposite direction. The light that was active when the motorist or bicyclist passed through the intersection was recorded. The four signal conditions studied were 1) green, 2) yellow after green, 3) red (after yellow), and 4) running the red light. The red (after yellow) condition meant the light turned red as the road users were already travelling at speed during the yellow phase. Running the red light meant the user was at a stop during a red phase and then accelerated through the intersection during the red phase.

Figure 26 - Exclusive pedestrian phase crossing on Green Street at the intersection with Goodwin Avenue in Urbana, Illinois

Motorist Behavior

Staff recorded 1,927 vehicles for left-turn, right turn and through movements on each leg. The results are summarized below in Figure 27.

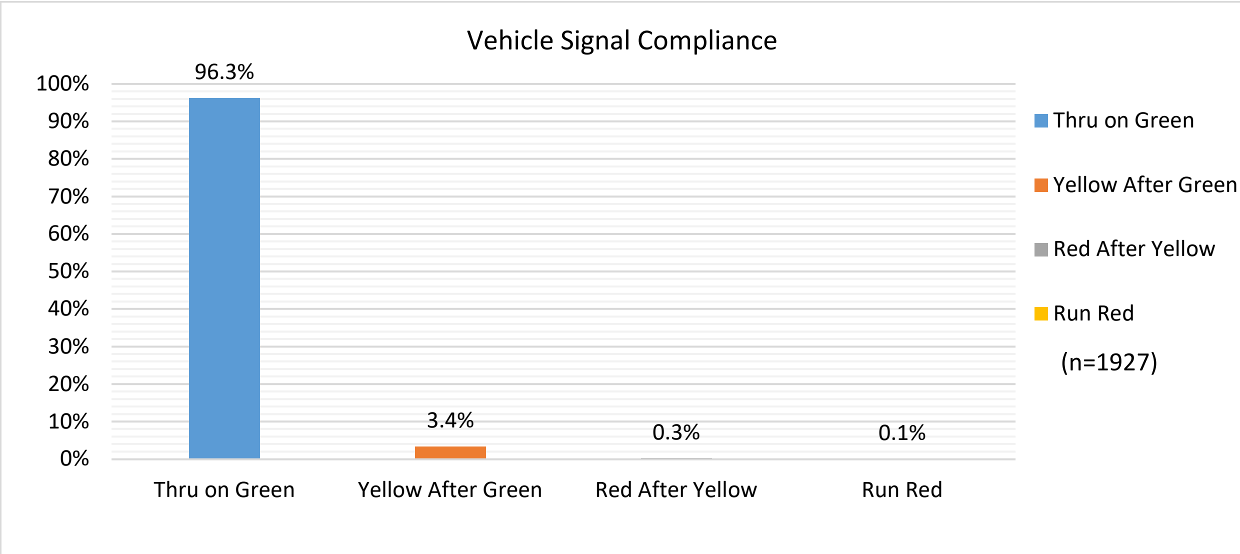


Figure 27 - Motorist behavior – vehicle signal compliance

Pedestrian Behavior

Pedestrian behavior recorded pedestrians using the facility properly. Recorded behavior included any pedestrian that left the curb before the signal change, any pedestrian that walked outside the pavement markings, and any pedestrian that walked after the signal had changed. The signal has multiple phases, with two pedestrian concurrent phases, and one phase being an exclusive pedestrian phase that lasts for 30 seconds, with a 15 second audio & visual countdown at the end of the phase.

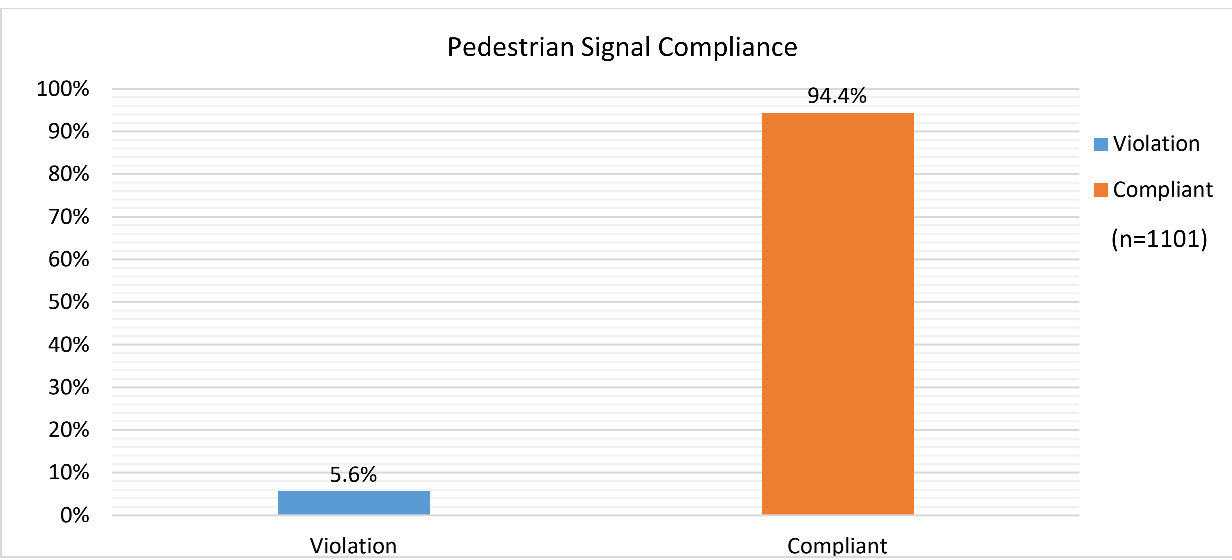


Figure 28 - Pedestrian behavior – pedestrian signal compliance

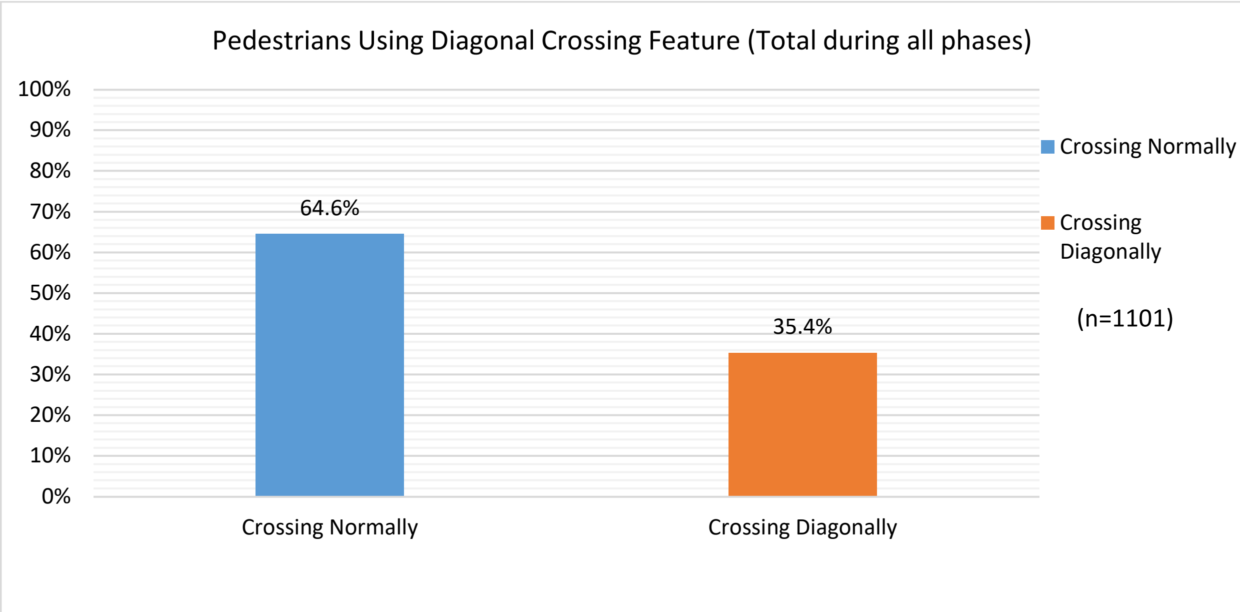


Figure 29 - Pedestrians using diagonal crossing feature

Discussion

Of the 1,927 vehicles recorded driving through the exclusive phase pedestrian crossing (Barnes Dance) along Green Street at the intersection with Goodwin Avenue, only nine vehicles were non-compliant with the signals, eight vehicles driving through the red signal (0.4%), and one vehicle (0.1%) driving through the red signal after stopping (running the red). Of the 1101 pedestrians recorded using the exclusive phase pedestrian crossing (Barnes Dance), only 62 pedestrians (5.6%) were noncompliant with the signals. Of the 1101 pedestrians that were recorded crossing through the intersection, 390 of those pedestrians (35.4%) crossed through the intersection diagonally. While conducting the study, staff members observed that at least one pedestrian pushed the pedestrian activation button during each phase.

On April 25, 2012, during the same time period before the Barnes Dance intersection was installed, 857 pedestrians were recorded crossing through the intersection using a Miovision system.[30] From 2012 to now, this represents a 22.2% increase in pedestrian usage of this intersection.

Conclusion

This exclusive pedestrian phase crossing (Barnes Dance) along Green Street at the intersection with Goodwin Avenue, was the most recent of three Barnes Dance facilities installed along the Green Street corridor. Based on the high percentage of compliance by both pedestrians and motorists, it can be concluded that the majority of people using this facility already have a good understanding of how an exclusive phase pedestrian crossing (Barnes Dance) operates. Because of the other two adjacent exclusive phase pedestrian crossings (Barnes Dance facilities) that have already been in use for an extensive period of time, this may have contributed to the high compliance rates at the Green Street location.

Crash Analysis – Barnes Dance

As part of this Feasibility Study, a crash analysis was performed for the following locations in two regions of the Illinois Department of Transportation (IDOT):

- State Street/Jackson Boulevard in Chicago (District One)
- Green Street/6th Street in Urbana, Illinois (District Four)
- Green Street/Goodwin Avenue in Urbana, Illinois (District Four)
- Green Street/Wright Street in Urbana, Illinois (District Four)

Eight total crashes were recorded at the one site in District One and two total crashes were recorded at one of the three sites in District Four between 2005 and 2013. At the intersection in Urbana, there was no crash data available before the implementation of the exclusive pedestrian phase crossing (Barnes Dance). At the intersection in Chicago, there was no crash data available after the implementation of the exclusive pedestrian phase crossing (Barnes Dance). Therefore, no crash trends could be determined.

There are numerous exclusive pedestrian phase crossings in use throughout the United States and Canada, including a Barnes Dance in downtown Chicago. The Barnes Dance facility has been used in both Vancouver, British Columbia and Kansas City, Missouri since the early 1940's followed shortly thereafter in Denver with the installation of several in the city's central business district.[31] However, Denver removed all of 45 their Barnes Dance facilities in 2011 in order to accommodate longer trains on their light rail system.[32] Nevertheless, numerous cities throughout the United States recently began constructing exclusive pedestrian phase crossings again. Illinois currently has four Barnes Dance intersections, including three in Urbana, with the most recent facility installed in 2014, and one constructed in Chicago in 2013. Another type of exclusive pedestrian phase crossing, the all-red, four-way pedestrian crossing, has been installed in approximately 25 States.

Table 4 - Examples of exclusive pedestrian phase crossing locations in North America, with locations in District One and Illinois shown in bold text.

Country	City/County	State	Intersection	Install Year
Canada	London	Ontario	Clarence St. & King St.	1960's
Canada	Toronto	Ontario	Young St. & Dundas St.	Unknown
Canada	Quebec City	Quebec	Various locations	Unknown
USA	Beverly Hills	California	Brighton Way & Canon Dr.	1987
USA	Beverly Hills	California	Brighton Way & Rodeo Dr.	1987
USA	Beverly Hills	California	Brighton Way & Beverly Dr.	1987
USA	Beverly Hills	California	Brighton Way & Camden Dr.	1987
USA	Beverly Hills	California	Brighton Way & Bedford Dr.	1987
USA	Beverly Hills	California	Dayton Way & Canon Dr.	1987
USA	Beverly Hills	California	Dayton Way & Beverly Dr.	1987
USA	Beverly Hills	California	Dayton Way & Rodeo Dr.	1987
USA	Los Angeles	California	Rodeo Dr. & Brighton Way	Unknown
USA	Los Angeles	California	Westwood Blvd. & La Conte Ave.	Unknown
USA	Oakland	California	8th St. and Webster St.	Unknown
USA	San Diego	California	5th Ave. & Market St.	2003
USA	Washington	District of Columbia	7th St. & H St.	2010
USA	**Chicago**	**Illinois**	**State St. & Jackson Blvd.**	**2013**
USA	**Urbana**	**Illinois**	**Green St. & S. 6th St.** **Green St. & S. Wright St.** **Green St. & Goodwin Ave.**	**2002** **2002** **2014**
USA	**Countryside**	**Illinois**	**55th St. & Plainfield Rd.**	**2010/2013**
USA	Ann Arbor	Michigan	Main St. & Stadium Blvd.	Unknown
USA	Reno	Nevada	Virginia St. & 2nd Ave.	Unknown
USA	New York	New York	Vesey St., Broadway, Park Row, and Ann St.	Unknown
USA	Akron	Ohio	E. Exchange St. and Grant St.	2013
USA	Pittsburg	Pennsylvania	Craig St. and Center Ave.	Unknown
USA	Pittsburg	Pennsylvania	Various streets	Unknown

USA	Seattle	Washington	Beacon St. and 15th Ave.	Unknown
USA	Seattle	Washington	108th NE near the transit center in Bellevue	Unknown
USA	Seattle	Washington	1st Ave. and Cherry St.	Unknown
USA	Seattle	Washington	1st Ave. and Pike St.	Unknown
USA	Seattle	Washington	1st Ave. and University St.	Unknown
USA	Seattle	Washington	West Seattle Junction on California Ave.	Unknown
USA	Seattle	Washington	15th Ave. & 40th St.	2014

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Pedestrian Signal Heads

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

Pedestrian signals are traffic control devices installed at signalized intersections and un-signalized marked crosswalks (which include pedestrian hybrid beacons) to provide positive guidance to pedestrians attempting to cross the street. Pedestrian signals prohibit crossing when conflicting traffic may impact the safety of the pedestrians. There are different types of pedestrian signal features and enhancements with varying functions and accessibility, including pedestrian signal head indications, countdown pedestrian signals, automated pedestrian detection, pushbutton detectors, accessible pedestrian signals and detectors (APS). Pedestrian signal heads and other signal enhancements are all dictated by the MUTCD in Section 4E. A summary of each enhancement based on MUTCD language is provided below. In addition to the pedestrian signal features listed in Table 1, this report should be used in conjunction with other pedestrian crossing facilities discussed in the following reports: crosswalk enhancements, signal phasing, and pedestrian hybrid beacons.

Table 1 - List of potential pedestrian signal enhancements

Facility	Report Location
Pedestrian Signal Head Indications	In this facility report
Countdown Pedestrian Signals	In this facility report
Pedestrian Detectors	In this facility report
Accessible Pedestrian Signals and Detectors (APS)	In this facility report

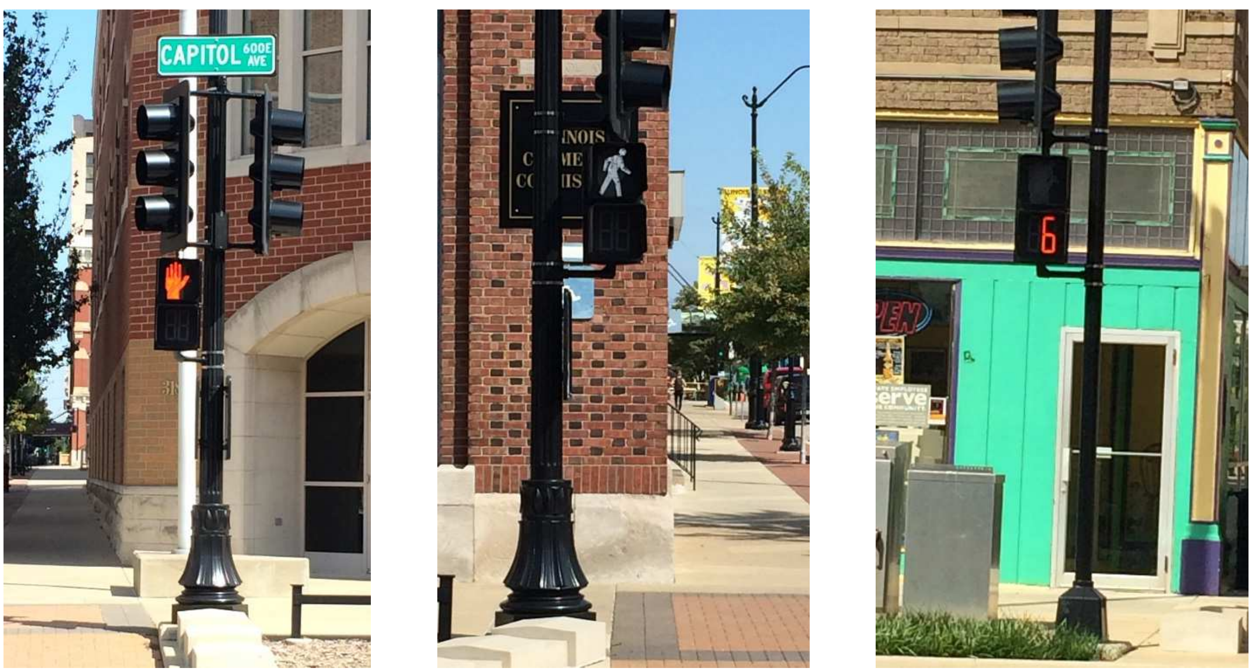

Figure 1 - Pedestrian signal heads in Springfield, Illinois, reflecting various indications (left to right: upraised hand (DON'T WALK), walking person (WALK), and countdown display indicating number of seconds remaining in the pedestrian change interval

Pedestrian Signal Head Indications (MUTCD, Sec. 4E.02 – Sec. 4E.06)

Pedestrian signal heads use a walking person (WALK) symbol and an upraised hand (DON'T WALK) symbol to indicate the proper time to cross.

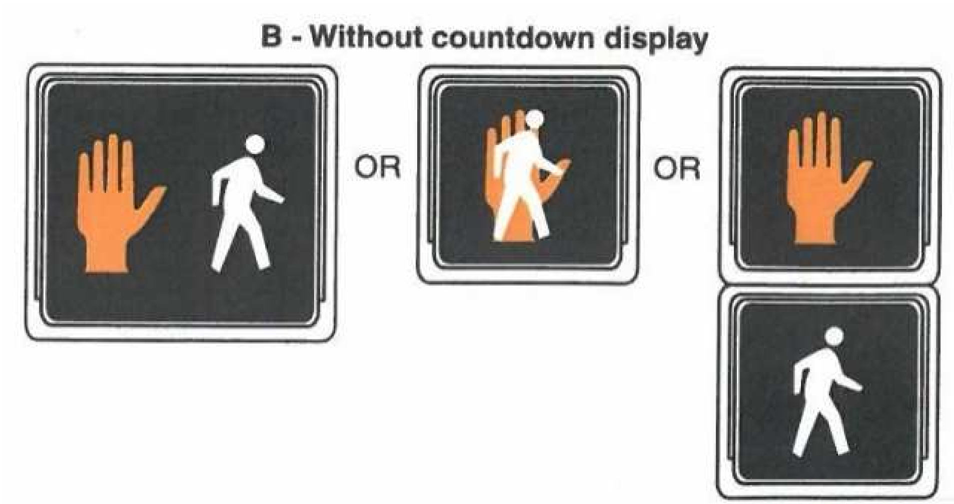

Figure 2 - Pedestrian signal head indications (Image: MUTCD, Sec. 4E.04)

Pedestrian Countdown Signals (MUTCD, Sec. 4E.07)

Pedestrian Countdown Signals display the available crossing time in seconds to complement the conventional flashing DON'T WALK phase of a traffic signal cycle. "All pedestrian signal heads used at crosswalks where the pedestrian change interval is more than seven seconds shall include a pedestrian change interval countdown display to inform pedestrians of the number of seconds remaining in the pedestrian change interval."[1]

The signal indications with countdown timers are as follows:

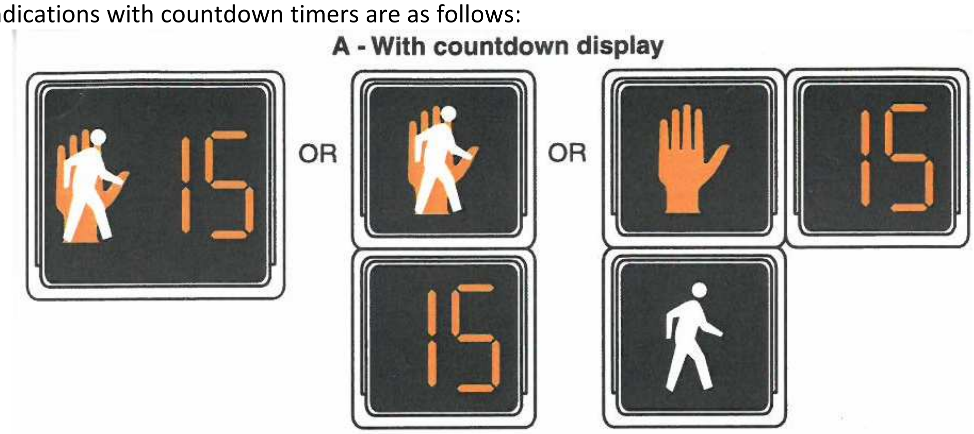

Figure 3 - Countdown pedestrian signals (IMAGE – MUTCD, Sec. 4E.04)

Pedestrian Detectors (MUTCD, Sec. 4E.08)

Pedestrian detection is accomplished through either pedestrian activated pushbuttons or passive detection devices. Pedestrian pushbuttons are placed within reach of pedestrians who are intending to cross each crosswalk and are clearly placed to show which pushbutton is associated with each crosswalk. Passive detection devices, or automated pedestrian detection, register the presence of a pedestrian in a position indicative of a desire to cross, without requiring the pedestrian to push a button. Some passive detection devices are capable of tracking the progress of a pedestrian as they cross the roadway for the purpose of extending or shortening the duration of certain timing intervals."[1]

Figure 4 - Pushbutton detectors with mandatory instructional signing mounted directly above the pushbutton (Image: MUTCD, Sec. 4E.08)

Accessible Pedestrian Signals and Detectors (APS) (MUTCD, Sec. 4E.09-4E.13)

Accessible pedestrian signals and detectors are devices that communicate information in non-visual formats to the visually impaired and hearing impaired, by the use of audible tones, speech messages, and vibrating surfaces, to allow them to more safely cross the street in situations where crossing may be more challenging. APS alerts the pedestrian to the existence and location of the pushbutton that activates the WALK signal, the beginning of the WALK interval, the direction of the crosswalk, and the location of the destination curb. APS is particularly useful at crossings where visually impaired individuals lack the traditional cues of crossing. Some crosswalks such as Barnes Dances or all-red pedestrian crossings, result in a signal phase where all traffic is stopped. The visually impaired individual may not know when to cross since they use the audible cues from moving traffic to begin their crossing. Other problems may arise at non-traditional crossings without a straight path. Roundabouts are especially challenging to the visually impaired as free flowing traffic does not provide the typical breaks in traffic flow. Additionally, crossings sometimes take a circuitous path through the roundabout. APS can help the visually impaired individual cross in these situations.

Features:

- A pushbutton locator tone
- A tactile arrow or vibrotactile arrow that vibrates during the WALK interval
- A speech walk message for the walking person (WALK) indication
- A speech pushbutton information message
- Braille message indicating the street being crossed (optional)
- Audible walk indication that is audible from the beginning of the associated crosswalk

For more details, features, warrants and design guidance of APS signals visit the Accessible Pedestrian Signals Guide at www.apsguide.org. The guide provides useful information compiled and produced by the NCHRP.

Costs

The average cost of a pedestrian signal is $1,480 each but may range from $130 to $10,000 in 2012 dollars.[2] Additional costs are dependent on the use of additional enhancements. The most expensive enhancement appears to be automated detectors which can range from $10,000 to $70,000 per crosswalk.[3]

$ $1,480 Average cost (2012 dollars)

Table 2 – Costs of pedestrian signals, with individual costs of components and optional enhancements

	Median Cost	Average Cost	Minimum	Maximum
Pedestrian Signal ($/EA)	$980	$1,480	$130	$10,000
Signal Face ($/EA)	$490	$430	$130	$800
Signal Head ($/EA)	$570	$550	$100	$1,450
Signal Pedestal ($/EA)	$640	$800	$490	$1,160
Pedestrian Detector – Furnish and Install ($/EA)	$180	$390	$68	$1,330
Pedestrian Detector – Pushbutton ($/EA)	$230	$350	$61	$2,510
Automated Detector ($/crosswalk)	~	~	$10,000	$70,000
Audible Pedestrian Signal ($/EA)	$810	$800	$550	$990
Pedestrian Countdown Timer Module ($/EA)	$600	$740	$190	$1,930

Design Guidance:

FHWA	Manual on Uniform Traffic Control Devices (MUTCD) Section 2B.52 and 4D.03. Chapter 4E. 2009 Edition, Revisions 1 & 2, May 2012 http://mutcd.fhwa.dot.gov/htm/2009/html_index.htm
FHWA	Signalized Intersection Design Guide Section 5.2.2 – Pedestrian Displays https://www.fhwa.dot.gov/publications/research/safety/04091/index.cfm
Illinois Department of Transportation	BDE Manual - Section 58-1.09(d) - Crossing Controls. http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Design-and-Environment/Illinois%20BDE%20Manual.pdf
AASHTO	Guide for the Planning, Design, and Operation of Pedestrian Facilities – Section 4.1 https://store.transportation.org/Item/CollectionDetail?ID=131
ite	ITE Walkable Urban Thoroughfares Chapter 10: Intersection Design Guidelines. Pedestrian and Bicycle Features at Signalized Intersections. http://library.ite.org/pub/e1cff43c-2354-d714-51d9-d82b39d4dbad
TRB	Accessible Pedestrian Signals Guide National Cooperative Highway Research Program www.apsguide.org

Figure 5 - List of design guidance manuals and documents

SAFETY

Pedestrian Signals

In 2011, 78% of all pedestrian crashes and 80% of fatal and serious injury crashes in Chicago occurred within 125 feet of an intersection."[4] Pedestrian signals are installed to increase safety at intersections by providing positive guidance to pedestrians trying to cross the street and to reduce crossings when conflicting traffic may impact the safety of the pedestrians.[5] There are different levels of pedestrian signals with varying functions and accessibility that can be used to increase the safety of pedestrians. They include pedestrian signal heads, pedestrian countdown signals, automated pedestrian detection/pushbutton detectors, and accessible pedestrian signals (APS) and detectors.

Pedestrian Signal Heads

According to the FHWA, pedestrian signal heads are installed to minimize vehicle-pedestrian conflicts and provide guidance to pedestrians on when to cross.[6] The AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* claims "research has indicated there are no significant differences in crash rates for traffic signals with no pedestrian signals and those with concurrent pedestrian signal phasing [conventional pedestrian signal crossings]. Thus, the installation of standard-timed pedestrian signals should not necessarily be expected to improve pedestrian safety at signalized intersections."[7] There are still numerous reasons for installing pedestrian signal heads as mentioned in the facility description and the referenced design guides. ITE simply recommends reducing pedestrian exposure to moving traffic as much as possible,[8] which pedestrian signal heads help achieve through its direct guidance. Furthermore, standard pedestrian signal heads can be enhanced with various features to increase motorist and pedestrian compliance and reduce crashes. Some of the enhancements pertaining directly to the pedestrian signal head are discussed below. Other enhancements are discussed in various facility reports, such as non-standard signal phasing (exclusive pedestrian phases or leading pedestrian intervals), hybrid signalization, or crosswalk specific features (markings and signage).

Pedestrian Countdown Signals

Intersections with pedestrian countdown timers are easier for most age groups to understand than conventional signals, thus increasing compliance. Pedestrians can judge how much time is left to cross the street safely, or decide to cross at the next cycle. Fewer pedestrians are left standing in the crosswalks when the signal changes. Pedestrians feel more comfortable and safer crossing the street when pedestrian countdown signals are present. Pedestrian countdown timers are required for all new pedestrian signal installations if change interval is greater than 7 seconds.

Figure 6 - Pedestrian walking in crosswalk with pedestrian countdown signals

A 2006 study was conducted by Schattler and Datta to determine the effects of the countdown signals on pedestrian and motorist behavior and risk taking at ten signalized intersections in Peoria, Illinois. The study observed five intersections with pedestrian countdown signals and five intersections with traditional pedestrian signals. Data was collected including pedestrian counts, crossing behavior, red-light running, and number of vehicles entering the intersection late in the yellow interval. The results of the study showed there was a higher rate of pedestrian compliance at intersections with countdown pedestrian signals (85% compliant) than at intersections with traditional pedestrian signals (64% compliant).[9] The study also showed that motorist risk taking is not affected by the presence of countdown pedestrian signals.

In 2012, a study by Verma was conducted at the intersection of Broadway and 2nd Avenue in San Diego, California to evaluate the effect of pedestrian countdown signals on performance measures including pedestrian compliance with the pedestrian signal indications, the proportions of pedestrians entering during the WALK signal, the proportions of pedestrians entering during the flashing DON'T WALK signal, and the proportions of pedestrians entering during the DON'T WALK signal. The study concluded that pedestrians adjust their speed to finish crossing the roadway by observing the countdown timer. It also concluded that pedestrians are more compliant with countdown pedestrian signals with a long intersection crossing distance and high motorist volumes (5.6% committed a specific violation compared to 21.4% before installation), but appeared to be less compliant on intersections with a short crossing distance and a high gap in motorist traffic (20.5% committed a specific violation compared to 12.5% before installation).[10]

Beyond compliance rates, countdown timers provide greater confidence to pedestrians, especially for older persons, when they know how much time remains in the crossing.[11] Countdown timers also benefit pedestrians with mobility impairments and without wheelchairs. Increased confidence leads to increased comfort and ultimately higher use with the facility. A survey by ITE and the AAA Foundation for Safety found pedestrians considered the following when rating pedestrian "level of service":[12]

- The ability to make a more informed choice based on ambient conditions.
- Allowing pedestrians to cross during the "flashing DON'T WALK" phase at a uniform walking speed and still complete the crossing prior to the beginning of the conflicting green.
- Reduced delay for the pedestrian.
- A reduced number of pedestrians in the crosswalk at the onset of amber.
- Improved pedestrian compliance with the "WALK" and "flashing DON'T WALK" indications

The only negative impacts reported by the survey respondents were "an increase in pedestrians entering during the change interval and pedestrians running to cross the intersection."

Pedestrian Detectors

Detectors allow activation of pedestrian specific phases. Pushbutton detectors, however, are often not utilized by pedestrians due to reasons such as inconvenience, inaccessibility, lack of confirmation of activation, or lack of understanding. Automated detectors have been shown to reduce the number of pedestrian crossing during the DON'T WALK signal and thereby reducing the number of conflicts between pedestrians and motorists. Providing confirmation that the button was activated was also useful in increasing pedestrian compliance.

Figure 7 - Pushbutton detector at a HAWK signal in Pekin, Illinois

In 2001, the Federal Highway Administration conducted a "before" and "after" video study to determine if automated pedestrian detectors, used with standard pedestrian pushbuttons, would decrease pedestrian-vehicle conflicts and decrease the number of pedestrians crossing during the DON'T WALK signal. Automated pedestrian detection systems were installed at sites in Los Angeles, California, Phoenix, Arizona, and Rochester, New York. Pedestrian behavior was observed before and after the installation of the automated pedestrian detectors at the study locations. In order to optimize traffic, some of the signals used were actuated traffic signals. The results of this study showed a 24% increase in the number of pedestrians who began crossing during the WALK signal and an 81% decrease in the pedestrians that crossed during the DON'T WALK signal at the intersection when both a pushbutton and an automated detector were present. "The data provided evidence that the use of devices to

APS Signals	
Increase in pedestrians crossing during WALK signal	24%
Decrease in pedestrians crossing during DON'T WALK signal	-81%

automatically detect the presence of pedestrians at signalized crossings can improve the compliance of pedestrians at pushbutton locations."[13]

Another TRB published study was performed in Miami Beach, Florida at two intersections. The study evaluated the effects of pushbuttons that give visual and audible feedback when they have been pressed and the amount of pedestrians who use the pushbuttons properly. The data showed a significant increase in the percentage of signal cycles in which pedestrians pressed the button. It also showed a significant increase in the percentage of pedestrians pressing the button who waited for the WALK signal.[14] PBIC further summarized three other studies on automated detection.[15] One by Pecheux, Bauer, and McLeod found a 9% decrease in the percentage of cycles where a pedestrian was trapped in the roadway at an automated detection crossing.[16] The study didn't find any other significant effects on conflicts or clearance times. Another study in Las Vegas by Nambisan, Pulugurtha, Vasudevan, Dangeti, and Virupaksha observed a location where automated detectors were used to activate increased lighting.[17] They observed increases in the percentage of pedestrians using the crosswalk and motorist yielding. This study highlighted another use of automated detection through activating increased lighting. On the other hand, a study by Lovejoy, Markowitz, and Montufar presented at the 2012 TRB annual meeting concluded automated detection had a relatively small impact on improving safety at the studied location in San Francisco.[18]

Accessible Pedestrian Signals (APS) and Detectors

The use of accessible pedestrian signals (APS) and detectors at pedestrian signals allows visually impaired pedestrians to use more accurate judgment at the onset of the WALK signal before crossing the street, reduces crossing time for those pedestrians during the DON'T WALK signal, and allows the visually impaired to cross the street independently. A study by Scott, Myers, Barlow, and Bentzen and summarized by PBIC observed 91% of visually impaired participants using the vibrating arrows to confirm the direction of the WALK signal.[15, 19]

Another TRB study was conducted in Atlanta, Georgia, to determine the effects of two types of accessible pedestrian signals on crossing behaviors of 24 visually impaired participants and compared it against crossing with no device.[20] The first accessible pedestrian signal device used a sound generator and vibrating hardware, which was integrated into the pedestrian pushbutton. Sounds, indicating the WALK signal, were made near the pushbutton. The second accessible pedestrian signal device contained a pulsing light-emitting diode to illuminate the message in the pedestrian signal head, which then transmitted a message to a handheld receiver carried by the visually impaired pedestrian. The handheld receiver provided a WALK, or a WAIT message. Pedestrian crossing time was based on the standard WALK signal. The results of the study showed that the time it took visually impaired pedestrians to cross the street was significantly shorter when the handheld device was used compared to when the audible pushbutton device was used. When using the handheld device, there were significantly shorter pedestrian crossing times compared to when using the audible pushbutton device and when not using any accessible pedestrian device at the control location. When using the audible device, there was no significant difference in the pedestrian crossing times seen compared using no accessible pedestrian device at the control location.

A before and after study by Scott, Barlow, Bentzen, Bond and Gubbe and summarized by PBIC observed an increase in visually impaired pedestrians beginning and ending their crossing within the crosswalk (non-jaywalking behavior), a decrease in crossing against the light, and an increase in "independence in determining a safe time to cross" after installation.[15, 21] Another study found improvements to visually impaired pedestrians maintaining alignment within the crosswalk with "participants aligned accurately 36.3% of crossing with standard APS, 68.1% with beaconing APS, and 71.0% with guidestrips."[22] Beaconing APS and guidestrips are enhanced prototype APS features to assist with alignment.

Figure 8 –APS pushbutton detectors. Left: Green Street and Goodwin Avenue in Champaign, Illinois. Right: Madison Street and Desplaines Avenue in Oak Park, Illinois.

APS signals also benefit all pedestrians since they provide an auditory or visual confirmation that the button was pressed. Confirmation increases compliance with the signals and reduces the percentage of pedestrians trapped in the crosswalk after the signal change.[14]

OPERATIONS

Pedestrian Signals

Pedestrian signals are installed at signalized intersections and non-signalized marked crossings to provide continuous movement of both pedestrian and vehicular traffic, thus improving operations for everyone. Pedestrian signals are activated by a set timer, a pedestrian activated pushbutton, or a detector. Pedestrian walking speed affects the operations of the pedestrian signals and is dependent on age and physical ability of each pedestrian. Pedestrian walking speed also affects how the pedestrian clearance interval and signal timing are set. For specific effects of various walking speeds on intersection LOS consult the *Pedestrian Signal Safety for Older Pedestrian* report produced by ITE and the AAA Foundation for Traffic Safety.[23]

Pedestrian Countdown Signals

Operation factors of pedestrian countdown timers are influenced by pedestrian walking speed, signal timing, and pedestrian understanding of how the facility works. Pedestrians are better informed on how many seconds they have left to safely cross the road before the red DON'T WALK symbol is displayed, thus providing continuous movement of pedestrian and vehicular traffic.

Because these are redundant visual displays, they should have a negligible effect on motorist operations but may improve pedestrian operations. The ITE study did find countdown timers increased pedestrian walking speeds for all age groups, which allows the intersection to clear faster but that may be offset by an increase in pedestrians entering during the change interval.[23]

Pedestrian Detectors

In some instances, signals that require activation may cause increased delay for pedestrians, especially if they do not activate or understand the need to activate to obtain the legal crossing phase. The pushbutton may also become blocked by snow, debris or unreachable by handicapped individuals. Pedestrians may also miss the previous cycle and then wait for the next cycle even though their direction has the green light. On the other hand, when the phase is activated for pedestrians, or if it is on a pretimed schedule without detection, then motorist delay increases.

Automated pedestrian detection can supplement pedestrian pushbutton detectors by automatically sensing when a pedestrian is waiting at a crosswalk, thus maintaining a continuous flow of pedestrian and vehicular traffic. Automatic detection may also cancel the pedestrian phase once it detects the pedestrian has cleared the crosswalk, thus improving vehicle operations.

Accessible Pedestrian Signals (APS) and Detectors

APS devices allow for the continuous operation and movement of all pedestrians crossing the street, including the visually impaired. Because APS devices are redundant visual and audio displays, they should have a negligible effect on motorist operations. APS also improves understanding and ease of use of the crossing for impaired individuals as discussed in the safety section, which has dual benefits for reducing delay of those individuals.

MAINTENANCE

Generally, maintenance of pedestrian signal heads and enhancements can be performed under traditional signal maintenance programs. Novel technology such as automatic or APS equipment may require additional maintenance or training.

Figure 9 - Access to pedestrian signal pushbutton obstructed by snow in Chicago

Accessible Pedestrian Signals (APS) and Detectors

Accessible pedestrian signals require both continuous monitoring and maintenance. In order to avoid dangerous crossings for pedestrians with vision impairments, agencies need to monitor accessible pedestrian signals for malfunctions relating to WALK indication, locator tone, and signal interaction. The overseeing agency should conduct an audit or checkup of APS installations on a regular basis, and more frequently if the weather is harsh. At a minimum, APS should be inspected every six months, after repairs to the intersection signals, poles or controller, and after changes to signal timing. Occasionally an agency may receive a complaint that a locator tone on an APS is too loud or needs maintenance. The volume of the tones and messages can be adjusted and should only be audible six feet to ten feet from the signal pole. The volume adjusts according to ambient noises, but if the environment around the pole changes significantly, the volume settings may need adjusted. Pushbutton manufacturers should be contacted with questions or ongoing problems.[24]

Street Sweeping & Snow Removal

During periods of snowfall, access to pedestrian signal pushbuttons may be obstructed. Some cities, such as Chicago, have municipal codes in-place which require all residents and business owners to be responsible for snow removal on sidewalks. Individuals and businesses who do not comply with the city municipal code are fined.[25] Snow removal from crosswalks can be done with traditional snow plows, however, care should be made not to block the crosswalk ramps with plowed snow.

Utility Cuts and Construction Damage

Pedestrian signal and appurtenances may require utility relocation when improvements are made to the existing roadway facility. However, generally pedestrian signals can be installed on existing poles avoiding any change to the roadway or sidewalk. Utility companies may require additional information or guidance on proper repair, and work should be inspected following replacement.

Pedestrian signals are more prevalent than other facilities that were studied and thus no specific locations were provided.

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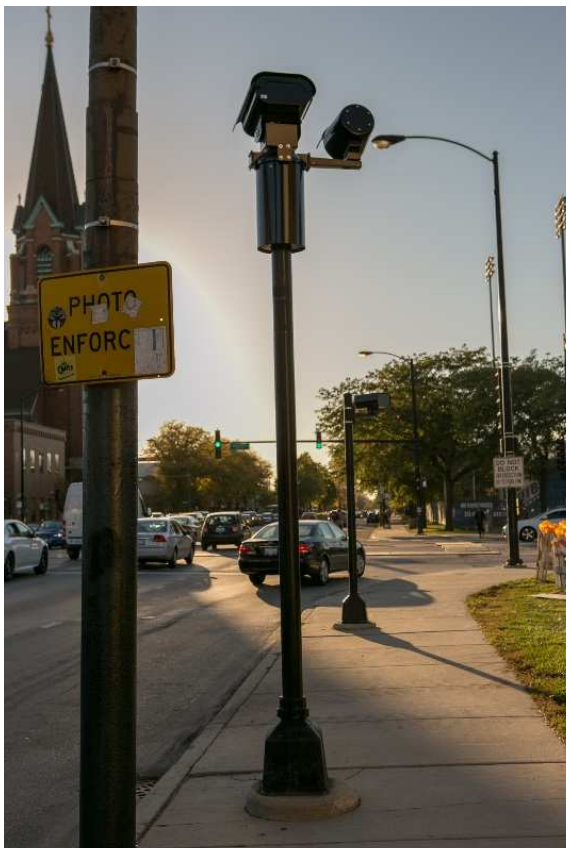
Red Light Cameras

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

Red light running camera systems are typically installed at signalized intersections where a safety problem with red light running has been documented. The systems are designed to increase safety at intersections by decreasing the frequency of angle crashes which are more likely to result in serious injury or death. The system tracks the status of the traffic signal, and typically utilizes video or laser technology to monitor the position and speed of vehicles approaching and passing the stop line. The red light cameras automatically photograph vehicles and their license plate number as they fail to stop during the red signal phase. Under the Illinois Vehicle Code, 625 ILCS 5/11-306 (C), a stop is defined as a complete and total cessation of movement.[1] The cameras record the date, time of day, time elapsed since the beginning of the red signal, vehicle speed, and license plate number on the vehicle. Photographic evidence is reviewed and red light violators are mailed tickets. In the City of Chicago and surrounding suburbs, intersections containing red light cameras typically consist of two cameras monitoring two of the four directional approaches.[2]



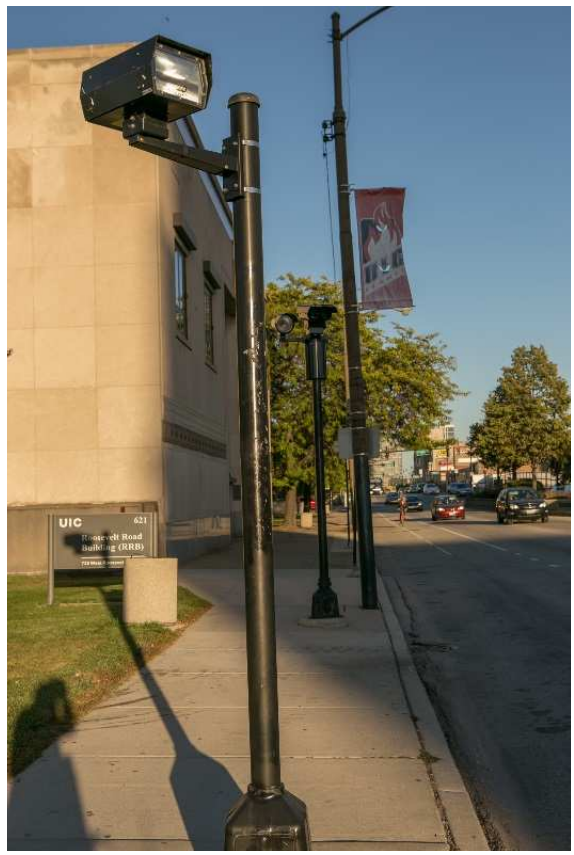


Figure 1 – Red light cameras along Roosevelt Road at Halsted Street in Chicago

Red light running has become a national safety problem resulting in deaths and injuries at signalized intersections.[3] According to 2012 United States crash statistics, approximately 683 people were killed and another 133,000 were injured because of red light running related crashes.[4] Half of the people killed in red light running crashes were not signal violators, but rather other motorists and pedestrians struck by the motorists who ran the light.[5]

Through surveys conducted by the National Highway Traffic Safety Administration (NHTSA), 97% of motorists felt that other drivers running red lights were a safety threat.[6] Additionally, 4% of motorists self-reported running red lights, with 1% of motorists running them “often” and 3% of motorists running them “sometimes”. When accounting for drivers entering an intersection just as the light turned from yellow to red, the NHTSA found 40% self-reported running the red-light. Another study found 39% of drivers admit to driving through a light that just turned red.[7]

According to the National Coalition for Safer Roads, more than 3.5 million red light violations were captured by red light cameras (RLCs) in 20 states, including Illinois. In 2013, 25 red light cameras in Illinois were studied, recording a total of 33,680 red light running violations over a population of 220,894. The average violation per camera was 1,354 and the average violation per day was 92.[8]

The City of Chicago has been utilizing red light camera enforcement since 2003.[2] Between 2005 and 2013, crashes of all types including the more dangerous right angle crashes have decreased at intersections with cameras. The City removed 36 red light cameras at 18 locations in January 2014 based on a dramatic decrease in crashes, with each of those locations experiencing one or less angle crashes and overall crash rate of less than 1% in the prior year.[9,10]

Features

Based on the Federal Highway Administration Red Light Camera Operational Guidelines (FHWA January 2005), the following are features of a red light camera system:[3]

- Curb-mounted red light camera systems either mounted on separate poles, or on traffic signal mast arms.
- Camera systems consist of camera units, intersection lighting, camera housing and supporting structure, vehicle detection, communications, and warning signs.
- Warning signs in advance of photo-enforced intersections.
- Additional lighting, typically flash units.
- Vehicle detection system consisting of mounted video detection cameras, radar sensors or detector loops in the pavement.
- Communication links between the intersection and the location where the data is being processed.

CDOT also installs pedestrian countdown timers at every intersection with an RLC.

Costs

Red light camera systems have high initial costs for installation along with monthly maintenance costs. The average implementation cost for an automated red light camera system ranged from $67,000 to $80,000 per intersection according to 1998 to 2002 prices.[11] This includes the cost of the camera equipment, installation, in-pavement inductive loop detectors, poles, wiring, and all other miscellaneous associated costs. Costs have dropped for the cameras as technology has improved. The City of Chicago paid $85,000 per camera between 2003 and 2006 dropping to $24,500 per camera between 2008 and 2010.[12] Maintenance, operation and management costs also varied over time. The City of Chicago currently has a contract with Xerox to provide maintenance, operation, and management of the City's red light camera program at a cost of $1,819 per camera, per month.[13]

$ $24,500/camera
Average cost to purchase and install

$ $1,819/camera
Maintenance, Operations, and Management Cost (Chicago)

Design Guidance

Manual on Uniform Traffic Control Devices (MUTCD)
Chapter 1A, Section 1A.08, Chapter 2B, Figure 2B-3s.
2009 Edition, Revisions 1 & 2, May 2012
http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf index.htm

Federal Highway Administration. Red Light Camera Systems Operational Guidelines, January 2005.
https://safety.fhwa.dot.gov/intersection/conventional/signalized/rlr/fhwasa05002/

Illinois Supplement to the MUTCD. 2009 Edition.
R10-I104 Sign Detail
https://idot.illinois.gov/Assets/uploads/files/Transportation-System/Manuals-Guides-&-Handbooks/Highways/Operations/2009%20ILMUTCD%20-%202014%20update.pdf

SAFETY 2-13 Policy Memo - Red Light Running Camera Enforcement Systems
http://www.idot.illinois.gov/assets/uploads/files/transportation-system/manuals-guides-&-handbooks/safety/safety%202-13%20-%20safety%20engineering%20policy%20memorandum.pdf

CDOT – Criteria and Prioritization Steps
http://www.cityofchicago.org/content/dam/city/depts/cdot/Red%20Light%20Cameras/RLCProcessingCriteria.pdf

Figure 2 - List of design guidance manuals and documents

SAFETY

Studies have found red light cameras provide safety benefits for both pedestrians and motorists that include:

- Reduction in red light violations and associated crashes.
- Reduction in right angle crashes, thus reducing fatalities and high severity crashes.
- Possible reduction in the number of vehicles exceeding the speed limit at red light camera sites since red light running often entails accelerating to make it through the intersection during a yellow light.[3]
- Community-wide increase in driver compliance with red lights.

Figure 3 - Red light cameras along Roosevelt Road at Halsted Street in Chicago

In 2005, the Federal Highway Administration performed an in depth study on the effectiveness of red light cameras in reducing crashes.[14] Several studies conducted from 1998-2001 were summarized and lessons learned were applied to a new study conducted by the FHWA. In this study, seven jurisdictions and 132 intersections were chosen across the United States. Crash effects and associated economic effects of red light cameras were estimated, including the severity of injuries. Injuries are often severe in right-angle crashes, whereas injuries tend to be less severe in rear end crashes. The results of the study showed a 25% decrease in total right-angle crashes, a 16% reduction in injury right-angle crashes, a 15% increase in total rear-end crashes, and a 24% increase in injury rear-end crashes (see Figure 4). Regression to the mean bias was accounted for in the analysis.

Total Right-Angle Crashes	-25%
Injury Right-Angle Crashes	-16%
Total Rear-End Crashes	+15%
Injury Rear-End Crashes	+24%

Figure 4 - Percent change in crashes before and after installation of red light cameras. Source: FHWA.

A study was conducted by the Insurance Institute for Highway Safety regarding red light running by motorists at red light camera sites.[15] This study compared crash data from facilities with red light cameras to facilities without red light cameras in 99 cities, in the United States, with populations over 200,000. Crash Data from 1992-1996 was compared to data from 2004-2008, with 38 of the 99 cities comprising the "cities without cameras" group (no cameras in either period) and 14 of the 99 cities comprising the "cities with cameras" group (cameras in 2004-2008 but not 1992-1996). Results indicated that the average annual rate of fatal red light running crashes in cities with red light camera sites decreased by 35% compared to a decrease of 14% in cities without cameras. Additionally, the average annual rate of fatal red light running crashes decreased by 14% at intersections with red light cameras compared to a 2% increase in cities without cameras at signalized intersections (See Figure 5).

Fatal Red Light Running Crashes - Cities with Cameras	-35%
Fatal Red Light Running Crashes - Cities without Cameras	-14%
Fatal Red Light Running Crashes – Signalized Intersections with	-14%
Fatal Red Light Running Crashes – Signalized Intersections	+2%

Figure 5 - Percent change in the average annual rate of fatal crashes at intersections with and without cameras. Source: Insurance Institute for Highway Safety.

In September 2010 and August 2011, the City of Chicago collected data at 96 intersections with red light cameras installed between 2006 and 2008.[16] A study was conducted at these intersections comparing crash data for two years before installation of red light cameras and two years after installation of red light cameras. The data collected included total number of intersection crashes, number of right-angle crashes, and number of rear-end crashes. Data collected at the intersections with red light cameras showed that the total number of intersection crashes decreased slightly (2%), right-angle crashes decreased significantly (52%), while rear end crashes increased significantly (54%). CDOT also claims pedestrian crashes declined by 8% at intersections with RLCs between 2005 and 2013 although a citywide crash reduction was not provided for a quick comparison.[2]

OPERATIONS

Red light camera devices do not directly affect the operations of vehicular or pedestrian traffic since they are a passive enforcement option, only activated after the traffic light turns red, and motorists should be stopping by law in compliance with the red signal indication.

Regarding signal timing, red light running can be decreased with proper signal timing, specifically yellow times (IIHS).[17] Traffic signal yellow times should be established in accordance with the MUTCD Guidelines and the ITE Informational Report.[18] "Changes in yellow times after the red light cameras are in-place and operational will affect the number of photographed violations, increasing the number of violations when yellow times are shortened and reducing the number of violations when yellow times are lengthened."[17] However, increasing the yellow timing for normal traffic operations would have a negative impact on traffic flow throughout the city, increasing both congestion and travel times. CDOT also claims more motorists speed up through a "yellow light" instead of slowing down, and therefore, driver behavior will not change.[2] Careful attention should be given to the yellow timing triggers when it impacts traffic flow through construction zones or from changing the signal timings.

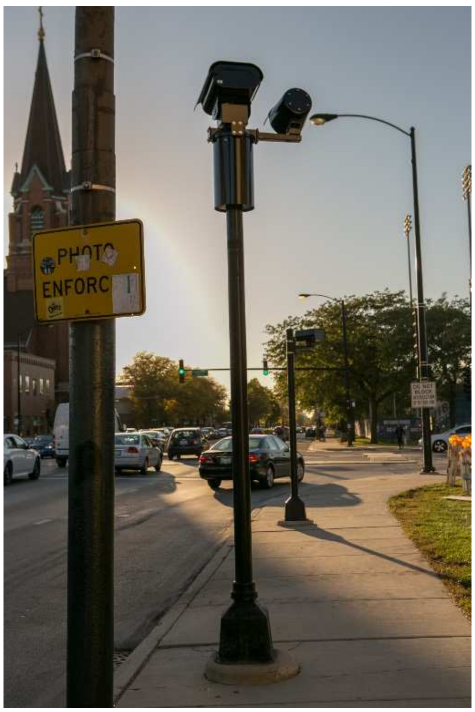


Figure 6 - Red light camera along Roosevelt Road at Halsted Street in Chicago

MAINTENANCE

Red light cameras require continuous maintenance and monitoring of the system which is typically done through a vendor contract.[3] The camera unit and housing equipment should be cleaned and tested, and the warning signs should be inspected. Adequate records should be kept on all inspection and maintenance activities. The City of Chicago's vendor currently provides bi-weekly reports on each of the system's cameras and holds regular meetings with CDOT to discuss. An "early warning" system has been implemented that alerts the vendor when unusual enforcement activity is detected, and CDOT posts daily red light camera violation totals at each location. Additionally, CDOT's vendor checks each camera remotely for camera image quality, system uptime, and data analysis.[19] Physical maintenance checks are performed each month on every camera.

Figure 7 - Red light camera with double photo flash units along Division Street at Ashland Avenue in Chicago

There are approximately 880 red light camera intersections in Illinois.[20] There are at least 80 cities in Illinois using red light cameras as of 2014.[4] Several example locations are listed below. Chicago installed their first red light camera in 2003 and currently has over 300 intersections equipped.[21]

Table 1 – Examples of red light camera locations in District One and Illinois

Country	City/County	State	Intersection
USA	Algonquin	Illinois	Acorn Ln. and Randall Rd.
USA	Berwyn	Illinois	26th Ave. and East Ave.
USA	Bolingbrook	Illinois	12 Locations
USA	Chicago	Illinois	348 cameras at 172 Locations
USA	Champaign	Illinois	Curtis St. and Neil St.
USA	Elmhurst	Illinois	Illinois Route 83 and Riverside St. York Rd. and Green St.
USA	Granite City	Illinois	Madison Ave. and 27th St.
USA	Melrose Park	Illinois	1st Ave. and North Ave. 5th Ave. and North Ave.
USA	Naperville	Illinois	95th St. and Book Rd.
USA	Oak Lawn	Illinois	95th St. and Ridgeland Ave. 95th St. and Cicero Ave.
USA	Orland Park	Illinois	151 St. and Harlem Ave. U.S. Route 45 (96th Ave.) and 151st St. 159th St. and Harlem Ave. 143rd St. and Harlem Ave. 151st St. and 94th Ave. 143rd St. and Lagrange Ave.
USA	Peoria	Illinois	Knoxville Ave. and War Memorial Dr. University Ave. and War Memorial Dr.
USA	Plainfield	Illinois	Route 30 and Renwick Rd. Route 59 and 135th St.
USA	Rolling Meadows	Illinois	Route 62 (Algonquin Rd.) and New Wilke Rd. Kirchoff Rd. and Rohlwing Rd.
USA	Rosemont	Illinois	River Rd. and Balmoral River Rd. and Devon Ave.
USA	Schaumburg	Illinois	Woodsfield Rd. and Meacham Rd. E. Higgins Rd. and Meacham Rd.
USA	Wheeling	Illinois	Elmhurst St. and Hintz

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[14] Federal Highway Administration (FHWA). April 2005. Safety Evaluation of Red-Light Cameras. United States Department of Transportation. Accessed August 13, 2014. https://www.fhwa.dot.gov/publications/research/safety/05048/05048.pdf

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[16] City of Chicago. December 2010. Red-Light Camera Intersections 2 Yr Before and 2 Yr After Average Crash Statistics Spreadsheet.

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[19] Chicago Department of Transportation (CDOT). *Automated Enforcement Report* . 2015. https://www.cityofchicago.org/content/dam/city/depts/cdot/Red%20Light%20Cameras/2015_Automated_Enforcement_Report.pdf

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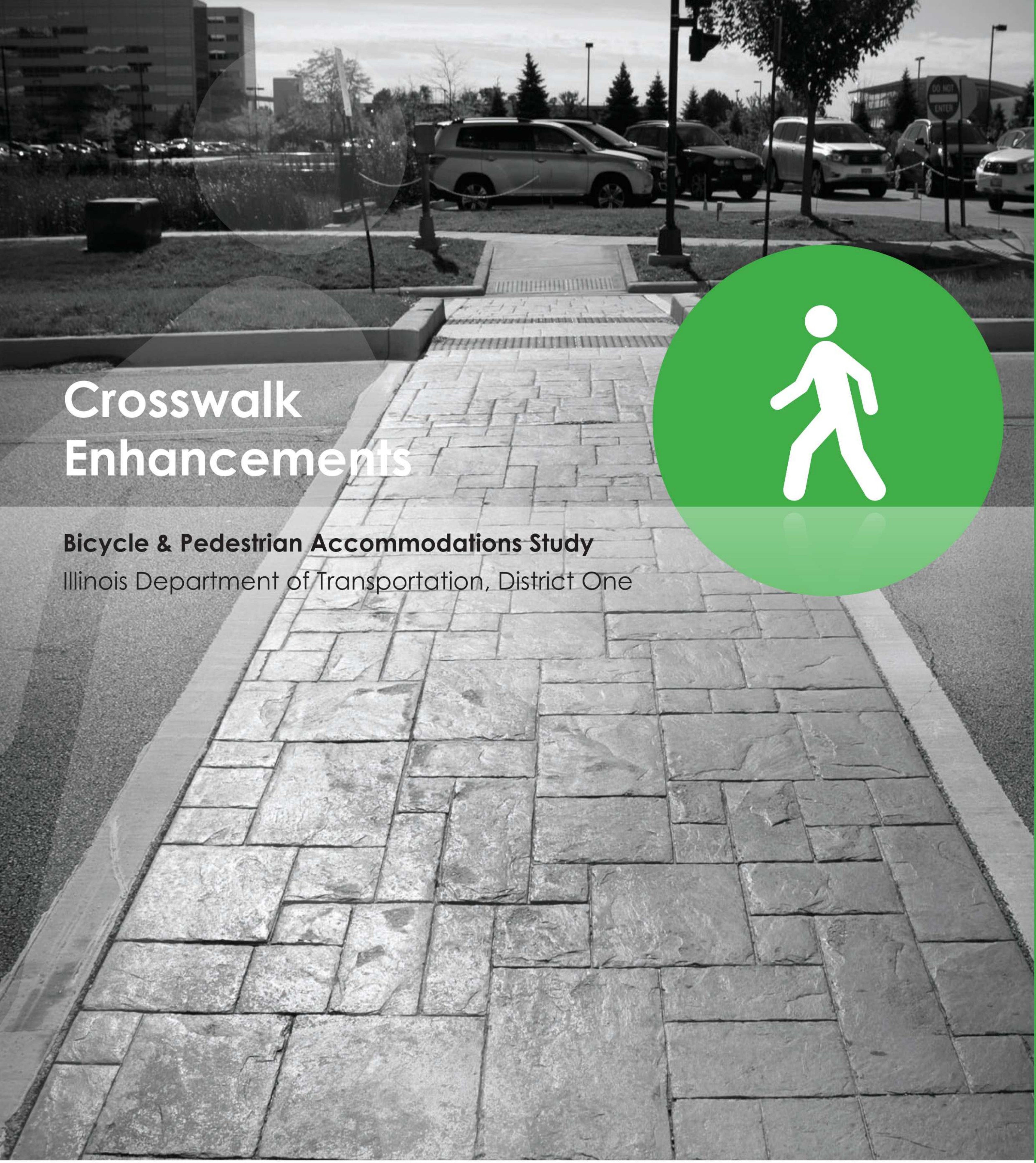

Crosswalk Enhancements

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Illinois Department of Transportation

DEMING
HONDA
STOP
ONE WAY

Crosswalk enhancements are not a specific treatment, but rather a group of facilities or treatments. There are many treatments that when added to a traditional marked crosswalk can increase crosswalk and pedestrian visibility and usage. Several of these facilities are covered under separate facility reports within the IDOT District One Bicycle & Pedestrian Accommodations Study, such as pedestrian signals with countdown timers, HAWK signals, rectangular rapid flashing beacons (RRFBs), in-roadway warning lights (IRWLs or "lighted crosswalks"), raised crosswalks, curb bump outs, and median refuge islands.

Table 1 - List of potential crosswalk enhancements

Facility	Report Location
Crosswalk Markings	In this facility report
Colored Pavement Markings	In this facility report
Alternative Paving Materials	In this facility report
Optical Illusion Pavement Markings	In this facility report
Signing Additions and Enhancements	In this facility report
Rectangular Rapid Flashing Beacon	RRFB Facility Report
HAWK Signal	HAWK Signals Facility Report
Pedestrian Signals	Pedestrian Signals Facility Report
Lighted Crosswalks	Lighted Crosswalks Facility Report
Raised Crosswalks	Raised Crosswalks Facility Report
Curb Bump Outs	Curb Bump Outs Facility Report
Median Refuge Islands	Median Refuge Islands

Figure 1 - Crosswalk enhancements utilizing alternative color and texture between crosswalk lines and supplemental unsignalized pedestrian crosswalk signs, on Lawrence Avenue in Chicago

In this report, a "crosswalk enhancement" refers to additional or enhanced pavement markings and signs that can include: high-visibility marking patterns, alternative materials or methods to pave, texture, and/or color the space between the crosswalk lines; optical illusion markings placed in advance of the crosswalk; and the addition and/or enhancement of standard pedestrian and school signs. These treatments are intended to improve the visibility of the crosswalk and focus motorist attention toward the crosswalk and the pedestrian.

"Crosswalk markings provide guidance for pedestrians who are crossing roadways by defining and delineating paths on approaches to and within signalized intersections."[1] Two white, parallel, transverse lines are the traditional means of marking a crosswalk. However, this basic marking may not necessarily lead to a safer crossing for pedestrians. Several studies have shown some traditional marked crosswalks to increase the risk of a pedestrian-motorist crash. In some situations, the removal of the marked crossings even resulted in a decline of crashes.[2] This does not mean that marking crosswalks are an improper tool in crash reduction, but instead other enhancements should be added considering the context of the crosswalk. Many of the crashes experienced in the marked versus unmarked crosswalk studies occurred on multi-lane roads with multi-threat crashes. These types of crashes can be mitigated with targeted enhancements.

There is currently no federal designation for what constitutes an enhancement in the MUTCD. However, FHWA discusses different tools for enhancing a crosswalk.[3] See the Design Guidance and Reference section for more information.

Crosswalk Markings

Marked crosswalks typically have three major variations consisting of 6" solid white, parallel transverse lines (standard); 12" wide longitudinal bars with or without a perpendicular border of solid white lines (ladder or continental/international, respectively); 12" wide diagonal zebra pattern, also with or without parallel border lines. Anything beyond 6" parallel transverse lines are considered higher visibility marking patterns.

"Transverse lines are sometimes considered the standard crosswalk marking pattern, with ladder and continental markings reserved for uncontrolled intersections or midblock crossings that would benefit from a more high-visibility marking. A key recommendation for ladder, continental, bar pair, and triple-four markings is to space the lines to avoid the wheel path of automobiles, since making this minor adjustment increases the durability of the markings."[2]

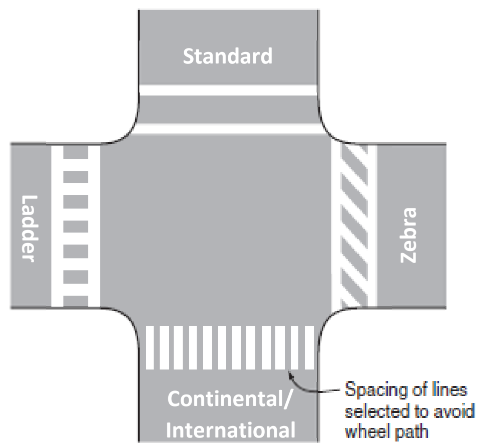

Figure 2 - Marked crosswalk variations. Top: transverse/standard; right: diagonal/zebra; bottom: longitudinal/continental; left: ladder. Modified diagram from MUTCD Section 3B.18.

Crosswalks can also have a few different designs consisting of 6” solid white lines marking the crosswalk with decorative colored bands that distinguish or enhance the crosswalk and an unmarked pedestrian travel path or 6” solid white lines marking the crosswalk with a color stamped thermoplastic walkway that has the appearance of pavers. These additional enhancements are described below.

Figure 3 – Example of bar-pair markings. Image: www.pedbikeimages.org, Dan Burden.

Colored Pavement Markings & Alternative Paving Materials

In 2013, the FHWA issued Official Ruling 3(09)-24(I) which is an official interpretation of Chapter 3G of the MUTCD on the approved uses of colored pavement. According to this ruling, “subdued-colored aesthetic treatments between the legally marked transverse crosswalk lines are permissible provided that they are devoid of retroreflective properties and that they do not diminish the effectiveness of the legally required white transverse pavement markings used to establish the crosswalk”.[4] See Figures 6 and 7 for examples of Alternative Pavement Marking and Brick Paved Crosswalks.

- Acceptable treatments may include brick lattice patterns, paving bricks, paving stones, setts, and cobbles.
- Acceptable colors may include red, rust, brown, burgundy, clay, tan, and other similar earth tone colors.
- Treatments should provide a contrast that aesthetically enhances the crosswalk and does not distract motorists.

The FHWA clarified the use of “Non-retroreflective and retroreflective Colored Pavement Treatments” in Interpretation Letter 3-178(I), in regards to the MUTCD. “Non-retroreflective colored pavement within the marked crosswalk lines for the purpose of decoration only is not considered to be a traffic control device, but the color of the pavement surface within the crosswalk should not degrade the contrast of the white crosswalk lines nor be potentially mistaken by road users as a traffic control application (i.e., to guide, warn, or regulate traffic)”.[5]

Retroreflective colored pavement within the marked crosswalk lines is considered a traffic control device because it is intended to communicate a traffic control message by enhancing the visibility of the crosswalk. However, such use is not compliant with the current edition of the MUTCD, which only provides for the use of diagonal or longitudinal white lines to provide enhanced visibility of a marked crosswalk.[5] Section 1A.10 of the MUTCD requires a written request for experimental approval for all traffic control devices that are not adopted into the MUTCD.[1]

Figure 4 - Layout of pavement markings along Clark Street approaching the intersection with Deming Place in Chicago

Optical Illusions and Zig-Zag Markings

Some cities, including Chicago, have implemented optical illusions on the pavement approaching crosswalks to slow down oncoming motorists. The optical illusions are supposed to appear as a 3D object in the roadway; common images are a standing person and a 3D zig-zag as shown in Figure 4. Some locations in the U.S. and several in Europe also utilize zig-zag white longitudinal lines, with European locations using it to restrict parking and improve sight lines on the approach to the crosswalk.

Signage

In addition to various enhancements on the pavement level, signing additions and/or enhancements can be equally or even more effective in increasing crosswalk and pedestrian visibility and usage. The addition of standard pedestrian/school warning signs can be important in defining the crosswalk location, providing warning in advance of a crosswalk, and establishing school speed zones. Stop Here For Pedestrians and In-Street and Overhead Pedestrian Crossing regulatory signs as shown in Figure 6 can be used to better indicate to road users where to stop and to remind road users to lawfully stop (in the state of Illinois) for crossing pedestrians. Signing enhancements improve the conspicuity of standard pedestrian/school regulatory or warning signs that are typically installed at or in advance of a crosswalk, hence providing additional warning to motorists approaching a crosswalk of the potential for crossing activity. There are a variety of methods noted in the MUTCD for enhancing conspicuity of standard signs which include but are not limited to:

- Increasing sign size
- Doubling-up of a sign by adding a second identical sign on the left-hand side of the roadway
- Adding a 3 inch wide retroreflective strip around the perimeter of a warning sign
- Adding a warning beacon or light emitting diode (LED) units to the sign, indicating specific periods when pedestrian activity is present or likely to be present
- Using a fluorescent yellow-green background color to further distinguish pedestrian crossing signs from other sign types (required for school signs)
- Adding a strip of retroreflective material to the sign support to supplement the sign
- Removing nearby non-essential and illegal signs that detract from standard signs
- Relocating signs to improve visibility by adjusting longitudinal and/or lateral position along the roadway

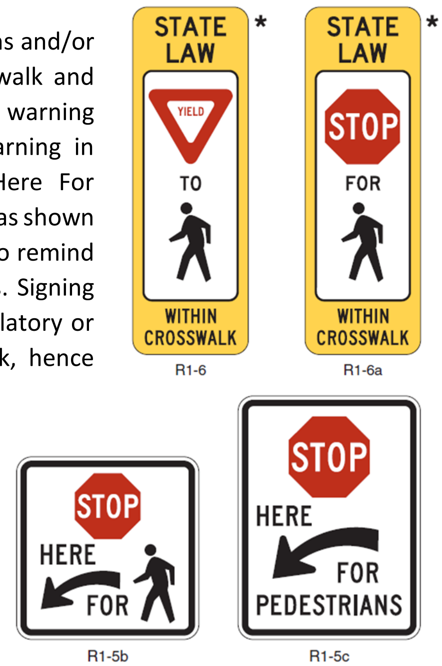

Figure 5- MUTCD pedestrian crossing signs for unsignalized crosswalks. MUTCD Section 2B.11.

Although using in-street pedestrian signs can be beneficial, these signing enhancements are optional in the MUTCD and therefore should only be used as appropriate based on engineering judgement.

Costs

The cost to install crosswalk enhancements varies depending on the materials and methods used for marking, texturing, and paving. The implementation cost for a crosswalk enhancement can range from $350 to $5,170. The cost for a crosswalk enhancement can be determined by adding together the cost of a crosswalk with the cost of each additional feature being used per location.[6] Additional costs are dependent on the use of additional enhancements.

$ $350 -$5,170 Cost Range

Table 2 - Costs of crosswalk enhancements

	Median Cost	Average Cost	Minimum	Maximum
Standard Crosswalk Striping ($/EA)	$340	$770	$110	$2,090
High Visibility Crosswalk ($/EA)	$3,070	$2,540	$600	$5,170
Longitudinal Markings ($/EA)	-	-	$350	$1,000
Crosswalk – brick or pavement scoring material ($/EA)	-	-	$2,500	$5,000
Crosswalk – patterned concrete ($/EA)	-	$3,470	-	-

Design Guidance:

Illinois Supplement to the MUTCD
Sections 2B.12, 2B.I70, 2C.I70, and 7B.09,11,12
http://idot.illinois.gov/Assets/uploads/files/Transportation-System/Manuals-Guides-&-Handbooks/Highways/Operations/2009%20ILMUTCD%20-%202014%20update.pdf

ITE Walkable Urban Thoroughfares
Chapter 10: Intersection Design Guidelines. Pedestrian Treatments at Intersections—Crosswalks
http://library.ite.org/pub/e1cff43c-2354-d714-51d9-d82b39d4dbad

Manual on Uniform Traffic Control Devices (MUTCD) –
Various sections
http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm

Urban Street Design Guide
Various sections
http://nacto.org/publication/urban-street-design-guide/

Figure 6 - List of design guidance manuals and documents

SAFETY

Crosswalk Markings

Some studies have been performed analyzing the effect of longitudinal markings (continental/international crosswalks) on crashes and visibility. In San Francisco, one study analyzing 54 intersections with longitudinal markings and 54 control (standard, transverse crosswalks) intersections found a 37% decrease in crashes.[7] Another study was conducted at 72 intersections in New York City and analyzed crashes within a 5-year period prior to the installation of high visibility markings (longitudinal markings) and a 2-year period after the installation of high visibility markings and found a 48% reduction in accidents after longitudinal crosswalk installations.[8] Longitudinal crosswalks are also more visible than transverse lines. A study by Fitzpatrick found they were first seen by drivers about 200 feet before transverse lines, almost twice the distance.[9] This increased sight distance results in "an additional 8 seconds of increased awareness of the crossing for a 30 mph operating speed." At night, the longitudinal crosswalks were seen about 100 feet sooner than transverse lines. Improvements over transverse lines were much greater at midblock, unsignalized crossings. Yielding rates and stopping distance in enhanced striped crosswalks also improve. In a TRB submitted study, Pulugurtha et al. found a 23% increase in motorists that yielded to pedestrians at longitudinal crosswalks and 10% more motorists yielded further than 20 feet from the crosswalk compared to the transverse location at mid-block crossings.[10]

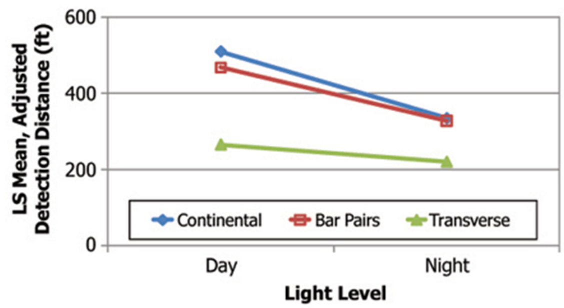

Figure 7 - Detection distance of longitudinal (continental) crosswalk markings versus parallel transverse lines (standard) at day and night. Image: Fitzpatrick, FHWA.

Colored Pavement Markings

A number of different cities have implemented colored pavement markings in their crosswalks; however, none have submitted follow up evaluations aside from the City of Chicago. In a report published in 2006 by the FHWA, the City of Chicago noted its findings on well over 100 school crosswalks that implemented yellow-green pavement markings. The report states, "Chicago's study found that the yellow-green crosswalk markings did not improve any quantifiable measures of effectiveness such as crashed or measured speeds. The study also found through surveys and interviews that the vast majority of school crossing guards, principals, and parents believe that the yellow-green markings did not help to increase driver awareness, reduce speeds, improve yielding behaviors, or make the crosswalks feel safer to pedestrians." As of 2006, the FHWA concluded that yellow-green crosswalk markings do not improve crosswalk safety.[11]

Figure 8 - Alternative pavement markings at a bicycle trail and pedestrian crossing in downtown Indianapolis, Indiana

Alternative Paving Materials in Crosswalks

The FHWA states that alternative paving materials have not shown any benefits other than enhancing an area's aesthetics; "The most common use of a colored pavement in conjunction with crosswalks is that of bricks, or asphalt that is stamped with a pattern and colored to simulate a brick appearance (red, rust, or brownish colors). These treatments have been deployed mostly in urban "streetscape" areas, with the primary purpose of enhancing the aesthetics of the area, in conjunction with other aesthetic treatments like decorative streetlights, benches and other street furniture, etc. "Although urban designers may sometimes ascribe enhanced visibility of the crosswalk (and, by implication, enhanced safety) as a secondary purpose of the colored pavement, there is no body of evidence that such safety benefits actually exist."[7]

Figure 9 - Brick paved crosswalk in Springfield, Illinois. Not MUTCD compliant due to no white striping on traversing sides of crosswalk.

Optical Illusion Pavement Markings

There is currently no research available that shows optical illusion pavement markings reduce crashes between motorists and pedestrians; however, there was a study completed by student Nicole M. Cambridge that found optical illusion pavement markings may have a slight effect on motorist yield rates. In 2012, graduate student Nicole M. Cambridge of the School of Psychology at Western Michigan University conducted a study on the zigzag 3D pavement illusions on Clark Street in Chicago. The purpose of her study was to evaluate the efficacy of the pavement marking prompt "LOOK FOR (Pedestrians)", which was a non-3D pavement marking installed right before the 3D zigzags, and then to evaluate the effect of the 3D zigzag pavement markings.[12]

Cambridge analyzed motorist yield rates when approaching the crosswalks while a pedestrian had a foot in the crosswalk, as if they were crossing. Behaviors were recorded during multiple sessions for four different phases:

1. Existing Site Conditions (No "LOOK FOR (Pedestrians)" or zigzag 3D pavement markings)
2. After Installation of "LOOK FOR (Pedestrians)" prompt
3. After installation of "LOOK FOR (Pedestrians)" prompt and 3D zigzag pavement markings
4. Six months after installation of "LOOK FOR (Pedestrians)" prompt and 3D zigzag pavement markings

Figure 10 - 3D optical illusion pavement markings on Clark Street in Chicago

"The addition of the 3D illusions did not produce significantly more yielding to pedestrians when added to the simple pavement marking prompt. Although… a clear difference in yielding occurred between baseline and the initial pavement marking prompt installation."[12]

Table 3 - Results of Cambridge's study on optical illusion pavement markings in Chicago

Motorist Yield Rates	Phase 1 *Existing Conditions*	Phase 2 *Look for Peds*	Phase 3 *3D Zigzags*	Phase 4 *6 Month Follow-Up*
Site 1	31.0%	51.0%	53.3%	53.0%
Site 2	34.0%	45.5%	48.8%	43.5%

Zig-Zag Markings

An experiment conducted by the Virginia Department of Transportation (VDOT) and its research arm, the Virginia Center for Transportation Innovation and Research (VCTIR), in 2009 tested two patterns of zig-zag pavement markings installed in advance of two crosswalks, where reduced mean vehicle speeds were observed within the zig-zag marking zones.[13]

Figure 11 - Zig-zag markings on the approach to various shared use path crossings in Virginia. Reprinted with permission, by Lance E. Dougald. Source: http://www.virginiadot.org/vtrc/main/online_reports/pdf/11-r9.pdf

Additionally, the speed reductions were sustained over time; "speed data revealed, that, in most cases, 6-month and 1-year after speeds remained at levels close to or below 1-week after speeds." Furthermore, the researchers performed surveys and found 61% of motorists noted a heightened awareness, 73% altered their driving behavior, and 40% noted an increased tendency to yield to crossing path users (60% noted no impact). However, motorists also did not understand the meaning of the zig-zag markings when presented without the context of crosswalk. "When seen with context, correct interpretations of their meaning increased, but not to levels compatible with guidance set forth in the MUTCD." Almost half (48%) noted a favorable opinion of the markings as shown in Figure 12.

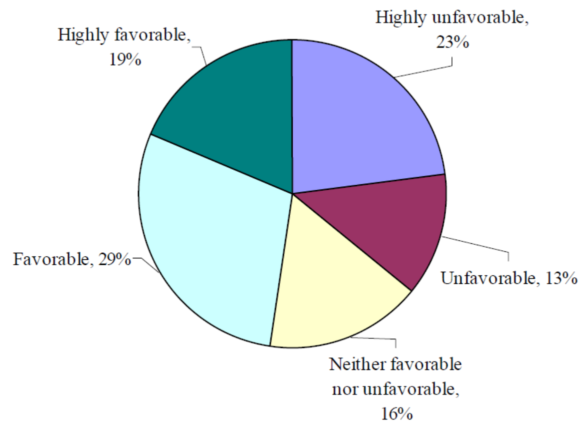

Figure 12 - Survey responses on overall opinion of markings. Chart by Lance E. Dougald. Reprinted with permission.

Zig zag markings are used in Europe to provide a warning of an approaching crosswalk and for regulatory parking restrictions to ensure adequate sightlines. Zig zag markings are a relatively new treatment in the United States and caution should be exercised when used within Illinois. MUTCD experimental status is required.

Signage

A study was conducted by the University of Illinois analyzing motorist yielding behavior at marked intersection crossings, unmarked intersection crossings, and midblock crossings, with in-street yield to pedestrian signs. Study results showed that "the crosswalks with in-street yield to pedestrian signs had the highest rate for the required to yield (21.8%) and the highest rate for the courtesy yields (5.9%). However, at locations with in-street yield-to-pedestrian signs, the proportions of motorists yielding to pedestrians increased, but the benefits are reduced when pedestrian volume is so high that motorist delay and queue is substantially increased, and motorists' frustration and willingness to engage in conflict with pedestrians is elevated."[14]

OPERATIONS

Most of the studies reviewed for this report did not indicate that crosswalk enhancements had any effect on motorist operations other than affecting motorist speeds (for example, see Virginia DOT study below). Furthermore, crosswalk enhancements serve to increase compliance by motorists who are legally obligated to stop whenever a pedestrian is present, whether the enhancements are installed or not. Regarding pedestrians, volumes may increase with the sustained use of enhancements due to the reduction in wait times and increased comfort that may be experienced.

"A study of a high-visibility zebra crossing in Edinburgh, United Kingdom found that the installation of a high-visibility crosswalk resulted in pedestrians spending significantly less time waiting to cross the road, being less likely to wait in the center median, and walking more slowly across the road."[2]

A study was conducted in Clearwater, Florida, comparing two locations with high visibility crosswalk markings enhanced with overhead illuminated signs against one control location. "Results found that the use of high visibility crosswalks resulted in significant increases in both driver yielding behavior and a 35% or more increase in pedestrians using the more highly visible crosswalks."[15]

Enforcement

Illinois law states that the motorist must come to a complete stop for pedestrians in a crosswalk, not for pedestrians waiting on the sidewalk who appear to want to cross. Results from a City of Chicago awareness campaign found many motorists are unaware of the legal requirement when approaching a crosswalk, therefore education and enforcement are needed to minimize pedestrian risks. The campaign and others included:

- In 2014, the City of Chicago conducted 69 crosswalk enforcement checks and wrote 1,234 citations for "Failure to Stop for Pedestrians in Crosswalks".
- The City of Chicago placed public service messages on CTA buses, bus shelters, and benches throughout the city to increase pedestrian safety.
- Chicago Police crosswalk awareness initiatives (CDOT 2014) - Off-duty, undercover police officers pose as pedestrians and observe motorist behavior. If motorists do not stop for pedestrians at crosswalks, as required by law, they are written a $50-$500 citation ticket (City of Chicago 2014). CDOT and the police department have previously conducted crosswalk enforcements from 2010-2013, resulting in the following:
  - 2010 - 60 crosswalk enforcement missions performed with 1,177 citations issued for "Failure to Stop for Pedestrians in Crosswalk" and 176 other citations.
  - 2011 - 55 crosswalk enforcement missions performed with 801 citations issued for "Failure to Stop for Pedestrians in Crosswalk" and 80 other citations.
  - 2012 - 70 crosswalk enforcement missions performed with 1,071 citations issued for "Failure to Stop for Pedestrians in Crosswalk" and 63 other citations.
  - 2013 - 69 crosswalk enforcement missions performed with 1,234 citations issued for "Failure to Stop for Pedestrians in Crosswalk" and 269 other citations.
  - 2014 - 40 crosswalk enforcement missions performed with 2,213 citations issued for "Failure to Stop for Pedestrians in Crosswalk" and 176 other citations.

MAINTENANCE

The most frequent maintenance problem with pavement markings is durability.[16] The type of pavement marking material chosen, such as paint, epoxy, or thermoplastic, will have an impact on the maintenance needs. The retroreflectivity of the pavement markings can also pose maintenance issues. Generally, a city or municipality is responsible for maintaining crosswalk enhancements, including all appurtenances. These agencies will need to take steps to ensure proper operation and maintenance of all crosswalks and appurtenances. Brick paved crosswalks are subject to heaving and uneven settling caused by freeze-thaw cycles, and they should be inspected to ensure compliance with ADA standards which require the accessible way to have a change in level equal to or less than ¼ inch.[17,18]

Street Sweeping & Snow Removal

Crosswalk enhancements mentioned in this report do not require additional effort beyond traditional street sweeping and snow removal methods; however, plow operators should take caution when clearing snow from brick paved crosswalks as loose bricks may be damaged or removed.

Utility Cuts and Construction Damage

During utility repairs, crosswalk enhancements may be impacted, but IDOT and most municipal utility policies require restoration to existing conditions by the utility owners. Utility companies may require additional information or guidance on proper repair; work should be inspected following replacement.

Drainage

Crosswalk enhancements mentioned in this report do not obstruct roadway surface runoff. Brick paved crosswalks may further facilitate surface drainage into a permeable stone or sand subbase.[19]

Typical Infrastructure and Associated Signage to Maintain

Alternative Paving Materials

- Brick lattice patterns, paving bricks, paving stones, setts, or cobbles

Colored Crosswalks

- Pavement Markings

Optical Illusion Pavement Markings

- Pavement Markings

Crosswalk enhancements can be found in almost every state in the United States; however, only a few locations in Illinois and other states were listed for reference.

Table 4 – Examples of Crosswalk Enhancement locations in the USA, with locations in District One shown in bold text

Country	City/County	State	Intersection	Description
USA	**Chicago**	**Illinois**	**Pulaski Boulevard between Wilson Avenue & Elston Avenue**	**Decorative lighting, stamped crosswalks, permeable pavers**
USA	**Chicago**	**Illinois**	**W. Congress Parkway & Wells Street**	**12" wide outside standard lines; color stamped thermoplastic material w/ paver look (inside)**
USA	**Chicago**	**Illinois**	**W. Congress Parkway & S. Dearborn Street**	**12" wide outside standard lines; one column of horizontal, color stamped thermoplastic material**
USA	**Chicago**	**Illinois**	**Downtown square**	**12" wide outside standard lines; faded, colored paint (inside)**
USA	**Chicago**	**Illinois**	**Clark Street & Deming Place**	**Zig-zag / optical illusion markings**
USA	**Crystal Lake**	**Illinois**	**Virginia Street & McHenry**	**12" wide outside standard lines; one column of horizontal, color stamped thermoplastic material (each side); color stamped thermoplastic material w/ large square look (inside)**
USA	**Crystal Lake**	**Illinois**	**Virginia Street & Dole Avenue**	**12" wide outside standard lines; column of horizontal, one color stamped thermoplastic material (each side); color stamped thermoplastic material w/ large square look (inside)**
USA	**Elgin**	**Illinois**	**Douglas Avenue & Chicago Street**	**Brick Pavers (missing outside white thermoplastic lines so it is not MUTCD compliant)**
USA	**Peoria**	**Illinois**	**Intersection of Main Street & Maplewood**	**Color stamped pavement w/ standard solid white edge lines**
USA	**Oak Brook**	**Illinois**	**Near Oakbrook Center**	**Enhanced crosswalk markings, improved pedestrian signals; Streetscape**
USA	**St. Charles**	**Illinois**	**1st Street & Illinois Street**	**12" wide outside standard lines; space; one column of color stamped thermoplastic material w/ paver look (each side); space; standard walkway pavement (inside)**
USA	Hammond	Indiana	-	Crosswalk enhancements - Streetscape
USA	Boston	Massachusetts	Commonwealth Avenue & Brookline Avenue	one column of horizontal, color stamped thermoplastic material (each side); color stamped thermoplastic material w/ paver look (inside)
USA	St. Louis	Missouri	Memorial Drive (near the Arch)	12" wide outside standard lines; color stamped thermoplastic material w/ diagonal, paver look (inside)
USA	Newport News	Virginia	Mariner Row	12" wide outside standard lines; color stamped thermoplastic material w/ horizontal, paver look (inside)
USA	Oak Harbor	Washington	8-state approved locations near Oak Harbor Schools	Pavement marking, enhanced with overhead lighting, electronic signs, flashing crosswalk

[1] United States Department of Transportation Federal Highway Administration (USDOT FHWA). May 2012. Manual on Uniform Traffic Control Devices (MUTCD) with Revisions 1 and 2, 2009 Edition.

[2] McGrane, Ann, Meghan Mitman. *An Overview and Recommendations of High-Visibility Crosswalk Marking Styles.* Pedestrian and Bicycle Information Center. Prepared for the Federal Highway Administration (FHWA). August 2013. http://www.pedbikeinfo.org/cms/downloads/PBIC_WhitePaper_Crosswalks.pdf

[3] United States Department of Transportation Federal Highway Administration (USDOT FHWA). February 10, 2014. *Designing Sidewalks and Trails for Access - Part II of II*, Section 8.5.1 Crosswalk Markings, Section 8.5.2 Crosswalk Research, 8.5.3 Recommendations for Enhancing Pedestrian Safety and Access, Section 8.5.3.1 Flashing Signals. Accessed February 13, 2015.
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[4] United States Department of Transportation Federal Highway Administration (USDOT FHWA). August 15, 2013. Interpretation Letter 3(09)-24(I) – Application of Colored Pavement. Manual on Uniform Traffic Control Devices. Accessed June 1, 2015.
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[5] United States Department of Transportation Federal Highway Administration (USDOT FHWA). April 27, 2005. Interpretation Letter 3-178(I) – Retroreflective Colored Pavement – Additional Clarification. Manual on Uniform Traffic Control Devices HOTO-1.Accessed August 20, 2014.
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[6] Bushell, Max, Bryan Poole, Daniel Rodriguez, Charles Zegeer. July 2013. *Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners and the General Public*. University of North Carolina Highway Safety research center. Accessed August 28, 2014.
http://www.pedbikeinfo.org/cms/downloads/countermeasure%20costs_report_nov2013.pdf

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[9] Fitzpatrick, K., S. Chrysler, V. Iragavarapu, and E.S. Park. *Detection Distances to Crosswalk Markings: Transverse Lines, Continental Markings, and Bar Pairs.* Transportation Research Record: Journal of the Transportation Research Board, *No. 2250*. Transportation Research Board of the National Academies, Washington, DC, 2011. http://www.fhwa.dot.gov/publications/research/safety/pedbike/10067/

[10] Pulugartha, S. S., V. Vasudevan, S. S. Nambisan, and M. R. Dangeti. *Evaluating the Effectiveness on Infrastructure-Based Countermeasures on Pedestrian Safety*. Presented at the 91st Annual Meeting of the Transportation Research Board, Washington, D.C., 2012. https://journals.sagepub.com/doi/10.3141/2299-11

[11] United States Department of Transportation Federal Highway Administration (USDOT FHWA). December 21, 2006. Yellow-Green Crosswalk Markings. Manual on Uniform Traffic Control Devices. Accessed August 20, 2014.
http://mutcd.fhwa.dot.gov/resources/policy/ygcrosswalkmarking/index.htm

[12] Cambridge, Nicole. *Effects of Symbol Prompts and 3D Pavement Illusions on Motorist Yielding at Crosswalks.* Western Michigan University. April 2012. http://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=1036&context=masters_theses

[13] Dougald, Lance E., *Best Practices in Traffic Operation and Safety: Phase II: Zig-zag Pavement Markings.* Virginia Transportation Research Council and Virginia Department of Transportation. December 2010. http://www.virginiadot.org/vtrc/main/online_reports/pdf/11-r9.pdf

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[16] United States Department of Transportation Federal Highway Administration (USDOT FHWA). 2015. Guide to Maintaining Pedestrian Facilities for Enhanced Safety. Accessed May 29, 2015. http://safety.fhwa.dot.gov/ped_bike /tools_solve/fhwasa13037/chap3.cfm

[17] Diefenderfer, Brian K., and Khaled A. Galal. February 2007. *Forensic Investigation of Brick Paver Crosswalks at Court Square in Charlottesville, Virginia.* Virginia Transportation Research Council. Final Report VTRC 07-R18. Accessed March 21, 2016. http://www.virginiadot.org/vtrc/main/online_reports/pdf/07-r18.pdf.

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Appendix

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Appendix

Bicycle & Pedestrian Accommodations Study

Illinois Department of Transportation, District One

Outline:

A. Outreach Documentation
   1. State DOT
   2. Advocacy Groups
   3. IML Survey

B. Data Collection
   1. Field Checklist
   2. Field Checklist Instructions
   3. Field Checklist Descriptions
   4. Behavior, Compliance, & Count Forms
   5. Measures of Effectiveness

C. Crash Modification Factors

Appendix A
Outreach Documentation

Appendix A-1
State DOTs

Date:	Thursday, April 2, 2015
Time:	1:00 PM CT (2:00 PM ET)
Subject:	Bike & Pedestrian Accommodations Study – State DOT Interview
Location:	Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Charles Frangos	Primera Engineers	312-242-6374	cfrangos@primeraeng.com
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Courtney Dwyer	MassDOT	857-368-6165	courtney.dwyer@state.ma.us
Josh Lehman	MassDOT (*retired)	857-368-6100	josh.lehman@state.ma.us
Lou Rabito	MassDOT	857-368-6100	Luciano.Rabito@dot.state.ma.us
Pete Sutton	MassDOT	857-368-6100	Peter.Sutton@dot.state.ma.us

1. Introductions

a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Massachusetts Department of Transportation (MassDOT) Bicycle and Pedestrian Coordinators.

b. In attendance from MassDOT was Courtney Dwyer, District 6 Bicycle & Pedestrian Coordinator; Josh Lehman, Bicycle and Pedestrian Program Coordinator *(Josh has since retired and his position has been assigned to Peter Sutton)*; Lou Rabito, Complete Streets Engineer; and Pete Sutton, Transportation Program Planner.

c. The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Pam Broviak, Project Manager for the study and also the District One ADA coordinator (*Pam has since changed bureaus)*; Aren Kriks is the Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred, Project Engineer for the study; Charles Frangos and Frank Zurek are civil engineers working for Primera on contract with IDOT.

2. Organization & Project Overview

a. The MassDOT bicycle and pedestrian team coordinates amongst all districts and each of the 13 planning agencies.

b. IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, and internal policies as well as recommendations. IDOT is looking for feedback from users and other state DOTs such as MassDOT. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements.

c. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with IDOT Central Office.

d. There is a potential for some of these tools or facilities to be installed as an experimental or pilot project within District One.

e. The final project report is due winter 2015-16.

3. Facilities

The following facilities are used by MassDOT:

a. Bicyclists:

i. Separated bike lanes

1. All separated bike lanes are on municipal roads. MassDOT has one proposed on Route 5 in District 2. MassDOT is also proposing them in a few other locations.

2. MassDOT is working with Toole Design Group to design a 6" full vertical curb, one-way, separated bikeway. The bikeway will have a minimum width of 5' at the narrowest point but will typically be 6' wide to allow for passing. Some municipalities have requested 6.5' wide.

3. *Local roads:* One local example of a separated bike lane is on Commonwealth Avenue in Boston. There are two travel lanes, on-street parking, the Green Line platform train, and a separated bike lane. At bus stops the bike lane is designed at the same elevation as the sidewalk so the city can use a sidewalk plow. The Commonwealth Avenue location also experiences several right-hook crashes and fatalities at one intersection. That location has a hill resulting in fast moving bicyclists.

ii. Buffered bike lanes: MassDOT uses recessed striping, green paint at various intersections and bicycle friendly rumble strips (with gaps). MassDOT typically uses a 2' to 4' separation between the bicycle lane and the motorist lane. Example routs include Holyoke Route 5 (4.5 miles long) and Hadley Route 116 (proposed). MassDOT is also considering a buffered bike lane on Bernardston Route 10 and Brimfield Route 20. A standard detail for pavement markings was provided by MassDOT and is included with these minutes.

iii. Green pavement markings: MassDOT provided a standard detail for green pavement marking striping through intersections. The detail is included with these minutes.

- **iv.** Road diets – MassDOT has six to seven locations where road diets were implemented. A report examining before and after data is due at the end of summer 2015.
- **v.** Widened shoulders – MassDOT uses a minimum of 5' shoulders.

b. Pedestrians:

- **i.** HAWK signals – two locations on local roads.
- **ii.** RRFB – one Rectangular Rapid Flashing Beacons on a state highway rotary.
- **iii.** Road diets
- **iv.** MassDOT does not use red light cameras, lighted crosswalks or pedestrian scrambles.
- **v.** *Local roads:* Some municipalities have pedestrian scrambles.

4. Topics:

a. Policy & Funding:

- **i.** The Healthy Transportation Directive, instituted by Richard A. Davy, Secretary of Transportation, aimed to triple the distance traveled by walking, bicycling, and transit by 2030.
- **ii.** Each MassDOT district has a checklist for minimum bicycle & pedestrian accommodations. Design exceptions must be approved by the chief engineer and secretary.
- **iii.** Federally funded projects are reviewed through MassDOT to ensure compliance.
- **iv.** MassDOT funds the entire project construction cost. Sometimes the municipality pays for the design.
- **v.** 2014 Massachusetts transportation bond bill called for $50 million for the complete streets certification program, championed by bike advocacy groups.
    1. Provides $5 million for the next 4 years.
    2. MassDOT is in the process of developing project selection criteria and equity language. Small projects such as restriping and signage are eligible.
    3. Municipalities must pass a Complete Streets policy to receive funds. MassDOT uses the NCSC certification, and requires approval by the MassDOT Bicycle and Pedestrian Advisory Board (MABPAB) or Healthy Transportation Initiative.

b. Public Involvement

- **i.** MassDOT has a public participation process with public hearings. One example includes a road diet on Route 12. It had two lanes in each direction with a wide shoulder but low traffic volumes that did not support that capacity. One lane was removed on a temporary basis and the corridor was reevaluated. MassDOT collected traffic and speed data as well as feedback from the community.

ii. The Massachusetts public is supportive of separated bike lanes and have requested them from MassDOT.

c. Maintenance

i. Massachusetts has comparable climatic conditions to the Midwest.

ii. All projects are turn-key whether they improve the municipality or not. MassDOT is not liable or exposed to any maintenance costs. When adding sidewalks or if there is a preexisting sidewalk MassDOT executes an agreement with municipalities: MassDOT maintains the roadway and the municipality maintains the sidewalk.

1. MassDOT does not have a way to enforce agreements. However, many municipalities have ordinances that require the property owner to clean and clear sidewalks. The City of Boston issues fines for infractions.

iii. Maintenance varies, one example is a shared use rails to trails path on a state owned railway. Massachusetts licenses out the path to four municipalities, each with its own policy for clearing snow and ice.

iv. MassDOT maintenance intensity depends on urban density.

v. Some MassDOT districts have issues with maintaining the green paint. MassDOT mentioned the need for an agreement with local municipalities to replace the green markings when worn down. The Boston Public Works Department is evaluating various green paint mixes to determine the best mix.

vi. The new MassDOT Separated Bike Lane Design Guide includes a chapter on maintenance.

vii. Snow removal is MassDOT's largest concern. MassDOT has sidewalk plows. Boston is purchasing specialized equipment for their separated bike lanes. The City of Brookline was originally planning to use painted buffers and flex posts for their separated bike lane to avoid purchasing specialized equipment but have since changed the design to a vertically and horizontally separated facility.

viii. MassDOT also mentioned the necessity for trash removal vehicles to include arms to extend over the barrier and pick up trash receptacles.

ix. MassDOT is meeting with utility companies to discuss requirements such as vacuum trucks that can clean out catch basins over the barrier.

d. Internal Guides

i. MassDOT developed Separated Bike Lane Design Guide to help provide guidance on local facilities. The guide includes, for example, intersection designs, signal timings, pedestrian islands, and signal progression for bicycles and pedestrians.

e. Training

i. MassDOT and FST developed complete streets training with three and six hour long classes.

f. NACTO

i. MassDOT has endorsed the NACTO Urban Bikeway Design Guide. Massachusetts was the 2nd state to do so. MassDOT uses the NACTO guide as a tool to look at innovative approaches to designs, which helped in the development of their Separated Bike Lane Design Guide.

1. First introduction was at a NACTO conference in NYC. Previously, MassDOT relied on AASHTO guidance and NACTO was their first step outside that.

ii. MassDOT does not endorse the USDG but that may change with their new secretary.

g. Counts

i. The local MPO performed chronological counts of bicyclists and pedestrians on a shared use path. The database can be found here: http://www.ctps.org/apps/bike_ped5/bike_ped_query.html

h. Studies

i. MassDOT does not have a program to perform studies but plan to in the future. However, MassDOT does have bicycling and walking audits.

i. GIS

i. MassDOT is overhauling their GIS and bicycle inventory. MassDOT is combining their inventory with the MPO database and will post it online shortly. The data will be publicly available and downloadable.

ii. MassDOT's inventory classifies facilities by bike lane, shared lane, off-road shared use path, paved and unpaved. The inventory will contain existing, planned, and concept facilities.

iii. Queries can be run on the inventory to gather statistics such as how many miles of sharrows, for example.

iv. Clusters of crashes were identified with their crash database and were used to increase enforcement in 12 communities. The next step identified by MassDOT is to determine possible infrastructure changes.

v. Updates are done manually.

j. IDOT:

i. IDOT uses an 80%/20% split for bicycle and pedestrian projects. For example, IDOT will contribute 80% of the cost to design and construct a shared-use path within IDOT ROW if the local municipality contributes 20% and agrees to maintain the facility.

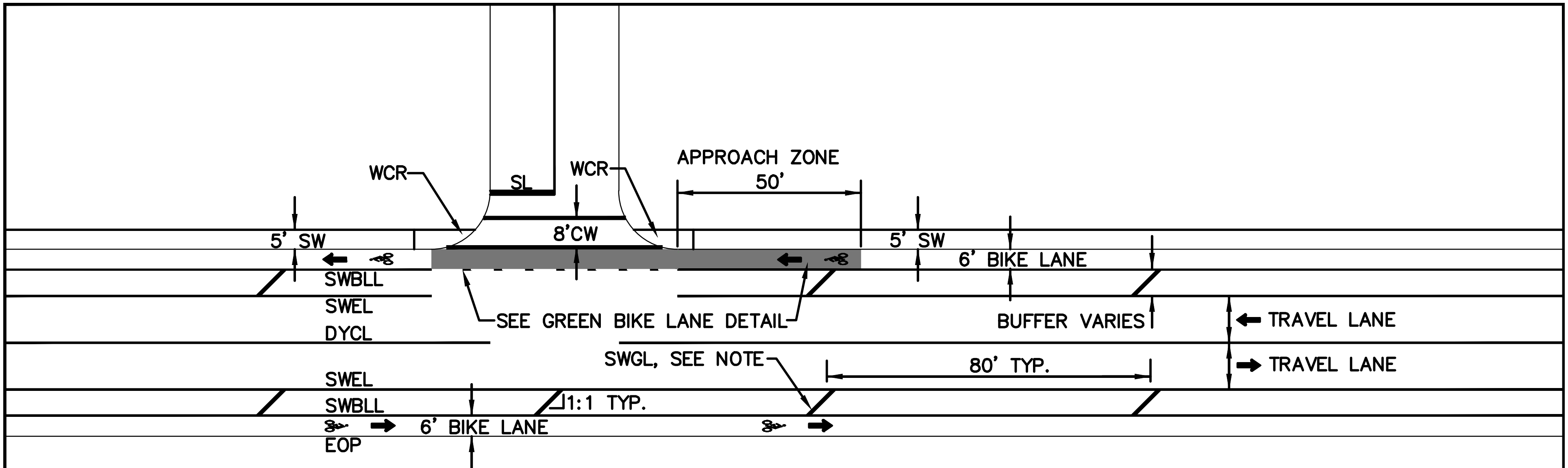
- **ii.** IDOT still maintains control of the ROW.
- **iii.** IDOT is using a 7.5’ minimum for separated bike lane widths, based on a CDOT standard.
- **iv.** The public is supportive of separated bike lanes. However, IDOT is also interested in the safety of the facility.
- **v.** IDOT will forward the final feasibility study to MassDOT after completion in the winter of 2015-16.

5. Miscellaneous:

a. The meeting concluded at 2:20 PM CT (3:20 ET)

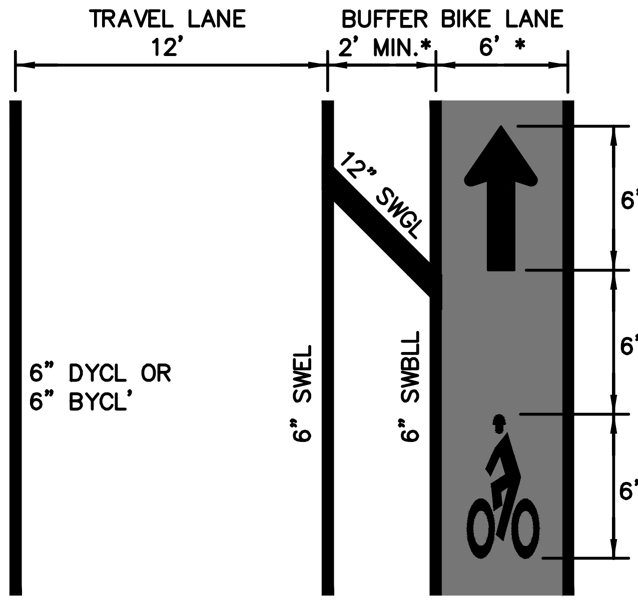
Attachments:

MassDOT – Bike Lane Markings.pdf

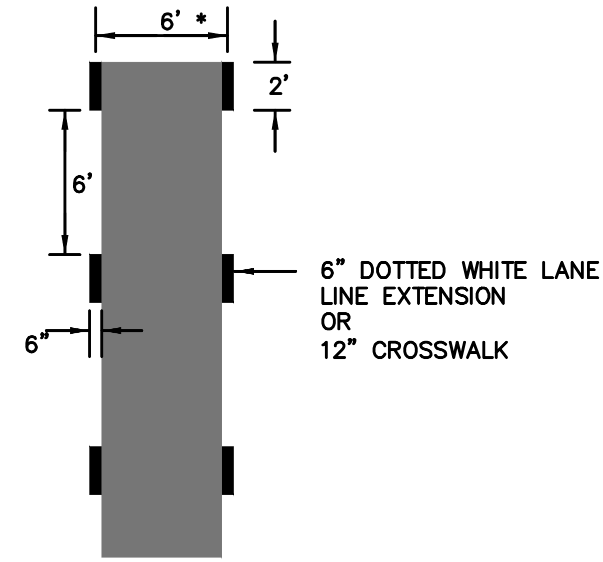


NOTES:
1. LOCATE BIKE SYMBOL AND ARROW OPPOSITE EACH OTHER IN NORHTBOUND AND SOUTHBOUND (OR EB / WB) BIKE LANES.
2. DESIRED BIKE LANE WIDTH = 6'. MINIMUM BIKE LANE WIDTH = 5'.
3. MINIMUM BUFFER WIDTH = 2'. DISCONTINUE BUFFER WHERE SUFFICIENT WIDTH IS NOT AVAILABLE.
4. WHERE SHOULDER IS 8' WIDE OR GREATER, MARK BIKE LANE 6' WIDE AND REMAINDER AS BUFFER
5. WHERE SHOULDER IS LESS THAN 8' WIDE, REDUCE BIKE LANE WIDTH TO 5' (MINIMUM). MAINTAIN 2' WIDE BUFFER (MINIMUM).
6. WHERE SHOULDER IS LESS THAN 7' TOTAL, DISCONTINUE BUFFER AND MARK BIKE LANE ONLY.
7. WHERE SHOULDER IS LESS THAN 5', DISCONTINUE BIKE LANE MARKINGS.
8. WHERE BIKE LANE CROSSES A SIDESTREET, APPLY GREEN PAINTED AREA, WITH WIDTH EQUAL TO ADJACENT BIKE LANE.
9. LOCATE SOLID WHITE 12" GORE LINES IN BUFFER AT 80' INTERVALS.

massDOT Massachusetts Department of Transportation Highway Division HIGHWAY DESIGN	TYPICAL INTERSECTION MARKINGS T-INTERSECTION	PROJECT: GREEN PAVEMENT MARKINGS THROUGH INTERSECTION	SCALE: N/A PROJECT NO.: N/A SHEET 1 OF 2



GREEN BICYCLE LANE MARKING THROUGH APPROACH ZONE



GREEN BICYCLE LANE MARKING THROUGH INTERSECTION

GREEN PAVEMENT BIKE LANE NOTES:

1. MARK BIKE LANE AT INTERSECTIONS, WITH GREEN PAVEMENT MARKING.
   1.1. MARK BOTH SIDES OF BIKE LANE WITH 6" SOLID WHITE BICYCLE LANE LINE (SWBLL) OR DOTTED WHITE LANE LINE EXTENSION.
   1.2. OMIT RIGHT SIDE LANE LINE WHERE BIKE LANE RUNS ALONG CURB OR EDGE OF PAVEMENT.
2. SOLID GREEN BIKE LANE SHALL CONTINUE THROUGH INTERSECTIONS WITH BORDERING DOTTED WHITE MARKINGS (2' DASH, 6' SPACE) ALONG SIDE, OR WITH BOARDING CROSSWALK LINE.
3. INSTALL BIKE LANE SYMBOL AND ARROW AT THE BEGINNING OF GREEN PAVEMENT, AT THE BEGINNING OF THE BIKE LANE AND AT $\frac{2}{10}$ MILE INTERVALS.

* DESIRED BIKE LANE WIDTH = 6'.
MINIMUM BIKE LANE WIDTH = 5'.
MINIMUM BUFFER WIDTH = 2'.

massDOT Massachusetts Department of Transportation Highway Division HIGHWAY DESIGN	DETAILS - BIKE LANE GREEN PAVEMENT MARKING THROUGH INTERSECTION	PROJECT: GREEN PAVEMENT MARKINGS THROUGH INTERSECTION	SCALE: N/A PROJECT NO.: N/A SHEET 2 OF 2

Date:	Tuesday, May 12, 2015
Time:	10:00 AM CT
Subject:	Bike & Pedestrian Accommodations Study – State DOT Interview
Location:	Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Tim Mitchell	MnDOT	651-366-4162	tim.mitchell@state.mn.us
Melissa Barnes	MnDOT	651-234-7376	melissa.barnes@state.mn.us

1. Introductions

a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Minnesota Department of Transportation (MnDOT) Bicycle and Pedestrian Coordinators.

b. In attendance from MnDOT was Melissa Barnes, Bicycle and Pedestrian Statewide Safety Engineer; and Tim Mitchell, Bicycle and Pedestrian Statewide Coordinator.

c. The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Pam Broviak, Project Manager for the study and also the District One ADA coordinator; Aren Kriks is the Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred, Project Engineer for the study; Frank Zurek is a civil engineer working for Primera on contract with IDOT.

2. Organization & Project Overview

a. MnDOT gave an overview of their policies, guides, manuals, and facilities as recorded below. Tim and Melissa are statewide coordinators. MnDOT has district level coordinators or staff that work on bicycle and pedestrian issues at each of the districts. MnDOT does not have a complete streets coordinator, but staff includes complete streets tasks as part of their effort. MnDOT's jurisdiction covers collectors, arterials, urban roads, and highways. MnDOT has some metropolitan routes as well as suburban main streets.

b. IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, and internal policies as well as recommendations. IDOT is looking for feedback from users and other state DOTs such as MnDOT. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements.

c. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with IDOT Central Office.

d. There is a potential for some of these tools or facilities to be installed as an experimental or pilot project within District One.

e. The final project report is due summer 2015.

3. Facilities

a. All facilities on IDOT's study list are allowed by MnDOT except red light cameras. Red light cameras were implemented by the City of Minneapolis but deemed illegal; all issued tickets were refunded.

b. The following facilities are currently used by MnDOT on state roads:

i. Bicyclists
1. Conventional bike lanes
2. Widened shoulders
3. Cycle tracks (in design). See *Topics* below for more information.
4. Two-stage turn queue boxes (in design)
5. MnDOT explored the use of green paint, however, their maintenance section had concerns about the frequency of reapplication needed.
6. Crossing pavement markings
7. Road diets

ii. Pedestrians
1. Enhanced crosswalks
2. In-roadway warning lights (IRWL). The IRWL were used on the freeway system to enhance lane markings. Issues were experienced with plowing and during freeze/thaw cycles salt and water were getting into the wiring. MnDOT is no longer using IRWL.
3. Rectangular rapid flashing beacons (RRFB)
4. HAWK Beacons. Some MnDOT engineers believe the HAWK beacons are being used incorrectly.
5. Bump outs
6. Leading pedestrian intervals

iii. Minneapolis has installed cycle tracks, green thermoplastic paint, and raised crosswalks. Minneapolis has not had any issues with maintaining raised crosswalks and they've had success with their green paint.

4. Topics

a. Policy

i. Minnesota passed a complete streets law in 2010 that went into effect in 2014. The policy gave MnDOT a series of benchmarks to meet over subsequent years. MnDOT is still in the process of fully implementing the law.

ii. MnDOT considers bicycle and pedestrian accommodations on every project including resurfacing projects.

iii. MnDOT retains ownership of all facilities within their right-of-way. According to coordination with the FHWA, MnDOT is obligated to maintain elements under MnDOT ownership. Therefore, maintenance agreements are only for snow removal, cracked sidewalk and other basic maintenance but other issues such as broken sidewalk panels and compliance issues are MnDOT's responsibility.

iv. MnDOT's complete streets group was originally placed within their bicycle and pedestrian group. Since some complete streets issues go beyond bicycle and pedestrian concerns, the group was moved to the engineering services and local government divisions, then moved again to the central planning and programming groups. Complete streets is supported by a steering team comprised of local government representatives, environmental staff, and other MnDOT staff.

b. Funding

i. MnDOT develops agreements with local governments to maintain facilities. If an agreement can't be reached, the bicycle and pedestrian accommodation can be exempted from the design.

ii. MnDOT's cost participation may be 100%, 80%/20%, 50%/50%, or none depending on the project circumstances.

c. Internal Guides

i. A best practices guide was developed by the local governments division. The guide examines specific treatments, differentiated by proven, tried, and experimental categories.

ii. MnDOT keeps their bikeway design guide separate from their traffic engineering manual. MnDOT is in the process of updating their bikeway design manual to reflect the latest AASHTO and NACTO guides. An internal draft of the updated guide will be completed at the end of 2015.

iii. MnDOT wrote a series of technical memorandums to inform of changes to the design manuals in the coming years.

iv. MnDOT has their own MUTCD manual.

d. NACTO

i. MnDOT cosigned a letter of support with the cities of Minneapolis and St. Paul, and the two surrounding counties. MnDOT did not fully endorse the guide due to the lack of opportunity with reviewing the facilities in a holistic way and the lack of some NACTO facilities in the MUTCD. However, the letter of support indicates to MnDOT staff to start using NACTO as a reference.

ii. MnDOT will incorporate NACTO designs into the upcoming MnDOT bikeway design manual.

e. Cycle tracks

i. MnDOT has a few cycle track locations in concept phase and one location in design phase. The in-design location is located on the Mississippi River bridge near Red Wing, Minnesota. MnDOT is constructing a new bridge to span the river and will include an adjacent shared use path. MnDOT is designing a protected bike lane to transition between the bridge shared use path and the on road bicycle facility at the bridge terminus in downtown Red Wing. The cycle track will cross two intersections, one with low vehicle volumes and the other at a higher volume, signalized intersection. MnDOT is considering a two-stage turn queue box at the signalized intersection.

ii. The cycle track will be two-way on one side of the street; MnDOT is removing parking on one side of the roadway. The barrier will most likely be a curb separation. MnDOT may start with temporary delineator installation to observe how the facility functions. The proposed width is 10' which is the maximum width based on site constraints. The roadway has 10,000 to 12,000 ADT.

iii. Minneapolis' cycle tracks use flexible delineators and parked vehicles. Minneapolis has raised and curb separated cycle tracks on Washington Avenue that is in construction.

f. Counts

i. MnDOT has experience with temporary and permanent count equipment. MnDOT has two permanent counters on a state suburban/exurban roadway and a trunk highway. MnDOT developed standard specifications for the counting equipment and use a consistent methodology for collecting data.

ii. MnDOT is developing an equipment training program for other jurisdictions that are feeding count data into the statewide database.

iii. MnDOT plans to incorporate the bicycle count program into the vehicle traffic system. MnDOT is looking for additional locations to install permanent counters to further reduce error.

iv. MnDOT calculated AADB factors from a larger dataset beyond the two permanent counters they have installed. MnDOT will provide their extrapolation factors report and count equipment report.

g. Inventory/GIS
   i. All MnDOT pedestrian facilities and compliant locations are inventoried in GIS.
   ii. Bicycle facilities are not inventoried yet but MnDOT is currently converting an old database of facilities to GIS. The database does not distinguish between specific facility types yet.

h. Training
   i. MnDOT's complete streets staff meets with local maintenance districts to clarify the complete streets policy and cost participation.
   ii. The bicycle and pedestrian group does quasi training with state advocacy groups and the State Department of Health. The group also performs workshops at the community level discussing things the community can do to become more bicycle friendly. The group sends staff to conferences and other workshops as well. The traffic safety group also hosts training sessions relating to signals and signage.
   iii. MnDOT hopes to formalize a bicycle and pedestrian training program once the new bicycle and pedestrian design manual is released.
   iv. MnDOT's ADA team performs internal and external training for ADA issues. MnDOT has performed training with consultants, contractors, and local units of government.

i. ADA
   i. MnDOT developed an ADA design guide separate from their complete streets policies. MnDOT has examined ADA compliance issues for five to six years. MnDOT's ADA team is separate from Tim & Melissa's staff.

j. IDOT
   i. Illinois' complete streets law was passed in 2007 and implemented by IDOT in 2010.
   ii. IDOT's funding split for bicycle and pedestrian accommodations is 80% state, 20% locals. IDOT replaces any bicycle and pedestrian accommodations at 100% if the accommodations are impacted by the project. IDOT pays 100% for on road facilities with the agreement that the locals pay for maintenance.
   iii. IDOT has a similar responsibility to MnDOT's regarding maintaining ADA compliance of sidewalks.

The meeting concluded at 11:10 AM CT

MEETING MINUTES

Date: Thursday, April 2, 2015
Time: 3:00 PM CT (1:00 PM PT)
Subject: Bike & Pedestrian Accommodations Study – State DOT Interview
Location: Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Basil Christopher	ODOT	503-731-3261	Basil.R.CHRISTOPHER@odot.state.or.us
Jessica Horning	ODOT	503-731-3359	Jessica.Horning@odot.state.or.us
Rodger Gutierrez	ODOT	503-986-3554	Rodger.C.GUTIERREZ@odot.state.or.us

1. Introductions

a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Oregon Department of Transportation (ODOT) Bicycle and Pedestrian Coordinators.

b. In attendance from ODOT was Basil Christopher, Bicycle and Pedestrian Coordinator, ODOT Region 1; Jessica Horning, Transit and Active Transportation Liaison; and Rodger Gutierrez, Statewide Bicycle and Pedestrian Standards Specialist.

c. The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Pam Broviak, Project Manager for the study and also the District One ADA coordinator (*Pam has since changed bureaus)*; Aren Kriks is the Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred, Project Engineer for the study; Frank Zurek is a civil engineer working for Primera on contract with IDOT.

d. Although some ODOT Bike/Ped staff participated in the phone call, it should be noted that question #1 asked for the contact information of the state bicycle coordinator and state pedestrian coordinator. The official bicycle & pedestrian coordinator for ODOT is Sheila Lyons, who was not a participant in the phone call. Her information is below:

Sheila Lyons, PE
Pedestrian & Bicycle Program Manager
555 13th Street NE, Ste. 2
Salem OR 97301
Sheila.A.LYONS@odot.state.or.us
503-986-3555

2. Organization & Project Overview

a. IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, and internal policies as well as recommendations. IDOT is looking for feedback from users and other state DOTs such as ODOT. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements.

b. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with IDOT Central Office.

c. There is a potential for some of these tools or facilities to be installed as an experimental or pilot project within District One.

d. The final project report is due winter 2015-16.

3. Facilities

a. The following facilities are used by ODOT:

b. Bicyclists

- **i.** Conventional bike lanes
- **ii.** Buffered bike lanes
- **iii.** Contra-flow bike lane – located on an off-ramp exit.
- **iv.** Left-side bike lane
- **v.** Widened shoulders – width is based on traffic volumes: 4' shoulder for under 2000 ADT, up to 6' and 8' depending on higher traffic volumes.
- **vi.** ODOT does not have corridor length cycle tracks. However, ODOT has on-street bike lanes that merge with pedestrians at intersections. ODOT approves of cycle tracks but have not found a viable location in their system yet. ODOT has funded cycle tracks on local routes.
- **vii.** Jug handle treatments
- **viii.** Bicycle crossing pavement markings
- **ix.** *Local roads*: Portland has installed bike boxes on highway approaches.

c. Pedestrians

- **i.** RRFB – ODOT has hundreds of Rectangular Rapid Flashing Beacons installations across the state.
- **ii.** HAWK Signals – ODOT has two HAWK signals on their system.
- **iii.** *Local roads:* Portland has an all-red intersection and may have a Barnes Dance.

Indicated in tables below.

- **Purple** = yes
- Blue = in the past, but not anymore

- Green = ODOT has funded on local agency roads
- Red = proposed on ODOT roads, but not implemented (yet)
- Gray = no

Bicycle Facilities	
Category	**Facility**
Bicycle Lanes	**Conventional Bike Lanes**
	Buffer Protected Bike Lanes (LaPine, McLoughlin)
	Contra-Flow Bike Lanes (I-84 exit 41)
	Left-Side Bike Lanes (Pioneer Pkwy)
	Widened Shoulders
Cycle Tracks	One-Way Cycle Tracks
	Two-Way Cycle Tracks Going to put one in on Powell (short jog) in 130s
	Raised Cycle Tracks
Low-Traffic	Bicycle Boulevards
Other	**Road Diets**
Category	**Feature**
Intersections	**Bike Boxes** (on side-street approaches)
	Two-Stage Turn Queue Boxes (cup handle treatments)
	Crossing Pavement Markings
	Median Refuge Islands
	Vehicle/Bicycle Mixing Zones
	Combined Bike Lane/Turn Lane
	Bicycle Signal Heads

Pedestrian Facilities	
Category	**Facility**
Intersections	Barnes Dance/Ped Scramble
	All Red, Four-Way Pedestrian Walk
	Enhanced Crosswalks
	Raised Ped Crossings
	Lighted Crosswalks
	Curb Radius Reduction (Bump Outs)
Signals	**Red Light Cameras**
	HAWK Signals
	Pedestrian Signals
	Rectangular Rapid Flash
	Road Diets

4. Topics

1. ODOT officially recognized the NACTO guides in a letter earlier this month, but did not use the word endorse or adopt.
2. http://nacto.org/wp-content/uploads/2015/10/Oregon-DOT-USDG-Endorsement-092515.pdf

ii. ODOT approves certain designs in the NACTO guides, including those brought forth by local agencies using federal funds.

iii. ODOT believes NACTO does a great job gathering information from across the country on innovative designs, however, the guide is limited in context.

iv. Many ODOT staff have attended NACTO training sessions.

f. Counts

i. ODOT partners with the METRO and the local MPO to conduct manual spring and fall counts. ODOT recruits volunteers to perform counts at about 300 locations. The locations include ODOT facilities, trails and local streets and are performed using the National Bike Ped Documentation (NBPD) project form. ODOT creates an annual report with the results.

ii. ODOT has permanent counters. They utilize inductive loops on multi-use paths installed in the late 1980's. More recently, ODOT has installed Eco-Counter brand loop detectors that detect both bi-directional bicyclists and pedestrians.

iii. ODOT verified their bicycle and pedestrian data collection equipment with the ODOT Statewide Data Collection Unit. ODOT found induction loop counts were 20% low on average so ODOT uses an adjustment factor. ODOT has also partnered with Portland State University (PSU) to examine loop designs that would increase detection rates. ODOT has also started using stencils to mark the optimal location for bicyclists to stop to increase the chance of detection. ODOT uses diamond and parallelogram patterns.

iv. All local vendors perform bicyclist and pedestrian counts on projects by default.

v. All counts are uploaded to a website for ODOT, METRO, and Portland to use.

vi. ODOT is working with PSU to develop a system that takes information from vehicle counters, push buttons, and loop detectors to feed into a central tracking system.

vii. ODOT's Eco-Counter data is available through the Eco-Counter website, which ODOT can share with IDOT.

viii. ODOT has utilized transit counts automatically collected through passenger bus counting systems.

ix. Portland also performs their own counts.

g. GIS

- **i.** ODOT has a statewide inventory of all bicycle, pedestrian and ADA facilities.
- **ii.** Bicycle facilities include shared travel lanes, bicycle lane markings, bicycle lane shoulders (5' shoulder width). ODOT has a separate inventory for shoulder widths and another for shared use paths.
- **iii.** ADA curb ramps were inventoried using compliance criteria that took into account running slope, cross slope, lip height, level landing, clear width, slope differential, truncated domes, and counter slope. The ADA inventory contains a rating scale to determine whether ramps meet current standards. It also approximates whether it meets 91 standards. New projects are required to check the inventory and update.

h. Studies

- **i.** ODOT will perform a before and after buffered bike lane study in the fall. The facility was recently added as part of a pavement repaving project. It was installed on an 8' wide shoulder. ODOT will examine operations, crash data and behavioral data such as wrong way riding or riding on the sidewalk.

i. Performance Metrics

- **i.** ODOT developed statewide performance metrics such percentage of urban highways with sidewalks and bicycle facilities.
- **ii.** ODOT developed a level of traffic stress model. ODOT is planning studies to evaluate stress on various bicycle facilities.
- **iii.** ODOT did not adopt the HCM, they have their own capacity analysis specific to ODOT.

j. Shared Use Paths

- **i.** ODOT is installing their first cross-bike shared use path with separate paths for bicycling and walking. It will include bike lane extension markings and green markings.
- **ii.** ODOT is considering using wider paths for traditional shared use paths to allow a proper split between modes.
- **iii.** ODOT will often not stripe shared use paths where they want users to decrease speeds. ODOT will leave the path unmarked and perhaps install signs instructing on proper usage.

k. IDOT

- **i.** IDOT has a complete streets law. The law was adopted in IDOT manuals in 2010. Any project that alters the travelled way will trigger the complete streets policy. IDOT has a step down approach to design exceptions. If the first facility cannot be implemented then the next tier is considered.

ii. IDOT uses an 80%/20% split for bicycle and pedestrian projects. For example, IDOT will contribute 80% of the cost to design and construct a shared-use path within IDOT ROW if the local municipality contributes 20% and agrees to maintain the facility.

iii. For conventional bike lanes, IDOT paves the road but asks the local municipalities to maintain the striping.

iv. IDOT is examining an option to construct an 18’ wide path with a shared left-turn bike lane, and separate 4’ wide limestone running paths during the reconstruction of North Lake Shore Drive. Lake Shore Drive is an IDOT highway along Lake Michigan in Chicago.

v. IDOT includes a chapter in their manuals that discusses bicycle facilities based on speed and traffic volumes.

vi. IDOT recently completed the state’s first Statewide Bike Plan.

vii. IDOT does not endorse NACTO. IDOT is reluctant to approve facilities that are not approved by AASHTO, however, IDOT has started a pilot cycle track project in Chicago on an IDOT road.

viii. IDOT is proposing road diets and isn’t opposed to them. The City of Chicago has also installed road diets. CDOT must provide support to IDOT in the form of an HCS analysis that removing travelling lanes minimally affects motorists.

ix. IDOT does enter into jurisdictional transfers with local municipalities, however the municipalities must then pay for and maintain the roadway.

x. IDOT has utilized interim MUTCD approval for some items, including flashing yellow turn lights. They also utilized a City of Chicago interim approval for bike signals for a proposed cycle track on a state route in Chicago.

xi. IDOT controls speed limits on state jurisdiction roadways only. The state does not monitor or control local roadways except for bridges. IDOT undergoes proposed changes in speed limits by performing a speed study and determining prevailing speeds.

I. Miscellaneous

i. ODOT utilizes a thermoplastic rumble strip at some locations.

ii. Portland has a modal hierarchy policy.

The meeting concluded at 4:15 PM CT (2:15 PT)

Date:	Friday, April 3, 2015
Time:	3:00 PM CT (1:00 PM PT)
Subject:	Bike & Pedestrian Accommodations Study – State DOT Interview
Location:	Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Paula Reeves	WSDOT	360-705-7258	ReevesP@wsdot.wa.gov

1. Introductions

- **a.** The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Washington State Department of Transportation (WSDOT) Bicycle and Pedestrian Coordinator.
- **b.** In attendance from WSDOT was Paula Reeves, Bicycle and Pedestrian Program Manager in the WSDOT Engineering Policy and Innovation Division.
- **c.** The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Pam Broviak, Project Manager for the study and also the District One ADA coordinator (*Pam has since changed bureaus*); Aren Kriks is the Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred, Project Engineer for the study; Frank Zurek is a civil engineer working for Primera on contract with IDOT.

2. Organization & Project Overview

- **a.** WSDOT Engineering Policy and Innovation Division is a new division of WSDOT. It was created in September 2014 to elevate bicycling and walking. The Division has access to and direct interaction with the construction and design offices and the front office. Paula has managed the bicycle and pedestrian program for ten years. Prior to that she was involved with local roads.
- **b.** WSDOT has district level bicycle and pedestrian coordinators but WSDOT is moving away from this internal organization. Instead WSDOT is focusing on bicycle and pedestrian teams in each region that look at topical issues.
- **c.** IDOT gave an overview of the study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, and internal policies as well as recommendations. IDOT is looking for feedback from users and other state DOTs such as WSDOT. The reports that IDOT is developing

focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements.

d. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with IDOT Central Office.

e. There is a potential for some of these tools or facilities to be installed as an experimental or pilot project within District One.

f. The final project report is due winter 2015-16.

3. Facilities

a. The following facilities are used, or approved for use, by WSDOT (bicycle facilities are also shown on the attached WSDOT Bicycle Facilities Poster):

b. Bicyclists

i. Shared lane markings (sharrows)

ii. Conventional bike lanes

iii. Buffered bike lanes

iv. Raised or curb separated protected bike lanes

v. Bollard or parking separated protected bike lanes – currently installed through a local contract

vi. Bike boulevards

vii. Shared use paths or trails

viii. Bike signals – WSDOT is installing their first bike signal on Bainbridge Island. WSDOT has statewide approval for bike signals.

ix. Green pavement – They use tinted asphalt due to its durability. A paint application was used in Port Angeles but it faded too quickly. WSDOT has statewide approval for green pavement.

c. Pedestrians

i. RRFB

ii. HAWK – some installed on state roads. In the Seattle area, the local traffic engineer has installed them but in most cases realized a full signal should have been installed instead. There were behavioral concerns. WSDOT is moving away from HAWK signals.

iii. In-pavement warning lights (IRWL, lighted crosswalks)

iv. *Local roads:* pedestrian scrambles (Barnes Dance)

4. Topics

a. Policy & Funding

- **i.** In 2011, Washington passed a complete streets act which set up the complete streets program and was primarily focused on grants to local agencies. The act required local governments to consult and coordinate with WSDOT.
- **ii.** WSDOT Paths and Trails Law requires the department to spend 0.3% of the total transportation budget to improve bicycle and walking conditions. This funding represents the minimum contributed toward bicycling and walking improvements.
- **iii.** Other funding sources include grant programs, SRTS grants, pedestrian & bicycle safety program, and the complete streets program resulting in $30 million annually.
- **iv.** The Transportation Partnership Act passed in 2005 contained a 16 year program for bicycle and pedestrian projects.
- **v.** When project engineers are preparing projects they review unfunded needs and then identify possible grants to accommodate required designs.
- **vi.** WSDOT does not have a policy on cost sharing. WSDOT approaches cities for partnering on sidewalks. If the city doesn't want to install a sidewalk WSDOT will typically install it but not maintain it.

b. Public Involvement

- **i.** WSDOT held an initial bicycle and pedestrian public involvement process with six public hearings and an open forum in 2008. The intent was to let the public voice their frustrations and stories. WSDOT also went to each local agency and collected unfunded needs (TIPS). WSDOT extracted the bicycle and pedestrian projects and found over $1 billion in unfunded needs including $600 million associated with the state highway system. WSDOT assembled all comments and responded to each one.
- **ii.** WSDOT updated the unfunded needs list in 2010 and will review again.

c. Maintenance

- **i.** WSDOT is responsible for areas between the curbs. Local jurisdictions are responsible for the areas outside the curb including the medians. Bicycle facilities are a grey area. WSDOT relies heavily on local agencies to address maintenance issues.
- **ii.** Issues of aging trails are arising. For example, the Burt Gilman shared use trail is degrading. The trail is an important facility that sees thousands of users.
- **iii.** WSDOT has built partnerships with tribal nations and other cities. The private sector has installed their own bicycle facilities, including facilities built by Google and Amazon.
- **iv.** WSDOT has an agreement with the Washington Association of Cities to decide cost responsibilities.

- **v.** WSDOT will share the maintenance agreement.
- **vi.** Maintenance crews are responsive to complaints or calls. Most of WSDOT's system does not receive heavy snowfall. However, Spokane receives heavy snowfall and has specialized equipment.

d. Internal Guides

- **i.** WSDOT developed a poster to showcase available bicycle facility designs. The poster helps clarify what facilities WSDOT is installing as well as what constitutes a bicycle facility. The poster was requested by the state secretary of transportation and is based on NACTO concepts and utilizes WSDOT graphics. WSDOT granted IDOT permission to modify and use the graphic.

e. Training

- **i.** WSDOT hosts a statewide meeting involving multiple DOT offices called Walkable Washington. WSDOT also hosts a statewide bike summit.
- **ii.** Engineering Policy and Innovation Division hosted bicycle and pedestrian workshops within each WSDOT region.

f. NACTO

- **i.** WSDOT adopted the NACTO guidelines. WSDOT was the first state to adopt NACTO.

g. Counts

- **i.** WSDOT has counted bicyclists and pedestrian for eight years. WSDOT's initial counting project contributed to the National Bike Ped Documentation Project (NBPD) and involved conversations with Alta.
- **ii.** Counts are performed with volunteers and involve volunteer training. WSDOT advertises in the media to solicit volunteers. WSDOT coordinates AM & PM counts in over 400 sites in 50 cities during a three day period. The Washington Statewide Bike Advocacy group also coordinates volunteers. The manual count program costs $10,000 per year. Manual volunteers also collect environmental characteristics. WSDOT will forward their count documentation.
- **iii.** WSDOT calculates before and after counts in some areas. For example, one project on Bainbridge island saw a 300% increase in bicycling and walking.
- **iv.** WSDOT installed permanent counters at six locations with a $300,000 grant. WSDOT is coordinating with EcoCounter to install additional permanent counters using another $50,000 grant. WSDOT uses diamond loop patterns for their EcoCounter detectors.
- **v.** WSDOT's count database is open and downloadable. It was the first open database of its kind and developed to share data with local municipalities. The counts are also being forwarded to designers and project development engineers within WSDOT. The WSDOT Data Office

has taken over inclusion of the data and management of the count program. Paula now plays an advisory role in the count program.

vi. Portland State University (PSU) is developing a guide to assist agencies with implementing a count program.

h. GIS/Inventory

i. WSDOT has a geocoded crash database. The crash database is not available online due to liability reasons. The Puget Sound-Seattle region crash database is online, however.

ii. WSDOT has a bicycle and pedestrian inventory. The inventory captures sidewalks, crossings, school zones and shared use paths.

iii. WSDOT has started incorporating local data and has assigned five staff members to the task of collecting info.

iv. The inventory was not widely received initially but popularity grew over time. For example, the WSDOT planning office is using the inventory and count data to develop corridor sketches.

i. ADA

i. WSDOT mentioned one example path in Bonney Lake that connected thousands of residents, single family homes, and a local school.
The path travelled up a steep incline and was initially determined to be non-ADA complaint. WSDOT developed an alternate route to determine a better ADA solution.

j. Miscellaneous

i. WSDOT's next focus is on design standards and design education.

ii. WSDOT has performed training programs with physical education teachers. WSDOT has covered 45 school districts and taught 60,000 students on bicycle and pedestrian safety issues.

k. IDOT

i. IDOT has nine districts. Chicago is located in District One which includes six surrounding counties.

ii. IDOT's central office oversees policy for all nine districts. Each district is standalone with its own budget and state routes. IDOT does not monitor or dictate local routes.

iii. IDOT has a complete streets law. The law was adopted in IDOT manuals in 2010. Any project that alters the travelled way will trigger the complete streets policy. IDOT has a step down approach to design exceptions. If the first facility cannot be implemented then the next tier is considered.

iv. IDOT uses an 80%/20% split for bicycle and pedestrian projects. For example, IDOT will contribute 80% of the cost to design and construct a shared-use path within IDOT ROW if the local municipality contributes 20% and agrees to maintain the facility.

v. Within District One, anything within the ROW, including sidewalks, is IDOT's jurisdiction. IDOT maintains the roadway surface whereas sidewalks are maintained by local municipalities. Crosswalks and bike lane pavement markings are maintained by the local agency.

vi. IDOT has inventoried all sidewalk infrastructure and is responsible for bringing it up to ADA requirements.

vii. IDOT does not endorse NACTO. IDOT is reluctant to approve facilities that are not approved by AASHTO, however, IDOT has started a pilot cycle track project in Chicago on an IDOT road.

viii. IDOT has utilized interim MUTCD approval for some items, including flashing yellow turn lights. They also utilized a City of Chicago interim approval for bike signals for a proposed cycle track on a state route in Chicago.

ix. IDOT mentioned difficulties with maintaining the asphalt pavement on shared use trails to comply with ADA requirements.

x. IDOT utilizes Miovision cameras that now automatically collect bicyclist and pedestrian counts. Miovision is a camera based data collection tool with mode sorting capabilities.

The meeting concluded at 4:15 PM CT (2:15 PM PT)

Attachments:

WSDOT - BicycleFacilitiesPoster_V04.pdf

WSDOT - graphicbikes.pdf

BICYCLE FACILITIES

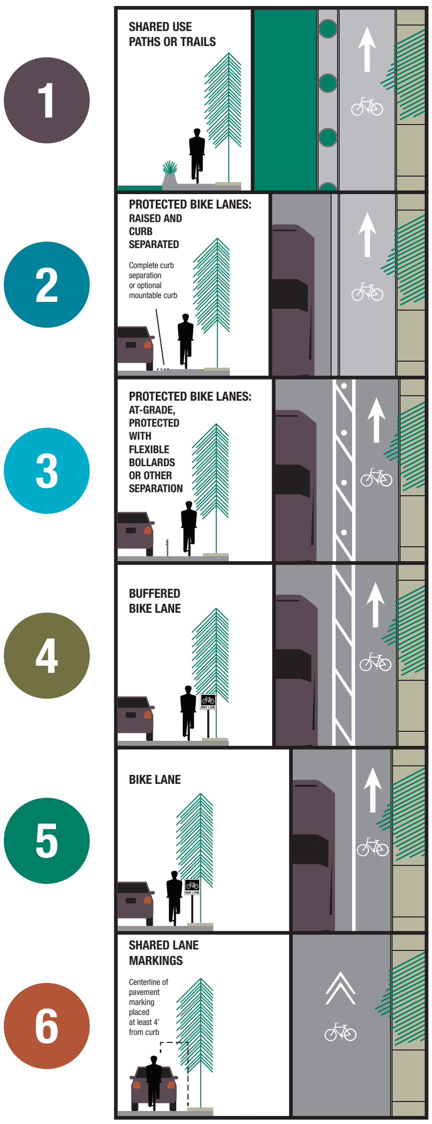
WSDOT

IMPROVING TRANSPORTATION DESIGN FOR BICYCLING IN WASHINGTON

WSDOT's primary goal is to make sure people get to where they're going safely no matter whether they drive, take the bus or train, bike, or walk. To help achieve our safety goals and make everyday bicycle travel better, WSDOT is developing a statewide system of interconnected corridors, parking, signage, and programs. Designing our transportation system to better accommodate bicyclists will help to resolve multiple complex and interrelated issues, including traffic congestion, air quality, climate change, public health, and livability.

WSDOT recognizes that bicyclists and pedestrians are vulnerable road users making up about 16 percent of all traffic fatalities statewide. When involved in a traffic collision, cyclists are seriously injured or killed over 90 percent of the time. Motor vehicle drivers and occupants are seriously injured or killed 39 and 30 percent of the time respectively. Nationally and in Washington State, pedestrian and cyclist deaths have been rising while overall traffic fatalities have declined. Improving safety for bicyclists and pedestrians often requires either slowing down vehicle speeds or physically separating or protecting bicyclists from fast moving traffic. This poster provides examples of some of the different types of bicycle facility designs that, when applied in the appropriate circumstances, will help improve safety for the traveling public.

MOST PROTECTED



LEAST PROTECTED

Illustration concept credit to NACTO

1 Shared Use Paths or Trails

Physically separated facilities like shared-use paths for bicyclists and pedestrians encourage more walking and bicycling. These facilities are often found along waterways, abandoned or active railroad and utility rights-of-way, limited access highways, or through parks and open space areas. Along high-speed, high-volume highways, paths and trails can be safer and more desirable than sidewalks or bike lanes. Paths and trails immediately adjacent to roadways may cross numerous intersecting roads and driveways that create hazards and other problems for path users. Creating safe and accessible intersections between paths and the road network is one of the most important aspects of design. For additional detail, see AASHTO's *Guide for the Development of Bicycle Facilities*, Section 5 Design of Shared Use Paths and NACTO *Urban Bikeway Design Guide*. See also *WSDOT Design Manual*, Chapter 1515.

2 Protected Bike Lanes: Raised and Curb Separated

Raised bicycle lanes may be at the level of the adjacent sidewalk, or set at an intermediate level between the roadway and sidewalk to separate the bicyclists from pedestrians. A raised bike lane may be combined with a parking lane or other barrier between the bike lane and the motor vehicle travel lane, and may allow for one-way or two-way travel by bicyclists. These facilities may be most appropriate along higher speed streets with few driveways and cross streets or along streets with multiple lanes, high traffic volumes, high speed traffic, high demand for double parking, and high parking turnover where bike lanes may not provide enough protection. For additional detail, see NACTO's Urban Bikeway Design Guide and MUTCD Figure 9C-3 for signage and marking requirements.

3 Protected Bike Lanes: At Grade, Protected with Flexible Bollards or Other Separation

A protected bike lane, sometimes called a cycle track or separated bike lane, is a type of preferential lane as defined by the MUTCD (See Federal Highway Administration (2009), Manual on Uniform Traffic Control Devices, Section 2G.01). Protected bike lanes are bike facilities that use a variety of methods for physical protection from passing traffic. By dedicating and protecting space for the cyclist, these facilities reduce risk of 'dooring' compared to a conventional bike lane and eliminate the risk of a fallen bicyclist being run over by a motor vehicle. In situations where on-street parking is allowed, protected bike lanes are located to the curb-side of the parking (in contrast to conventional bike lanes). Bollards, or posts can be installed along a bike lane to make the separation clear to cyclists and drivers, and increase cyclists' sense of security. Bollards can range from flexible posts to more rigid posts. See NACTO Urban Bikeway Design Guide for additional design detail and MUTCD Section 3B.24 for signage and marking requirements.

4 Buffered Bike Lanes

Buffered bike lanes are conventional bicycle lanes paired with a designated buffer space, frequently using painted markings, separating the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane as defined by MUTCD Section 3D-01. See MUTCD Sections 3D-02 and 3B.24 for signage and marking requirements. See also NACTO *Urban Bikeway Design Guide* for additional design detail.

5 Conventional Bike Lanes

Bike lanes designate an exclusive space for bicyclists through the use of pavement markings and signage and are primarily installed to increase the mobility of bicyclists in congested areas. They are best applied where motor vehicle speeds are lower. The bike lane is located directly adjacent to motor vehicle travel lanes and flows in the same direction as motor vehicle traffic. Bike lanes are typically on the right side of the street, between the adjacent travel lane and curb, road edge, or parking lane. See AASHTO's *Guide for the Development of Bicycle Facilities*, Chapter 4 *Design of On-Road Facilities* and *WSDOT Design Manual*, Chapter 1520.09 Bicycle Lane Design for additional detail.

6 Bike Boulevards or Neighborhood Greenways

Bicycle boulevards are streets with low motorized traffic volumes and speeds, designated and designed to give bicycle travel priority. Bicycle Boulevards use signs, pavement markings, and speed and volume management measures to discourage through trips by motor vehicles and create safe, convenient bicycle crossings of busy arterial streets. On bike boulevards, shared lane markings, or "sharrows," are preferred road markings used to indicate a shared lane for bicycles and motor vehicles. Among other benefits shared lane markings provide direction and reinforce the legitimacy of bicycle traffic on the street and recommend proper bicyclist positioning. The Shared Lane Marking is the bike-and-chevron "sharrow," illustrated in MUTCD figure 9C-9 and cannot be used on shoulders, in designated bicycle lanes, or to designate bicycle detection at signalized intersections. (MUTCD 9C.07 03).

Bike Crossings-Intersections, Parking & Signage

Properly designed intersections are critical to ensure bicycle safety and connectivity. Designs for intersections with bicycle facilities should reduce conflict between bicyclists and vehicles by heightening the level of visibility, denoting a clear right-of-way, and facilitating eye contact and awareness with competing modes. Intersection treatments can resolve both queuing and merging maneuvers for bicyclists, and are often coordinated with timed or specialized signals. See NACTO Urban Bikeway Design Guide for additional intersection design detail and Association of Pedestrian and Bicycle Professionals Bicycle Parking Guidelines for more bicycle parking guidance.

Contact:
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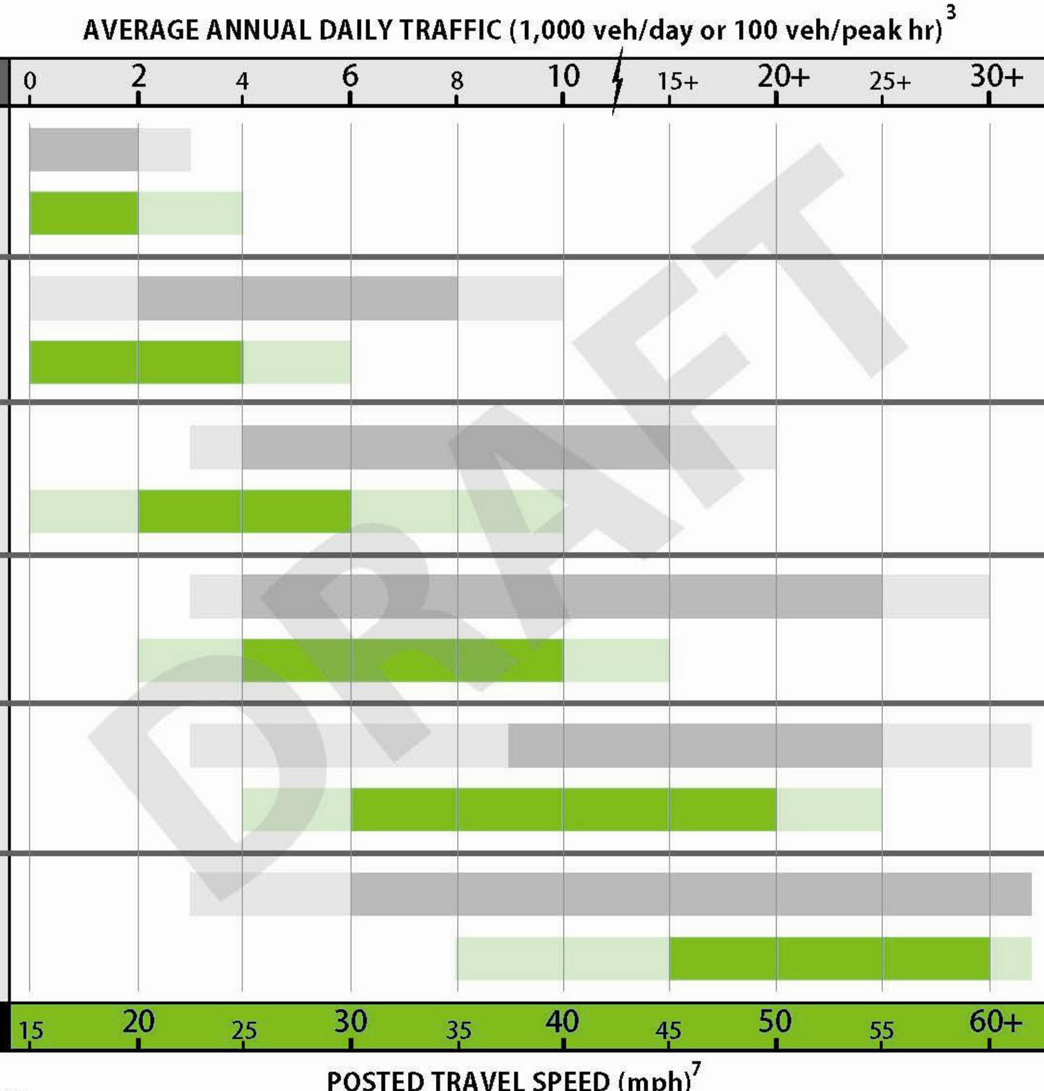
WSDOT Engineering Policy and Innovation
360-705-7258
Reevesp@wsdot.wa.gov

WSDOT Websites:
http://www.wsdot.wa.gov/bike
http://www.wsdot.wa.gov/walk

BICYCLE FACILITY CONTEXTUAL GUIDANCE



FACILITY TYPE[1]	STREET CLASS[2]	ADDITIONAL FACTORS[4]
NEIGHBORHOOD GREENWAY ●●○○ Comfortable and attractive bicycling environment without utilizing physical separation; typically employs techniques to prioritize bicycling.	LOCAL	• Emergency Route
SHARED LANE MARKING ●○○○ Marking that is applicable on roadways where speed differential between motorists and bicyclists is low and/or to fill short gaps in the bikeway network.	LOCAL	• Percent Heavy Traffic • Multiple Travel Lanes • Sufficient Road Space • Sufficient Road Space • Critical Network Link
BIKE LANE ●●○○ Exclusive space for bicyclists through the use of pavement markings and signage (without buffers or barriers).	COLLECTOR ARTERIAL	• High Turnover Parking • Front-in Diagonal Parking • Percent Heavy Traffic • Multiple Travel Lanes • Sufficient Road Space
BUFFERED BIKE LANE ●●●○ Traditional bike lane separated by painted buffer to vehicle travel lanes and/or parking lanes.	COLLECTOR ARTERIAL	• Insufficient Road Space • Illegal Parking/Loading • Sidewalk Riding • Sufficient Road Space
Protected Bike Lane ●●●● Physically separated bikeway. Could be one or two way and protected by a variety of techniques	COLLECTOR ARTERIAL	• Frequent Driveways • Park or linear corridor • Insufficient width for Sidewalk
SHARED USE PATH[5] ●●●● Completely separated from roadway, typically shared with pedestrians	ARTERIAL FREEWAY	•Frequent Intersections •High Pedestrian Volume

LEGEND

SEPARATION[6]

- ●○○○ Minimal Separation
- ●●○○ Moderate Separation
- ●●●○ Good Separation
- ●●●● High Separation

min	VOLUME	max
min	SPEED	max
Acceptable	Desired	Acceptable

NACTO

INSTRUCTIONS:

This chart offers guidance as to what types of treatments are recommended depending on street classification, speed, and volume. No matter where bikeway treatments are applied, special care needs to be paid to intersections, driveways, on-street parking, sight distance, and aditional factors.

NOTES:

1. Refers to specific bicycle facilities described in the NACTO Urban Bikeway Design Guide. See http://www.nacto.org for detailed design guidance. Many local roads function just fine as they are due to their low traffic volume and speed.
2. Categories from http://www.fhwa.dot.gov/planning/fcsec2_1.htm. The use of functional classes provides some general context for the cases in which bicycle facilities are most likely to be implemented. Land use and additional factors (see 4) should always take precedence in determining which facility type to select.
3. Urban peak hour factors typically range from 8 to 12 percent of AADT. For the purposes of this chart, the peak hour is assumed to be 10 percent of AADT.
4. Noted additional factors include a selection of considerations that may influence the selection of bicycle facility type where roadway speed/volume values overlap over multiple facilities. Many of the factors that suggest increasing separation are common across multiple facility types like bike lanes, buffered bike lanes and cycle tracks.
5. Design guidance for shared use paths can be found in the AASHTO Guide for the Development of Bicycle Facilities.
6. Increased separation of bicycle facilities from motor vehicle traffic typically results in higher levels of user comfort and appeals to wider skill levels of bicyclists.
7. This chart considers posted speed limit only. The 85th percentile speed may vary, and may change with implementation of a bikeway.

Date:	Thursday, April 23, 2015
Time:	1:00 PM CT
Subject:	Bike & Pedestrian Accommodations Study – State DOT Interview
Location:	Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
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Francis Schelfhout	WisDOT	608-785-9947	francis.schelfhout@dot.wi.gov

1. Introductions

a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Wisconsin Department of Transportation (WisDOT) Bicycle and Pedestrian Coordinators.

b. In attendance from WisDOT was Jill Mrotek Glenzinski, Statewide Bicycle & Pedestrian Coordinator; Michelle Brokaw, Southwest Region (Madison) Bicycle & Pedestrian Coordinator; Paul Vraney, Roadway Standards Engineer; Francis Schelfhout, Southwest Region (La Crosse) Bicycle & Pedestrian Coordinator (Francis was unable to join the call due to technical difficulties with the conference call line but his contact info is included for sharing purposes).

c. The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Pam Broviak, Project Manager for the study and also the District One ADA coordinator (*Pam has since changed bureaus)*; Aren Kriks is the Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred, Project Engineer for the study; Frank Zurek and Charles Frangos are civil engineers working for Primera on contract with IDOT *(Charles is no longer with Primera).*

2. Organization & Project Overview

a. WisDOT gave an overview of their positions. Jill is the Statewide Bicycle & Pedestrian Coordinator located at the central office in Madison. She is the liaison for national and statewide issues and works on planning and design policy. Jill also coordinates with the Bureau of Transportation Safety located in the Division of the State Patrol. Paul works in the standards unit, developing design standards for WisDOT's facility development manual.

WisDOT also has regional bicycle & pedestrian coordinators that split their time among bike and pedestrian issues and regional planning work such as transit or park & ride issues. The time spent on the bike and ped issues varies amongst the regions. Michelle is the regional coordinator for the Madison district in the Southwest Region. She spends about 75% of her time on bicycle and pedestrian guidance.

b. IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, and internal policies as well as recommendations. IDOT is looking for feedback from users and other state DOTs such as WisDOT. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements.

c. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with IDOT Central Office.

d. There is a potential for some of these tools or facilities to be installed as an experimental or pilot project within District One.

e. The final project report is due winter 2015-16.

3. Facilities

a. The following facilities are used by WisDOT:

b. Bicyclists

i. Shared use paths: WisDOT is flexible when considering shared use paths instead of sidewalks in certain applications. The community is required to provide a compelling argument that sidewalks should be changed to shared use paths, and the WisDOT region is responsible for making the decision. WisDOT has experienced many crashes between adult bicyclists and motorists with shared use paths in urban areas. WisDOT observed reduced crashes at one location by moving bicyclists from a sidewalk to an on-road facility. WisDOT is performing additional studies to confirm that shared-use paths lead to higher crash rates between bicyclists and motorists, especially in urban areas.

ii. Widened shoulders: WisDOT has flexibility in installing rumble strips. WisDOT keeps a 4’ clear zone outside the rumble strip to benefit bicyclists and for oversized trucks to straddle the rumble strip. The paved shoulder policy wasn’t necessarily created for bicyclists but it does benefit bicyclists. WisDOT is also developing a standard for rumble strips on concrete pavements. WisDOT does not yet have a policy for urban shoulders.

iii. WisDOT has implemented road diets and left side bike lanes on state routes as well.

- iv. WisDOT led the design of a raised bike lane on a local road. The raised bike lane was installed on Bay Street in Milwaukee. Originally the locals wanted a facility over the interstate but a compromise was reached by using Bay Street and on-road facilities instead. WisDOT has not received any feedback from Milwaukee regarding snow plowing, drainage or other maintenance issues.
- v. WisDOT has received requests for separated bike lanes particularly in the Southwest Region. Most requests have been for inappropriate locations with low volumes or inadequate width. WisDOT is awaiting further guidance from FHWA.

c. Pedestrians

- i. WisDOT has refuge islands, one pedestrian scramble, lighted crosswalks, bump outs, and HAWK signals on state routes.
  1. WisDOT performed studies on RRFBs and HAWK signals and found compliance rates to be lower than the national average. WisDOT believes a median refuge island would increase compliance rates with an increased focus on education, outreach, and enforcement.

4. Topics

a. Policy

- i. Wisconsin implemented a complete streets law in 2009. The law directed WisDOT to consider bicyclists and pedestrians on projects unless several exemptions are met. The complete streets law is detailed in Trans 75, the transportation administrative code and guidance that was developed and provided in the WisDOT Facility Design Manual. WisDOT has followed USDOT policy for complete streets inclusion. The state law and subsequent guidance helped Wisconsin clarify the decision making criteria.
- ii. WisDOT developed check sheets to document design decisions and include in a design study report. The reports and check sheets are not tracked in a central database and instead are kept with the project throughout its development process. The check sheet is a 47 page chapter in WisDOT's facility development manual. It provides a background on complete streets and instructions on how to meet an exemption. WisDOT also developed a tool to choose alternatives when a certain facility can't be installed. For example, for on-street bicycle accommodations there are 15 levels of alternatives starting with a bicycle lane down to a wide travel lane.
- iii. Trans 75 also contains different thresholds for urban and rural areas.
- iv. An exemption may be allowed if a local municipality refuses to maintain a proposed bicycle or pedestrian facility and passes an ordinance that they will not construct it.

v. There is a proposal to repeal the Wisconsin complete streets law in the current budget proposal*. Post meeting: since the conference call, Wisconsin Administrative Code Trans 75 has been repealed as of July 2015. Wisconsin State Statute 84.01(35) has modified from "ensure bikeways and pedestrian ways are established" to "shall give due consideration to establishing bikeways and pedestrian ways……" Moving forward, WisDOT has been since working to determine its project application and details for FDM inclusion.*

vi. WisDOT has jurisdiction of many roadways such as arterials and collectors in urban areas.

b. Funding

i. Every bicycle and pedestrian project has an 80%/20% funding split with locals. For facilities on state highways, however, shoulders and bike lanes are part of the road so no cost share is required. WisDOT has a separate manual for cost sharing.

ii. New sidewalks were originally split at 80/20 with WisDOT paying 100% for DOT construction impacts to existing sidewalk. Now, WisDOT also pays 100% where sidewalk facilities are required. Resurfacing sidewalk is still at 80/20.

c. Public Involvement

i. WisDOT works with the state bike advocacy group, Share and Be Aware. WisDOT provides education to motorists, bicyclists, and pedestrians. They educate the public on the rules of the road, provide presentations, hold bike rodeos, and present crash rates. WisDOT discusses projects requested by the public and examines those requests for viability.

d. Maintenance

i. Routine maintenance agreements are required for any sidewalk or local cost participation agreement.

ii. WisDOT installs the facility and the locals maintain the striping.

iii. WisDOT mentioned that Madison maintains their 1970's era cycle track with small, Jeep-type vehicles.

e. Internal Guides

i. WisDOT has a Bicyclist Design Manual and a Pedestrian Best Practices Guide.

f. NACTO

i. WisDOT does not include the NACTO guides in its standards and refers to AASHTO bike/ped guidelines. They use language to refer to the FHWA memorandum regarding NACTO's use, however.

g. Counts

i. WisDOT does not have a statewide counting program. WisDOT does have some regional pilot count projects. Some of the Wisconsin MPO's are also implementing count programs. Some WisDOT regions perform robust intersection counts.

h. Inventory/GIS

i. WisDOT does not have an inventory of bike facilities. WisDOT tracks signage and marked bike lanes region by region.

i. ADA

i. Michelle is familiar with ADA requirements as part of her job as regional bicycle & pedestrian coordinator.

ii. WisDOT pays 100% for curb ramps as part of any roadway alteration projects. WisDOT is determining responsibility for other compliance upgrades. For example, if cross slopes exceed requirements WisDOT is unsure who is responsible for upgrades. Generally, however, WisDOT undertakes the upgrades if the issue can be corrected within the scope of the project.

iii. If an ADA complaint is made regarding curb ramps WisDOT makes the upgrade. Sidewalk ADA complaints are still an uncertain area.

iv. WisDOT does not typically correct sidewalk cross slopes unless something is within the realm of the project.

v. WisDOT limits the color of their detectable warnings to white and yellow because those colors were found to have the highest detectability and contrasting color. WisDOT has used cast iron detectable warning pads which have better resistance to snow plows. WisDOT also tried stainless steel but the pads would roll and create a tripping hazard. Plastic didn't work either; coworkers would collect the plastic knobs and scatter them in Jill's cube! WisDOT has experienced some issues with installing the cast iron pads due to the weight and radii requirements.

j. IDOT

i. IDOT finished their first ADA transition plan in the late 1990s.

ii. Generally, IDOT only fixes sidewalk if it was altered under their project. IDOT has a similar sidewalk replacement plan for state projects: IDOT is provided a certain quantity of sidewalk squares to replace under each project.

iii. IDOT also has a hierarchy table with bicycle lanes at the top, then shared lanes, etc…. Basically if criteria is met for ADT and speed IDOT would install the bicycle facilities with locals maintaining the striping.

iv. IDOT is not considering endorsing NACTO. IDOT is focused on designing the state's first separated bike lane on a state route in the City of Chicago. The facility will include one-way cycle tracks on both sides of the street, removing some parking and installing curb separation. It will include two bike signals, a bike box, and push button actuation for bicycles. IDOT will monitor the projects in the following years.

v. IDOT mentioned that the City of Chicago designs 8' wide cycle tracks to accommodate plows.

vi. IDOT does not have an inventory of bicycle facilities. The local MPO, Chicago Metropolitan Agency for Planning, collects all local plans and assembles a GIS database.

vii. IDOT collects bicycle counts on a project by project basis. IDOT utilizes Miovision to automatically collect bicyclist and pedestrian counts.

viii. IDOT has recommended the use of cast iron detectable warning pads but is still awaiting approval from the central office.

The meeting concluded at 2:30 PM CT

Date: Thursday, September 3, 2015
Time: 2:00 PM CT
Subject: Bicycle & Pedestrian Accommodations Study – CDOT Interview
Location: Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
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Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Scott VanDerAa	Primera Engineers	630-324-5168	svanderaa@primeraeng.com
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Mike Amsden	CDOT	312-742-2973	mike.amsden@cityofchicago.org

1. Introductions

- **a.** The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Chicago Department of Transportation.
- **b.** In attendance from CDOT was Mike Amsden, Assistant Director of Transportation Planning.
- **c.** The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Aren Kriks is the Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred, Project Engineer for the study; Scott VanDerAa and Frank Zurek are civil engineers working for Primera on contract with IDOT.

2. Organization & Project Overview

- **a.** CDOT gave an overview of the bicycle and pedestrian program at CDOT. CDOT does not have a sole bike/ped coordinator. The bike & ped programs instead fall under two sections with the Division of Project Development: Traffic Design and Citywide Services. Traffic Design is responsible for infrastructure planning, design and implementation. Mike Amsden oversees bike/ped infrastructure planning, design and implementation within Traffic Design. Citywide Services is responsible for education (Ambassadors), enforcement, and the Divvy program. Sean Wiedel oversees Citywide Services.
- **b.** Outside of these main sections, other CDOT staff also collaborate on bike & ped projects. For instance, project managers in the Division of Engineering are responsible for roadway reconstructions, viaduct removals, and shoreline revetments. The Division of Engineering collaborates with Project Development for input and recommendations on ADA or complete streets projects. Furthermore, the Division of Engineering is responsible for ADA design and accessibility improvements, ensuring they are built to compliance. Janet Attarian, in the Division of Project Development, oversees sustainable design and livability including streetscapes and the Make Way for People programs. These projects often include bicycle & pedestrian elements.

c. IDOT gave an overview of the Bicycle & Pedestrian Accommodations Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, and internal policies as well as recommendations. IDOT is looking for feedback from users and other DOTs. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements.

d. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with IDOT Central Office.

e. There is a potential for some of these tools or facilities to be installed as an experimental or pilot project within District One.

f. The final project report is due winter 2015-16.

3. Facilities

a. All facilities on IDOT's study list are allowed by CDOT.

b. The following facilities are currently used by CDOT or were discussed in detail during the meeting:

i. Bicyclists

1. Cycle tracks (cycle tracks, separated bicycle lanes, and protected bicycle lanes are used interchangeably in these minutes):

a. CDOT is examining protected intersections with concrete islands that protect bicyclists through an intersection. Several intersections will have partially protected intersections as part of the Loop Link project.

b. CDOT is revisiting protected bicycle facilities originally installed with pavement markings and flexible delineators for possible upgrade to curb-protected bicycle lanes.

c. CDOT has not received much feedback on the short stretch of curb-separated bicycle lane on Sacramento Boulevard.

d. CDOT is observing cycle tracks for drainage issues. Lessons learned from Clybourn showed that more attention needs to be paid to low points in the roadway in addition to just inlet locations. However, if inlets or other utilities need to be reconstructed the City will instead compromise on curbs instead of drainage due to cost reasons (unless the project scope already includes roadway reconstruction).

e. CDOT is interested in the comparison between the full curb separation on Clybourn and the end-cap style used on Milwaukee Avenue. The end caps were installed to show people where to park and to improve sightlines and reduce intersection crashes by restricting motorists from parking too close to the intersection. The endcap style is similar to the New York City cycle track style.

f. Parking hasn't been a major issue for cycle track installations.

g. CDOT still plans to continue installation of bollard protected bicycle lanes if necessary. CDOT prefers cycle tracks to buffered bicycle lanes.

2. Buffered Bicycle Lanes

   a. CDOT's policy is to stripe two lines with hatch marks (tick marks) on the parking side for all buffered bicycle lanes. If the street is wide enough, they will install a buffer on both sides of the bicycle lane. CDOT prefers the parallel lines of the buffer to just a single line with tick marks.

3. Buffered shared lane (Barrow)

   a. CDOT considers this a marked shared lane and not a high-level facility. Preliminary observations suggest bicyclists are able to position themselves better within the lane but CDOT is still analyzing the data.

4. Mixing Zone

   a. CDOT's mixing zone with shark teeth yield markings on Desplaines Street at Adams Street is a non-standard design for the city. CDOT's concern is it may encourage higher speed turns. CDOT favors the NYC design which utilizes sharper tapers.

5. Bicycle Boxes

   a. CDOT utilizes bicycle boxes mostly at locations with large bicycle queues and high volumes (30 bicyclists queued at a traffic signal for instance). CDOT does not install bicycle boxes to assist with turning movements as some other cities do.

ii. Pedestrians

1. CDOT has not actively pursed in-roadway warning lights or HAWK signals.

2. Raised Crosswalks

   a. Chicago has raised crosswalks on 5859 S. Stony Island and another on Ellis Avenue. Both locations have high pedestrian volumes, slower vehicle speeds, and a nearby pedestrian generator. CDOT had initial concerns with larger vehicles, buses and plows so they utilized a shallower slope on Stony Island. They were installed within the last couple years.

3. *Post meeting: Red-light camera questions can be directed to Larry McPhillips at CDOT: lawrence.mcphillips@cityofchicago.org.*

4. Topics

a. Policy

i. Installations are prioritized as described in the City's Streets for Cycling Plan 2020, pedestrian plans, modal hierarchy, and examining crash data.

ii. CDOT is attempting to improve their installation process by involving bicycle and pedestrian projects in multiple projects and planning phases. The City's Complete Streets policy and initiatives have helped to accomplish this.

iii. CDOT has undergone jurisdictional transfers in the past, East-West Wacker Drive is one example. There were also discussions in 2011 and 2012 regarding the Jackson Boulevard bicycle facility. The City and State could not agree on a cost so no transfer occurred.

iv. CDOT is trying to stick with a 6' clear minimum width for cycle tracks in the downtown area, not due to maintenance requirements but to allow riders space to pass (areas outside the CBD require 7.5' clear zone for maintenance requirements). CDOT cited the Dutch CROW Manual that has guidance for their minimum width. The Dutch use a 2m (6.6 foot) minimum width and is designed for comfort and enjoyment.

b. Funding

i. Bicycle & pedestrian projects are paid for by incorporating them in streetscape or resurfacing projects, or using CMAQ, TIF, aldermanic menu funds, G.O. Bond, or Divvy revenues. Each alderman receives approximately $1.3 million a year in menu funds which are used for infrastructure improvements in their wards, including bicycle lanes, bicycle boulevards, restriping old lanes, bicycle parking or corrals. Some wards do participatory budgeting and most of the time at least one bicycle project gets chosen.

ii. CDOT also receives sponsorship funds from BlueCross BlueShield through their Divvy arrangement. CDOT receives $2.5 million a year for bicycle and pedestrian projects.

iii. CDOT has also received funding from the Department of Water Management and the USEPA for projects that include storm water best management practices.

iv. The pedestrian program has also used Highway Safety Improvement Program funds for high crash areas. Walk to Transit and Safe Routes to School have also been used as a funding source.

c. NACTO

i. CDOT officially endorses the NACTO guides and uses them frequently.

d. Data Collection

i. CDOT scales their data collection effort based on the impact of the project. For example, data collection is minimal for conventional bicycle lanes. Data was collected for the Dearborn 2-way cycle track for a bike signal report for the FHWA given experimental status at the time of installation, but the facility was eventually given interim approval in the MUTCD so CDOT is no longer required to perform the study.

ii. CDOT does not have dedicated funds or staffing for before and after data collection and are lacking more in-depth studies. Other groups have performed studies on CDOT facilities including the National Institute for Transportation in Communities (NITC). NITC performed counts, studies, and surveys on the Dearborn and Milwaukee cycle tracks in the *Lessons from the Green Lane* report. TyLin also performed a buffered bicycle lane and lateral positioning study in Chicago as part of a National Cooperative Highway Research Project.

iii. IDOT is interested in intersection crash analysis and right-hooks especially. CDOT mentioned most of their projects were installed in 2012, 2013 and 2014, therefore only a few sites have more than one year of after crash data based on the crash data they have received from the state through 2013. CDOT mentioned they want to do a better job at collecting ridership and pedestrian data to perform more robust crash analyses. IDOT requested crash data from CDOT on their protected bike lane installations.

iv. CDOT mentioned 1) most locations have very limited 'after' data, and crashes tend to go down the longer the project is in, 2) exposure data is limited – if crashes went up, how did ridership change? There may be situations where total crashes increase, but crash rates decrease, 3) new designs often require tweaking and adjustment to improve the design, and 4) crash data is important, but so is perceived safety and user satisfaction.

v. CDOT will send IDOT the 55th street (full road diet and cycle track) report which analyzed crashes. Bicycle crashes went from 4.2 crashes per year to 2.8 crashes per year, but were a small part of total crashes which decreased significantly. Pedestrian crashes also decreased.

e. Counts

i. CDOT has been performing manual counts. CDOT collects monthly and cordon counts. They are improving their count program and is attempting to develop a methodology for determining and applying count factors.

Many of the city's projects also use Miovision cameras at intersections that automatically count bicycles and pedestrians. CDOT will also install a permanent infrared detector shortly to count pedestrians.

ii. CDOT mentioned they are not confident about the puck data on Dearborn Street. The sensors were not specifically designed for bicyclists and their proximity to the parking and travel lane may have caused errors. CDOT could not define a consistent margin of error. CDOT is currently not using sensors.

iii. IDOT asked about partnering to perform counts. CDOT is open to partnering with CMAP to create a count program. Some project location counts were submitted to Tom Murtha. CDOT recalls that the earlier CMAP program may have had issues with cameras or manual counts. CDOT also has counts from developers that they want to share in a central database. CDOT is interested in IDOT collaboration as well. IDOT agrees that CMAP is the best agency to standardize the myriad ongoing count programs in the region.

f. Public Involvement

i. CDOT only hosts public meetings with the support and approval of the Alderman. CDOT mentioned the IDOT requirement to hold public meetings for smaller projects such as installing a single pair of bump outs or removing 1-2 parking spots. CDOT can approach the alderman with the request to hold a public meeting but are often denied

ii. So far, no backlash has been received on Clybourn other than a concern from a local business owner.

iii. CDOT will go door-to-door soliciting feedback on large-impact projects.

iv. CDOT believes backlash for many projects drops anywhere from one to three months after installation, however they understand the concerns many people have. For example, cycle tracks are a new design to many people and confusion is common at first.

g. Coordination

i. CDOT is an FHWA Focus City which involves working with the city on improving education and enforcement initiatives. CDOT has a good relationship with Greg Piland from the FHWA.

h. Challenges

i. CDOT's biggest concern is the processing and scaling of design variances with the State. CDOT is required to submit time-consuming and repetitive design variances for many smaller projects. Whereas a large project like a viaduct removal will have adequate time and budget to complete a design variance, smaller projects, like bicycle and pedestrian designs, often don't have the funds or the time necessary to complete a variance or perform the necessary coordination with IDOT.

ii. CDOT believes the FHWA has come a long way in terms of encouraging and embracing more innovative design. The FHWA has encouraged DOTs at the state and city level to push the envelope and encourage flexibility. Examples include FHWA's Safer People, Safer Streets Initiative, their memo on bicycle and pedestrian design flexibility, their report called, "Bicycle and Pedestrian Funding, Design and Environmental Review: Addressing Common Misconceptions", allowing green pavement and bike signals, and the release of the *Separated Bike Lane Design Guide*.

iii. CDOT also has challenges with procurement and not having specific items in their contracts.

iv. CDOT encountered resistance on a cycle track project in Douglas Park. Residents opposed the project and stopped construction therefore CDOT installed a buffered bicycle lane instead.

v. CDOT has not removed facilities due to increases in crashes or other reasons.

i. Maintenance

i. CDOT tested several (approximately 5-10) vehicles for street sweeping. One example includes a parking lot Green Machines/vacuum sweepers that always clogged. CDOT recently purchased an Elgin Broom Badger that fits within the 7.5' wide cycle tracks on streets outside the CBD. Dearborn Street is wide enough for a regular street sweeper. Downtown street sweeping is supplemented by manual hand sweeping by the Department of Streets and Sanitation. Street sweeping equipment was purchased using BlueCross BlueShield sponsorship funds.

ii. CDOT utilizes a pick-up truck acquired for clearing snow. These trucks came from existing city fleet, including from other Departments. Downtown, CDOT uses a Bombardier that can clear a 4' wide path and also uses it to clear snow on bridges. On facilities farther from downtown, the city has removed the bollards to let standard width plows clear the lanes.

iii. CDOT's network of cycle tracks makes it easier to create a circuit for street sweeping and plowing. CDOT is creating a network of facilities partly because of this benefit.

iv. CDOT uses Divvy revenue and Aldermanic funds for bicycle lane restriping, including potential use for a maintenance program for annual restriping that is under development. CDOT also utilizes arterial resurfacing projects as an opportunity to restripe facilities. CDOT is pushing to minimize use of striping on certain facilities to reduce maintenance costs.

v. CDOT is happy with the durability of their preformed thermoplastic green pavement panels. Some projects have been installed in 2011 and the green pavement still looks good. CDOT originally installed green pavement across every driveway and intersection but now only installs at major driveways and uncontrolled intersections. On Kinzie Street, CDOT originally used epoxy that was rolled on but it didn't last very long. Green pavement was applied on concrete but it didn't last long either. CDOT previously provided NACTO with information regarding their green pavement installations, and recommended NACTO as a resource on green pavement best practices. *Post meeting: CDOT recently used MMA (Methyl Methacrylate) on the Clinton Street two-way cycle track.*

j. Bicycle Parking

   i. CDOT installs about 500 bicycle racks a year. CDOT uses CMAQ funds and partnerships with local business districts/SSAs to install custom designed racks. CDOT doesn't charge the public to install a rack. The public can request racks at any time but CDOT will not install them in front of residential properties or in the vicinity of other unused bicycle parking. Chicago, like other major cities, has problems with bicycle theft but usually it's a result of the owner not locking up properly or locking to street signs or other easily thwarted structures. CDOT has one full-time staff whose sole job is to survey bicycle rack locations.

5. ***Post Meeting:*** *although not discussed at the meeting, the following information is included for reference.*

   a. *CDOT maintains a bicycle facility inventory in GIS. It includes bicycle facilities by type, installation date, and maintenance/upgrade date.*

   b. *CDOT maintains an ADA inventory in spreadsheet form.*

   c. *CDOT provided a one-page summary of the Green Lane project's study of Chicago locations and crash analyses of the Dearborn and 55th Street cycle tracks.*

The meeting concluded at 3:30 PM CT

Attachments:

CDOT - 55th_Cottage Grove to Lake Park Pre-Post Crash Review

CDOT - Dearborn_Polk to Kinzie_08_13 Pre-Post Crash Review

CDOT - Green Lane Project, Summary Sheet 2015 0309

E 55th Street Pre/Post Crash Review

S Cottage Grove Ave to S Lake Park Ave

CDOT CHICAGO DEPARTMENT OF TRANSPORTATION

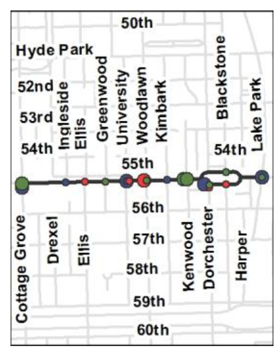
RAW CRASHES BY INJURY TYPE, 2008 -2013 (July 2012 omitted)

PRE-INSTALLATION TYPE OF CRASH (January 2009 – June 2012)	PEDALCYCLIST	PEDESTRIAN	VEHICULAR	TOTAL CRASHES BY INJURY TYPE	PERCENT OF TOTAL CRASHES
K - Fatal	0	0	0	**0**	**0.0%**
A - Incapacitating Injury	1	4	5	**10**	**3.5%**
B - Nonincapacitating Injury	9	6	19	**34**	**11.8%**
C - Reported injury , not evident	7	6	17	**30**	**10.4%**
PDO -Property damage only	2	1	212	**215**	**74.4%**
TOTAL CRASHES BY MODE	**19**	**17**	**253**	**289**	**100.0%**

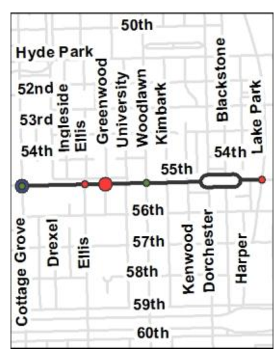
POST-INSTALLATION TYPE OF CRASH (August 2012 – December 2013)	PEDALCYCLIST	PEDESTRIAN	VEHICULAR	TOTAL CRASHES BY INJURY TYPE	PERCENT OF TOTAL CRASHES
K - Fatal	0	0	0	**0**	**0.0%**
A - Incapacitating Injury	1	0	1	**2**	**3.2%**
B - Nonincapacitating Injury	3	3	6	**12**	**19.4%**
C - Reported injury , not evident	0	0	0	**0**	**0.0%**
PDO -Property damage only	0	0	48	**48**	**77.4%**
TOTAL CRASHES BY MODE	**4**	**3**	**55**	**62**	**100.0%**

ANNUALIZED CRASHES BY INJURY TYPE, 2008 -2013 (July 2012 omitted)

PRE-INSTALLATION TYPE OF CRASH (January 2009 – June 2012) Annualized: 4.5 years	PEDALCYCLIST	PEDESTRIAN	VEHICULAR	TOTAL CRASHES BY INJURY TYPE
K - Fatal	0.0	0.0	0.0	**0.0**
A - Incapacitating Injury	0.2	0.9	1.1	**2.2**
B - Nonincapacitating Injury	2.0	1.3	4.2	**7.6**
C - Reported injury , not evident	1.6	1.3	3.8	**6.7**
PDO -Property damage only	0.4	0.2	47.1	**47.8**
TOTAL CRASHES BY MODE	**4.2**	**3.8**	**56.2**	**64.2**



POST-INSTALLATION TYPE OF CRASH (August 2012 – December 2013) Annualized: 1.42 years	PEDALCYCLIST	PEDESTRIAN	VEHICULAR	TOTAL CRASHES BY INJURY TYPE
K - Fatal	0.0	0.0	0.0	**0.0**
A - Incapacitating Injury	0.7	0.0	0.7	**1.4**
B - Nonincapacitating Injury	2.1	2.1	4.2	**8.5**
C - Reported injury , not evident	0.0	0.0	0.0	**0.0**
PDO -Property damage only	0.0	0.0	33.9	**33.9**
TOTAL CRASHES BY MODE	**2.8**	**2.1**	**38.8**	**43.8**



Dearborn Street Pre/Post Crash Review

W Polk Street to W Kinzie Street

RAW CRASHES BY INJURY TYPE, 2008 -2013 (December 2012 omitted)

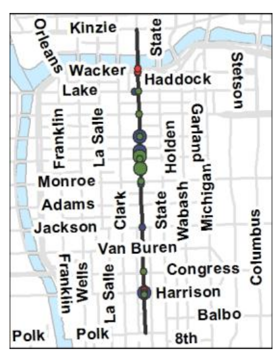
PRE-INSTALLATION TYPE OF CRASH 2008 - November 2012	PEDALCYCLIST	PEDESTRIAN	VEHICULAR	TOTAL CRASHES BY INJURY TYPE	PERCENT OF TOTAL CRASHES
K - Fatal	0	0	0	**0**	**0.0%**
A - Incapacitating Injury	0	15	6	**21**	**2.5%**
B - Nonincapacitating Injury	18	46	45	**109**	**12.8%**
C - Reported injury , not evident	12	44	37	**93**	**10.9%**
PDO -Property damage only	3	4	623	**630**	**73.9%**
TOTAL CRASHES BY MODE	**33**	**109**	**711**	**853**	**100%**

POST-INSTALLATION TYPE OF CRASH January 2013 – December 2013	PEDALCYCLIST	PEDESTRIAN	VEHICULAR	TOTAL CRASHES BY INJURY TYPE	PERCENT OF TOTAL CRASHES
K - Fatal	0	0	0	**0**	**0.0%**
A - Incapacitating Injury	0	2	3	**5**	**3.7%**
B - Nonincapacitating Injury	5	8	5	**18**	**13.4%**
C - Reported injury , not evident	3	1	4	**8**	**6.0%**
PDO -Property damage only	0	0	103	**103**	**76.9%**
TOTAL CRASHES BY MODE	**8**	**11**	**115**	**134**	**100%**

ANNUALIZED CRASHES BY INJURY TYPE, 2008 -2013 (December 2012 omitted)

PRE-INSTALLATION TYPE OF CRASH 2008 - November 2012 (annualized: 4.92 years)	PEDALCYCLIST	PEDESTRIAN	VEHICULAR	TOTAL CRASHES BY INJURY TYPE
K - Fatal	0.0	0.0	0.0	**0.0**
A - Incapacitating Injury	0.0	3.1	1.2	**4.3**
B - Nonincapacitating Injury	3.7	9.4	9.2	**22.2**
C - Reported injury , not evident	2.4	8.9	7.5	**18.9**
PDO -Property damage only	0.6	0.8	126.7	**128.1**
TOTAL CRASHES BY MODE	**6.7**	**22.2**	**144.6**	**173.5**

POST-INSTALLATION TYPE OF CRASH January 2013 – December 2013 (annualized: 1 year)	PEDALCYCLIST	PEDESTRIAN	VEHICULAR	TOTAL CRASHES BY INJURY TYPE
K - Fatal	0	0	0	**0**
A - Incapacitating Injury	0	2	3	**5**
B - Nonincapacitating Injury	5	8	5	**18**
C - Reported injury , not evident	3	1	4	**8**
PDO -Property damage only	0	0	103	**103**
TOTAL CRASHES BY MODE	**8**	**11**	**115**	**134**



EVALUATING CHICAGO'S PROTECTED BIKE LANES

Findings from the National Institute for Transportation and Communities (NITC)

In June 2014, NITC published a report evaluating protected bike lanes around the country, including the Dearborn Street and Milwaukee Avenue PBLs in Chicago. The report, "Lessons From the Green Lanes," evaluates each project in detail through surveys of roadway users and residents as well as data analysis and observations.

"Designs with more physical separation had the highest scores. Buffers with vertical objects...all resulted in considerably higher comfort levels than buffers created only with paint."

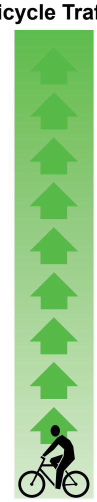
-Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the U.S.

DEARBORN STREET – TWO-WAY PROTECTED BIKE LANE

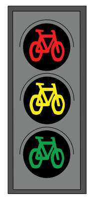
After Installation:

- 99% of bicyclists surveyed feel safer on Dearborn.
- 86% of bicyclists surveyed ride on Dearborn more frequently.
- 53% of bicyclists surveyed ride a bicycle more frequently overall because of the Dearborn Bike Lane.
- 21% of bicyclists surveyed switched modes of transportation.
- 53% of motorists surveyed feel bicyclists' behavior is safer and more predictable.

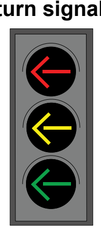
171% Increase in Bicycle Traffic



77-93% of bicyclists stopped at red lights



84-92% of motorists complied with the left-turn signal

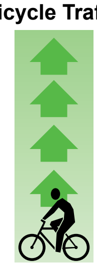


MILWAUKEE AVENUE – PROTECTED BIKE LANE

After Installation:

- 96% of bicyclists surveyed feel safer on Milwaukee.
- 31% of bicyclists surveyed ride on Milwaukee more frequently.
- 32% of bicyclists surveyed ride a bicycle more frequently overall because of the Milwaukee Bike Lane.
- 10% of bicyclists surveyed switched modes of transportation.
- 44% of motorists surveyed feel bicyclists' behavior is safer and more predictable.

21% Increase in Bicycle Traffic



Average of 1,160 bicyclists in AM and 953 bicyclists in PM on Milwaukee Avenue

As part of Chicago's goal to install 100 miles of barrier/buffer protected bike lanes by Summer 2015, Dearborn Street and Milwuakee Avenue represent 2.0 miles of the 85.5 miles installed since 2011.

BUILDING A NEW CHICAGO

CDOT CHICAGO DEPARTMENT OF TRANSPORTATION

Date:	Monday, February 8, 2016
Time:	3:00 PM CT
Subject:	Bike & Pedestrian Accommodations Study – Red Light Cameras
Location:	Teleconference

Attendees	Company	Phone Number	Email Address
David Pulsipher	CDOT	312-742-7621	david.pulsipher@cityofchicago.org
Scott VanDerAa	Primera Engineers	630-324-5168	svanderaa@primeraeng.com
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com

1. Introductions

a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study and Red Light Cameras with CDOT.

b. In attendance from CDOT's Division of Traffic Safety was David Pulsipher. The project team was introduced: Scott VanDerAa and Frank Zurek are civil engineers working for Primera on contract with IDOT.

2. Organization & Project Overview

a. IDOT gave an overview of the study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, and internal policies as well as recommendations. IDOT is looking for feedback from users and other state DOTs such as WSDOT. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements.

b. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with IDOT Central Office.

3. Topics

a. Red Light Cameras

i. The City does not consider bicycle or pedestrian crashes in their RLC analysis and implementation.

b. Speed Cameras

i. Speed cameras are based on, to some extent, the occurrence of bicycle and pedestrian crashes with motorists. CDOT developed speed zones that weighs all crashes within a 1/8 mile boundary around a park or school. Crashes considered include total crashes, speed related crashes, crashes involving people under 18 years old, serious and fatal crashes and bicycle & pedestrian crashes. Youth and speed crashes are weighted double toward a zone's total score. CDOT also gives extra points for areas of high youth populations. The points are part of a first level analysis and are added up over a rolling three year period to determine placement of the cameras.

ii. The cameras are geographically spread for policy reasons and so that no region has more than 10% of the program. Safety zones are distributed equally throughout the six different regions of the city.

iii. CDOT produces an annual report on the effectiveness of speed cameras, located on their website.

c. Miscellaneous

The meeting concluded at 3:15 PM CT

Appendix A-2
Advocacy Groups

Date: Wednesday, February 11, 2015
Time: 11:00 AM
Subject: Bike & Pedestrian Accommodations Study – Advocacy Group Interview
Location: Teleconference

Attendees	Company	Phone Number	Email Address
Pam Broviak	IDOT-Programming	847-705-4074	pamela.broviak@illinois.gov
Charles Frangos Frank Zurek	Primera Engineers Primera Engineers	312-242-6374 312-242-6453	cfrangos@primeraeng.com fzurek@primeraeng.com
Heather Schady Jim Merrell	Active Transportation Alliance Active Transportation Alliance	312-216-0467 312-216-0470	heather@activetrans.org jim@activetrans.org

1. **Introductions**
   - ***a.*** The purpose of this meeting was introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Active Transportation Alliance (ATA).
   - ***b.*** In attendance from ATA was Heather Schady, Senior Transportation Planner at the Policy and Planning Manager and Jim Merrell, Campaign Director for advocacy and policy for ATA. Jim Merrell runs several bike infrastructure campaigns, especially in the City.
   - ***c.*** In attendance from IDOT was Pam Broviak, Project Manager for the IDOT study and also the District One ADA coordinator. Aren Kriks (not on the call), is the Project Engineer for the study and is also the District One bicycle coordinator.

2. **Organization & Project Overview**
   - ***a.*** ATA gave an overview of their organization. ATA was created 30 years ago, initially as a bicycle advocacy group but evolved into a bicycle, pedestrian and transit advocacy group several years ago. ATA organizes the annual Bike the Drive event, works with local schools, is a planning consultancy and writes bicycle and pedestrian plans, including many in the Chicagoland area.
   - ***b.*** ATA also runs public meetings and performs media relations work. Last summer ATA started a new initiative to bring ideas to suburban Chicago. Using their connections to area municipalities and members ATA built a suburban campaign to catalyze next generation bicycle infrastructure. ATA is encouraging suburban communities to become more bike friendly. This initiative started after developing bike & ped plans for local governments. ATA saw an opportunity to move their plans along and to grow support for implementation.
   - ***c.*** IDOT gave an overview of the Bike & Ped Study. Through this study, IDOT is gathering data, guidance, and recommendations to IDOT guidance. IDOT is reviewing internal policies and creating new guidance moving forward for the planners and designers at IDOT. IDOT is interested in learning where cycle tracks fit and what works best. IDOT is looking for feedback from users and organizations like ATA. IDOT is interested in how facilities fit economically and with local land uses. IDOT welcomes any additional innovations or ideas.

d. The final project report is due summer 2015.

3. **Topics:**

a. **General Comments**

i. ATA summarized the opinion of bicyclists and pedestrians in Chicagoland: users want more of what they're seeing, faster. Users see isolated locations being improved but would like a connected network of low stress facilities across the area.

ii. Anecdotal feedback has been very positive about cycle tracks in particular, mirroring the results of the *Lessons from the Green Lane* report.

iii. ATA gave further insight into the Chicago/Suburban dynamic, mentioning that CDOT has the staff and capabilities to navigate the IDOT process for improving bicycle and pedestrian facilities using federal funds whereas most suburban agencies don't have the staff or time to accomplish that.

b. ***Survey***

i. IDOT is interested in developing a survey for ATA's members. The survey would include the questions on the attached topic list and possibly questions pertaining to their member's comfort/safety regarding various facilities

ii. ATA has a 20,000 membership roster in addition to a more targeted leadership network that includes leaders from various councils around the six county area. ATA is open to forwarding a survey on to their members.

iii. ATA is developing surveys for neighborhood greenways as part of another initiative. IDOT's survey is focused on infrastructure and should not overlap or precede ATA's survey.

iv. ATA suggested that photos could be provided of different facilities for respondents that are unfamiliar with the specific facility. ATA has completed similar in-person surveys during public meetings and it was a popular way to gather input, although this was done for specific projects only.

c. **Data Sharing**

i. Most of ATA's surveys and data gathering pertains to specific projects or groups. ATA data includes comments from the public regarding specific streets residents would like facilities on.

ii. ATA recommended looking at their Chicagoland Bike Map which includes user generated data to determine best routes. The bike map includes all of District One.

iii. With funding from Cook County, ATA created the *Complete Streets, Complete Networks* manual. The manual "provides information to assist planners, designers and decision makers in developing a new design approach to enable better and safer active transportation." The manual provides guidance on which facilities work for various densities and land uses, including suburban and rural contexts. ATA provided two copies at the meeting.

d. **Maintenance**

i. Users are seeing issues emerging with maintenance but comments are usually shaped from an overall positive outlook on the facilities. For example, people love riding on them so now they want to see it maintained and open consistently so they can continue using the facilities.

ii. ATA gave an overview of their insight into Chicago maintenance procedures. The City has been removing bollards so crews can plow to the curb but then some people were parking curbside. Business districts were shoveling snow into the cycle track after it's been plowed, so ATA talked to the Chamber of Commerce to inform their constituents not to shovel it into the bike lane. It closed the maintenance loop of keeping the cycle track clear of snow.

e. Partnerships

i. ATA has found that local chambers of commerce have noticed and are welcoming the increase in bicyclists through their district. The chambers are looking for ways to encourage spending in their districts and attract more bicyclists.

ii. ATA partnered with the West Town Chamber of Commerce. ATA helped pull the Chamber's disparate bike planning elements together and package it into a bike planning district. The Chamber created a program with 15-20 business to offer discounts to bicyclists and host events during bike to work week. ATA also worked with the Lakeview Chamber of Commerce this past June and was approached by the Six Corners area on ways to become a bike friendly district as well.

f. Pedestrian Campaigns

i. ATA is currently running Safe Crossings, a pedestrian-focused campaign designed to raise awareness about intersection safety and work with community partners to push for more dedicated funding for pedestrian improvements throughout Chicagoland.

ii. ATA staff worked with local agencies and performed crash analyses to create a list of the "10 most dangerous intersections in Chicago and the Suburbs."

g. Transit Campaigns

i. ATA is working with Cook County to create a dedicated revenue source to bring in additional funds.

ii. ATA is advocating for BRT and are on various committees regarding its implementation. ATA is excited about the multi-modal aspect of the BRT plans, such as cycle tracks built into the redesigns.

h. Other Advocacy Groups

- **i.** ATA provided a list of suggested advocacy groups to contact:
  1. Women Bike Chicago
  2. Black-led Bicycling Organizations
     - **a.** Slow Roll
     - **b.** Friends of the Major Taylor Trail
  3. ENLACE – Little Village community group
  4. Trails for Illinois – Suburban trails focused group led by Steve Buchtel

i. The meeting concluded at 12:00 PM.

Date: Wednesday, April 8, 2015
Time: 3:00 PM CT (1:00 PM PT)
Subject: Bike & Pedestrian Accommodations Study – Advocacy Group Interview
Location: Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Craig Williams	Assoc. of Ped & Bike Professionals (APBP)		craigwilliams@altaplanning.com

1. Introductions

- **a.** The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Association of Pedestrian & Bicycling Professionals (ABPB).
- **b.** In attendance from APBP was Craig Williams, co-founder and current Treasurer of APBP.
- **c.** The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Pam Broviak, Project Manager for the study and also the District One ADA coordinator *(Pam has since changed bureaus)*; Aren Kriks is a Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred is a Project Engineer for the study; Frank Zurek is a civil engineer working for Primera on contract with IDOT.

2. Organization & Project Overview

- **a.** APBP was originally organized as a group of U.S. bicycling and pedestrian professionals. APBP was created to allow an exchange of information. APBP is comprised of state bicycle and pedestrian coordinators, local coordinators, consultants, and to some degree, advocacy groups. APBP has over 1100 members.
- **b.** APBP has recently encouraged the formation of local chapters. There are 10 to 15 local chapters.
- **c.** IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of national and international research, engineering studies, a review of internal policies, and recommending new guidance. IDOT is looking for feedback from users and organizations like APBP. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements. IDOT is interested in specific issues related to those three factors as well as the infrastructure's impact on the community.

- **d.** The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with the IDOT Central Office.
- **e.** The final project report is due winter 2015-16.

3. Pedestrians

- **a.** APBP suggested IDOT also focus the study on seniors. Since the population of Americans over 65 years old will double in the next several years there will be an increased need to accommodate seniors. Many seniors will not be driving and will need other methods of travelling. This will require creating spaces where people can travel without a car.
- **b.** APBP does not place much emphasis on ADA requirements as they are primarily focused on able bodied pedestrians.

4. State DOTs/Governments

- **a.** APBP agrees with IDOT that there is no consistency amongst state DOTs and bicycle and pedestrian coordinator positions. Some states have coordinator positions in either planning or engineering, but not both. If the coordinator is located in the engineering design office, they may lack policy direction. If the coordinator is located in planning, they may lack interaction with the design engineers. APBP believes there should be positions in planning and design, and at each district.
  - **i.** The Minnesota DOT has several bicycle and pedestrian professionals in the central office and at least one in planning and design at each of the districts. There is little interface between the ADA coordinators and other bicycle and pedestrian coordinators.
  - **ii.** APBP believes the pedestrian coordinator should understand and have some level of responsibility for the sidewalk network and crosswalks as it pertains to ADA requirements.
- **b.** A strong and committed leadership allows for bicycling and pedestrian professionals to commit to and design progressive facilities. Chicago is one example of a city with strong leadership that place bicyclists and pedestrian at a high priority. Other strong cities include Indianapolis, Indiana, Davis, California, and Minneapolis/St. Paul, Minnesota.
  - **i.** Court driven regulations can induce progressive policies. However, instituting progressive policies before regulations are enacted allow governmental agencies to save money in the long term. For example, Caltrans was forced by the courts to spend $1.1 billion on upgrading their facilities after a lawsuit filed by a disabilities advocacy group.
- **c.** California has endorsed the NACTO Urban Bikeway Design Guide, the Urban Streets Design Guide, and the ITE guides. California has passed legislation that the state must update their design manuals. Caltrans will update their manuals by January 2016. Standard Caltrans arterials include bike lanes in

their designs. A public involvement initiative was developed as Caltrans redid their design manual to include cycle tracks (see attached email with legislation).

5. **Training**

   a. APBP publishes a few guides including the *Bike Parking Design Guidelines.* APBP hosts professional development seminars and webinars.

      i. APBP coordinates with the National Complete Streets Coalition (NCSC) to develop presentations for a variety of audiences.

      ii. APBP developed a *Designing Facilities for Accessibility* course in cooperation with the US Access Board.

   b. APBP's webinars are archived at their website and include topics such as ADA transition plans, and bicycle and pedestrian facility design courses.

   c. APBP recommends the use of short, 15 minute videos addressing specific bicycle and pedestrian issues. This allows designers to research specific aspects required for their job instead of attending a day long training course. Michigan DOT has example training sessions that teach specific issues or rules.

   d. IDOT relayed that FHWA has a series of videos on 504 ADA regulations. IDOT also utilizes the state T2 technology transfer center to teach four ADA classes a year. IDOT plans to start recording the course and make available online.

   e. APBP hosts a professional workshop every other year. The next workshop will be in St. Louis in September 2015. The workshop is focused on information exchange and examines current topics such as bike parking, bike sharing, and pedestrian issues.

   f. APBP & IDOT discussed transportation camps. Transportation camps are information exchanges about transportation aimed toward younger professionals. They are also known as "unconferences."

   g. IDOT requested that Primera include training recommendations in the overall feasibility report.

6. Manuals

   a. APBP stated that the AASHTO *Guide for the Development of Bicycle Facilities* is important as a base guide. Each engineer should have copies of the AASHTO guide. Many of the items in chapter 17 of the IDOT BDE manual were based on the 1994 or 1999 AASHTO bike guide and haven't been updated since then. APBP considers the IDOT design manuals the most important manuals for IDOT's engineers. Therefore, updates to the IDOT manuals will make the most progress toward IDOT accommodating bicyclist and pedestrians.

   b. APBP also believes in the usefulness of the NACTO guides, especially as an illustration of progressive designs. The NACTO guide is not necessarily a design guide but a depiction of what other cities are doing. Many of the designs in the NACTO guides are allowed by MUTCD but packaged differently. NACTO helps engineers see what can be installed. NACTO will be developing a third edition of the Urban Bikeway Design Guide.

- **c.** AASHTO took cycle tracks out of their recent bike guide which hurt its acceptance.
- **d.** ABPB believes engineers want designs that are clearly documented by AASHTO or IDOT guides. Otherwise engineers may feel liable for certain designs leading them to not consider the progressive designs.
- **e.** APBP expects progressive advancements in the 2017 MUTCD. Additions will include bike boxes, green paint, and markings through intersections.

7. IDOT

- **a.** APBP mentioned that Priscilla Tobias was on an international scan team that travelled overseas to observe bicycle and pedestrian facilities in Europe. The trip was hosted by FHWA and funded by the Green Lane Project.

8. Miscellaneous

- **a.** APBP does not have a photo database.
- **b.** APBP only performs surveys of its members concerning salary or professional issues.

9. The meeting concluded at 4:00 PM CT (2:00 PM PT)

Illinois Department of Transportation

Date:	Wednesday, March 18, 2015
Time:	11:00 AM
Subject:	Bike & Pedestrian Accommodations Study – Advocacy Group Interview with Access Living
Location:	Teleconference

Attendees	Company	Phone Number	Email Address
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Ann Ford	Centers for Independent Living	217-525-1308	annford@incil.org
Gary Arnold	Access Living - Chicago CILs	312-640-2199	garnold@accessliving.org
Adam Ballard	Access Living - Chicago CILs	312-640-2195	aballard@accessliving.org
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com

1. Introductions

a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Illinois Network of Centers for Independent Living (ILCILs) and the local Chicago center: Access Living.

b. In attendance from ILCILs was Ann Ford, Executive Director of the statewide network, Gary Arnold, Public Affairs with Access Living, and Adam Ballard, Advocacy Manager with Access Living.

c. The project team was introduced: From IDOT was Pam Broviak, ADA coordinator and project manager, Aren Kriks, Project Engineer, and Marla Kindred, Project Engineer. From Primera was Frank Zurek, Civil Engineer working for Primera on contract with IDOT.

2. Organization & Project Overview

a. Access Living is focused on the City of Chicago. Overall, there are 23 centers for independent living across Illinois, and each CIL offers people with disabilities the tools for accessing opportunities. CILs helps transition people with disabilities outside Illinois as well. Each center is different depending on the demographics of the area. Access Living has a number of programs in housing, education, healthcare, and other issues. All centers share a similar mission integrated throughout all programs, which is to identify barriers to independence and allow people with disabilities to be fully included in their communities and live where they want to live. Each center has a defined service area, loosely based on population with the downstate areas servicing up to 9 counties.

- ***i.*** Access Living is comprised of members, consumers, supporters and allies.
- **ii.** Access Living has town hall style meetings. Access Living's next meeting is Friday, March 20 to discuss funding.

b. IDOT gave an overview of the Bike & Ped Study. Through this study, IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, a review of internal policies, and recommending new guidance. IDOT is looking for feedback from users and organizations like CILs. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements. IDOT is interested in specific issues related to those three factors as well as the infrastructure's impact on the community.

c. The final project report is due summer 2015.

3. **Topics:**

a. **General Comments**

i. Access Living partnered with the Active Transportation Alliance (ATA),

1. Identifying dangerous intersections. About 10 intersections were identified. The most dangerous can be the 6-way intersections such as Milwaukee, Chicago Avenue and Ogden Avenue, as well as interchange entrance and exit ramps. Roosevelt Road and the Dan Ryan is also another dangerous intersection. It has crosswalks and signage but pedestrians must come very close to traffic. South of Taylor Street the interchanges and bridges have poor quality sidewalks and treacherous crossings.

2. Also partnered with ATA on policy changes. They helped to change the crosswalk law from yielding to stopping for pedestrians.

3. Their partner at ATA was Kyle Whitehead, Campaign Manager.

ii. Access Living's consumer base has concerns with bicycle lanes that are pushing out parking. It poses a potential conflict where a wheelchair accessible vehicle needs to unload on a certain side of the street and the bike lane causes potential conflict points.

iii. In times of inclement weather, impassable sidewalks sometimes force people to using the bicycle lanes or any lane that is open and clear. Some disable people use mobility devices that are sensitive to damaged sidewalks or snow filled routes so they may use the bike lane.

iv. Bus stops are sometimes also not kept clear. Snow and ice removal is a major concern reiterated by Access Living. Downtown Chicago is typically ok when it comes to snow removal, but becomes an issue out in the neighborhoods. Some neighborhoods are also inaccessible due to poor sidewalk maintenance.

v. Some consumers expressed concern over bike lane and crosswalk intersections. It's unclear who yields to who at these crossings, whether it's a motorist, bicyclist, or pedestrian.

b. **Requests**

i. Access Living requested wider sidewalks

ii. Access Living is interested in safe and accessible intersection crossings. They want crosswalk ramps in good repair and holes in sidewalks or streets addressed.

iii. Access Living was aware of previous efforts in Chicago to create an application to map out a specific accessible route and accessible train stations but is unaware of the outcome of that project.

iv. Access Living is interested in Audible Pedestrian Signals (APS) devices that let pedestrians know where the push buttons are. Access Living is only aware of a few locations in Chicago with APS and would like to see it expanded.

c. **Suburban Contexts**

i. Suburban bus stops are poorly designed with some stops on grass strips with no way for wheelchairs to access.

ii. Suburban centers include AIM in Dupage, also serving Kane and Kendal Counties. Lake County center serves Lake and McHenry. Progress Center serves suburban Cook County.

d. **Future Feedback**

i. IDOT requested Access Living provide any feedback as it comes up. IDOT is particularly interested in what sites are easy to use and any successful intersections.

e. The meeting concluded at 11:45 AM.

Date:	Thursday, March 19, 2015
Time:	3:00 PM
Subject:	Bike & Pedestrian Accommodations Study – Advocacy Group Interview
Location:	Teleconference

Attendees	Company	Phone Number	Email Address
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Charles Frangos	Primera Engineers	312-242-6374	cfrangos@primeraeng.com
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Ed Barsotti	League of Illinois Bicyclists	630-978-0583	ed@bikelib.org

1. Introductions

a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the League of Illinois Bicyclists (LIB).

b. In attendance from LIB was Ed Barsotti, Executive Director.

c. The project team was introduced: from IDOT was Pam Broviak, Project Manager for the study and also the District One ADA coordinator; Aren Kriks is the Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred, Project Engineer for the study; Charles Frangos and Frank Zurek are civil engineers working for Primera on contract with IDOT.

2. Organization & Project Overview

a. LIB gave an overview of their organization. LIB was formed in 1992. LIB has 1700 members and is a statewide organization. LIB surveyed their members and found the number one interest of LIB's membership is bike friendly road design. LIB is focused on AASHTO guide advocacy, infrastructure advocacy at the policy level, and are ramping up efforts at the project level. LIB submits comments on the Department's multi-year plan (MYP) as well.

b. LIB has served as a consultant for 17 towns. LIB has hosted seminars for over 1000 planners and engineers on bike planning and infrastructure topics. LIB has focused on education over the past three years including BikeSafetyQuiz.com developed to mainstream education of bicyclists and motorists. Overall LIB is attempting to improve bicycling conditions.

c. IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, a review of internal policies, and recommending new guidance. IDOT is looking for feedback from users and organizations like LIB. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements. IDOT is interested in specific issues related to those three factors as well as the infrastructure's impact on the community.

d. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with IDOT Central Office.

e. There is a potential for some of these tools or facilities to be installed as an experimental or pilot project within District One.

f. The final project report is due summer 2015.

3. Topics:

a. LIB Challenges

i. Grid level street network:

1. Crossings of arterial roads can serve as barriers at non-signalized streets. Also, issues arise such as bicyclists not triggering actuated signals. There are bicycle friendly triggering options in the MUTCD.

2. Access to destinations may be restricted on side streets, requiring use of arterial roads.

3. *Post meeting:* LIB recognizes cycle tracks in dense urban areas are positive for a broad range of bicyclists assuming intersections are properly designed for.

ii. Suburban network:

1. Most difficult area for bicycle travel, if the road network is not a grid.

2. Requires heavy reliance on arterials for point A to point B trips, often on county or IDOT roads. Therefore arterials require accommodations for bicyclists and pedestrians. While bike lanes were also an option in the old 1990s IDOT BDE policy, the bike accommodation used was almost always one extra foot on the outside curb lane. This latter solution was initially intended for 20-30 mph roadways with small setbacks and not meant for 45 mph suburban roadways. Much of the IDOT bikeway system was built out as 13 foot wide lanes between 1990 and 2010, but these are severely inadequate for bicycling. LIB recommends retrofitting these roadways.

3. Side paths became the focus after the 2010 complete streets policy was created to implement the 2007 complete streets law.

a. Side paths work well on busier, faster roads without many crossings.

b. One seasonal issue is that sidepaths aren't usually plowed of snow properly in the winter.

c. A larger issue is the required 20% local match. Some towns equate sidepaths with biking, recreation, and optional, whereas paying for sidewalks may be an easier sell. As District 6 found, municipal indecisiveness on paying the match can lead to project delays and re-designs. Getting local matches in unincorporated areas is very difficult and can lead to gaps – LIB recommends policy flexibility here, such as using paved shoulders.

d. LIB considers a 5' sidewalk or carriage walk useful where no bicycle accommodations can be built. The 2010 policy did not address where sidewalks should be added.

4. *Post meeting:* LIB has not yet developed an opinion on the use of cycle tracks in suburban areas where motorists do not often stop at stop lines or see pedestrians in crosswalks.

iii. Rural network:

1. Rural areas are a concern where rumble strips are placed. LIB applauds IDOT's recent rumble strip design standard, with 8" width, 4" separation from edge line, and longitudinal gaps for bikes. The standard is vague about it, but LIB recommends that rumble strips only be installed when a minimum 3 foot clear zone is included to the right of the rumbles. The federal government recommends a 4 foot clear zone but LIB considers a 3 foot clear zone as adequate.

2. IDOT relayed that rumble strips are sometimes installed incorrectly in the middle of the shoulder which reduces the clear zone. Construction should ensure they are installed properly.

3. LIB discussed connections between rural towns. Where nearby, hard-surfaced township or other low-traffic roads connect the same towns, the need for paved shoulders or other bicycle facilities on the state road is greatly lessened. However, where such parallel alternatives do not exist, the only facilities upon which to add bicycle infrastructure are often the State Roads. Illinois Route 72 between Pingree Grove and Gilberts in Kane County was mentioned as an example of this because that roadway provides the only connecting route.

4. *Post meeting:* LIB believes the wider shoulders of the 2010 rural paved shoulder policy are very generous. If difficulty and/or cost of implementing these widths would result in no paved shoulders at all, then LIB encourages the use of the pre-2010 paved shoulder policy.

iv. Intersections

1. Bicycling on sidepaths (or sidewalks) along busier roads tends to be more functional than recreational, as highway intersections create issues and traffic noise may create an unpleasant environment. The number of cyclists will likely be lower than on recreational trails with their own rights-of-way, but the impact on those fewer users' safety is very significant.
2. There has been an increased emphasis on throughput at intersections with continuous turning motions and large turning radii. Stop lines are being pushed back further, to unrealistic locations where motorist stop line and crosswalk yielding adherence is poor. Crosswalks are long and far from the parallel route. LIB gave an example in Buffalo Grove: out of 39 bike crashes, 35 were along the Buffalo Grove side path system on arterial roads. LIB speculates the stop lines and crosswalks are pushed back too far. Motorists look left but don't look right for contra-flow side path cyclists leading to this high number of intersection crash types.
3. As part of its efforts to advocate this intersection treatment for sidepaths, LIB has developed a tech brief on right-turn corner islands, which are more important than median refuge islands. The brief mentions right of way concerns.
    - **a.** Right turn corner islands isolate the turning motions and split up the conflicts. Right turn corner islands allow the stop bar to be placed closer to the intersection. Unfortunately, no sidepath user crash reduction factors are currently developed for right-turn corner islands.
    - **b.** Kane County DOT's intersections of Galena & Orchard in Aurora and Randall Road and Fabyan in Geneva have right-turn corner islands incorporated in the design. Another good example is on Perryville Road in Winnebago County.
    - **c.** From observations, right-turning motorists are more likely to yield for sidepath users going to a right turn corner island than for those in a standard crosswalk, further from the parallel road. Right turn corner islands also encourage motorists to look in the proper direction for oncoming bicyclists.
    - **d.** Right turn corner islands allow a perpendicular crossing which is easier and quicker for bicyclists and pedestrians.
4. LIB believes many engineers assume crossings at signalized intersections are always safer than midblock crossings. However, in certain places many bicyclists prefer midblock crossings because of all the problems encountered at intersections such as decreased yielding rates by motorists and long or difficult

crossings. LIB felt a mid-block crossing with a median would often be better than a typical large, multilane suburban intersection.

5. IDOT believes the intersection challenges are compounded by an earlier trend of installing diagonal curb ramps, resulting in ramps at the radii point. The current requirement per PROWAG is to provide a ramp for each crosswalk. And it is best if these can be oriented perpendicular to the crossing. Therefore, crossings have been pushed back on the radius to the radius point if possible. Therefore, this need to better accommodate pedestrians is another reason the stop bars have been pushed further away from the parallel route.

v. BLOS

1. The BLOS model was developed in 1995 by Bruce Landis and Sprinkle Consulting. The model is meant to be used for on-road bicycling only, regardless of whether or not there are dedicated on-road bike accommodations. The model does not include off road facilities or protected bike lanes. An off-road model was also attempted but the only input parameter term that was statistically significant was the width of the intersection. BLOS works well in measuring on-road comfort level for adult bicyclists, but its use needs additional guidance. LIB considers BLOS the best model available with the following three caveats:
   - **a.** Inputting more than a 4’ paved shoulder is outside the range tested in the model. LIB halves incremental shoulder width above 4’.
   - **b.** The BLOS model was developed in a Florida area with a 2% maximum truck percentage, which is much lower than the 8-10% observed in Northeast Illinois. For roads with more trucks, using the BLOS formula directly leads to significant errors unless truck percentage is adjusted. IDOT pointed out the lack of regard for grade in the calculation can result in an inadequate BLOS rating if the grade is significant as it can be in some communities.
   - **c.** The BLOS model’s parking term is affected linearly by on-road parking occupancy percentage. Above 10-20%, this does not reflect reality, as cyclists will not be weaving in and out of shorter unoccupied parking areas.
2. LIB classifies bicyclists into three categories: Recreation cyclists who seek roads with a BLOS of A or B; people who bike for transportation by choice and seek roads with a BLOS of low B to high C or better; and club level cyclists who are comfortable with a BLOS of C or better.
3. A striped off space, such as a paved shoulder or a bike lane, has the most impact on the BLOS score. Bicycle pavement markings

do not have a significant impact. While bicycle markings help encourage proper direction, on-road bicyclists want a delineated space above all else.

4. LIB developed an empirical side path suitability score which uses the number of crossings as the most critical element. Side paths are useful and effective for areas with good access control and few crossings between intersections.

b. BLR/BDE Changes

i. LIB advocates for adding increased flexibility in the BDE Chapter 17 design standards. Specifically, a hierarchy of backup design options should be provided when the primary recommendation cannot be met. Wisconsin DOT develop one such example.

ii. Central Office may or may not decide to update the BDE manual. Implementation or changes at the statewide level will most likely not be made until the central bicycle & pedestrian coordinator position is filled.

iii. IDOT stated the Bureau of Local Roads may use this report. The IDOT study team has reached out to all the bureaus in District One and coordinated the facilities being studied with the bureaus. This study will result in a manual to share with the bureaus.

iv. LIB's impression with the 1996 version of Chapter 17 was that it had some flexibility although it may not have adequately stressed bicycle lanes and when those are more appropriate than wide outside lanes. The current selection table in Chapter 17 is an improvement in stating which bikeway type is more appropriate in various contexts. However, its lack of backup options is a problem for implementability and flexibility for designers.

c. **Maintenance of Shared-Use Paths**

i. IDOT inquired about maintenance of side paths and if constructing the side path to a higher standard initially would reduce maintenance later on.

ii. LIB responded that Todd Hill contracted a consultant firm with Greg Luttrell to study the sidepath and off-road trail construction technique issue in 2005(?). Todd was interested in ways of improving the construction details to help minimize maintenance in the long term. At the time, Todd had not seen a similar study being done elsewhere.

iii. IDOT pointed out that the current specification for pedestrian facilities including shared use paths does not include a base, and therefore the surface can be placed directly on the subgrade. This design is not one established for the purpose of providing for low maintenance.

d. Training

i. LIB believes most planners and engineers do not receive much training in bicycle accommodations in college or through continuing education.

While policies may have flexibility, some planners and engineers may not take advantage of it due to their lack of training on the topic.

ii. LIB is interested in teaming up with IDOT to develop and perform a training session for the Department's engineers.

iii. IDOT suggested LIB team up with Gwen Montgomery from the T2 program to develop and teach a class through T2.

e. Other State DOTs

i. Wisconsin DOT has several layers of backups built into their Complete Streets design standards. If a certain bicycle or pedestrian facility can't be constructed then the designers can choose the next best option.

1. *Post meeting:* http://roadwaystandards.dot.wi.gov/standards/fdm/11-46.pdf
2. *Post meeting:* http://www.dot.wisconsin.gov/projects/state/docs/complete-streets-rules.pdf.

f. Technology

i. LIB has not thought about the use of various technology tools such as smartphone apps or connected or driverless vehicle technology.

g. Statewide Plan

i. LIB will examine the various suggestions in the Statewide Bike Plan and get back to IDOT with some targeted suggestions.

h. Miscellaneous:

i. *Post meeting:* LIB hopes the latest FHWA guidance on road diets will improve industry acceptance of this treatment for roads that have extra capacity.

ii. *Post meeting:* The median island, mid-block crossing CRF of 40% (estimate) needs to be considered instead of just the Zegeer study discouraging marked crosswalks on certain types of roads.

iii. *Post meeting:* According to http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/mutcd/, combined bike lane/turn lanes are disallowed by MUTCD, but shared lane marking in exclusive turn lanes are allowed.

iv. *Post meeting:* Wide-laned (>=18 ft), suburban residential streets with moderate (2-3K) to low traffic and very sparse (<5-10%) parking that politically can't be removed are very desirable in bike planning, but not addressed well by AASHTO. Signage alone may not be sufficient. Exclusive bike lanes eliminate parking, or (if not) puts the bike lane far out into the street beyond a wide parking area that is not generally used. Similarly, since parking is permitted, shared lane markings would have to be at least 11 feet from curb – which is improper where there are very few to no parked cars. A compromise treatment, used in places including Fargo Boulevard and Lewis Drive in Geneva, is what LIB calls a "combined bike/parking lane". A solid fog line is striped on each side of the road, 7-8' from curb, with that space essentially acting like an urban paved shoulder. The occasional parked car can be there and feel more secure about it. Cyclists use it, but leave it to pass a parked car – just as they would if no stripe was present. The narrowed travel lane may have passive traffic calming benefits. The road would be signed as a Bike Route (or use similar MUTCD-approved wayfinding signage), since the Bike Route designation has no geometric* or striping requirements – it is a flexible treatment. BLR District 1 is currently reviewing Palatine's use of these (ITEP grant). Our hope is that this treatment be allowed by IDOT for situations defined above. *[*- IDOT BLR has misinterpreted the 1999 AASHTO guide (confirmed by one of its authors) and required signed bike routes to have lanes of 13' or more, regardless of traffic count. This is clarified in the 2012 version.]*

i. **The meeting concluded at 4:00 PM.**

   i. The following documents were provided after the meeting and included with these minutes:

      1. Porkchop Technical Brief.pdf
      2. LIBBikePlanImplementationPriorities031014.docx
      3. BikePlanPolicySuggestions083013_CoverLetter.pdf
      4. BikePlanPolicySuggestions083013.pdf

Date: Friday, April 10, 2015
Time: 1:00 PM CT (2:00 PM ET)
Subject: Bike & Pedestrian Accommodations Study – Advocacy Group Interview
Location: Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Matthew Roe	NACTO	646-324-8352	matthew@nacto.org

1. Introductions

a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the National Association of City Transportation Officials (NACTO).

b. In attendance from NACTO was Matthew Roe, Director of the Designing Cities Initiative.

c. The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Pam Broviak, Project Manager for the study and the District One ADA coordinator; Aren Kriks is a Project Engineer for the study and the District One bicycle coordinator; Marla Kindred is a Project Engineer for the study; Frank Zurek is a civil engineer working for Primera on contract with IDOT.

2. Organization & Project Overview

a. NACTO is a non-profit association that represents large cities on transportation issues, with 43 member cities, including 20 full members and 23 smaller affiliates. NACTO and its cities are committed to advancing street design practice and guidance, especially bicycle and pedestrian guidance.. Chicago is a full member, sharing information with peers such as New York, Philadelphia and San Francisco. There are no other members in Illinois. Other nearest members include Minneapolis, Detroit (full members), Madison, and Indianapolis (affiliates). Smaller cities are allowed to apply and are usually encouraged by invitation. Membership is approved by the NACTO board.

b. NACTO develops guidance and helps cities achieve their urban transportation goals, especially bicycle and pedestrian goals within urban contexts. NACTO has published an Urban Bikeway Design Guide (UBDG) and Urban Streets Design Guide (USDG). NACTO completes training workshops around the country, primarily in NACTO member cities. NACTO also performs peer group activities, building a common vision, sharing data, peer-to-peer exchange in workshops and conferences, and regular communication among member cities. One of the core values of NACTO is the ability for their members to coordinate with each other.

c. IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of national and international research, engineering studies, a review of internal policies, and recommending new guidance. IDOT is looking for feedback from users and organizations like NACTO. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements. IDOT is also interested in the infrastructure's impact on the community.

d. The intent of this study is to provide guidance, information, and tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with the IDOT Central Office.

e. The final project report is due summer 2015.

3. Bicyclists

a. UBDG updates, driven by the peer group that created that UBDG, are likely to include advisory bike lanes and/or dashed broken lines to indicate a shared lane.

b. Left-side bike lanes are used frequently on one-way networks. Left side bike lanes are helpful for parking/dooring issues, and they help increase visibility and reduce interactions with driveways.

c. Many cities have used bike boulevards. The primary design and interjurisdictional challenge arises at intersections when bike boulevards are crossing large arterial roads. Therefore states need to understand the implications of those facilities and crossings.

d. Many cities are installing double buffered bike lanes, which alert bicyclists of door zones. The minimum width is 7' (2' buffer, 3' lane, 2' buffer) but 10' wide lanes (3', 4' , 3') are common. IDOT also mentioned door zone markings and "barrows" being used in some places. The term barrow was coined by Streetsblog in reference to a single buffer-style pavement stripe adjacent to the parking lane in conjunction with a shared-lane marking to promote proper lane positioning for cyclists to avoid the door-zone.

e. Center sharrows for shared lanes have been well documented. IDOT also mentioned that Chicago has been installing dashed box markings on some shared lanes.

f. Green lanes are helpful for encouraging bicycle travel and visibility of both bikes and bike infrastructure. Solid green can be used to indicate an exclusive bike space or bike facility, and dashed green can be used to highlight conflicts along a bike's path of travel.

4. Pedestrians

a. The USDG has a design control elements section that is useful for IDOT.

b. Pedestrian scrambles are not in the USDG.

5. NACTO Guides

a. The UBDG has received endorsements from 41 cities and eight states. NACTO mentioned the FHWA has supported the use of the guides through a memorandum. (In general, the FHWA does not endorse guidance but rather supports their use.)

b. California has adopted the USDG at a legislative level allowing cities and towns to adopt the USDG in addition to their Caltrans Highway Design Manual. This specifically enabled cities and towns in California to apply USDG to their own local roads in addition to state owned roads. California was initially the most restrictive but is now exhibiting flexibility in their designs. Washington State DOT (WashDOT), MassDOT, and MnDOT have also endorsed the guides. WashDOT may have cosponsored a recent training session on the guide.

c. The NACTO guides are developed through a member peer group review process. NACTO members from various cities have planners and engineers that work through a committee process to create the guidance. Cities that often provide leadership include Chicago, Portland, NYC, San Francisco, Philadelphia, and Austin. City officials, several engineering consultants, and policy staff have coauthored the guides and provided additional peer review. Engineering technical review was performed by a Professional Engineer. All facilities in the NACTO guide have been constructed and tested in the member cities and/or exist in other U.S. guidance.

d. UBDG, updated in 2012, will be updated online in the near future. The USDG, released in 2013, will be updated during new print runs.

e. NACTO is developing a Transit Street Design Guide.

6. Performance measures:

a. NACTO included a performance measures section in the USDG. It includes a discussion of what makes a street successful for different modes and what performance measures are relevant.

b. NACTO encourages multi-modal performance measures. One successful safety measure is the number of severe injuries and fatalities per mile of street. Another measure is public life surveys, which are surveys of people conducting non-transportation activities such as social or economic activities. Pedestrian connectivity and travel time is another useful measure.

c. Intersection LOS and vehicle delay can be helpful when tweaking intersection signal operations and anticipating changes to traffic, but the measure is not helpful for allocating space on the roadway as it does not account total capacity or other goals.

7. Maintenance

a. NACTO member cities are very interested in maintenance, as they typically own and maintain a wide network of bike facilities of many types. Protected bike lanes/cycle tracks including parking-protected bike lanes and raised cycle tracks, and many other types of facilities, have been built in various climates and contexts, from humid subtropical (Florida) to semi-arid with snow (Salt Lake City, Denver) to humid continental (Toronto, Minneapolis, Chicago).

b. NACTO mentioned that NYC utilizes the sanitation department to clear snow due to the city's large street network. NYC outfits their garbage trucks with snow plow blades. Therefore, NYC designed most of their cycle tracks to a minimum of 10' including buffers to accommodate the width of the garbage trucks, with a side benefit of accommodating very high bicycle volumes Chicago, Toronto and many other cities use smaller vehicles to plow cycle tracks and can design narrower cycle tracks. San Francisco and other cities have purchased sweepers capable of operating in 4' clear zone, allowing narrow cycle tracks for constrained corridors.

8. State Roads

a. NACTO understands the difficulty of designing streets that carry large vehicles and heavy traffic within an urban context with transit, pedestrians, and bicyclists.

b. IDOT does not have the flexibility that cities have to prohibit trucks; IDOT is required by law to accommodate trucks. IDOT does, however, have design exceptions that prevent overbuilding at intersections with low truck volumes.

c. NACTO mentioned alternatives such as low-radius curbs to encourage slow speed turns, using advance stop bars to accommodate wider turns where a large curb radius would be inappropriate, using alternate vehicles, and rules for slow speed (down to 5mph) local deliveries. The USDG focuses its intersection recommendations on pedestrian and driver safety. The USDG specifically recommends that streets use a frequently-present vehicle, such as a delivery truck, as the *design vehicle*, with the largest permitted vehicle used as a *control vehicle,* that is capable of turning but whose speed is not prioritized over life safety.

d. NACTO mentioned the biggest challenge facing cities are obtaining approval from the state and applying funding. The funding process is divorced from the design process. Furthermore, the state review engineer can deny a project for almost any issues, including capacity and safety oriented projects. As a result some cities are afraid of not supporting specific facilities. Therefore the State application of Federal funding needs to be sensitive to local issues.

e. NACTO has heard of some states using jurisdictional transfers, including Portland, Oregon and Oakland, California. However, NACTO does not believe transfers are always a requirement to constructing innovative bike facilities. They may be more relevant if they simplify or streamline maintenance and operations, e.g. when a city is better positioned to undertake those responsibilities in an urban setting than the state is. States and cities vary widely in ownership of arterials: in North Carolina even smaller streets are often state-owned, while in New York City, all roadways are maintained by the City including the few state-owned highways.

9. Policy

- **a.** Large member cities sit on the NACTO policy committee. The committee creates NACTO policy statements that then guide staff. Policy advocacy, including at the federal level, is one of the reasons NACTO was originally created in the 1990s. Eventually NACTO members focused as much or more on design than federal advocacy given the ample opportunities NACTO members had to change the cities themselves. However, there has also been increased movement from USDOT and FHWA, including the recently published Separated Bikeway Design Guide.
- **b.** The next area of focus for most cities is expanding out their network of bicycle facilities, reconnecting their pedestrian networks, and improving transit street design.

10. Training

- **a.** NACTO hosts full day workshops that included a half day of presentations and a design charrette to apply principles from the USDG and UBDG in real life situations. The design charrettes allow members to critique each other's designs. The workshops have drawn 30-50 attendees on average, and up to 80 in large cities.
- **b.** NACTO has participated in a number of sessions through the Major Cities Committee at the annual TRB meeting, including the launch of the USDG.
- **c.** NACTO hosts the annual Designing Cities Conference. The next one will be October 28-31 in Austin.
- **d.** NACTO is teaming with ITE with FHWA support on a USDG training series, with full-day workshops held in Washington DC, Memphis, Hollywood FL, and planned for Tucson and other locations. NACTO also teams with APBP, ITE and other groups for open webinars.

11. IDOT

- **a.** IDOT has an ongoing cycle track pilot project in the City of Chicago. IDOT will collect before and after data.

12. Miscellaneous

- **a.** NACTO mentioned there are opportunities and challenges with automated vehicles. Originally the emphasis was on vehicle to vehicle communication but that method doesn't work with bikes and pedestrians. The final stage of development is completely driverless vehicles. Some implications include the ability to use narrower lanes and reduce capacity requirements since driverless cars make more efficient use of space. There is little consensus about how these vehicles might affect VMT and transit ridership.

13. The meeting concluded at 2:15 PM CT (3:15 PM ET)

Date: Friday, March 27, 2015
Time: 1:00 PM
Subject: Bike & Pedestrian Accommodations Study – Advocacy Group Interview
Location: Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Mark Plotz	NCBW	202-223-3621	mark@bikewalk.org

1. Introductions

a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the National Center for Bicycling and Walking (NCBW).

b. In attendance from NCBW was Mark Plotz, Senior Associate/Program Manager.

c. The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Pam Broviak, Project Manager for the study and also the District One ADA coordinator; Aren Kriks is the Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred, Project Engineer for the study; Frank Zurek is a civil engineer working for Primera on contract with IDOT.

2. Organization & Project Overview

a. NCBW gave an overview and history of the organization. It was originally founded in 1977 as the Bike Federation of America. The Bike Federation of America became part of the Project for Public Spaces in 2011. NCBW offers pro bono technical assistance for bicycling and walking issues. NCBW also performs Safe Routes to School (SRTS) work and collaborates with the League of American Bicyclists and Rails to Trails. The primary role of NCBW is hosting the ProWalkProBikeProPlace conference every two years and assembling the CenterLines newsletter.

b. IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering studies, a review of internal policies, and recommending new guidance. IDOT is looking for feedback from users and organizations like NCBW. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements. IDOT is interested in specific issues related to those three factors as well as the infrastructure's impact on the community.

c. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with the IDOT Central Office.

d. The final project report is due winter 2015.

3. Other Organizations:

a. People for Bikes provides technical assistance to cities. They organize tours for the city's engineers and planners to travel to Europe and observe bicycle facilities there and also send engineers to conferences. People for Bikes only works with cities for the time being due to the presence of advocacy groups in those regions. People for Bikes selected Pittsburgh to be in the 2014-2015 Green Lane Project protected bike lane program.

b. NCBW suggested that IDOT contact Dan Goodman at the FHWA. Dan is writing the upcoming protected bike lanes handbook.

c. NCBW suggested that IDOT contact the State Smart Transportation Initiative (SSTI), based in Wisconsin. SSTI can provide support on context sensitive solutions and performance measures for state programs.

4. Other State DOTs:

a. NCBW has helped NJDOT and PennDOT develop context sensitive solutions. NCBW worked with the states to setup a responsible charge at the local level to oversee implementation and open up funding for SRTS. Locals were also having trouble navigating the competitive process. NJDOT will now prequalify some consultants that the locals can choose from and work with the local LTAP program. PennDOT provides funding for technical assistance to local governments to help with management. IDOT mentioned that the local technical assistance program in the District is handled by the local MPO, the Chicago Metropolitan Agency for Planning (CMAP).

b. MassDOT has adopted the NACTO guidelines. MassDOT is currently reviewing their existing projects to implement other complete streets features.

c. NCBW suggested that IDOT contact Mary Anne Koos, Special Projects Coordinator at the Florida DOT. FDOT's audit team reviews state highway projects with respect to pedestrian safety operations. FDOT interviews state DOT staff, users, and advocates. FDOT's program has been successful and fatalities are starting to decline on state roads. Higher fatality rates are shifting to the county and city roads because local designs aren't being updated.

5. Other Contract Work:

a. NCBW worked for an MPO in New Jersey to develop a complete streets implementation plan for the county. NCBW mentioned it was a challenge to encourage newer facilities. Even though the state accepted the NACTO guidelines, the county did not. The local design firms were not aware of current designs. NCBW mentioned advocates have been helpful educating the public and practitioners on the latest design practices.

6. Training and Outreach:

a. NCBW has a professional development program, which is open to state employees.

b. NCBW has invited PennDOT to ProWalkProBikeProPlace but PennDOT did not have programs in place for training.

7. Technology

a. Carnegie Mellon was at the ProWalkProBikeProPlace conference. Carnegie Mellon developed a tool to measure sidewalk width and crosswalks. The tool can identify potential problems. It can detect a broken surface for example.

b. Los Angeles has purchased iPhone data to calculate biking and walking rates.

8. Miscellaneous Topics:

a. NCBW noticed that the popularity of topics has changed over the years. The biggest topic today is protected bike lanes.

b. NCBW mentioned Peter Hearth, from Northeastern University, is an expert on bicycle level of service (BLOS). Peter has mapped out low stress bike routes and measured the user's stress through blood pressure and heart rate monitors. The national highway institute has previously compiled BLOS research based on survey data, but this new research from Peter Hearth may be more accurate.

c. NCBW mentioned work by John Pucher and Ralph Buehler. They looked at cycling trends in six to nine cities in the US and three cities in Canada. Their book is *City Cycling*.

9. IDOT

a. IDOT may be interested in a bicycle & pedestrian facilities training program following the completion of the feasibility study. IDOT currently relies on federal highway training sessions and advocacy group guidelines. IDOT also mentioned the T2 training program, the LTAP group, and the ADA classes ongoing at IDOT.

10. The meeting concluded at 2:00 PM CT

Date:	Friday, March 13, 2015
Time:	11:00 AM
Subject:	Bike & Pedestrian Accommodations Study – Advocacy Group Interview
Location:	Teleconference

Attendees	Company	Phone Number	Email Address
Charles Frangos Frank Zurek	Primera Engineers Primera Engineers	312-242-6374 312-242-6453	cfrangos@primeraeng.com fzurek@primeraeng.com
Stefanie Seskin	Nat. Complete Streets Coalition		sseskin@completestreets.org

1. Introductions

- ***a.*** The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the National Complete Streets Coalition (NCSC)
- ***b.*** In attendance from NCSC was Stefanie Seskin, Deputy Director of NCSC, a program of Smart Growth America.
- ***c.*** The project team was introduced: Pam Broviak, Project Manager for the IDOT study and also the District One ADA coordinator (not in attendance). Aren Kriks is the Project Engineer for the study and is also the District One bicycle coordinator (not in attendance). Charles Frangos and Frank Zurek are civil engineers working for Primera on contract with IDOT.

***2.* Organization & Project Overview**

- ***a.*** NCSC gave an overview of their organization. NCSC represent many professional organizations such as the American Planning Association (APA) and the American Society of Landscape Architects, and also partners with transportation consulting firms such as Stantec.
- ***b.*** NCSC's mission is to provide a forum for interested groups to collaborate and advance the Complete Streets movement. NCSC undertakes a variety of activities, including creating and sharing resources on Complete Streets policy and implementation. As part of their work, they offer workshops to interested agencies at the state, regional, county, and local level, both as part of larger grants as fee-for-service.
- ***c.*** NCSC works with any group or agency interested in Complete Streets, including local chapters of national organizations, governments, and municipalities, Local partners in IDOT Region One included the Active Transportation Alliance, Cook County, and other municipalities.
- ***d.*** IDOT gave an overview of the Bike & Ped Study. Through this study, IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of available national and international research, engineering

e. The final project report is due summer 2015.

3. Topics:

a. General Comments

i. NCSC gave a few suggestions for webinars and other resources. A webinar hosted by Sam Schwartz Engineering on Bicycle Level of Traffic Stress is available online, based on a Mineta Transportation Institute report on Low Stress Streets for Bicycling and Connectivity.

ii. NCSC mentioned there are numerous bike & ped research projects completed or being carried out through TRB.

iii. NCSC is working on a guide of various performance measures, which is now available for free on its website (see here and here). The guide can be used for before and after studies where a user can set their goal and measure it. The guide includes standard performance measures such as speed and crashes as well as other measures such as economics, environmental concerns and community impact. Overall, 50+ measures were identified, each of which has between 2-12 metrics.

iv. NCSC works with ITE members on design controls and policies. ITE is updating its various documents including the upcoming Traffic Engineering Handbook updates. One example change to the handbook includes recommending 10' or less lane widths for urban areas and speeds of 45mph or less. Other issues brought up include the current design vehicles used in traffic engineering, or using only the 15 minute peak period for traffic studies which results in overbuilt roads. A better option is to use the two-hour peak period. NCSC works with communities to think through this mindset.

v. NCSC agrees with CDOT's modal hierarchy change where the most vulnerable users generally are put first. NCSC agrees with the context sensitive nature of the hierarchy as well but understands adoption of CDOT's hierarchy is difficult in other municipalities

b. Guidance

i. USDOT endorses the use of the NACTO Urban Bikeway Design Guide and Urban Streets Design Guide, and the ITE/Congress for the New Urbanism recommended practice Designing Walkable Urban Thoroughfares: A Context Sensitive Approach. The FHWA encourages all regions to work with the states to apply more flexible design standards that connect communities for biking and walking. (FHWA recently released its own guidance on planning and designing separated bike lanes.)

ii. ITE has a Complete Streets Council to organize all of its guidance and work to align with Complete Streets.

iii. NCSC finds that most states take their design guidance from AASHTO and modify the guidance for their needs. FHWA participates in the

AASHTO guides but do not control them. It is the state's responsibility to modify the national guides while also integrating the ideas coming out of cities into the state guides.

c. State DOTs

i. IDOT is not alone in advancing bike & ped designs in the state; other states are progressing as well.

1. For example, Florida has several chapters in their plans and preparations manual on how to use complete streets, although the Florida manual is still lacking in many areas.

2. Another example is the Massachusetts Department of Transportation, who adopted the NACTO guides and has long used context sensitive design in their manual. The challenge is not just saying that the State DOT is adopting context sensitive designs but actually implementing the changes, which requires training and changing the project delivery and design process.

3. Washington State DOT has also advanced bike and ped issues within their organization. WSDOT see it as key to their mission of reducing facilities but also being a good steward of public space and taxpayer money. WSDOT invests in the right designs and emphasize operations and maintenance over new construction.

4. PennDOT and NJDOT developed a guidebook five to six years ago called the Smart Transportation Guidebook, integrating context, and biking and walking.

5. North Carolina, California, Minnesota, Vermont, and Michigan DOTs have or are examining updates to their manuals, processes, and training. Several states have implementation plans describing how to update their manuals and what to update, notably Minnesota and California.

ii. The State Smart Transportation Institute published a report that summarizes the work State DOT's are doing overall entitled *Innovative DOT – A Handbook of Policy and Practice.* SSTI is comprised of researchers that publish technical guidance plus this guide on sharing ideas and collaborating with various state DOTs. SSTI also published a report on Caltrans a year ago, indicating how Caltrans can change their approach.

iii. Cities and counties can move quicker with new designs because of the smaller bureaucracies.

***d.* Suburban Contexts**

i. NCSC believes that suburban land use patterns don't preclude suburbs from being friendly for walking, bicycling, and transit use. There is still a demand and need for multimodal access in suburban areas. One example includes a Vermont 4-lane roadway with turn lanes at the demand and need for multimodal access in suburban areas. One example includes a Vermont 4-lane roadway with turn lanes at the intersections but with a comfortable sidewalk and shared use path alongside the road. There are options that work within the suburban context. However, NCSC mentioned bike and ped users in suburban areas are not considered during design as much as they should be.

e. ***The meeting concluded at 12:00 PM.***

Date:	Thursday, April 2, 2015
Time:	10:30 AM
Subject:	Bike & Pedestrian Accommodations Study – Advocacy Group Interview
Location:	Teleconference

Attendees	Company	Phone Number	Email Address
Aren Kriks Marla Kindred	IDOT IDOT	847-705-4186 847-705-4124	aren.kriks@illinois.gov marla.kindred@illinois.gov
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Amy Hill	Safe Kids Illinois	312-227-6692	alhill@luriechildrens.org

1. **Introductions**
    - **a.** The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with Safe Kids Illinois (Safe Kids), a coalition member of Safe Kids Worldwide.
    - **b.** In attendance from Safe Kids was Amy Hill, Coordinator for Safe Kids Illinois and Program Manager for the Injury Prevention and Research Center at Lurie Children's Hospital.
    - **c.** The project team was introduced: from IDOT was Aren Kriks, the Project Engineer for the study and also the District One bicycle coordinator; Marla Kindred, Project Engineer for the study; Frank Zurek, civil engineer working for Primera on contract with IDOT.
2. **Organization & Project Overview**
    - a. Safe Kids Worldwide is a global organization dedicated to preventing injuries in children, the number one killer of kids in the United States. Around the world, a child dies from an unintentional injury every 30 seconds. And millions of children are injured in ways that can affect them for a lifetime.
    - b. Safe Kids works with an extensive network of more than 500 coalitions in the United States and partners with organizations in 25 countries around the world to reduce injuries from motor vehicles, sports, drownings, falls, burns, poisonings and more. Safe Kids Illinois is led by Ann and Robert H. Lurie Children's Hospital of Chicago, which provides staff, operation support, and other resources to assist in achieving their common goal: keeping kids safe. Based on the needs of the community, Safe Kids implements evidence-based programs, such as car-seat checkups, safety workshops, and sports clinics that help parents and caregivers prevent childhood injuries.
    - c. Safe Kids focuses on the perception of crossing streets safely. Safe Kids observes people engaging in unsafe behavior and safety issues are sometimes a result of poor user choices so they constantly realize a need for education. Safe Kids focuses on the neighborhoods.
    - d. IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a

review of available national and international research, engineering studies, a review of internal policies, and recommending new guidance. IDOT is looking for feedback from users and organizations like LIB. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements. IDOT is interested in specific issues related to those three factors as well as the infrastructure's impact on the community.

e. The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with the IDOT Central Office.

f. The final project report is due summer 2015.

3. Partnerships:

a. Safe Kids receives funding from Kohl's and American Automobile Association (AAA) for vehicle passenger safety outreach. Safe Kids is also focused on child passenger safety in rural areas. In Chicago, Safe Kids partners with the Active Transportation Alliance (ATA), the Consumer Products Safety Commission, and community agencies interested in injury prevention.

b. Safe Kids also relies on the Lurie Children's Hospital Child Health Data Lab. The lab tracks injury trends and compiles data and different types of mechanisms for bicycle and pedestrian facilities.

   i. The lab tracks intentional and unintentional accidents or acts of violence.

   ii. Safe Kids will connect IDOT to the lab.

c. Amy Hill participates on conference calls for a Safe Routes to School (SRTS) committee. SRTS provides data through the Child Health Data Lab.

4. Studies

a. The Child Health Data lab performed a pedestrian safety study at various schools. The study focused mainly on personal choices and how pedestrians interact with the environment. One example location was at Clark and Ashland on Chicago's north side.

b. Safe Kids performed a bumpout study. One example location was at Murphy School in cooperation with Sam Schwartz Engineering. They offered to share the study with IDOT if they can find it.

c. Safe Kids mentioned difficulties with collecting injury data at specific intersections due to low crash rates.

d. Kyran Quinlan, an academic pediatrician interested in injury prevention at Rush Hospital, performed a hot spot study of crashes on Chicago's south side.

5. Outreach:

a. Safe Kids Worldwide developed the infographics on pedestrian safety found at the Safe Kids Worldwide website.

b. Safe Kids has an email list with a couple hundred subscribers.

c. Safe Kids hosts a meeting on the second Thursday of every month. Next one is April 9 from 11:30 to 1:00. About 20 community members usually attend.

d. Safe Kids advocates for helmet use to kids and parents. However, helmet acceptance rate is still low. They teach the philosophy of making better choices instead of using scare tactics.

e. When asked if more education is needed, they felt people often make poor choices relative to safety such as not wearing a helmet or looking both ways to cross a street. Sometimes the issue is a lack of a basic sidewalk.

f. Safe Kids, in collaboration with the CDOT Bicycling Ambassadors, performs community events, focusing on crosswalk safety and helmet use.

g. Safe Kids uses social media with their most popular stories being personal stories.

h. Safe Kids may perform other research in the areas of ADA and disabled persons accommodations only if funds are specifically available for those areas.

6. The meeting concluded at 11:30 AM CT

Illinois Department of Transportation

MEETING MINUTES

Date: Tuesday, May 26, 2015
Time: 1:00 PM
Subject: Bike & Pedestrian Accommodations Study – Trails for Illinois Interview
Location: Teleconference

Attendees	Company	Phone Number	Email Address
Pam Broviak	IDOT	847-705-4074	pamela.broviak@illinois.gov
Aren Kriks	IDOT	847-705-4186	aren.kriks@illinois.gov
Marla Kindred	IDOT	847-705-4124	marla.kindred@illinois.gov
Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Steve Buchtel	Trails for Illinois	708-365-9365	steve@trailsforillinois.org

1. Introductions
    a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with Trails for Illinois (TFI)
    b. In attendance from TFI was Steve Buchtel, Executive Director.
    c. The project team was introduced: from IDOT was Pam Broviak, Project Manager for the study and the District One ADA coordinator (*Pam has since changed bureaus)*; Aren Kriks is a Project Engineer for the study and the District One bicycle coordinator; Marla Kindred is a Project Engineer for the study; Frank Zurek is a civil engineer working for Primera on contract with IDOT.
2. Organization & Project Overview
    a. Trails for Illinois is a statewide advocacy group that promotes trail projects. TFI's projects include the Cal Sag Trail in cooperation with Friends of the Cal Sag Trail. The Cal Sag Trail is a large project on forest preserve ROW, local municipality ROW, and includes off street and on street facilities. TFI has worked on and fundraised for the Big Marsh project in cooperation with the Chicago Park District and SRAM. TFI also provides consultant services and is a sub to AECOM on the Cook County Long Range Transportation Plan. TFI performed advisory roles with Northeast Illinois forest preserves on maintenance and promotion issues. TFI also helped the Adventure Cycling Association establish a U.S. Bike Route from Hammond, IN to Kenosha, WI.
    b. IDOT gave an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of national and international research, engineering studies, a review of internal policies, and recommending new guidance. IDOT is looking for feedback from users and organizations like TFI. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements. IDOT is also interested in the infrastructure's impact on the community.

- **c.** The intent of this study is to provide guidance and information on pedestrian and bicycle facilities to the district and to create tools for the District to aid in implementing bicycle and pedestrian facilities. The study findings will also be shared with IDOT Central Office.
- d. The final project report is due winter 2015-16.

3. Demographics
   - a. TFI found that the majority of users are using the trails for recreation, health and fitness. Some users choose to ride to work or they are riding to work for fitness and exercise reasons. TFI believes most users enjoy being amongst nature and are not necessarily conservationists or environmentalists. However, people who spend time outdoors become more favorable toward environmental messaging; they place a higher value on the environment.
4. Concerns
   - a. Connectivity is the dominant concern over the last 30 years. Connectivity is largely being solved in Northeast Illinois although some gaps and issues still exist. In one year, the Northeast Illinois system may become the most connected trail system in the U.S. with 500 miles of connected trails. Dayton, Ohio currently holds that distinction with 300 miles of connected trails. Illinois trails sometimes navigate the connectivity issue by creating flexible routes that use multiple rights-of-way.
   - b. Street crossings are another major concern for trail users. Most crossings have basic pedestrian facilities that may not serve the trail user very well. For instance, many crossings require bicyclists to slow down, stop, then speed up, which can be irritating to bicyclists. Large intersections are difficult to navigate and uncomfortable. They are a turnaround point for many trail users. An example crossing is at Illinois Route 50 (Cicero Avenue) and the Midlothian Meadows Trail. Trail users have to cross Illinois Route 50 to access a nearby grocery store. While the trail map shows a well-connected route, many trail users turn around at Illinois Route 50.
   - c. Trail traffic is a concern in popular areas. Crowding complaints have been heard through newspaper articles and other anecdotal information. TFI suggests that some trails be revisited to determine if design changes are necessary, such as widening, rerouting, or separating users on the trail. TFI developed a trails etiquette card for MWRD for use along the Willow Springs Trail (I&M Canal). TFI also suggests revisiting the 10’ design standard to determine if it should be updated.
   - d. IDOT & TFI discussed lighting along trails. TFI supports the use of lighting as it allows additional time on the trail, however, installations can be controversial. Many towns battle over whether to light the trail, facing concerns such as bright areas near residential properties, trail use at night, and other NIMBY issues. The decision to light the trail is typically the local municipality’s decision.

e. Signage is a concern for trails that navigate on-street routes. Signage should be a continuous, visual reinforcement, ideally with trail specific signage. Users become aggravated if a trail does not provide adequate directional cues.

f. IDOT inquired about the prevalence of dead animals on the trail. TFI replied that the organization hasn't heard the issue come up. The issue many be unique to certain trails.

g. When trails cross driveways, the slope should not follow the driveway apron but instead maintain the slope through the crossing. In addition to providing for level crossings for accessibility, it also provides a visual cue to motorists that there is a thoroughfare crossing the driveway.

5. Best Practices

   a. Median refuge islands or "porkchops" at the corner radius can provide for a comfortable and safe crossing. It divides the crossing into one or two smaller exposure windows. People immediately understand the facility when they see it for the first time. It allows crossing users to navigate through only one direction of traffic at a time. Bridges and tunnels are also a great option but may be cost prohibitive.

   b. TFI recommends that IDOT consider mid-block crossings in some circumstances. Mid-block crossings may feel safer due to the user crossing directly in front of the motorists, versus at an intersection where crossing users and turning motorists may not see each other.

   c. Intersections can also be preferable to some trail users since they feel comfortable crossing at a red light with a designated and permissible pedestrian signal crossing phase.

   d. TFI recommends the use of Rectangular Rapid Flashing Beacons (RRFB) due to their low cost and ease of installation. The on-demand flashing beacon also encourages compliance by only flashing during times when trail users are crossing. Older continuous flashing beacons sometimes lead to complacency and loss of respect on the motorist's part.

   e. Diagonal crossings can also be realigned perpendicular to shorten the crossing distance, minimize exposure and increase visibility.

6. Trail Maintenance

   a. Some Northwest Indiana towns are constructing asphalt trails with a flush, concrete curb. The curb helps reduce crumbling at the edges, a particularly common problem in NW Indiana due to the swampy terrain. IDOT also mentioned the curbs may help with repaving by providing a grade controlled surface for the pavers to follow, thereby maintaining slope and ADA requirements through repaving operations.

   b. TFI believes trails built in the last 10 to 15 years are built to a reliable standard, under federal guidance with professional engineers and approved contractors. Many maintenance problems on trails may be on trails that are more than 15 years old. Perhaps some old, unmaintained trails can be retired if not rebuilt to current standards. Count data is needed to support this option.

c. Gravel is TFI's choice trail material. Building gravel trails is a viable, low cost alternative to maintaining asphalt trails. While gravel trails have short lifespans (< 10 years), they are cheaper to repair. Gravel trails only require labor and gravel as opposed to a paving contractor. Volunteers can also be used to maintain the trail, performing work such as brush clearing, mowing, invasive species removal, and crowd-sourced inspections. The www.americantrails.org website has cost tables to help decide between asphalt or gravel trails. Well maintained gravel trails can support wheelchair movement.

d. Snow removal on trails depends largely on what purpose the municipalities want the trail to serve during the winter. Some uses include snow covered trails for fat tire bikes or skiers or plowed trails for commuters.

7. Counts

   a. TFI performs trails counts through the Making Trails Count initiative.

   b. TFI counts are on a project by project basis or on contract with certain agencies. TFI is currently performing counts with the Crystal Lake Park District and McHenry County Park District.

   c. TFI submitted a RTP grant for funds to purchase counters for the Cal-Sag Trail.

8. Surveys

   a. TFI performs survey data collection through the Making Trails Count initiative, utilizing electronic counters and volunteer survey teams. The results are located on the TFI website.

9. Miscellaneous

   a. Solar powered, or internally lighted trails, may be useful to address concerns of trail opponents by providing a lighted trail that does not create light pollution.

   b. *Post meeting:* TFI provided Greg Calpino's contact info. He is the contact for the curbed-lined, shared use paths used in Indiana.

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10. The meeting concluded at 2:30 PM

Date: Friday, May 15, 2015
Time: 10:00 AM CT
Subject: Bike & Pedestrian Accommodations Study – CMAP Interview
Location: Teleconference

Attendees	Company	Phone Number	Email Address
Carlos Feliciano	IDOT	847-705-4106	carlos.feliciano@illinois.gov
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Frank Zurek	Primera Engineers	312-242-6453	fzurek@primeraeng.com
Scott VanDerAa	Primera Engineers	630-324-5168	svanderaa@primeraeng.com
John O'Neal	CMAP	312-386-8822	joneal@cmap.illinois.gov

1. Introductions
   a. The purpose of this meeting was to introduce and discuss the IDOT District One Bicycle and Pedestrian Accommodations Study with the Chicago Metropolitan Agency for Planning
   b. In attendance from CMAP was John O'Neal, Bicycle and Pedestrian Program Manager.
   c. The project team was introduced: from IDOT was Carlos Feliciano, In-house Studies Unit Head; Pam Broviak, Project Manager for the study and the District One ADA coordinator; Aren Kriks is a Project Engineer for the study and the District One bicycle coordinator; Marla Kindred is a Project Engineer for the study; Frank Zurek and Scott VanDerAa are civil engineers working for Primera on contract with IDOT.
2. Organization & Project Overview
   a. CMAP is the local MPO for the region. CMAP produces the regional comprehensive plan, *GO TO 2040*. The plan is slated to be revised starting next year.
   b. John O'Neal is staff liaison to CMAP's Bicycle and Pedestrian Task Force, an advisory body which has existed for several years within CMAP. The Task Force aims to coordinate all stakeholders around bicycle and pedestrian issues and opportunities. The Task Force is comprised of representatives for the region's counties, municipalities, Councils of Mayors, and Forest Preserve Districts, federal and state transportation agencies (including IDOT), advocacy organizations, , and other entities seeking improvement in bicycle and pedestrian accommodations and conditions in northeastern Illinois. The Task Force meets quarterly and, per the committee structure at CMAP, forwards its policy recommendations to the CMAP's Transportation Committee, on which the Task Force has an official representative. The Task Force is CMAP's means of interacting and coordinating regional stakeholders on bicycle and pedestrian issues. The Task Force is one of many committees and working groups at CMAP, including those which focus on transportation, (advanced

technology, operations, freight, and policy), in addition to others focused on economic development, land use, housing, fiscal policy, etc..

c. IDOT gave CMAP an overview of the Bike & Ped Study. IDOT is gathering data, guidance, and recommendations to assess the feasibility of a number of bicycle and pedestrian infrastructure improvements. This work includes a review of national and international research, engineering studies, a review of internal policies, and recommending new guidance. IDOT is looking for feedback from users and organizations like CMAP. The reports that IDOT is developing focus on the safety, operations, and maintenance aspects of various bicycle and pedestrian infrastructure improvements. IDOT is also interested in the infrastructure's impact on the community.

d. The intent of this study is to provide guidance, information, and tools for the District, which will be of use in implementing bicycle and pedestrian facilities as requested by the previous IDOT secretary of transportation. The study findings will also be shared with the IDOT Central Office.

e. The final project report is due summer 2015.

3. Coordination

a. CMAP coordinates with IDOT as mandated by federal law. CMAP also engages with local agencies through the Local Technical Assistance (LTA) program. The LTA program provides planning assistance to local and subregional governments and agencies that may not have the resources or capacity to develop plans on their own. CMAP is currently working on four to five bicycle and pedestrian plans with local agencies. CMAP has also partnered with advocacy groups like the Active Transportation Alliance (ATA). CMAP, in partnership with the National Complete Streets Coalition and ATA recently developed a Complete Streets Toolkit. Currently, CMAP is partnering with ATA on several LTA projects, including one for the South Council of Mayors to work with several communities in south suburban Cook County to explore, and develop Complete Streets policies and approaches to roadway planning, design, construction, and maintenance. This work is being carried out in part with funding from the Cook County Partners in Community Health (PICH) Grant, awarded by the CDC. Through the LTA program, CMAP provides direct (staff) assistance, as well as grant funding to hire consultants to develop plans for local and subregional agencies. LTA is in its 4th year and includes an annual call for applications. The LTA program funded 25 projects in the last round (announced in October 2014). Over the time that the program has existed, CMAP has seen increased interest in non-motorized transportation projects.

b. CMAP developed and published criteria by which they fund bicycle and pedestrian projects through the Transportation Alternatives Program (TAP) and the Congestion, Mitigation and Air Quality (CMAQ) Improvement program. The methodologies and criteria used to review and evaluate proposals for TAP and CMAQ funds are available online on CMAP's website. TAP criteria include an evaluation of how the proposed project relates to and will help complete the Regional Greenways and Trails Plan (RGTP, adopted in 2009).

In evaluating TAP project proposals, CMAP staff considers the extent to which a proposed project will help complete a planned segment or achieve connectivity to the RGTP network, as well as other measures of the potential impact of project.

4. Outreach

    a. CMAP maintains the Soles & Spokes blog or weekly update, which provides summaries and links to important new bicycle and pedestrian planning resources, news items, and funding opportunities. The updates cover recently released academic, government agency, and advocacy organization studies, initiatives, programs and reports, as well as news on trails, bikeways, and walkability in our region. CMAP recently highlighted, for example, a report from the Transportation Research Board's National Cooperative Highway Research Program describing methods and technologies for counting pedestrians and bicyclists.

5. Training

    a. CMAP has organized half-day, one-day, and multi-day workshops on bicycle and pedestrian planning and safety in the past, sometimes in cooperation with the FHWA, IDOT, and other federal and state agencies, as well as the American Planning Association, ASCE, and APWA. CMAP has also hosted workshops and training on ADA. CMAP has also performed training regarding Safe Routes to School and pedestrian safety audits. CMAP believes that opportunities exist for IDOT expand the Department's training programs to include local officials and agency staff in their training.

    b. CMAP developed the Local Ordinances and Toolkits program in order to develop planning and policy resources for local agencies – especially the 284 municipalities in our region. The selection of topics to be addressed is based on input received from surveys of the region's municipalities and other stakeholders. The Complete Streets Toolkit, which was developed for this program, was designed as a website with several elements. The introductory material defines Complete Streets and discusses its benefits, providing talking points for elected officials, advocates, and others who want to advance a Complete Streets approach. Sections on Complete Streets policy development and implementation are directed at government or agency who would typically be charged with such tasks. In other sections, the Toolkit provides an image gallery of overall design concepts and considerations (to achieve Complete Streets), as well as bicycle, pedestrian, and transit facility types, and roadway design treatments intended to help achieve traffic calming and safe crossing of roadways. The Toolkit also provides information on and links to additional resources on Complete Streets and related topics. As mentioned above, the toolkit was developed in partnership with the National Complete Streets Coalition and ATA. Many of the photos used were taken by Dan Burden of the Walkable and Livable Communities Institute (WALC). Primera will contact Mr. Burden to request use of some of his photos in the IDOT's feasibility study. CMAP has also offered to share the sources of photos relating to bicycle and pedestrian transportation with IDOT.

6. Counts

    a. CMAP has performed some one-off counts throughout the region, some using Miovision video data collection devices. CMAP recommended coordinating with Tom Murtha, who has managed the count program in recent years. Primera will contact Tom for more information on that program.

    b. CMAP understands the need for a consistent, long term approach to collecting bicycle and pedestrian volumes. New technology is making it easier. Some agencies around the country are using visual counters at pinch points to count users. The visual aspect provides the additional benefit of showing the public the increase in volumes occurring in their area. San Diego, California and Minneapolis, Minnesota are example communities with a robust counting program.

7. GIS

    a. CMAP's GIS work, gathered in the Bikeway Information System (BIS), is a collection of plans from various jurisdictions, created by different people at different times. CMAP views the BIS as an ongoing project and has a team that researches existing plans and transfers them into the BIS (geodatabase). CMAP makes this data available to the public through its Data Hub. CMAP includes bicycle plans or plan elements from LTA projects and from local communities, counties, Forest Preserve Districts, park districts, and Councils of Mayors. CMAP assumes that, typically, local communities have the greatest familiarity with plans and plan goals and recommendations in their jurisdiction and in their areas. For example, CMAP would typically assume that staff at the Village of River Grove would be aware of and incorporate any subarea plans – such as the bicycle-pedestrian circulation plan for Triton College, which is located within the Village – into a Village-wide bicycle and pedestrian plan. The ongoing process of updating the BIS includes communication – through projects, programming activities and other means – with municipalities and planning/programming agencies such as Councils of Government and Councils of Mayors in order to learn about and include new plans and new facilities. Recently, CMAP (as part of an LTA project) surveyed the 35 South Council communities and found that a number of them had developed plans and/or recently installed bikeway facilities like bike lanes, buffered bike lanes, shared lanes, etc.

    b. IDOT suggested that CMAP consider including space for user (municipal staff, general public?) input of plans on CMAP's website in order to improve and simplify the process by which the BIS is updated. CMAP is interested in developing an input process but has concerns about quality control and how it fits within their data gathering and data sharing procedures.

    c. CMAP is planning to improve the BIS, which at present is not one analyzable file, but rather a collection of compendium of plans, that may overlap and are produced for different purposes and with varying levels of detail/accuracy, so that it is topologically unified and would therefore be utilized for route modeling and other purposes. CMAP is at present considering issuing a RFP for scoping and completing this work. One difficulty that would have to be overcome is that the BIS contains plans by many jurisdictions that overlap and are "nested" within each other. Creating one file would make individual jurisdictions' changes difficult to manage.

8. Surveys

   a. CMAP, as part of LTA projects and other programs, regularly surveys municipalities, Counties, Councils of Mayors and other groups. One survey, in relation to the development of a bicycle and pedestrian plan for the Village of Arlington Heights, received over 2000 responses and included interactive mapping capabilities. In general, this and other surveys show that residents want progressive bikeway facilities that will improve conditions for cycling, bicycle safety, and bike network connectivity. The surveys also consistently indicate that local and subregional officials, transportation professionals, and residents perceive that one of, if not the, biggest challenges to safe and convenient biking and walking in our region are the high speed, high volume arterial roadways – often under state jurisdiction – which were planned, designed, and built only (or primarily) to move automobiles at the highest possible speed. These automobile-oriented roads very often undermine the possibility of safe and convenient walking and bicycling and should be retrofitted to accommodate all users by slowing traffic and improving the amenities/facilities for pedestrians and bicyclists so that a balance of roadway users can be achieved.

   b. In addition, survey respondents from municipal and county DOTs, public works and planning departments, and other agencies have consistently expressed the need to allow for and encourage flexibility in design, so that roads which serve long-distance regional travel, but which also, in certain segments, serve more local and multimodal travel, should have decreased speed limits and very different designs/cross sections/goals when as they enter and pass through an urbanized area (which is the majority of District One); respondents and practitioners alike understand the need for more context sensitive solutions and roadway design that is related to surrounding land use, existing and future, and to community goals relating to livability, access, and sustainability. In Northeast Illinois, many areas are seeing an increase in seniors and children on roads that traditionally served regional travel and therefore need to be redesigned to accommodate these new users.

   c. CMAP's long range comprehensive planning document aggregates the trends identified in the surveys.

9. Recommendations

   a. One challenge facing local communities is funding. The 20% match is difficult for some communities to meet. CMAP mentioned other progressive states are waiving the local match requirement.

   b. CMAP recommends adding more and more up-to-date standards, guidance, and information (per NACTO, ITE's Walkable Urban Thoroughfares manual, new FHWA resources, and AASHTO's newest (2^{nd} Edition) bikeway design guide) on bicycle and pedestrian facilities and treatments to the BDE and BLR manuals.

   c. CMAP recommends looking at federal guidance and rules for categorical exclusions – and the broader goals behind the rules. Many items in the public right-of-way have minor impact on federal requirements, and thus should be expedited through the federal process.

10. Miscellaneous

    a. CMAP sees bicycle and pedestrian accommodations as part of the modernization of the transportation system called for in GO TO 2040 and many other plans, including IDOT's long range plans. Modernization means creating a transportation network that is up to date, contemporary, works for all users, and is sustainable in the future. It involves integrating land use and context into the transportation system.

    b. Some CMAP staff are considering driverless cars in their research and discussions. APWA recently held a panel discussion on ride-sharing and shared mobility technologies. The public has traditionally thought about 'owning' transportation, but now there are new ways of sharing transportation outside the traditional public transit mindset. The technology seems mature but it's just a matter of convincing the public that it's viable.

    c. Lack of sufficient dedicated funding; out-of-date, conventional thinking about road design and the "purpose" of roads; burdensome permitting processes and timeframes whenever federal funds are utilized; along with unpredictable changes in elected officials and their priorities and commitments, and lack of communication within and among governments and government agencies or departments – all present challenges to consistently, successfully, and fully incorporating the most effective and game-changing (in terms of safety and mode shift) bicycle and pedestrian infrastructure in the roadway system that all depend on.

11. The meeting concluded at 11:30 AM CT

Appendix A-3
IML Survey

Introduction

A survey was conducted at the Illinois Municipal League (IML) annual conference, which occurred on October 17-19, 2013. The IML is an organization which gives local municipalities a voice in Illinois legislation, and whose governing board consists of Mayors and Village Presidents across the state of Illinois. The survey was administered by two IDOT staff at the IDOT sponsored booth. Municipal officials were asked to take the survey as they approached the booth. The purpose of this survey was to collect data from Illinois municipalities regarding bicycle and pedestrian planning, design, usage, and education in their communities.

Survey Method

The survey was distributed as a tri-fold pamphlet. The questions were primarily multiple choice, but several asked for specific examples of projects, locations, or suggestions. The suggestion responses were grouped into categories to allow for quantitative analysis.

Survey Questions

Figure #	Questions Asked
1	Choose your position:
2	Does your community have a bicycle and/or pedestrian plan (please note which)?
3	If not, does your community have plans to develop one, or would do so if funding or guidance was provided?
4	Below is a diagram of various bicycle accommodations, please note if your community would be comfortable with each type of facility. Check the box if your community would support the use of the bicycle facility below:
5	Rank the overall level of accommodation perceived for bicycles and pedestrians along State Routes in your community:
6	People in my community primarily bicycle or walk for the following reasons (select all that apply):
7	The typical age of a cyclist in my community found using an on-road bicycle facility is:
8	The typical age of a cyclist in my community found using an off-road bicycle facility is:
9	Is your community interested in adding/increasing (bicycle/pedestrian facilities)?
10	If yes to any of the above, choose which of the following would best help your community implement the above (rank in importance with 1 being most important).
11	List some of the hurdles or challenges your community faces in the implementation of bicycle and pedestrian facilities?
12	What do you believe is the best way to educate and notify the public about bicycle and pedestrian accommodations and what information might you need to effectively do so?
13	Please feel free to fill out the comment section below to voice any general or particular concerns with accommodating bicycles and pedestrians along State roadways in your community.

Results

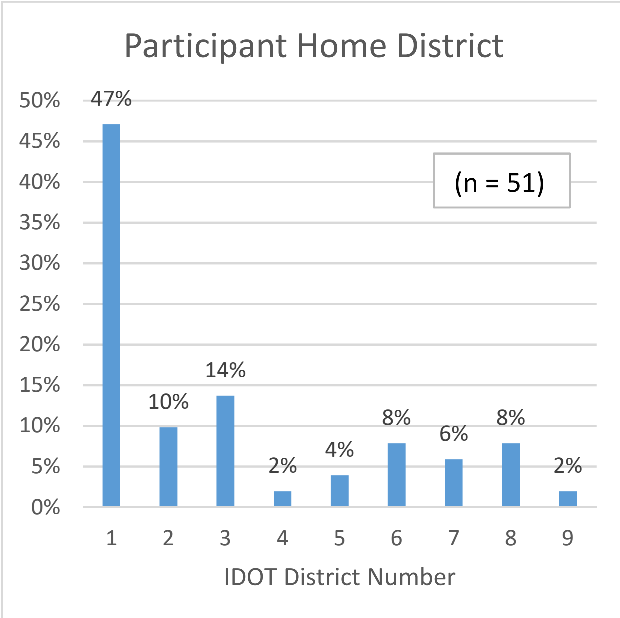


Figure 1 - Breakdown of IDOT Districts of participating municipal representatives

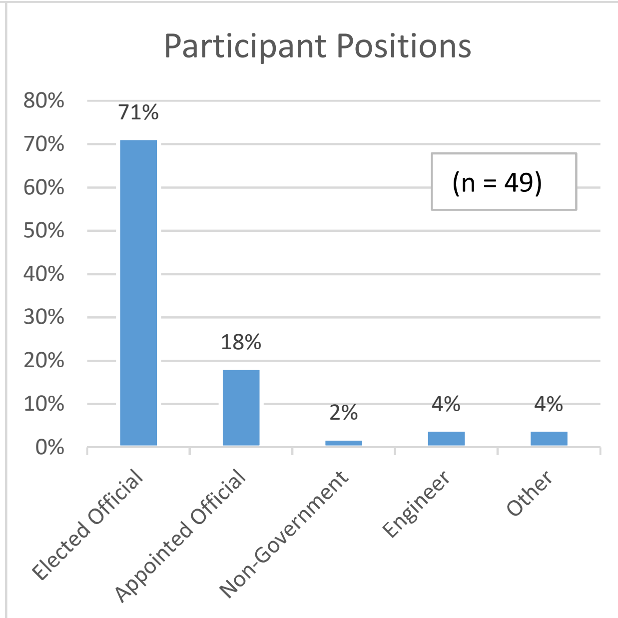


Figure 2 - Breakdown of municipal representative positions

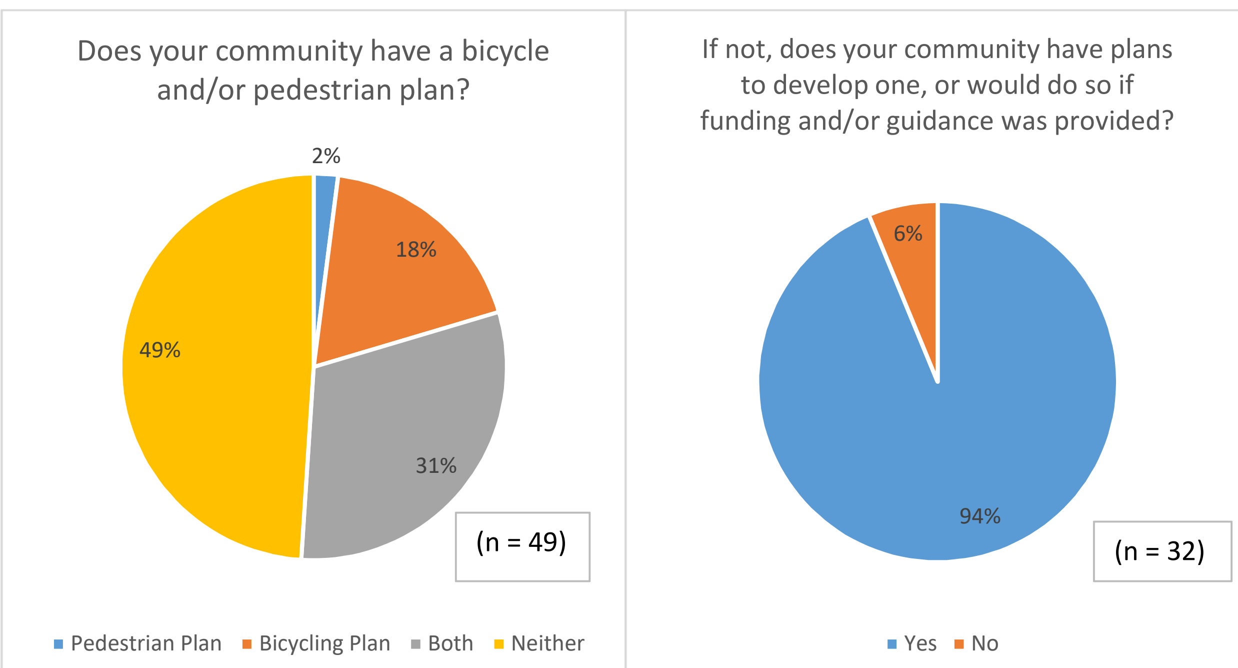


Figure 3 - Question: does your community have a bicycle and/or pedestrian plan (please note which)? If not, does your community have plans to develop one, or would do so if funding or guidance was provided?

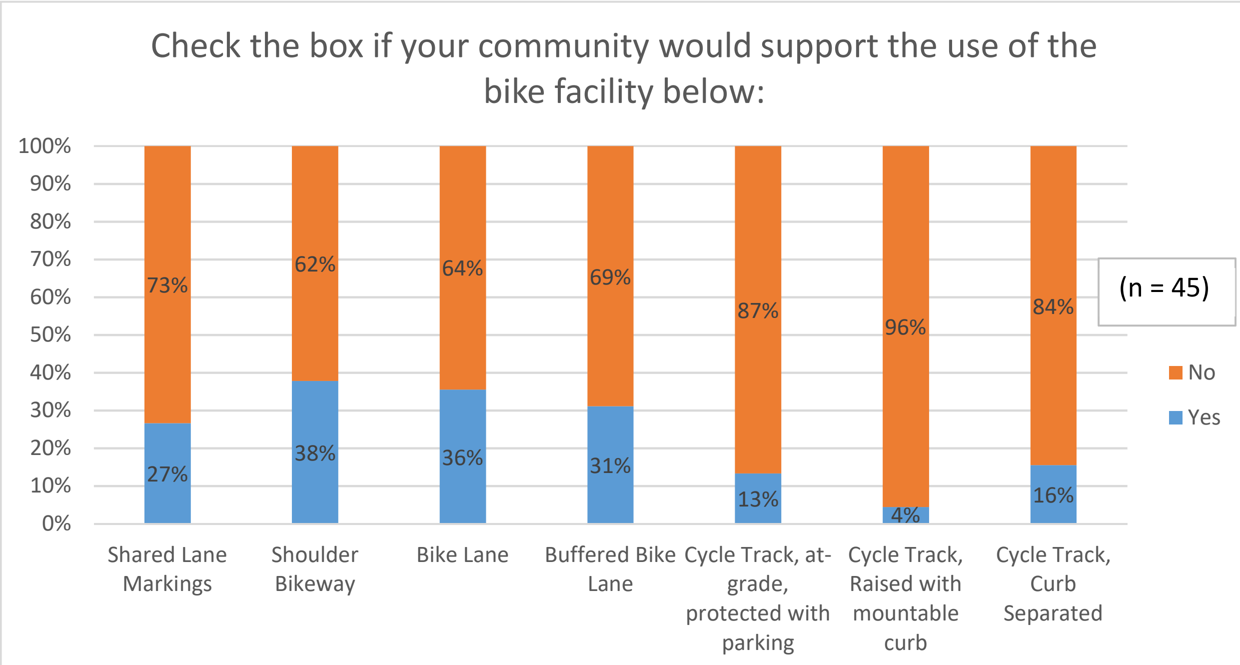


Figure 4 - Question: check the box if your community would support the use of the bicycle facility below

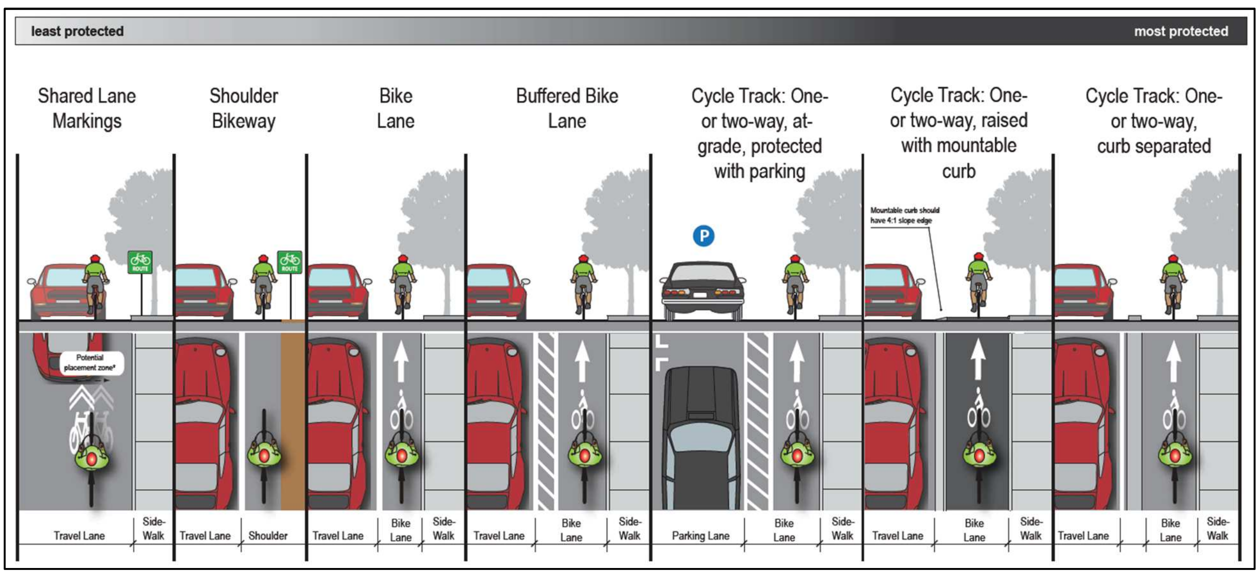


Figure 5 - Types of bicycle facilities (source: Washington County, Oregon Bicycle Facility Design Toolkit, December 2012)

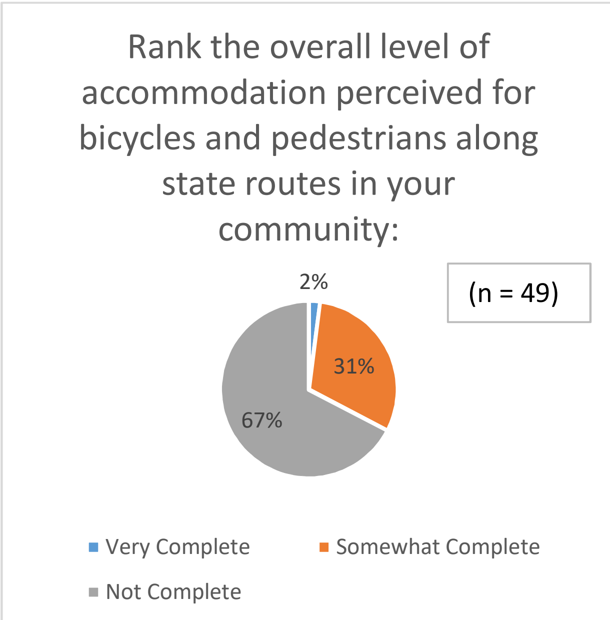


Figure 6 - Question: rank the overall level of accommodation perceived for bicycles and pedestrians along state routes in your community

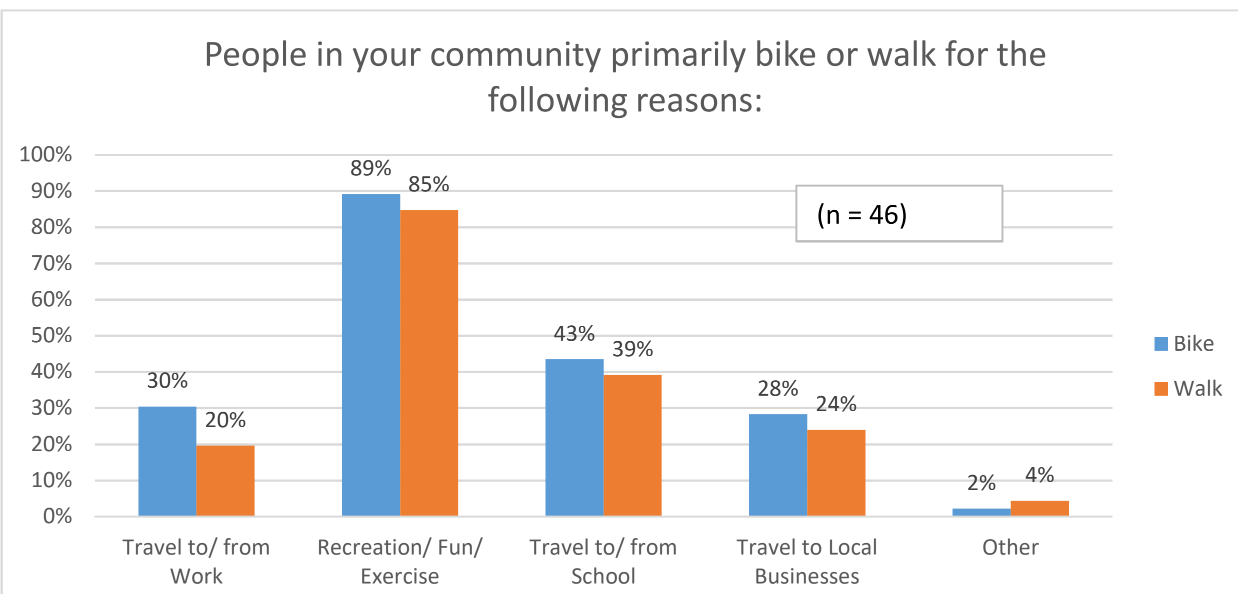
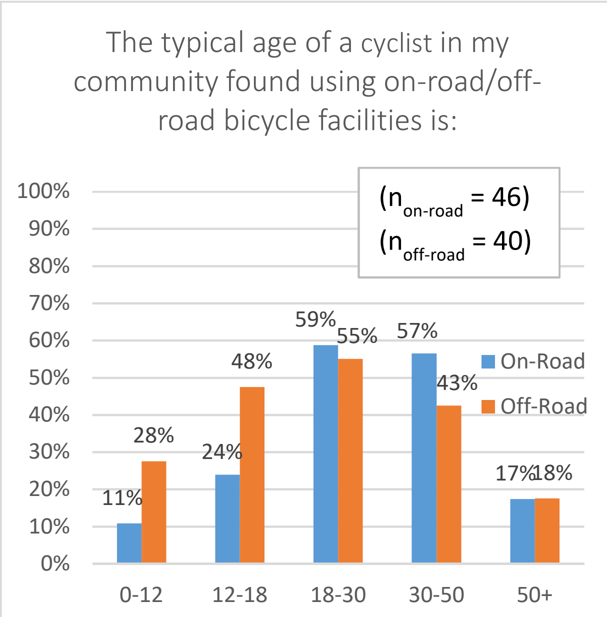


Figure 7 - Question: people in your community primarily bike or walk for the following reasons



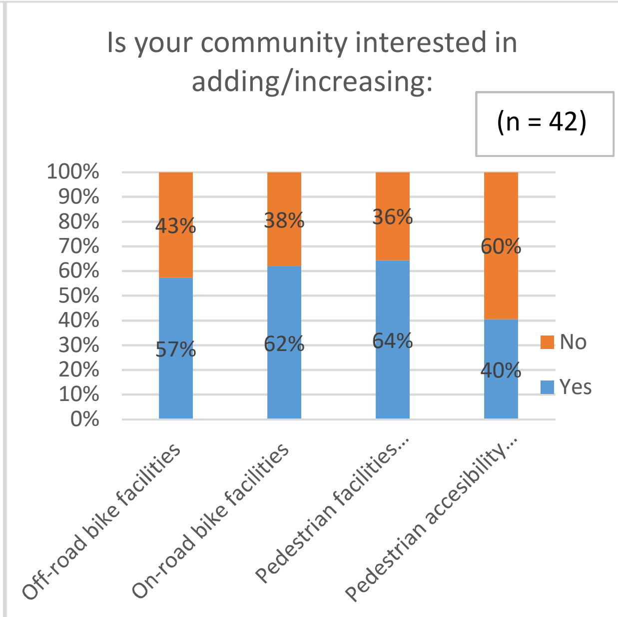


Figure 8 - Question: the typical age of a cyclist in my community found using on-road/off-road bicycle facilities is

Figure 9 - Question: is your community interested in adding/increasing

Survey Participants were asked to rank the following resources in terms of how much t*he item* could help the community add or increase bicycle and/or pedestrian facilities. The resource rankings were compiled, and a weighted ranking for each resource was calculated. The resulting hierarchy is shown below with 1 being the most useful resource and 8 being the least useful.

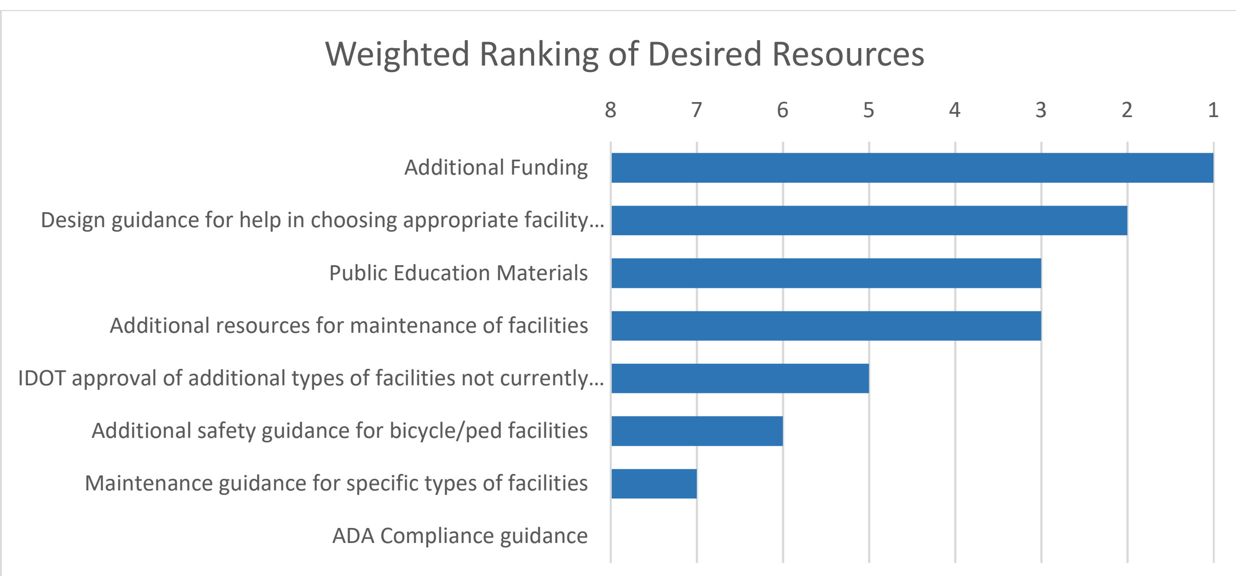


Figure 10 - Question: choose which of the following would best help your community implement bicycle & pedestrian facilities

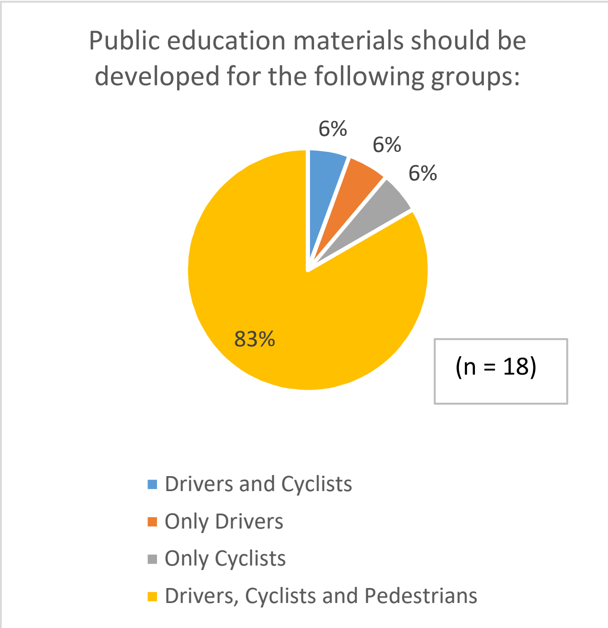


Figure 11 - Public education materials should be developed for the following groups

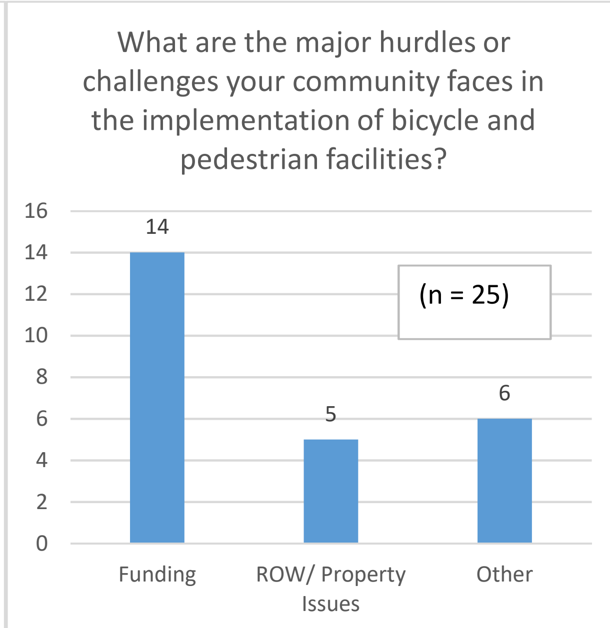


Figure 12 - Question: List some of the hurdles or challenges your community faces in the implementation of bicycle and pedestrian facilities

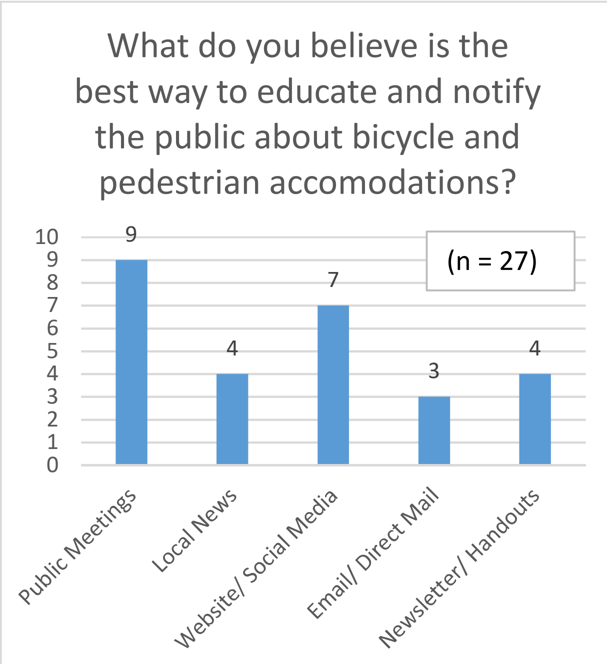


Figure 13 - Question: What do you believe is the best way to educate and notify the public about bicycle and pedestrian accommodations and what information might you need to effectively do so?

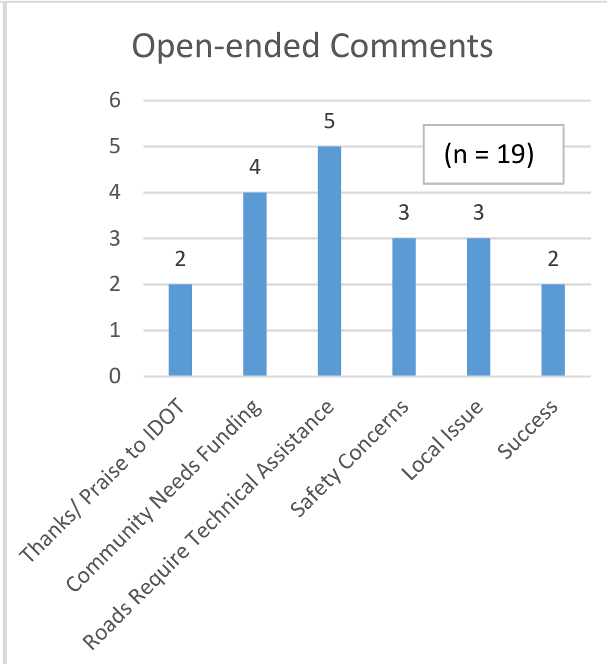


Figure 14 - Feel free to fill out the comment section below to voice any general or particular concerns with accommodating bicycles and pedestrians along state roadways in your community.

Discussion

There were a total of 50 community representatives that took this survey (one particular participant represented two districts). Out of these, 47% of the participants represented IDOT District One, 14% represented IDOT District Three, and the remaining districts each were accounted for in 10% or less of the survey participants. The overwhelming majority of participants were government officials (89%), with 71% elected and 18% appointed. The remaining survey participants were non-government officials, engineers, or listed "other" as their occupation.

Nearly half (49%) of all surveyed participants have neither bicycle nor pedestrian plans in their communities, about a third (31%) have both in place, and 18% of participants have only bicycle plans, and only one community (2%) has only a pedestrian plan. Of the communities that did not have both bicycle and pedestrian plans in place, 32 of the 34 surveyed (94%) would develop these plans given the necessary funding and expertise.

When asked what types of bicycle facilities would be of interest to these communities (shown in Figure 5), there was a wide range of responses. The options given were: shared lane markings, shoulder bikeway, bicycle lane, buffered bicycle lane, at-grade cycle track protected with parking, raised cycle track with mountable curb, and curb separated cycle track (multiple selections were allowed for this question). The facility that garnered the most interest was the shoulder bikeway with 38% support, followed closely by a standard bicycle lane at 36%. Raised cycle track with mountable curb garnered the least support with only 4%. Solely analyzing the data shown in Figure 4 illustrates which facilities are popular across the state but does not wholly show which facilities would be best suited for urban/suburban/rural environments. For further understanding of the responses, the survey results should be compared to the urban/rural context of each community.

Only one community, Coal City, ranked the overall level of accommodation for bicycles and pedestrians as "Very Complete". Of the surveyed communities, two-thirds ranked their level of accommodation as "Not Complete" with the remaining third having "Somewhat Complete" accommodations. This data may indicate that having a bicycle and/or pedestrian plan, as 51% of communities do, is just one piece of the puzzle. In order to implement these projects, these communities will require financial and technical assistance as well.

When asked why community members are likely to bicycle and/or walk, the percentages of bicyclists and pedestrians closely matched with 89% and 85% citing recreation/exercise as the principle reason, respectively. This trend can be seen in Figure 7. The next most common reason to bicycle and/or walk was for travel to and from school with 43% and 39% for biking and walking, respectively. Travel to and from work, and travel to and from local businesses had similar responses with around 25% of survey participants selecting these answers (multiple responses were allowed for this question).

The typical age of cyclists seems to differ between on-road facilities and off-road facilities. Off-road facility users tend to be younger, specifically used more by cyclists aged 0-18, while on-road facilities are used more by cyclists aged 18-50. This trend can be viewed in Figure 8. Users aged 50+ use on-road and off-road facilities at a nearly identical rate – 17% and 18% respectively.

When asked if their communities would be interested in adding or increasing bicycle and pedestrian facilities, the municipal representatives leaned towards "Yes" in each category except for "Pedestrian accessibility (ADA compliance)". About 60% of the communities are interested in off-road bicycle facilities, on-road bicycle facilities, and pedestrian facilities.

The municipal representatives were asked to rank the following eight resources in terms of how helpful they would be in adding or increasing bicycle and pedestrian facilities: additional funding, additional resources for maintenance of facilities, design guidance, maintenance guidance, safety guidance, ADA compliance guidance, IDOT approval of additional types of facilities, and public education materials. This question was incorrectly completed by 37% of the representatives – they would place a check mark or "x" next to a few answers without ranking them. To analyze this data, the check marked responses were ignored and the ranked answers were analyzed. Answers were assigned point values from one to eight based on the ranking. An answer ranked number one would receive eight points, answers ranked number two would receive seven points, answers ranked number three would receive six points, etc. The point values were summed for each response in order to gauge overall importance. The top three answers for this question, beginning with most important, were additional funding, design guidance, and additional resources for maintenance. The rankings can be viewed in a list in Figure 10.

Public education materials were ranked fourth overall on the priority list in the previous question. Survey participants were asked where they think those public education materials should apply if used. The results can be seen in Figure 11 and favor materials for drivers (94%), cyclists (94%), and pedestrians (83%).

Funding was the main topic of discussion when participants were asked what the major hurdles or challenges are for their community in the implementation of bicycle and pedestrian facilities. Even though the question was open ended, 14 of the 25 responses to this question mentioned funding. The next most common response concerned right-of-way/property issues. Other barriers mentioned include parking concerns, community awareness, and infrastructure limitations.

Survey participants were also asked what they think would be the best mediums for disseminating information about bicycle and pedestrian accommodations in the community. A variety of responses were given, but the most popular was "public meetings" which appeared on 47% of surveys. Websites and social media came in as the next most popular, appearing on 37% of surveys, followed by local news with 21%, newsletters/handouts with 21%, and finally, email/direct mail with 16%.

When asked for additional comments, 15 survey participants responded. The most common response, appearing on 33% of comments explained that the communities required technical assistance to implement bicycle and pedestrian facilities. A desire for more funding and financial assistance appeared in 27% of comments, and safety concerns appeared in 20% of comments. Other comments included concerns about residents losing parking, cancelled construction projects, current construction projects, and praise for IDOT for help with bicycle paths.

Conclusion

Of the 50 community representatives, the majority were elected officials from District One. The municipal representatives are overwhelmingly in support of bicycle and pedestrian facilities but differ on the level of accommodations they would consider installing. The representatives also believe the majority of their residents primarily bike and walk for recreational reasons. As evident from Figure 3, 94% of communities without bicycle and/or pedestrian plans would develop one given proper funding and guidance. In general, the primary obstacles to improving bicycle and pedestrian facilities in these communities are funding, lack of technical assistance, and safety concerns. In the open ended question, the most mentioned concern was a request for technical assistance, a concern mirrored in the ranking of desired resources, where technical assistance (design guidance) received the 2nd highest ranking behind funding.

References

Washington County, Oregon. 2012. *Bicycle Facility Toolkit, December 2012.* Accessed June 8, 2015. http://www.co.washington.or.us/LUT/Divisions/CPM/upload/WaCo_Toolkit_Dec2012.pdf.

Appendix B

Data Collection

Appendix B-1

Field Checklist

Route: ____________________________________ City/Township: ______________________________
Cross Street: ______________________________ County: ____________________________________
Date: _____________________________________ Job Number: ________________________________
Inspector: _________________________________ Checked by: ________________________________

Current Weather

Temperature: __________ °F

Clouds:
☐ Sunny/Mostly Clear (0-25%)
☐ Mostly Sunny / Partly Cloudy (26-50%)
☐ Partly Sunny /Mostly Cloudy (51-75%)
☐ Cloudy / Overcast (76-100%)
☐ Thunderstorm

Precipitation:
☐ None
☐ Mist / Fog
☐ Light Rain
☐ Rain
☐ Snow

Wind Speed:
☐ Calm
☐ Slight Wind
☐ Windy (20-29mph)
☐ Very Windy (> 30mph)

Past Weather

Date: ____ /____ /____ Date: ____ /____ /____ Date: ____ /____ /____ Date: ____ /____ /____ Date: ____ /____ /____
High: ___°F Low: ___°F High: ___°F Low: ___°F High: ___°F Low: ___°F High: ___°F Low: ___°F High: ___°F Low: ___°F
Precip: ____________ Precip: ____________ Precip: ____________ Precip: ____________ Precip: ____________

Environment

Land Use:
☐ Residential
☐ Commercial
☐ Industrial
☐ Park
☐ Natural

Density:
☐ Central Business District (CBD)
☐ Urban
☐ Suburban
☐ Exurban
☐ Rural

Intersections In Project Area

ID	Intersecting Street	# of Street Legs
Example	*Ogden Avenue*	*4*
A		
B		
C		
D		

Signals

Major Road (study road)
None: ______________
Stop-sign: ______________
Traffic Signal: __________
Other Signal: ___________

Minor Road (secondary)
None: ______________
Stop-sign: ______________
Traffic Signal: __________
Other Signal: ___________

Actuation
Pretimed: ______________
Semi-actuated: _________
Actuated:____
Ped Actuated: ___________.

Ped Signalization
Ped Signal: ___________
Countdown timer: ______

Label arrow with diagram orientation: ☐

Draw the intersection(s) with signals and pavement markings here:

Roadway Items

General
Number of Lanes: _______
Lane Width: ____________ (FT)
Shoulder Width: _________ (FT)
Misc Widths: __________
______________________ (FT)
Speed Limit: ____________ (MPH)

Structures
☐ Highway Underpass
☐ Railroad Viaduct
☐ Bridge (overpass)
☐ Highway Access Ramps

Street Lights
☐ Traditional Street Lamps
☐ Street & Sidewalk Lights
☐ Separate Sidewalk Lights
☐ Intersection Lighting Only
☐ No Public Street Lighting

Delineation
☐ Curb & Gutter
☐ Curb Only
☐ Gutter Only
☐ HMA Shoulder
☐ Agg. Shoulder
☐ Grass

Parking
☐ No Parking
☐ Parallel Parking
☐ Diagonal Pull-in Parking
☐ Diagonal Back-in Parking
☐ Perpendicular Pull-in Parking
☐ Perpendicular Back-in Parking

ADA Parking
☐ On-street ADA Parking
Number of ADA parking spaces per mile: _________ (estimate)

Rumble Strips
☐ Shoulder Rumble Strips
☐ Centerline Rumble Strips

Approx. Number of Driveways per Mile: _______________

Drainage

Sewer Cover Direction
☐ Std. Chicago Perforated Lid
☐ Curb Box Lid (parallel to traffic)
☐ Curb Box Lid (perpendicular to traffic)
☐ Curb Inlet

Flooding
☐ Gutter Only
☐ 1-4’ from EOP
☐ ¼ of Street
☐ ½ of Street
☐ ¾ of Street
☐ Full Street

Drainage Issue Causes
☐ Clogged Inlets
☐ Heavy Rain
☐ Flow Restrictors
☐ Other (explain): ______
____
____

Pavement

Street Material
☐ HMA
☐ Concrete
☐ Gravel
☐ Dirt

Pavement Condition
☐ Poor
☐ Fair
☐ Good
☐ Excellent

Pavement Issues
☐ Rutting
☐ Spalling
☐ Potholes
☐ Pavement Pieces/Debris

Pavement Cleanliness & Usability
☐ Unusable
☐ Usable but Vehicles Must Drive Slow
☐ Dirty
☐ Clean

Sidewalk/Sidepath Pavement

Material
☐ HMA
☐ Concrete
☐ Gravel
☐ Dirt

Condition
☐ Poor
☐ Fair
☐ Good
☐ Excellent

Issues
☐ Uneven Path
☐ Cracks
☐ Holes
☐ Pavement Pieces/Debris

Cleanliness & Usability
☐ Unusable
☐ Party Usable
☐ Dirty
☐ Clean

Pavement Markings

Bike Facilities
☐ Sharrows
☐ Bike Lane
☐ Buffered Bike Lane
☐ Parking Separated Bike Lane
☐ Left Side Bike Lane
☐ Contra-flow Bike Lane

Bike Facility Width
________________ (LF)

Left Turns
☐ Dedicated Left-turn Lanes
☐ Shared Left-turn and Through Lane
☐ Shared Center Median Turn Lane
☐ Left Turns Prohibited

Colored Pavement
☐ Green (Bike)
☐ Blue (ADA)
☐ Red
☐ Yellow
☐ Neon

Crosswalks
☐ Traditional Crosswalk
☐ International Style
☐ Colored Pavement
☐ School Colored Pavement Markings
☐ Textured Pavement
☐ Patterned Pavement
☐ Raised
☐ In Roadway Warning Lights
☐ High Visibility

Crosswalk Ramps
☐ Appear up to code
☐ Appear deficient
☐ Deteriorating
☐ Detectable Warning Strip is Damage
☐ No Curb Ramps Within Project Limits

Crosswalk Rate on Major Route
Number of Intersections: ________

Number of Crosswalks: __________

Crosswalk Rate: ________________

On-street Features

Bike Lane Separation
☐ Bollards
☐ Curb
☐ Planters
☐ Grade Separation
☐ Jersey Barrier
☐ Not Applicable

Embedded Lights/Reflectors
☐ Centerline Reflectors
☐ Travel Lane Reflectors
☐ Bike Lane Lights (Embedded)

Off-street Features

Pedestrian/Bike Facilities
☐ Sidewalk WB/NB Side Width: ___ Distance to EOP: __(LF)
☐ Sidewalk EB/SB Side Width: ___ Distance to EOP: __(LF)
☐ Shared-use Path WB/NB Side Width: ___ Distance to EOP: __(LF)
☐ Shared-use Path EB/SB Side Width: ___ Distance to EOP: __(LF)

Are there gaps in the sidewalk/sidepath network? ☐ Yes ☐ No

Signage

Stop for Pedestrians in Crosswalk
☐ In-street Sign
☐ Post Mounted Outside Traveled Way

Pedestrian Signage
☐ Pedestrian Crossing
☐ Pedestrian Crossing Ahead
☐ School Crossing

Wayfinding Signage
☐ Bike Route
☐ Distance to Points of Attraction
☐ Historic Districts

Notes

____
____
____
____
____
____
____
____
____
____
____

Photo Locations:

____
____
____

Appendix B-2

Field Checklist Instructions

Complete the IDOT Bicycle and Pedestrian Accommodations Study *Field Check List* at least once for each location studied. Use the *Field Check List – Photo Descriptions* document for definitions and photos of each item.

Category Notes:

Weather

Fill out the past weather information only if traffic tubes were installed; the past weather shall be filled out the day that the tubes are collected.

Environment

See photo description document for instructions.

Intersections

Use this section if there are multiple intersections within the field visit limits. For instance, on the Clybourn Avenue cycle track study, traffic tubes were set up mid-block between Ogden Avenue and Larabee Street while surveys were conducted at the Division Street intersection. Label each street with an identifier (A, B, C… etc.) to distinguish intersections in future categories.

Traffic Control/Signalization

Choose the signalization for each intersection called out in the previous category. Write in the identifier if that item applies.

Roadway Items

Choose all that apply for any item within 1/8 of a mile of the location being studied. For *Edge of Pavement Delineation* choose the first material that defines the edge of pavement. For example, most urban locations the edge of pavement is defined by a curb and gutter. For rural locations the edge is defined by an aggregate shoulder.

Drainage

For the drainage check, choose one or more items that extends from and including the edge of pavement until the sidewalk or grass. Note if there is flooding issues present within 1/8 of a mile of the study location during the field visit and use your best judgment to determine the cause of the flooding.

Pavement

See photo description document for instructions.

Pavement Markings

Choose the bike facility pavement markings within 1/8 of a mile of the study location. Only record left turn lanes if they are within the study location. Always fill out the crosswalk rate however.

Physical On-Street Features

See photo description document for instructions.

Off-street Features

See photo description document for instructions.

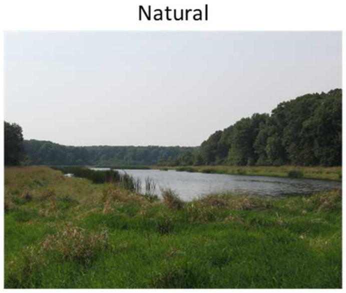
Signage

For the *Wayfinding Signage*, record if it is present within 1/8 of a mile of the study location. For other items only include if it is present at the study location.

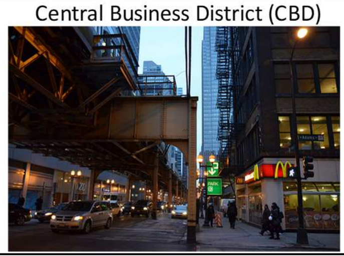
Appendix B-3

Field Checklist Descriptions

Land Use

Residential 	Land is used as a residential area, with many single family homes or multi-tenant housing.
Commercial 	Land is used as a commercial area, with many stores.
Mixed-Use 	Land has mixed-use development, such as commercial on the first floor and residential above, or evenly split development on the block.
Industrial 	Land is primarily used as an industrial area, with many factories and manufacturing businesses.
Park 	Land is used as a recreational or park area
Natural 	Land is kept in it's natural state and may be protected, like a forest preserve

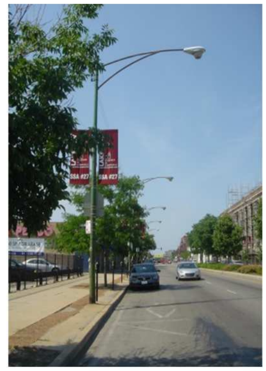
Density

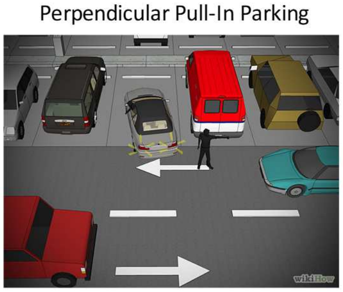
Central Business District (CBD) 	Commercial and office center of a city
Urban 	Area with high population density
Suburban 	Area with lower population density
Exurban 	Small community beyond the suburbs. Balance of suburban and rural features. Typically comprised of new subdivisions and farm land.
Rural 	Small towns or farm land outside metropolitan regions.

Vehicle Signalization	
None 	The street being studied has no signalization at the intersection
2-Way Stop Sign 	The street being studied has a 2-way stop sign at intersection/crosswalk
4-Way Stop Sign 	Street has 4-way stop sign at intersection/crosswalk
Traffic Signal 	Street has traffic signal at intersection/crosswalk

Actuation	
Pretimed	Observe the traffic signals to determine if users do not trigger any signal phases.
Semi-Actuated	Observe the traffic signals to determine if users trigger any signal phases.
Actuated 	Observe the traffic signals to determine if users may actively or passively trigger a signal phase. May be noticed by looking for embedded detector loops but not all actuated signals have visible marks for detector loops.
Pedestrian Actuated 	Traffic signal is pedestrian actuated. Look for pedestrian activation buttons.

Pedestrian Signalization	
Pedestrian Signal 	Pedestrian Signalization at intersection/crosswalk has a signal
Pedestrian Countdown Timer 	Pedestrian Signalization at intersection/crosswalk has a countdown timer
Pedestrian Activation Button 	Pedestrian Signalization at intersection/crosswalk has a pedestrian activation button

Street Lights	
Traditional Street Lights 	Street has lighting on one or either side of the street
Street Lamps with Sidewalk Lights 	Street has lighting to illuminate both the street and sidewalk
Intersection Lighting Only 	Only the intersection has lighting
No Public Street Lighting	Street has no lighting

Parking	
No Parking 	Street does not have parking
Parallel Parking 	Street has parallel parking
Diagonal Pull-In Parking 	Street has diagonal pull-in parking
Perpendicular Pull-In Parking 	Area has perpendicular pull-in parking
Diagonal Back-In Parking 	Area has diagonal back-in parking
Perpendicular Back-In Parking 	Area has perpendicular back-in parking

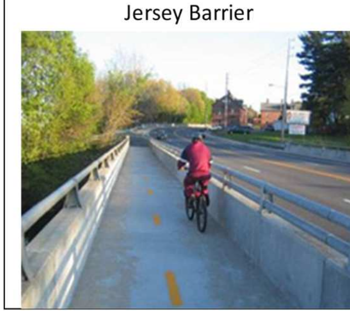
Drainage	
Curb & Gutter 	Street has both a curb and gutter
Curb Only 	Street only has a curb
Gutter Only 	Street only has gutter
HMA Shoulder 	Shoulder is made of hot-mix asphalt
Agg. Shoulder 	Shoulder comprised of course aggregate, size CA-6 or CA-10
Dirt Shoulder 	Street shoulder is dirt
Grass 	Edge of pavement is grass

Sewer Cover Direction	
Standard Chicago Perforated Lid 	Sewer has circular pattern with open slots
Curb Lid (Parallel to Traffic) 	Sewer cover is over sewage opening in gutter and has long slats parallel to traffic
Curb Lid (Perpendicular to Traffic) 	Sewer cover is over sewage opening in gutter and has long slats perpendicular to traffic

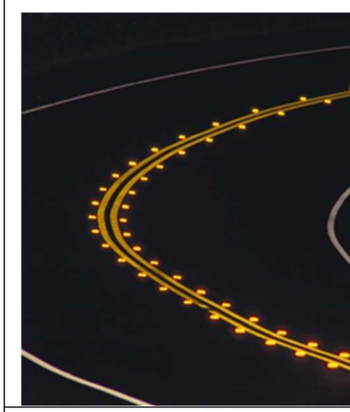
Colored Pavement	
Green (Bike) 	Color of pavement is green for bicycles
Blue (ADA) 	Color of pavement is blue for the disabled
Red/Yellow (Pedestrian) 	Color of pavement is red

Flooding	
Gutter Only 	Flooding only occurs in the gutter
Street Flooded 	Flooding occurs in street at varying degrees

Bike Facilities	
Sharrows 	Street has chevron arrows accompanied by a bicycle
Bike Lane 	Street has bike lane painted on it
Buffered Bike Lane 	Bike lane painted with buffer
Parking separated Bike Lane 	Bike lane installed between parked cars and sidewalk
Left-Side Bike Lane 	Bike lane is on the left side of traffic
Contra-Flow Bike Lane 	Bike lane direction goes against traffic

Bike Separation	
Bollards 	Bike lane is separated from the street with bollards
Curb 	Bike lane is separated from the street with a curb
Planters 	Bike lane is separated from the street with planters
Grade Separation 	Bike lane is separated from the street with elevation
Jersey Barrier 	Bike lane is separated front the street with concrete or plastic Jersey Barrier

Crosswalks	
Traditional Crosswalk 	Crosswalk has two solid, 6 in lines running across street
International Style Crosswalk 	Crosswalk has multiple solid white bars parallel to direction of traffic
Colored Pavement 	Crosswalk has colored-in pavement
Textured Pavement 	Crosswalk composed of stamped concrete or asphalt outlined in white markings
Patterned Pavement 	Crosswalk with patterned pavement markings
Raised 	Crosswalk installed at or near the same grade as the adjoining sidewalks. Typically looks like a wide speed hump with a marked crosswalk.
Embedded Lights 	Crosswalk with pedestrian activated lights embedded along either side of it

Embedded Lights/Reflectors	
Centerline Reflectors 	Embedded reflectors along centerline of street
Travel Lane Reflectors 	Embedded reflectors along travel lane lines in a highway or multilane road
Bike Lane Lights 	Embedded reflectors along bike lane in street

Pedestrian Signs	
Pedestrian Crossing 	Pedestrian sign that tells where pedestrians will cross
Pedestrians Crossing Ahead 	Pedestrian sign that alerts motorists pedestrians may cross up ahead
School Crossing 	Pedestrian sign that alerts motorists of a crosswalk near a school up ahead

Stop for Pedestrians in Crosswalk	
In-Street Sign 	"Stop for Pedestrian" sign installed in street
Post Mounted Outside Traveled Way 	"Stop for Pedestrian" sign mounted on post

Way finding Signage	
Bike Route 	Sign that shows a designated bike route. It is typically the most comfortable route through a certain area.
Distance to Points of Attractions 	Sign that tells how far a point of interest is from one's current location
Historic District 	Sign that tells one of a historic sight

Appendix B-4

Active Transportation Alliance Field Check List

STEP 1: EXISTING CONDITIONS

PROJECT NAME: ____________________ PROJECT MANAGER: ____________________

AGENCY: ____________________ PROJECT AREA & BOUNDARIES: ____________________

PLACE

DEVELOPMENT PATTERN

CHARACTER OF THE AREA:

☐ Rural ☐ Suburban ☐ Urban

Population Density: ____________________

Avg. Block Length: ____________________

NETWORK CHARACTERISTICS:

☐ Traditional Urban Grid

☐ Conventional Suburban

LAND USE

LAND USE MIX:

☐ Residential: ____________________

☐ Commercial: ____________________

☐ Mixed Use: ____________________

☐ Single Use: ____________________

DISTRICT/ZONING

CLASSIFICATIONS, SITE PLANS, RELATED ORDINANCES

____

____

____

LIST NEARBY DESTINATIONS

(e.g., schools, parks, trails, retail centers, transit stations, office campuses, etc.)

____

____

MODE

SITE VISITS

DATE/TITLE FINDINGS

____

____

____

____

TRANSIT SERVICE

CLASSIFICATIONS, SITE PLANS, RELATED ORDINANCES

____

____

____

____

TRAVEL MODES USED:

☐ Pedestrian ☐ Bicycle ☐ Private Vehicles ☐ Freight

☐ High Occupancy Vehicles ☐ Recreational Vehicles

☐ Farm Equipment ☐ Equestrian ☐ Other: ____________

TRANSPORTATION STUDIES/COUNTS

On existing transit route? ☐ Yes ☐ No

Within ¼ mile of bus stop? ☐ Yes ☐ No

Within ½ mile of rail stop? ☐ Yes ☐ No

Within 3 miles of rail stop? ☐ Yes ☐ No

PROJECT AREA CRASH AVERAGES

Motor Vehicle Crashes: ____________ Data Year(s): ____________

Bicycle Crashes: ____________ Data Year(s): ____________

Pedestrian Crashes: ____________ Data Year(s): ____________

Other incidents: ____________ Data Year(s): ____________

Hot Spots: ____________________

BIKEWAYS CONNECTIVITY

No. of direct on-street bikeways connections: ____________

No. of on-street bikeways within 3 miles: ____________

No. of direct off-street trail connections: ____________

No. of off-street trail connections within 3 miles: ____________

LINK

Jurisdiction:

____

Agency Contact:

____

____

Total ROW Width: ______

Curb-to-curb Width: ______

Posted Speed: ______

Typical Vehicle Speed at 85th Percentile: ______

Bridges/Underpasses: _____

Average Daily Traffic: ________

Multi-modal Level of Service: ________

Pedestrian Level of Service: ________

Bicycle Level of Service: ________

Vehicle Level of Service: ________

FUNCTIONAL CLASSIFICATION:

☐ Principal/Primary Arterial

☐ Secondary Arterial

☐ Collector

☐ Local Street

Data Collection - Example Checklist

Checklist courtesy of Active Transportation Alliance

EXISTING CROSS SECTION

DIRECTION 1: ☐ N. BOUND ☐ S. BOUND ☐ E. BOUND ☐ W. BOUND

Sidewalk ☐ No ☐ Yes
No. of Gaps ____
Total Width _______
Curb Zone _____ ft.
Furniture Zone _____ ft.
Pedestrian Zone _____ ft.
Frontage Zone _____ ft.

Shared Use Path ☐ No ☐ Yes
No. of Gaps ____
Total Width _______
Permitted Users:
☐ Pedestrians ☐ Equestrian
☐ Bikes ☐ Other ________

Traffic Buffer: ☐ No ☐ Yes
☐ Planting Strip _____ ft.
☐ Vehicle Parking _____ ft.
☐ Bicycle Facility _____ ft.
☐ Other _______________
____

Lighting: ☐ Yes ☐ No
☐ Pedestrian Scale
☐ Street Scale ☐ Combined
Signage: ☐ Yes ☐ No
Street Trees: ☐ Yes ☐ No
Utilities: ☐ Yes ☐ No

Modal Conflict Points
(non-intersection)
No. of Driveways _____
No. of Alleys _______
Other _______________
____

Transit ☐ Yes ☐ No
No. of Stops ___________
Sheltered Stops ________
Sidewalk Access ________
Near a Crosswalk _______

On-street Bikeway
☐ Yes ☐ No
No. of Gaps____
Shared Lane
☐ Yes ☐ No Width _______
Separated Bikeways
☐ Yes ☐ No Width _______
Protected Bikeways
☐ Yes ☐ No

Vehicle/Travel Lanes

qty.	ft.	ft.	ft.	ft.

Dedicated Transit Lanes
☐ No ☐ Yes
Describe:
____
____
____

DIRECTION 2: ☐ N. BOUND ☐ S. BOUND ☐ E. BOUND ☐ W. BOUND

Sidewalk ☐ No ☐ Yes
No. of Gaps ____
Total Width _______
Curb Zone _____ ft.
Furniture Zone _____ ft.
Pedestrian Zone _____ ft.
Frontage Zone _____ ft.

Shared Use Path ☐ No ☐ Yes
No. of Gaps ____
Total Width _______
Permitted Users:
☐ Pedestrians ☐ Equestrian
☐ Bikes ☐ Other ________

Traffic Buffer: ☐ No ☐ Yes
☐ Planting Strip _____ ft.
☐ Vehicle Parking _____ ft.
☐ Bicycle Facility _____ ft.
☐ Other _______________
____

Lighting: ☐ Yes ☐ No
☐ Pedestrian Scale
☐ Street Scale ☐ Combined
Signage: ☐ Yes ☐ No
Street Trees: ☐ Yes ☐ No
Utilities: ☐ Yes ☐ No

Modal Conflict Points
(non-intersection)
No. of Driveways _____
No. of Alleys _____
Other _______________
____

Transit ☐ Yes ☐ No
No. of Stops ___________
Sheltered Stops ________
Sidewalk Access ________
Near a Crosswalk _______

On-street Bikeway
☐ Yes ☐ No
No. of Gaps____
Designated Bike Lane
☐ Yes ☐ No Width _______
Separated Bikeways
☐ Yes ☐ No Width _______
Protected Bikeways
☐ Yes ☐ No

Shared Travel Lanes

qty.	ft.	ft.	ft.	ft.

Dedicated Transit Lanes
☐ No ☐ Yes
Describe:
____
____
____

TRANSITIONS

DIRECTION 1: ☐ N. BOUND ☐ S. BOUND ☐ E. BOUND ☐ W. BOUND

☐ Gateways Locations: _________________________
☐ Mixing Zones: Dashed Transitional Markings ☐ Yes ☐ No
☐ Narrowing Lanes: Location & Dimensions:
____
____

☐ Medians: ☐ Painted ☐ Raised ☐ Continuous
☐ Curbing ☐ Yes ☐ No ☐ Partial __________________
☐ Mid-block Bulb-outs _________________________
☐ Chicanes __________________________________
____

☐ Speed Humps: Qty. ___ Locations: _____________
☐ Bollards and Railings Locations: ________________
☐ Street Signs ☐ Wayfinding Signs ☐ Identity Signs

DIRECTION 2: ☐ N. BOUND ☐ S. BOUND ☐ E. BOUND ☐ W. BOUND

☐ Gateways Locations: _________________________
☐ Mixing Zones: Dashed Transitional Markings ☐ Yes ☐ No
☐ Narrowing lanes: Location & Dimensions:
____
____

☐ Medians: ☐ Painted ☐ Raised ☐ Continuous
☐ Curbing ☐ Yes ☐ No ☐ Partial __________________
☐ Mid-block Bulb-outs _________________________
☐ Chicanes __________________________________
____

☐ Speed Humps: Qty. ___ Locations: _____________
☐ Bollards and Railings Locations: ________________
☐ Street Signs ☐ Wayfinding Signs ☐ Identity Signs

EXISTING INTERSECTIONS AND MID-BLOCK CROSSING TREATMENT

[PRINT EXTRA PAGES FOR EACH INTERSECTION LEG/CROSSING]

Location: ____

Controlled: ☐ Yes ☐ No ☐ Signalized ☐ Stop Sign ☐ Other ____

Leg/Crossing: ____

Convergence: ☐ 3 way ☐ 4 way ☐ 6 way ☐ Other ____

CROSSING & SIGNALIZATION

Crossing Distance: ____ft.
Advance Stop Bar: ____ ft.
Marked Crosswalk
☐ No ☐ Yes Width: ____ ft.

Crosswalk Style:
☐ Longitudinal Lines
☐ Diagonal Lines
☐ "Ladder"
☐ Colored
☐ Stamped
☐ Other__________

Other Features:
☐ Raised crossing
☐ Painted Median
☐ Crossing Island
☐ Right Turn Island
☐ Curb Ramps Both Sides
☐ ADA Compliant Ramps

Pedestrian Indicator
☐ Yes ☐ No
Timing: _____ ft. /sec.
☐ Automated ☐ Actuated

Accessible Push Button:
☐ Yes ☐ No
☐ Countdown Indicator
☐ Lead Pedestrian Interval
☐ Caution Signage
☐ Flashing Beacon
☐ Pedestrian Hybrid Beacon
☐ Rapid Flash Beacon

Bicycle-only Indicator:
☐ Yes ☐ No
☐ Automated ☐ Actuated

LANE CONFIGURATION

Shared Through Lanes

qty.	ft.	ft.	ft.	ft.

Shared Left Turn Lanes

qty.	ft.	ft.	ft.	ft.

Shared Right Turn Lanes

qty.	ft.	ft.	ft.	ft.

Bicycle Through Lanes
☐ No ☐ Yes, ____ft.
☐ Dedicated
☐ Marked Shared

☐ Bike Box
☐ Transitional Dashing
☐ Colored Pavement

Transit Through Lanes
☐ No ☐ Yes ____ft.
☐ Dedicated
☐ Marked Shared

Transit Stops:
☐ Near Side ☐ Far Side
☐ None

Inbound Turn Radius
☐ Wide ☐ Tight
Outbound Turn Radius
☐ Wide ☐ Tight

INSERT INTERSECTION DIAGRAM:

Appendix B-5
Measures of Effectiveness

	Measure of Effectiveness	Typical Usage	Instructions	Type of Study	Reference
Safety	Crashes	Investigate trends with crashes. Compare to average crash trends for the district.	Examine IDOT crash data. Separate crashes by severity of injury and collision type. Compare against type of facility that the crash occurred on. Search for any trends or patterns such as injury severity goes down with the installation of protected bike lanes.	Crash Analysis	HSM
	Number of Crashes by type	Investigate trends with crashes. Compare to average crash trends for the district.	Examine IDOT crash data. Separate crashes by severity of injury and collision type. Compare against type of facility that the crash occurred on. Search for any trends or patterns such as injury severity goes down with the installation of protected bike lanes.	Crash Analysis	HSM
	Crash Rate	Ultimate measure of effectiveness to determine facility safety.	Examine IDOT AADT and crash data. To obtain the bike volumes for use in calculating crash rates, short term counts will be performed then extrapolated out to AADB using Primera developed conversion factors.	Crash Analysis	HSM
	Yielding (Stopping)	Determine motorist compliance with facility, especially pedestrian signals and other crossing facilities	Observe percentage of motorists stopping for pedestrians or bicyclists using an official crossing facility. Compare before and after yield rates if possible.	Compliance	ITE
	Changes in pedestrian travel path	Are pedestrians using the new facility or jay walking?	Observe percentage of pedestrians using designated crosswalks versus those jay walking.	Compliance	ITE
	Pedestrian hesitation or backup	Determine if the facility is comfortable or perceived to be safe.	Observe pedestrian behavior when attempting to use a facility. Record whether pedestrians take any steps back after the initial attempt, how many attempts they make, if they wait in the street or on the sidewalk, wait time, any hostile behavior from motorists.	Comfort	FHWA 2000
	Pedestrian activation of device (percent)	Determine if the facility is being utilized or the public is aware of and educated on the use of it.	Observe percentage of pedestrians activating the crossing device.	Compliance	ITE
	Pedestrian compliance with signals and/or markings other than crosswalks	Since signals or markings were installed to increase safety (among other factors), non-compliance will potentially lead to a higher crash rate.	Observe percentage of pedestrians complying with signals or markings. Compliance means following any pedestrian crossing lights or any pedestrian oriented markings such as Chicago's "←Look→" stamps on cycle tracks.	Compliance	ITE
	Pedestrian understanding of traffic control device	Understanding will lead to compliance and use of the facility	Conduct survey of users	Survey	ITE
	Motorist compliance with signals and/or markings	Since signals or markings were installed to increase safety (among other factors), non-compliance will potentially lead to a higher crash rate.	Observe percentage of motorists complying with signals or markings. Signal compliance means following any red lights, no turn on red restrictions, pedestrian crossing lights or bike signals.	Conflict	ITE
	Bicyclist compliance with signals and/or markings	Since signals or markings were installed to increase safety (among other factors), non-compliance will potentially lead to a higher crash rate.	Observe percentage of bicyclists complying with signals or markings. Signal compliance means following any red lights, no turn on red restrictions, pedestrian crossing lights or bike signals.	Conflict	ITE
	Traffic Speed	Traffic speed is known to be a major influence on crashes and crash severity. Does the facility change the speed of the motorists? Is a collision at the speeds measured within the range of survivability for a pedestrian or bicyclist.	Set up counting tubes or use a radar gun to measure speeds. Compare to posted speed limits. If tube equipment is not available perform space-mean speed measurements by dividing a defined segment length by the travel time of the vehicles. To obtain the highest number of measurements in the shortest time measure the speed at midblock locations without any traffic control.	Spot Speed	ITE
	Bike Comfort LOS	BLOS is a traveler based perception of how well a facility or roadway operates and quantified through a six letter grade level (Florida DOT 2009). Typically used on suburban routes.	Measure effective width of outside lane, vehicle volumes, vehicle speeds, truck volumes, and pavement condition.	Comfort	FHWA
	Ped Comfort LOS	PLOS is a traveler based perception of how well a facility or roadway operates and quantified through a six letter grade level (Florida DOT 2009). Typically used on suburban routes.	Record existence of sidewalks, measure lateral separation of pedestrians from motorized vehicles, motorized vehicle volumes and speeds.	Comfort	FHWA
	BEQI/PEQI	Similar to BLOS but involving more detailed factors suitable for urban environments. May be more appropriate for a GIS data base of NE Illinois routes.	Complete detailed inventory of facility. See San Francisco Department of Public Health website on the Program on Health, Equity and Sustainability.	Observational	San Francisco
	Police Citations	Police citations indicate compliance with facility or point to unsafe trends. Help gain a perspective on operations not available during in-field evaluations or crash data.	Obtain and examine police citation data. Compare the amount and type of police citations on the study facility to other streets without the facility. One example analysis: are more people receiving tickets for parking in cycle tracks versus parking in traditional bike lanes?	Compliance	FHWA 2011
	Inadequate Looking	Examine the potential for conflicts by watching user behavior while operating within or before entering the facility.	Staff will station near driveway entrances at unsignalized midblock locations and count the number of users looking both ways before entering the facility. Whether the user went left or right and from which side of the road they entered will be recorded	Conflict	ITE
	Number of Conflict Points	Conflict points are locations of potential crashes so identifying the number of conflict points relative to other facilities is an indirect measure of safety.	Obtain design drawings of the facilities or utilize aerials. Determine conflict points in the office.	Conflict	ITE

	Measure of Effectiveness	Typical Usage	Instructions	Type of Study	Reference
Operational	Motorist LOS	How does the facility affect motorist delay and free flow speed.	Review geometry, measure before and after vehicle volumes for segment LOS. For intersection LOS calculate delay by comparing signal changes, pedestrian crossing times, and effective green times before and after installation.	Intersection Delay	ITE
	Queues	Used to identify hot spots, operational problems at certain points (lane merge due to cycle track entrance or weaving bicyclists causing congestion).	Observe any queues building and compare to calculated theoretical queue length.		HCM
	Traffic Volumes	Do traffic volumes change before and after installation of the facility?	Utilize IDOT AADT counts or perform additional counts depending on facility to obtain more detailed data such as mode splits. If the facility is not yet installed and a before & after study can be performed then perform detailed traffic volume measurements before and after installation.	Volume	ITE
	Deceleration pattern on approach	Are motorists slamming on the brakes or coasting to a stop? May give insight into whether the facility is noticeable, predictable and understood. Indicator of future crashes.	Observe motorists as they approach the facility, especially if it requires a stop. Are the motorists slamming on the brakes or coasting slowly to a stop. Are they surprised by the facility or did they appear to have adequate reaction time and sight distance?	Conflict	ITE
	Bicyclist Preferences	Identify popular bicyclist routes, issues with current geometric configuration, or conflict areas.	Develop location and facility specific survey sheets. Follow FHWA and CDOT survey procedures. Perform surveys within three weeks of counts. Utilize a base set of questions developed by the National Bike and Ped Documentation Project (NBPD 2010).	Survey	FHWA / CDOT
	Bicyclist Queuing	Determine if the facility has enough capacity for bicyclists	Observe percentage of bicyclists passing other bicyclists.	General Statistics	ITE

References:

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State of Florida Department of Transportation. *Quality / Level of Service Handbook.* Tallahassee, FL: Systems Planning Office, 2009.

Traffic Analysis Toolbox: Volume VI: Definition, Interpretation, and Calculation of Traffic Analysis Tools Measures of Effectiveness. U.S. Department of Transportation Federal Highway Administration. Last modified August 2, 2013. http://ops.fhwa.dot.gov/publications/fhwahop08054/execsum.htm

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U.S. Department of Transportation Federal Highway Administration. "Examples of MOEs for field evaluations." *Pedestrian and Bicyclist Traffic Control Device Evaluation Methods.* FHWA-HRT-11-035. By Susan T. Chrysler, Kay Fitzpatrick, Marcus A. Brewer, and Mike Cynecki. McClean, VA: Office of Safety Research and Development, 2011.

Appendix B-6

Behavioral Field Data Sheets

BICYCLIST DATA COLLECTION – SCREENLINE COUNT FORM
MOTORIST COMPLIANCE – SCREENLINE COUNT FORM
ARDMORE/KENMORE

Observer: ______________________________

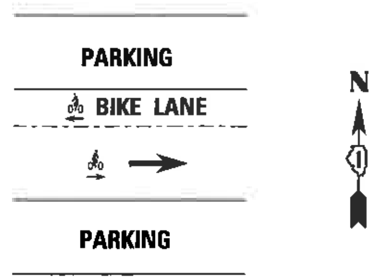
Date: __________

Location: ______________________________

Count Period: ______________________________

Temp.: ________ Precip.: _____ Clouds: ________

Sheet ____ of ____



Bicyclists

Bikes – West to East

Bikes – Outside of Lanes

Bikes – Wrong Direction in Bike Lane

Bikes – Riding on Sidewalk

Bikes – East to West

Bikes – Outside of Lanes

Bikes – Wrong Direction in Bike Lane

Bikes – Riding on Sidewalk

Motorists

Motorists – West to East

Driving in Bike Lanes West to East

Parking in Bike Lanes West to East

BICYCLIST DATA COLLECTION – SCREENLINE COUNT FORM
MOTORIST COMPLIANCE – SCREENLINE COUNT FORM
BERWYN/KENMORE

Observer: ______________________________

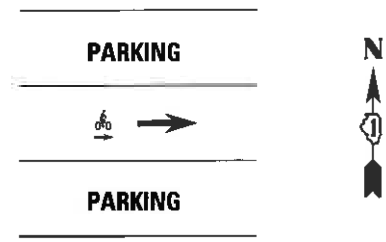
Date: ____________

Location: ______________________________

Count Period: ______________________________

Temp.: __________ Precip.: ______ Clouds: __________

Sheet _____ of _____



Bicyclists

Bikes – West to East

Bikes – Outside of Lanes

Bikes – Wrong Direction

Bikes – Riding on Sidewalk

Bikes – East to West

Bikes – Outside of Lanes

Bikes – Wrong Direction

Bikes – Riding on Sidewalk

Motorists

Motorists – West to East

Driving in Bike Lanes West to East

Parking in Bike Lanes West to East

INADEQUATE LOOKING DATA COLLECTION
MOTORIST COMPLIANCE – SCREENLINE COUNT FORM
ARDMORE/KENMORE

Observer: ______________________________

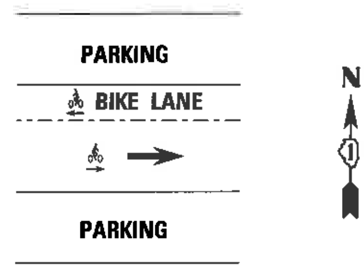
Date: __________

Location: ______________________________

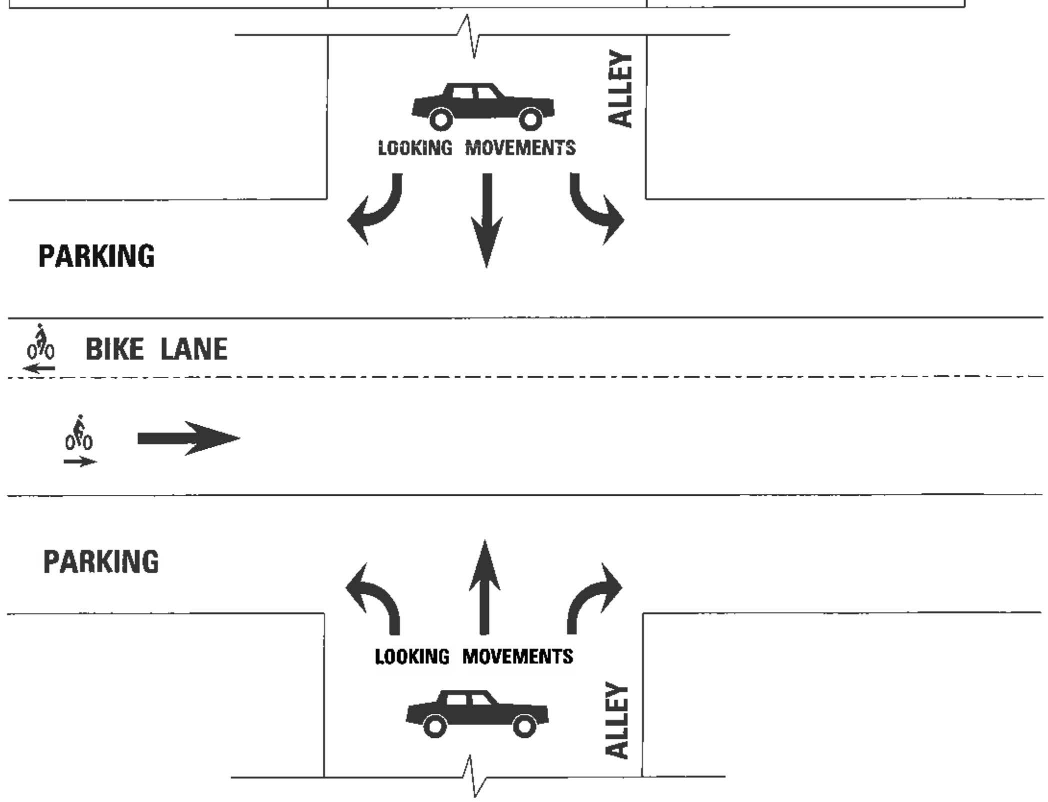
Count Period: ______________________________

Temp.: ________ Precip.: ______ Clouds: ________

Sheet ____ of ____



LOOKING LEFT	LOOKING STRAIGHT	LOOKING RIGHT



LOOKING LEFT	LOOKING STRAIGHT	LOOKING RIGHT

* Use one line per vehicle. Place a tally mark for each direction motorist looks.

INADEQUATE LOOKING DATA COLLECTION
MOTORIST COMPLIANCE – SCREENLINE COUNT FORM
BERWYN/KENMORE

Observer: ______________________

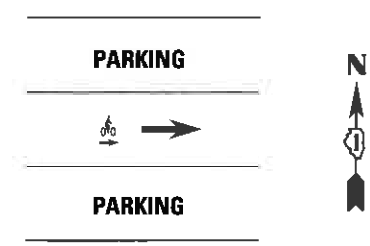
Date: __________

Location: ______________________

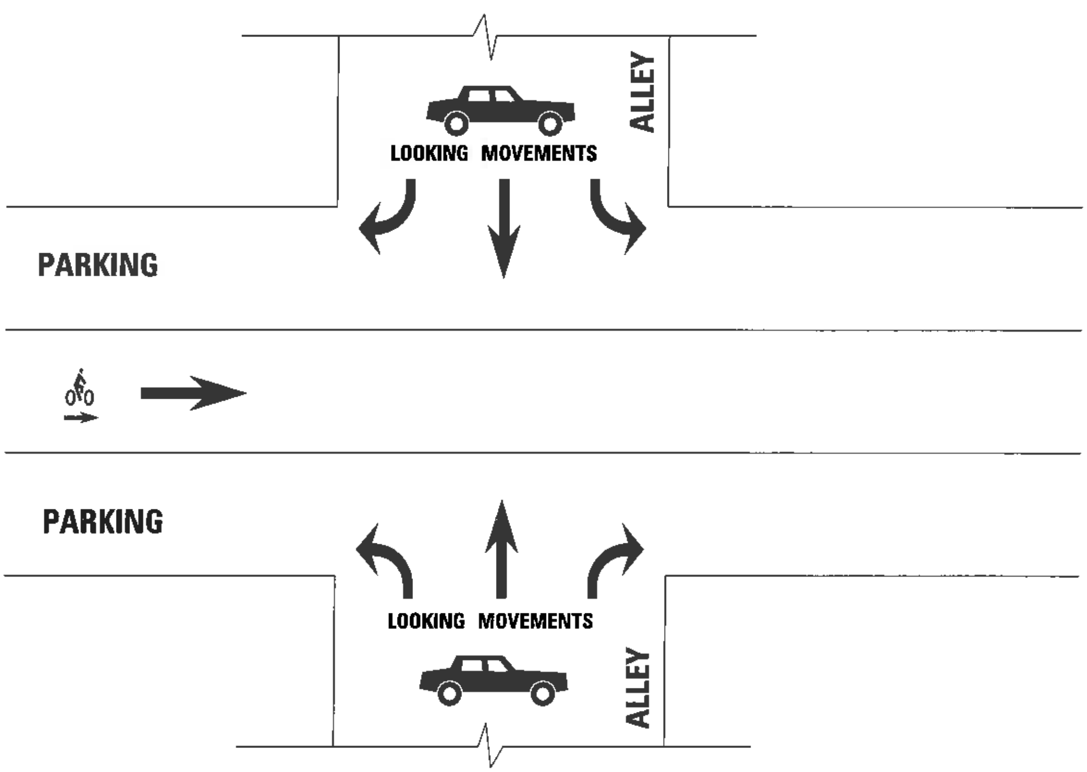
Count Period: ______________________

Temp.: ________ Precip.: ______ Clouds: ________

Sheet _____ of _____



LOOKING LEFT	LOOKING STRAIGHT	LOOKING RIGHT



LOOKING LEFT	LOOKING STRAIGHT	LOOKING RIGHT

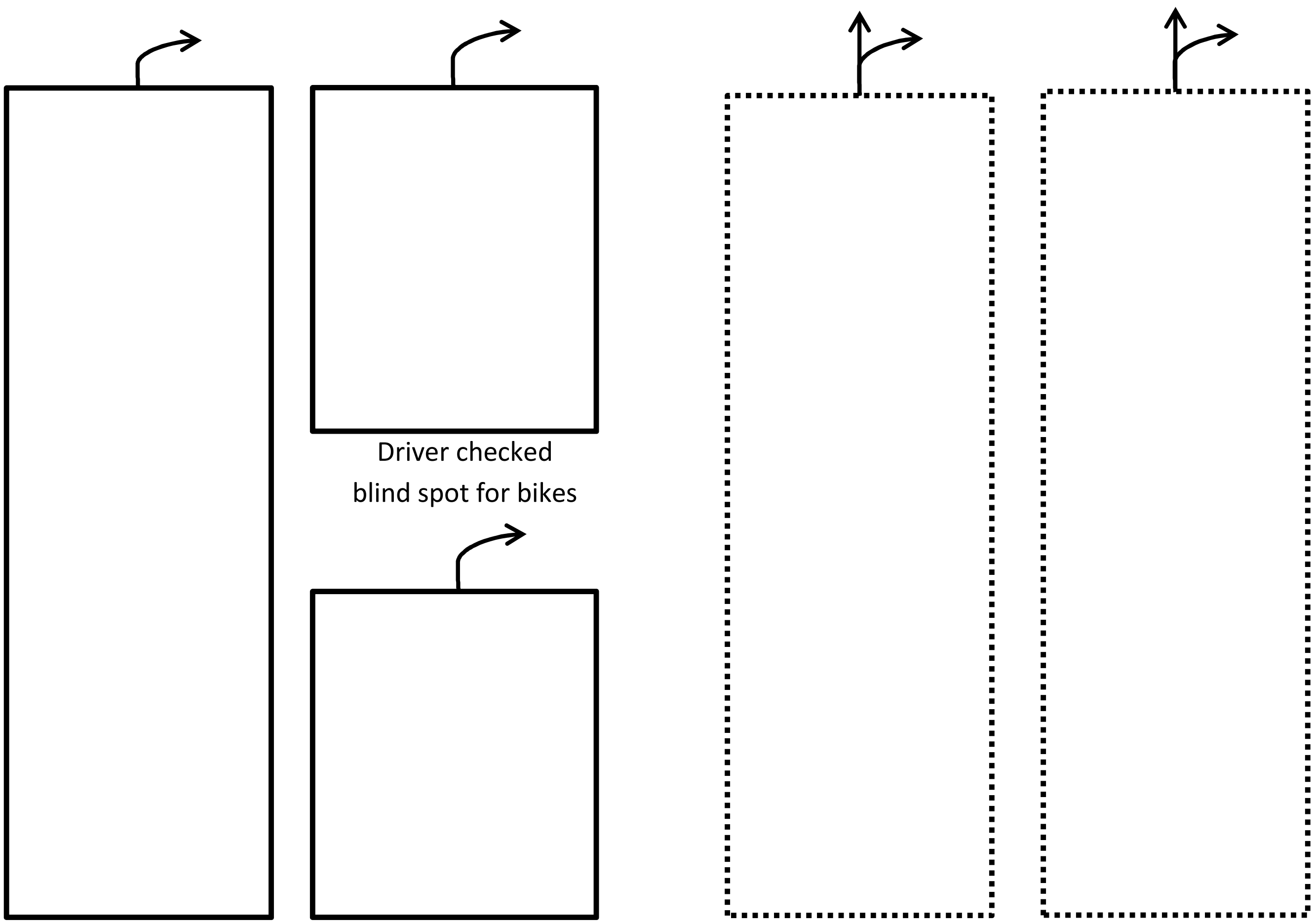
* Use one line per vehicle. Place a tally mark for each direction motorist looks.

Vehicle/Bicycle Mixing Zones
Evaluation Sheet

ILLINOIS DEPARTMENT OF TRANSPORTATION, DISTRICT ONE, BICYCLE & PEDESTRIAN ACCOMMODATIONS STUDY

Date: ______________________________ Observer: ______________________________

Time:______________________________ Weather: ______________________________



Driver did not check blind spot or mirror for bikes

Driver checked blind spot for bikes

Driver checked mirror for bikes

Bicyclist didn't check for merging vehicles

Bicyclist checked for merging vehicles

- "Driver checked blind spot for bikes" means the driver turned their head to the right to look through their back passenger window for cyclists when approaching the intersection.
- "Driver checked mirror for bikes" means the driver turned their head or eyes to the right to check their passenger side mirror for cyclists when approaching the intersection.
- "Bicyclist checked for merging vehicles" means the bicyclist turned their head left or checked a mirror to look for merging vehicles when approaching in intersection.

Illinois Department of Transportation

Two-Stage Turn Boxes
Dearborn and Monroe

Date: ______________________ Observer: ______________________

Time: ______________________ Weather: ______________________

Through

N

Used Bike Box

Nearly Used Box

Completely Neglected Box

Through

Bike Boxes
Data Collection Form

ILLINOIS DEPARTMENT OF TRANSPORTATION, DISTRICT ONE, BICYCLE & PEDESTRIAN ACCOMMODATIONS STUDY

Date: ______________________________ Observer: ______________________________

Time: ______________________________ Weather: ______________________________

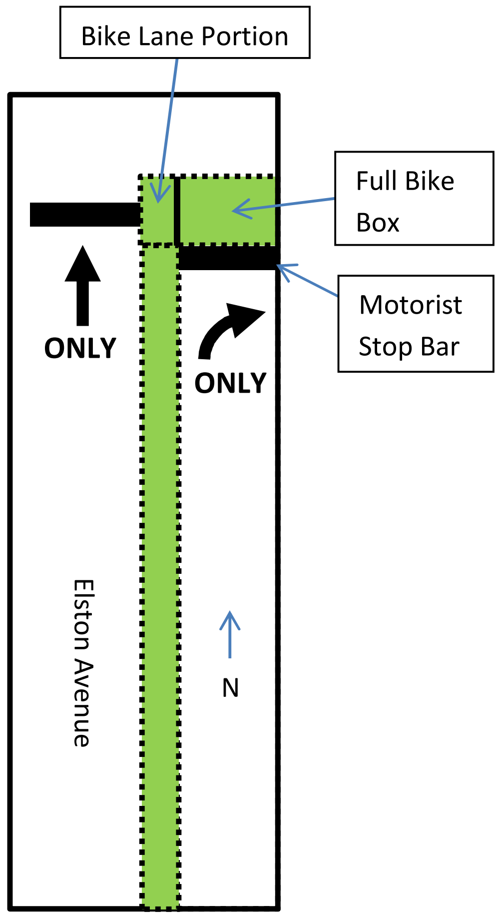
Cyclist inside the bike boxes

Bicyclist stopping Inside the bike lane Portion of the bike box

Non-compliance cyclist out of the bike boxes

Drivers complying with the bike box

Drivers non-compliance with the bike box



- "Driver complying with the cyclists bike box" means the driver does not block the cyclist bike boxes which are painted on the ground at a cross intersections.
- "Driver non-compliance with the cyclist's bike box" means the driver blocks access to the bike box at the stopped intersection.
- "Bicyclist usage of bike boxes" means the cyclist is in full use of the bike box.
- "Bicyclist non – usage of the provided bike box" means the cyclist does not utilize the full bike box while stopped and stays only within the bike lane portion of the bike box.
- Bicyclist stopping inside the bike lane' means the cyclist who don't use the bicycle box and stay in the bike lane while waiting

Motorist Behavior Field Sheet

Observer: ________________________________ N/S Street: ________________________________

Date: ____________________________________ E/W Street: _______________________________

Time: _______to________

Draw in North

Temp.:______Precip.:_______Cloudiness:______

Instructions: record the actions of motorists when a pedestrian is crossing the roadway. Place a tick in the appropriate box depending on how the motorist stopped or didn't stop at the crossing.

→	←
Non-Stopping	Non-Stopping
Practically Stopped—0 to 3 mph	Practically Stopped—0 to 3 mph
Stopped by Traffic	Stopped by Traffic
Voluntary Full Stop	Voluntary Full Stop

MOTORIST BEHAVIOR SHEET

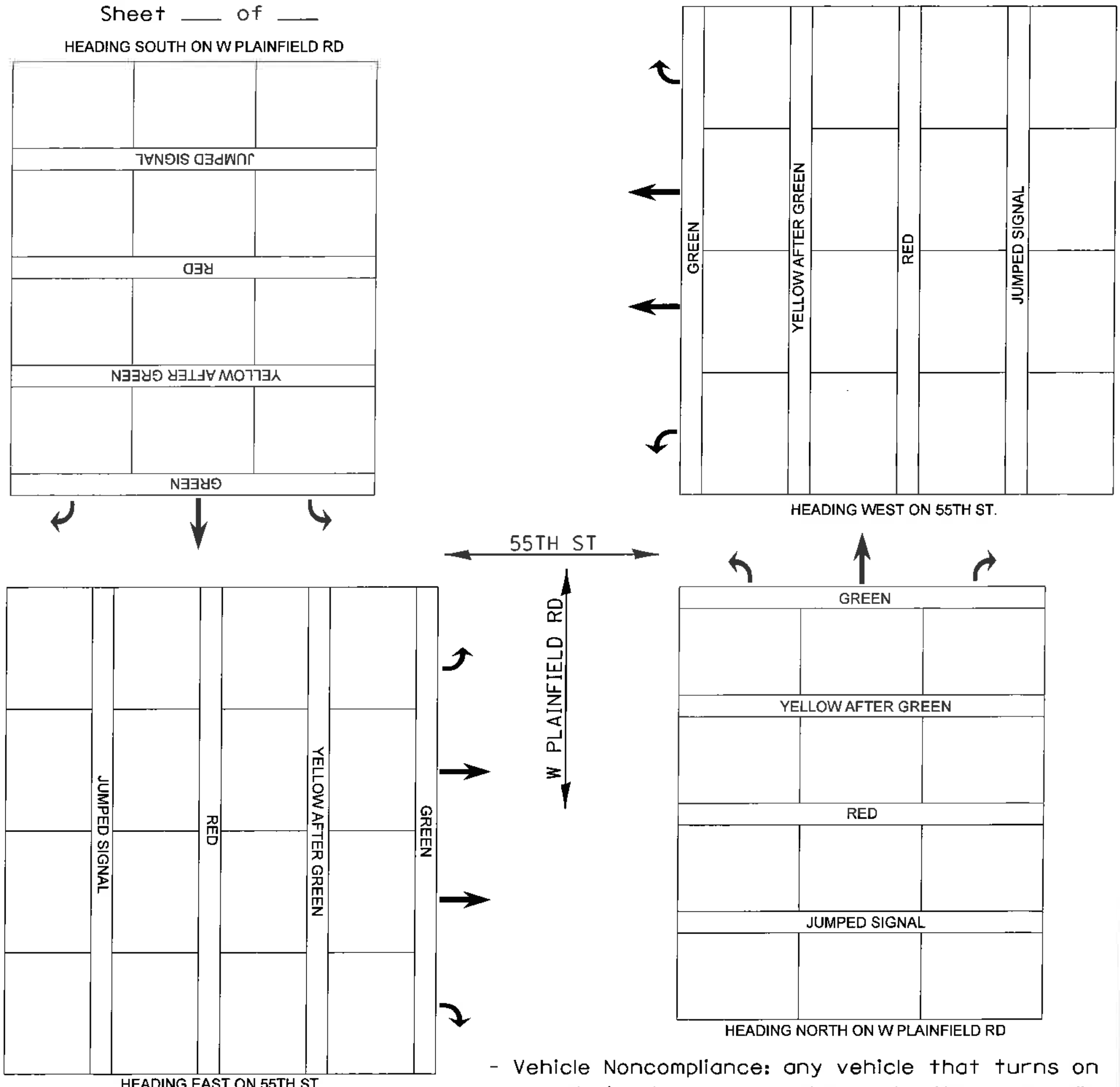
Observer: ____________________

Date: ________ to ________

Time: ____________________

Temp.: __________ Precip.: __________ Clouds: __________

Sheet ___ of ___



- Vehicle Noncompliance: any vehicle that turns on a red signal, or encroaches onto the crosswalk during a red or yellow signal phase.

Instructions:
- Record the actions of the motorist when a pedestrian is crossing the roadway.
- Place a tick in the appropraite box depending on how the motorist stopped or didn't stop at the crossing.
- Begin a new sheet every 15 minutes.

MOTORIST BEHAVIOR SHEET

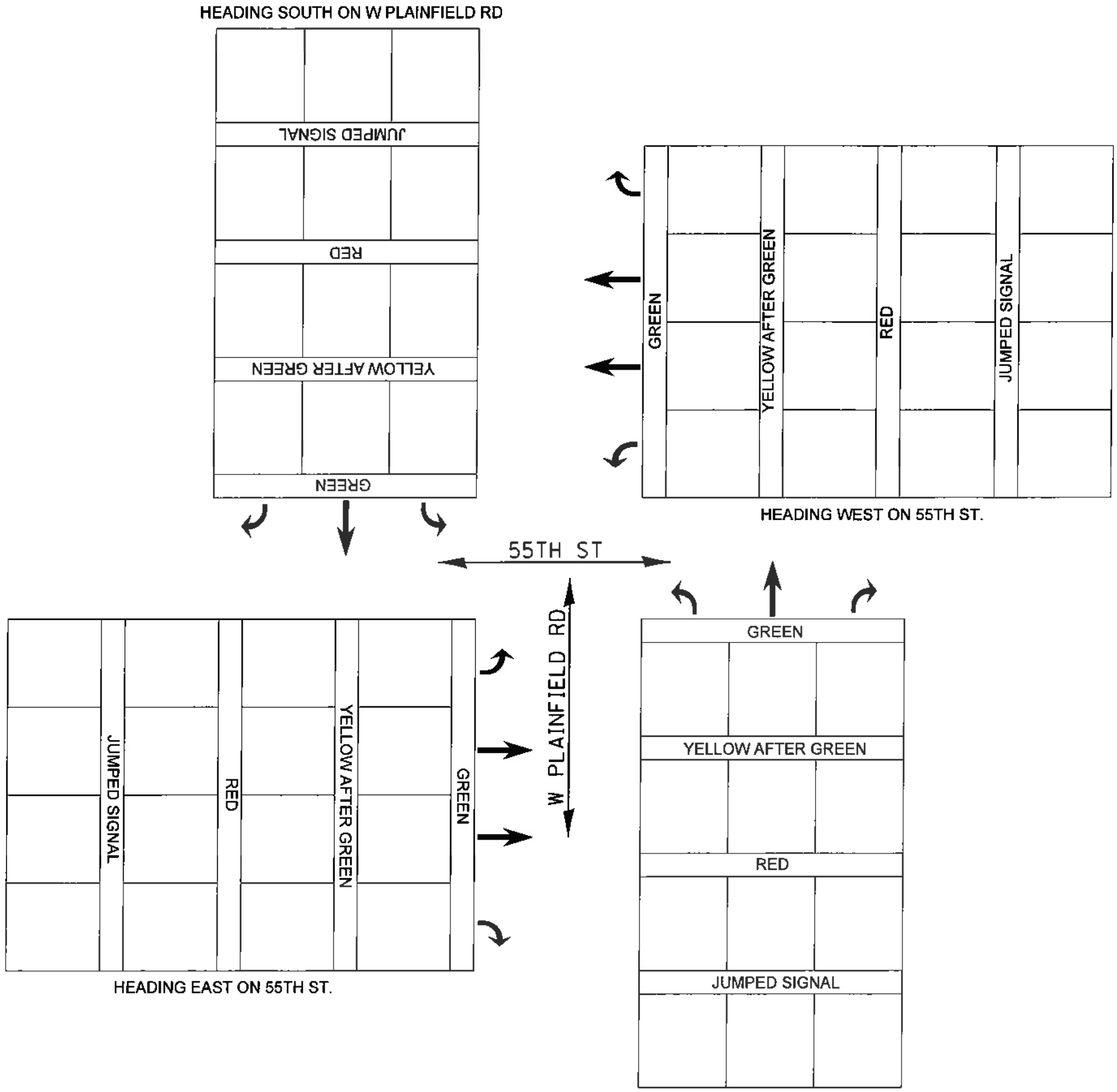
Observer: ____________________

Date: ________ to ________

Time: ____________________

Temp.: __________ Precip.: __________ Clouds: __________

Sheet ___ of ___



Instructions:
- Record the actions of the motorist when a pedestrian is crossing the roadway.
- Place a tick in the appropraite box depending on how the motorist stopped or didn't stop at the crossing.
- Begin a new sheet every 15 minutes.

- Vehicle Noncompliance: any vehicle that turns on a red signal, or encroaches onto the crosswalk during a red or yellow signal phase.

Driver Observance of Traffic Signals

Field Sheet

Location ____

Time ___________to_____________ Weather ____

N/S Street _____________________________ E/W Street _____________________________________

Directions: Each box represents the direction of traffic on the street at an intersection. Tally the cars by direction of travel and the signal indication as the vehicle leaves the intersection. Signal indications are as follows: Green, Yellow After Green, Red, and Running the Light. Use a new sheet every 15 minutes.

Key: For motorists use I, for cyclists use O.

Left	Straight	Right
	Green	
	Yellow After Green	
	Red	
	Running the Light	

HAWK Signal Pedestrian Signal Compliance Field Sheet

Observer: ____________________________________

Date: ____

Time Period: _______to_______

Temp: _________ Precipitation?: _________

Cloudiness: ______________

Location: _____________________________________

Pedestrian Direction (circle one): ___North/South___

Instructions: Watch and record the amount of pedestrians that cross the intersection when the light is in the following stages with the pedestrian signal; off (Do Not Walk), yellow (Do Not Walk), solid red (Walk) and flashing red (timed amount to walk). Use a new sheet every 15 minutes.

Stepped from Curb on		
Off		Off
Yellow		Yellow
Solid Red	Crosswalk	Solid Red
Flashing Red		Flashing Red

Crossed Diagonally		
Off		Off
Yellow		Yellow
Solid Red		Solid Red
Flashing Red		Flashing Red

Pedestrian Behavior Field Sheet

Observer: ______________________________________

Date: ____

Time: _______to_______

Temp.:_______Precip.:________Cloudiness:________

Instructions: Record the time (in seconds) pedestrians wait to cross from the moment they stop on the sidewalk edge to the moment they enter the crosswalk and start their crossing.

For pedestrians who jaywalk or hesitate and motorists who do not stop simply make a tally in the respectful area.

Hesitation: scenarios include peds who step out onto the crosswalk then step back onto the sidewalk, those that stop in the crosswalk waiting for traffic to clear, or who breaks stride in the middle of crossing.

TIME (s) Waiting to Cross

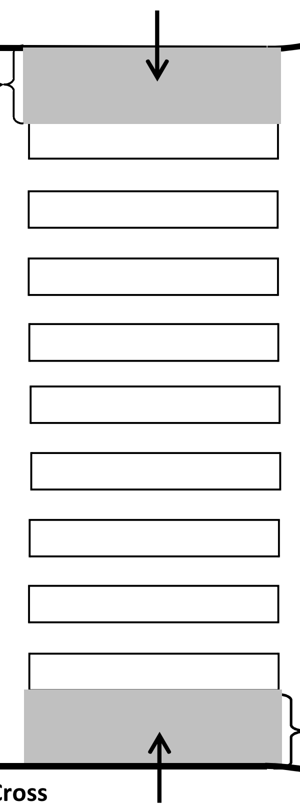
Ped. Who Activate Lights	Ped. Who Do Not Activate	Ped. Who Jaywalk

Jaywalk: Anyone who crosses the road illegally, i.e. not on the crosswalk

Draw in North arrow

Hesitation

Street Name



Hesitation

Street Name

TIME (s) Waiting to Cross

Ped. Who Activate Lights	Ped. Who Do Not Activate	Ped. Who Jaywalk

PEDESTRIAN COUNT SHEET

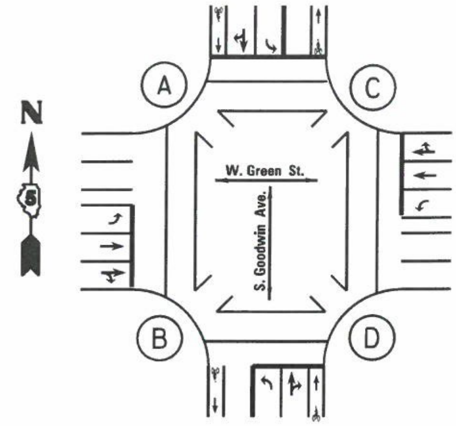
STAFF MEMBER 1

Observer: ______________________________

Date: ____________________ Time: ____________________

Weather: ______________________________

Sheet ___ of ___



Instructions:
Pedestrians shall be counted starting at the point of beginning and according to their direction of travel. Begin a new sheet every 15 min.

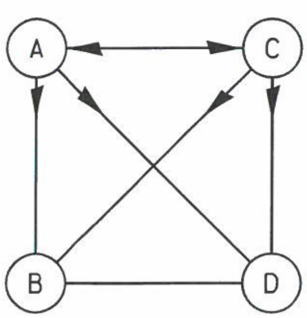
Phase Violation shall be any pedestrian that leaves the curb before the signal, any pedestrian that walks out side of the pavement marking, any pedestrian that walks after the signal.

PHASE 1

	A–C	C–A
PHASE VIOLATION		
TOTAL		

PHSAE 2

	A–B	B–A
PHASE VIOLATION		
TOTAL		

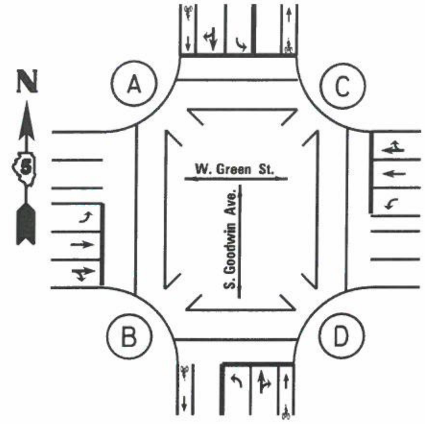


PHSAE 3

	A–B	A–D	A–C
PHASE VIOLATION			
TOTAL			

	C–A	C–B	C–D
PHASE VIOLATION			
TOTAL			

PEDESTRIAN COUNT SHEET
STAFF MEMBER 2



Observer: ______________________________

Date: ________________ Time: ________________

Weather: ______________________________

Sheet ___ of ___

Instructions:
Pedestrians shall be counted starting at the point of beginning and according to their direction of travel. Begin a new sheet every 15 min.

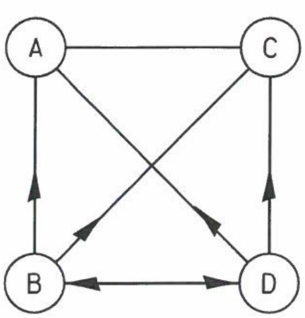
Phase Violation shall be any pedestrian that leaves the curb before the signal, any pedestrian that walks out side of the pavement marking, any pedestrian that walks after the signal.

PHASE 1

B–D	D–B	
		PHASE VIOLATION
		TOTAL

PHSAE 2

C–D	D–C	
		PHASE VIOLATION
		TOTAL



PHSAE 3

↑ B–A	↗ B–C	B–D →	
			PHASE VIOLATION
			TOTAL

D–B ←	↖ D–A	D–C ↑	
			PHASE VIOLATION
			TOTAL

PEDESTRIAN COUNT/COMPLIANCE SHEET

Observer: ______________________

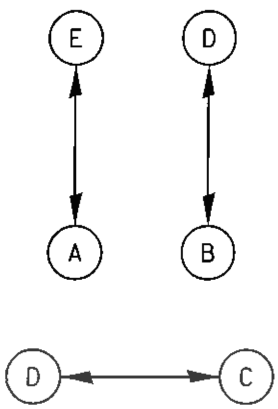
Date: __________ to __________

Time: ______________________

Temp.: ___________ Precip.: ___________ Clouds: ___________

Sheet ___ of ___

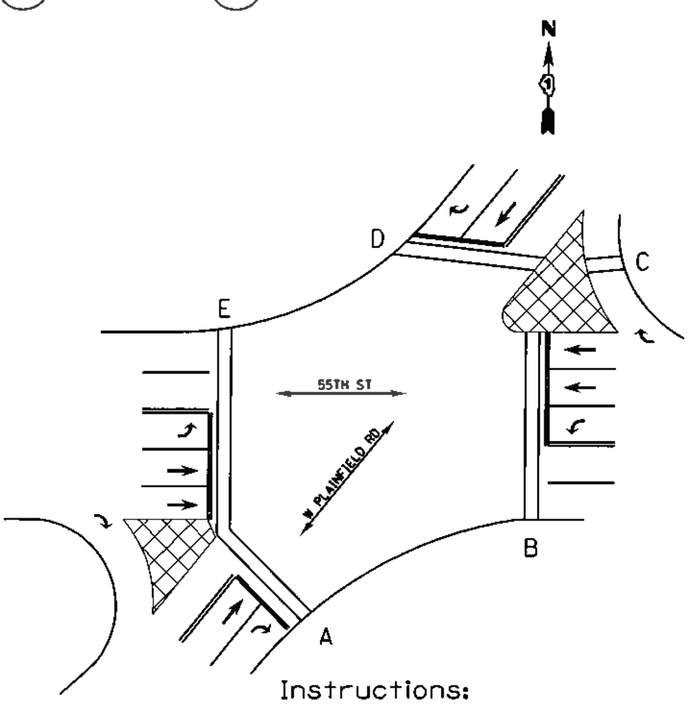
PEDESTRIAN PHASE



Instructions:
- Pedestrians shall be counted starting at the point of beginning and according to their direction of travel.
- Begin a new sheet every 15 min.

A-E	E-A	B-D	
			TOTAL

D-B	C-D	D-C	
			TOTAL



Instructions:
- Pedestrians shall be observed and noncompliance recorded by placing a tick mark in the appropriate boxes.
- Begin a new sheet every 15 min.

PEDESTRIAN NONCOMPLIANCE

LEAVES CURB BEFORE WALK SIGNAL
WALKS OUTSIDE OF THE PAVEMENT MARKINGS
WALKS AFTER THE WALK SIGNAL EXPIRES

- Pedestrian Noncompliance: any pedestrian that leaves the curb before the signal, walks outside of the pavement marking, or walks after the signal.

Instructions for the Right Turn on Red after Stop Compliance Field Sheet

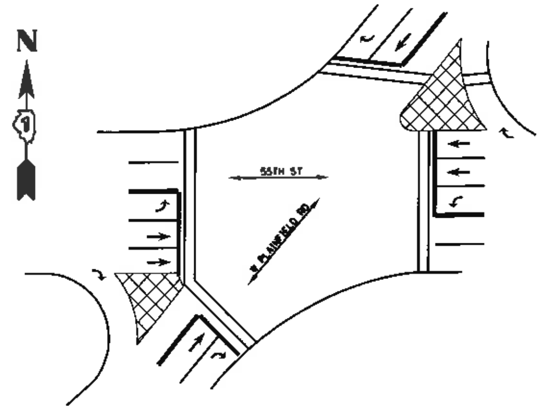
The measure of violation of "right turning on red" is the observed slowing or brake light application of through traffic, or interference with pedestrians. The following conditions may identify a right turn on red:

- Failing to completely stop at the stop line or before passing a crosswalk if pedestrians are present;
- Interfering with a pedestrian in either crosswalk being traversed; or
- Causing sudden slowing of a vehicle in the cross street that has a green indication.

The observer should be able to see the study vehicles as they arrive at the traffic signal and the cross traffic on the through street. Observe every right-turning vehicle that passes through the intersection during the study. Record the following observations:

- When the signal is green, record how many vehicles:
    - Turn on green or yellow;
    - Stop on red, waiting for green before turning;
    - Stop on red behind a vehicle waiting for green before turning right (the turn is executed on green); and
    - Attempt to turn on red,
    - The signal turned to green before turn is executed (the turn was completed on green).
- When signal is red:
    - Determine if vehicle arrived as a single vehicle or as part of a queue waiting at the signal.
    - Determine if the vehicle made a full stop (a brief cessation of movement), was stopped by vehicular or pedestrian cross traffic, or did not stop at all before entering the intersection.

RIGHT TURN COMPLIANCE SHEET



Observer: ______________________

Date: __________ to __________

Time: ______________________

Temp.: __________ Precip.: __________ Clouds: __________

Sheet ___ of ___

INDICATION	ACTION	CARS	TRUCKS	TOTAL CARS	TOTAL TRUCKS
ON GREEN	TURNED ON G OR Y				
	STOPPED ON R, WAITED FOR G, TURNED ON G				
	BEHIND A WAITER (above) TURNED ON G				
	ATTEMTED TO TURN ON R TURNED ON G				
ON RED NO QUEUE	FULL STOP				
	STOPPED BY CROSS TRAFFIC				
	STOPPED BY PEDESTRIAN				
	NO STOP				
ON RED QUEUE	FULL STOP				
	STOPPED BY CROSS TRAFFIC				
	STOPPED BY PEDESTRIAN				
TOTALS					

Instructions:

Observe and count every right turning vehicle that passes through the intersection. Begin a new sheet every 15 minutes recording the following:

- When signal is green, record number of vehicle that:
  - turn on green or yellow
  - stopped on red, waited for green before turning
  - stopped on red behind vehicle waiting for green before turning
  - attempted to turn on red, signal turns green before turn was executed
- When the signal is red:
  - Determine if vehicle arrived as single vehicle or as part of a queue waiting at signal.
  - Determine if vehicle made a full stop, was stopped by vehicular or pedestrian cross traffic, or did not stop at all before entering the intersection.

Begin a new sheet every 15 minutes.

VEHICLE TURNING MOVEMENT COUNT

N

FOUR-APPROACH FIELD SHEET

N/S Street: Clybourn

Time: 7:00 to 7:15

E/W Street: Clybourn

Date: ______

C= passenger cars, stationwagons, motorcycles, pick-trucks.

T= other trucks. (Record any school buses as SB)

B= Bicycles. (on street and sidewalk

P= Pedestrians

Temp. ______ Cloudiness ______ Precip. ______

Observer ______

SE

Cars	Trucks	Bikes	Pedestrians
69	1	14	0

Additional Bike Information

Female	Sidewalk	Wrong Way
2		

Cars	Trucks	Bikes	Pedestrians
38	1	1	1

Additional Bike Information

Female	Sidewalk	Wrong Way
1		

NW

MOTORIST MOVEMENT SHEET

Observer: ____________________

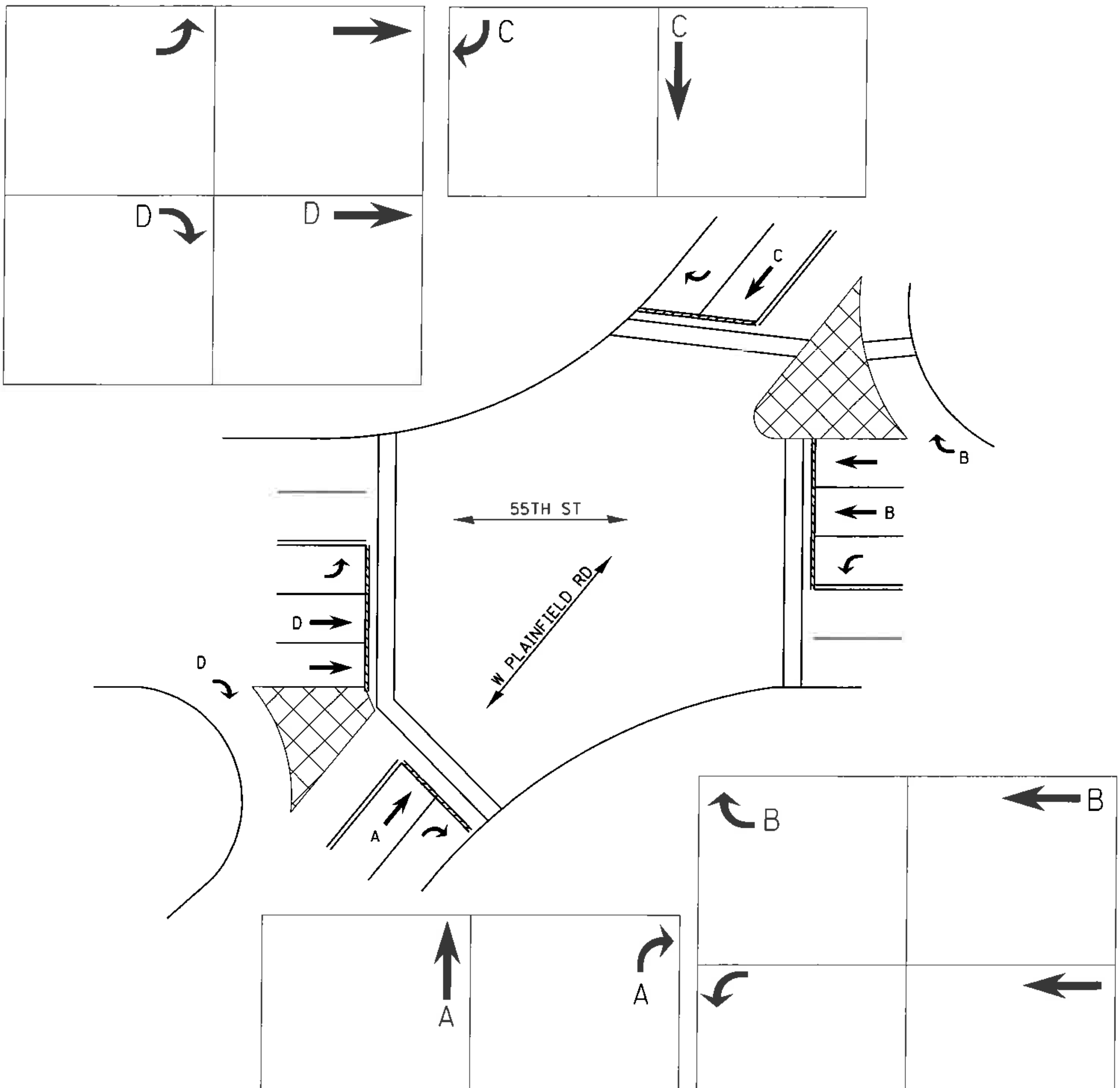
Date: ________ to ________

Time: ____________________

Temp.: ________ Precip.: ________ Clouds: ________

Sheet ___ of ___

N



Instructions:
Record the number of vehicles and their movement by placing a tick mark in the appropriate box.
Begin a new sheet every 15 minutes.

VEHICLE TURNING MOVEMENT COUNT

FOUR-APPROACH FIELD SHEET

N

N/S Street______________________________ Time________ to ________

E/W Street______________________________ Date______________________________

C= passenger cars, stationwagons, motorcycles, pick-trucks.

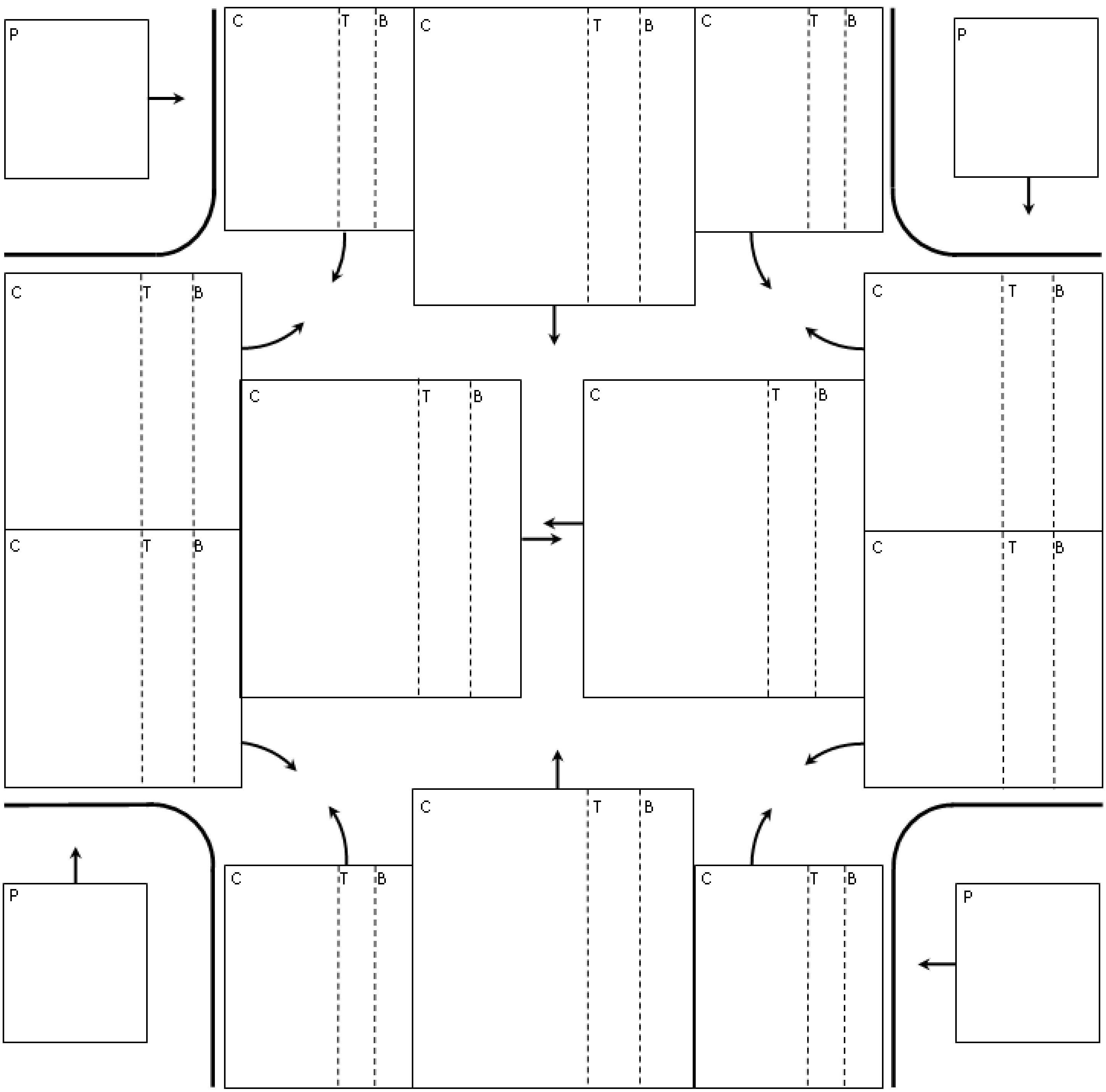
T= other trucks. (Record any school buses as SB)

B= Bicycles. (on street and sidewalk

P= Pedestrians

Temp.______ Cloudiness__________ Precip.__________

Observer______________________________



Appendix C
Crash Modification Factors

What is a Crash Modification Factor (CMF)?

When an engineer is faced with an identified safety issue or is requested to implement safety initiatives that provide additional safety benefits at a particular location, there are many treatments or facilities that can be installed to alleviate the issue or increase safety. Crash Modification Factors (CMFs) are used to measure the effectiveness of various treatments. The Highway Safety Manual (HSM) states "CMFs quantify the change in expected average crash frequency (crash effect) at a site caused by implementing a particular treatment (also known as a countermeasure, intervention, action, or alternative), design modification, or change in operations. CMFs are used to estimate the potential change in expected crash frequency or crash severity (plus or minus a standard error) due to implementing a particular treatment. The application of CMFs involves evaluating the expected average crash frequency with or without a particular treatment, or estimating it with one treatment versus a different treatment" (Highway Safety Manual, 2010). It is important to note that CMFs represent the long term expected change in crash frequency, and are merely a prediction based on previous studies. Actual crashes may vary from what the CMF predicts (FHWA 2010).

Application of CMFs

A CMF is a numerical multiplicative factor that modifies the number of expected crashes per year at a site after installing a countermeasure. CMFs greater than 1.0 indicate the crash frequency will increase. CMFs less than 1.0 indicate the crash frequency will decrease. For example:

> *Village XYZ has a roadway segment without any bicycle facilities. In 2014 there were 10 crashes between vehicles and bicycles for every 1000 bicyclists that rode that segment. To mitigate these crashes, the Village wants to install a facility to reduce the number of expected crashes. Village XYZ researches various bicycle facilities and determines that a conventional bicycle lane will fit within their budget and has a credible CMF value of 0.5 for vehicle/bicycle crashes. After installation of the facility, the Village expects 5 vehicle/bicycle crashes per year (10x0.5=5) for every 1000 bicyclists riding on that segment.*

CMF Clearinghouse

CMF Clearinghouse is a website that houses a vast library of CMFs with details on how the CMF was calculated. It is funded by the U.S. Department of Transportation Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. The CMFs are developed by the Highway Safety Manual, FHWA studies, Transportation Research Board Papers, Journals, and state research, among other sources.

Resource Link
WWW.CMFCLEARINGHOUSE.ORG/

Clearinghouse Study Quality Rating

Reviewers judged the reliability of each CMF based on five categories— study design, sample size, standard error, potential bias, and data source (see Table 1). The final quality rating is based on a weighted score. Study design and sample size categories receive twice the weight of the other characteristics; quality = (2 * study design) + (2 * sample size) + standard error + potential bias + data source.

"The star quality rating indicates the quality or confidence in the results of the study producing the CMF. While the reviewers applied an objective as a possible set of criteria, the star quality rating still results from an exercise in judgment and a degree of subjectivity. The star rating is based on a scale (one to five), where five stars indicates the highest or most reliable rating. It should be noted that information may be missing from a study report for specific characteristics such as sample size. In these cases, the rating is based on available information and the CMF will likely receive a lower rating due to the lack of information" (CMF Clearinghouse).

Table 1 - CMF Clearinghouse star quality rating descriptions

Relative Rating	Excellent (2 points)	Fair (1 points)	Poor (0 points)
Study Design	Statistically rigorous study with reference or randomized experiment and control	Cross sectional study or other coefficient based analysis	Simple before / after study
Sample Size	Large sample, multiple years, diversity of sites	Moderate sample size, limited years, and limited diversity of sites	Limited homogeneous sample
Standard Error	Small compared to CRF	Relatively large SE, but confidence interval does not include zero	Large SE, confidence interval includes zero
Potential Bias	Controls for all sources of known potential bias	Controls for some sources of potential bias	No consideration of potential bias
Data Source	Diversity in States representing different geographies	Limited to one State, but diversity in geography within State	Limited to one jurisdiction in one State

Score	Star Rating
14 (max)	5 stars
11-13	4 stars
7-10	3 stars
3-6	2 stars
1-2	1 stars
0	0 stars

CMFs Listed on CMF Clearinghouse

Table 2 below lists existing examples of CMFs provided by the Clearinghouse website in 2015. They are provided for informational purposes only and the Department does not make any recommendations towards their use. Users should exercise caution with applying CMFs with a low star rating. For the CMF factors please view the Clearinghouse website.

Table 2 - CMFs listed on CMF Clearinghouse's website in 2015.

Facility	Study Information					
	Prior Condition	ADT or Area Type	Location	# of CMFs Found	Crash Type	Quality Rating
Conventional Bicycle Lane	No Bicycle Facilities	Urban Roads	New York, New York	2	Vehicle / Bicycle	★★★
	No Bicycle Facilities	5,000-28,000 Roads	Copenhagen, Denmark	2	Vehicle / Bicycle	★★
Separated Bicycle Lane	No Bicycle Facilities	5,000-28,000 Roads	Copenhagen, Denmark	6	Vehicle / Bicycle	★★★
	No Bicycle Facilities	Urban Road	Montreal, Canada	2	Vehicle / Bicycle	★★★
Bicycle Boulevard	Many traffic calming devices	Urban and Suburban Roads	Berkley, California	1	Vehicle / Bicycle	★★★
Raised Pedestrian Crosswalk	No Prior Conditions	Urban and Suburban Crosswalk	Meta-Analysis	1	All	★
	No Prior Conditions	Urban and Suburban Crosswalk	Meta-Analysis	1	Vehicle / Pedestrian	★
HAWK Signal	Stop Controlled	Minor Road Crosswalk	Tucson, Arizona	1	All	★★★★
	Stop Controlled	Minor Road Crosswalk	Tucson, Arizona	1	Vehicle / Pedestrian	★★★
Barnes Dance/ Pedestrian Scramble	Traditional Crosswalks	Urban Intersection	New York, New York	1	Vehicle / Pedestrian	★★
Widened Shoulder	Shoulder with width "X"	Rural 2-Lane Intersection	38 Countries	1	Vehicle / Pedestrian	★★★

CMFs Calculated From IDOT Studies

Three CMFs were calculated as a part of the IDOT Bicycle and Pedestrian Accommodations study. The data was based on crashes provided by IDOT, short term count data provided by the Chicago Department of Transportation (CDOT), and average annual daily bicycle (AADB) conversion factors developed during the study. The number of study sites and crashes analyzed for each facility are shown in
Table 3.

Table 3 - CMF site background

Facility	# of Study Sites	# of Crashes
Separated Bicycle Lane	5	115
Buffered Bicycle Lanes	3	65
Bicycle Signal Heads	13	18

The crash rates were developed as part of crash analyses for Separated Bicycle Lanes and Bicycle Signal research in District One. See those respective reports for more information concerning the crash rates used in calculating the CMFs. Crash data was collected from 2008 to 2013, and bicycle volume data was collected between 2011 and 2013 and extrapolated out using bicyclist volume growth rates for previous years and calculated separately. All crash severity types were included in the analysis. The analyses also simple before and after studies.

See Table 5 for the crash modification factors. Note, CMF can also be expressed as a Crash Reduction Factor (CRF) using the function: CMF=1-(CRF/100). Further background information for the three CMF's are explained in several reports within this study: ridership trends and AADB factor calculations to calculate crash rates are explained in section 3.2 – General Operations Findings; and Separated Bicycle Lanes, Buffered Bicycle Lanes, and Bicycle Signals are explained in their respective facility reports.

Table 4 – Crash reduction factors for three bicycle facilities

Facility	Before Installation			After Installation			Percent Reduced (CRF)
	Min. Years of Data	Units	Value	Minimum Years of Data	Units	Value	
Separated Bicycle Lane	3	Crashes per Million Bike Miles	110.94	1	Crashes per Million Bike Miles	56.41	-49%
Buffered Bicycle Lanes	3	Crashes per Million Bike Miles	75.84	1	Crashes per Million Bike Miles	64.43	-15%
Bicycle Signal Heads	7	Crashes per Million Bikes in Intersection	159.1	1	Crashes per Million Bikes in Intersection	56.8	-64%

Table 5 - Crash modification factors for three bicycle facilities

Facility	Study Information						
	Prior Condition	ADT or Area Type	Location	# of Study Sites	Crash Type	Quality Rating	CMF
Separated Bicycle Lane	Either no bike facilities or an existing conventional bicycle lane	Urban	Chicago	5	Vehicle / Bicycle	N/A	**0.51**
Buffered Bicycle Lane	No Bicycle Facilities or an existing conventional bicycle lane	Urban	Chicago	3	Vehicle / Bicycle	N/A	**0.85**
Bicycle Signal Head (in conjunction with facility improvements)	No prior bicycle facilities	Urban	Chicago	13	Vehicle / Bicycle	N/A	**0.36**

Discussion

While the HSM did not publish any bicycle or pedestrian CMFs, they did acknowledge various crash trends for multiple facilities. In regards to conventional bicycle lanes the HSM states, "Providing dedicated bicycle lanes in urban areas appears to reduce bicycle-vehicle crashes and total crashes on roadway segments… Three types of bicycle-vehicle crashes may be unaffected by bicycle lanes: (1) where a bicyclist fails to stop or yield at a controlled intersection, (2) where a driver fails to stop or yield at a controlled intersection, and (3) where a driver makes an improper left-turn (37)." This trend differs from the CMFs posted on CMF Clearinghouse which have 3 star quality ratings and show vehicle/bicycle crashes increasing after installation of bicycle lanes. The variance between the two raises questions regarding the validity of the CMF Clearinghouse's posted CMFs and/or if the HSM's published trends are reliable.

The listed CMFs on CMF Clearinghouse might not have been published in the 2010 HSM due to a variety of reasons; the studies could have occurred after the publication of the 2010 HSM, or the quality of CMFs in the Clearinghouse was of insufficient quality to be published in the HSM. In the CMF Clearinghouse database, there are multiple CMFs listed for the same crash type and from the same study. It is often unclear which value is correct or if there is a difference between the CMFs, although a comparison tool is provided by the Clearinghouse to compare some attributes of each study. CMFs are provided as a resource and should only be used at the engineer's discretion.

Conclusion

Crash modification factors are a practical method of quantifying and comparing the rate of crashes after the installation of various bicycle and pedestrian treatments. CMF Clearinghouse is currently the only well-known database that houses bicycle and pedestrian CMFs. Furthermore, CMFs do not exist for many innovative bicycle and pedestrian facilities. CMF Clearinghouse maintains a "CMF Most Wanted List" which includes bump-outs, rectangular rapid flashing beacons, bicycle boxes, bicycle loops, and the effect of rumble strips on bicycles. While the CMF Clearinghouse is sponsored by U.S. Department of Transportation Federal Highway Administration, the majority of their CMFs are not listed in the 2010 Highway Safety Manual. More research and data collection needs to be completed to develop additional reliable CMFs. Since the CMFs calculated by District One are only simple before and after studies, further studies should be performed using an empirical Bayes method for more reliable factors.

References

American Association of State Highway and Transportation Officials. "13.12. Crash Effects of Roadway Treatments for Pedestrians and Bicyclists." *Highway Safety Manual*. 1st ed. Vol. 3. Washington, D.C.: American Association of State Highway and Transportation Officials, 2010. 13-47+. Print.

Federal Highway Administration (FHWA). 2010. *A Guide to Developing Quality Crash Modification Factors.* Report by Frank Gross, Bhagwant Persaud, and Craig Lyon. FHWA-SA-10-032. http://safety.fhwa.dot.gov/tools/crf/resources/fhwasa10032/

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