FINAL REPORT

Computer-Aided Scheduling and Dispatching System: Impacts on Operations and Coordination

Project IVA-H1, FY 98

Report No. ITRC FR 98-3

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16. Abstract

Using the implementation of a computer-aided scheduling and dispatching (CASD) system in Peoria as a case study, the study documents the insights gained from the evaluation effort and provides recommendations regarding the statewide deployment of such systems. With respect to productivity, vehicle assignment limitations must be eliminated to allow the CASD system to optimize vehicle use. With respect to management: (a) Decision-makers must require well defined and pre-formatted training delivery schedules to be included in implementation; (b) As CASD systems are implemented state-wide, a user group of managers should meet periodically to exchange information, explain innovations, and discuss issues arising as the systems are used in paratransit operations. With respect to training: (a) East step of the preferred scheduling and dispatch process must be mapped and linked to the new CASE. (b) A pre-defined and formal training period must precede installation and "live" implementation of CASD. (c) Training and reference manuals must be distributed and prominently placed at each computer terminal. (d) Managerial training in developing and interpreting report data is the most often cited failure of CASD at the manager's level. Vendor training for this extraordinarily important task should become part of any implementation effort. With respect to Automatic Vehicle Location (AVL) and Mobile Data Terminals (MDT) systems: Concurrent implementation of AVL/MDT overcomes the problem of run-posting in that no new personnel need be hired, manifest entries are out of the control of the driver, and no interpretation or data-entry mistakes will be entered into the system; all providing more accuracy and timeliness. With respect to CASD technology in the long-term: (a) Contract administrators must implement fixes to ensure appropriate training is received by site managers to ensure management can access and understand CASD data. (b) Contract managers must ensure that project management support is provided to augment already busy paratransit managers. (c) The best evaluation of CASD will follow from implementation of AVL and MDT systems. With respect to quality of service: Allowing unrestricted use of vehicles will impact passenger perceptions of on-time rates more favorably. With respect to cost – effectiveness: Contract managers must enforce vendor accountability for training, report construction support and software documentation to ensure the potential CASD cost-effectiveness changes.

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Illinois Department of Transportation

Illinois Transportation Research Center

Project IVA-H1, FY 98

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Executive Summary

COMPUTER-AIDED SCHEDULING AND DISPATCHING SYSTEM: IMPACTS ON OPERATIONS AND COORDINATION

Project IVA-H1, FY 98

Report No. ITRC-FR 98-3

This study represents a continuing effort in the State of Illinois to determine the impacts of computer-aided scheduling and dispatching (CASD) systems on paratransit service. Using the implementation of such a CASD system in Peoria as a case study, the research team documents the insights gained from the evaluation effort and provides recommendations regarding the statewide deployment of such systems.

To accomplish the objectives of the study we structured the research effort into seven tasks: (1) a literature review; (2) telephone interviews with paratransit operators; (3) a description of the paratransit environment; (4) a documentation of the pre-implementation activities; (5) monitoring and recording productivity parameters; (6) a description of post-implementation impacts; and (7) a cost-effectiveness evaluation. We documented the activities in these seven tasks in four technical memoranda that comprise the final report that follows this executive summary.

The literature review provides an overview of CASD systems and their main components including descriptions of types of software available, features included in most packages, and possible benefits of implementation of computerized scheduling and dispatching systems. The review presents methods of evaluation of these systems and possible effects of automation on organizations and employees, as well as strategies for dealing with the negative effects of computer automation. The review also presents a variety of efficiency, effectiveness and quality of service measures found in the literature and concludes with a discussion of measurement issues and sources of data in paratransit operation.

Transit measures have changed little since their formal introduction over fifty years ago, and have traditionally been oriented toward evaluation of fixed route services. The Americans with Disabilities Act and increasing numbers of aged and mobility disadvantaged travelers have combined to place more focus on paratransit transportation services, and consequently on the development of appropriate measures for these types of demand response agencies.

The introduction of CASD systems allows for dramatic increases in the quality and quantity of performance related data. Due to increases in accuracy, archiving functions, built in reporting capabilities and the ability to track a wider range of activities related to paratransit operations, a new set of performance measures may evolve that will be more oriented to paratransit operations. Because of the difference in mission of paratransit operators, new performance measures more appropriate to serving the mobility disadvantaged are likely to include a greater

emphasis on quality of service indicators such as on-time performance, reservations convenience, and related quality measures.

The survey of paratransit operators sought the experiences of operators across the country with CASD systems and provided insights into the processes used, problems encountered and benefits and costs experienced in implementing these systems. While a number of automation efforts have been implemented, at best few, if any, implementation processes have been observed and methodically described. The purpose of the survey was to collect responses from paratransit operators who have experienced the transition to CASD systems, including key productivity measures of passenger trips/vehicle hour, costs per service hour, total vehicle miles and quality of service measures. The survey was designed to collect a range of qualitative information found to be important during research on this project. General descriptive information for each operator (e.g. peak vehicles and employees), major software features, transition to automation issues, training and support were also collected.

The survey provides several important findings that may assist future implementations of CASD systems in Illinois. In particular, fully half of the operators surveyed do not use major features of their new CASD system. Importantly, most operators do not use one of the most lauded features, optimization. It is evident that many operators have transitioned to CASD technology in a way that does not position the organization to take full advantage of the newly acquired technology. For the vast majority, the way that operators conduct business has not changed to match the capabilities of the new system.

On a separate issue, operators surveyed have noted gains in efficiency, effectiveness and quality, with some reporting significant changes, but on the whole, pre and post implementation comparisons do not show the kind of dramatic efficiency changes operators have hoped for. By far, the most significant changes have occurred in the reduction of administrative time related to manifest preparation and passenger information record keeping. This survey indicates that the most likely non-administrative effect experienced by operators regardless of size or mission is reduction in call intake time.

Training issues are significant and have seriously degraded potential positive impacts at most sites surveyed. Training is a variable dependent on both the desire of the site manager to fund, and the vendor representative's experience level. Training efforts are likely to become a lightning rod for discontent as the staff transitions to the new system, and management should make every effort to ensure that funding and time are allocated for training as early as possible.

This survey indicates that no vendor has provided satisfactory report generation capabilities or the training required to create and interpret the report output. Vendors and funding agencies must be made aware of this shortfall early to allow for custom reports to be added to the initial pricing model, and that separate, focused training is provided for management.

Operators are strongly in favor of adding a dedicated project manager to the CASD implementation process. Very few transit managers have the time or training to handle the increased responsibilities associated with implementation of CASD systems. While the vendor has performed admirably in some cases in this capacity, their vested interest and limited ability to integrate the unique needs of each site limits their effectiveness.

Overall, the implementation of CASD has been positively welcomed in this survey sample, but few operators are able or willing to fully exploit the power of CASD technology. Both policy and personnel issues limit full implementation of CASD systems. As long as agencies restrict use of their vehicles to certain groups of passengers, optimization algorithms can not reduce vehicle usage, and as long as training and attitudes do not match needs, personnel problems will persist.

The description of the paratransit environment includes characteristics of the service area, user characteristics, aspects of the service itself and potential for coordination of service. CASD systems are designed to support coordinated transit activities and provide the technological solution to the multi-agency brokerage concept. At the time of the study, three paratransit agencies served the Peoria tri-county area. Because of some overlap of service area and other long-standing customer arrangements, there are frequent occasions when vehicles from the three agencies cross paths while providing transportation to Peoria area residents. This overlap occurs almost exclusively in the boundary area between the officially designated Peoria urbanized and rural areas. It is likely that such coordinated transit will result in more efficient utilization of vehicles.

Curently, no formal coordination exists between the three providers in the Peoria tri-county region. Issues of funding, organizational longevity, and politics are major barriers to efforts at coordination of paratransit and other demand response transportation activities. Until these issues are addressed, it is unlikely that coordinated activities will occur.

The documentation of pre-implementation activities contains a description of daily operations of Door to Door, Inc. (DTD), a medium sized paratransit property located in central Illinois. The report provides an overview of the organization's personnel structure, a detailed description of the agency's manual operations from receipt of a request for service to dispatching, and a brief description of vehicle operations and the customer complaint process. The agency's financial environment, service area and characteristics are briefly outlined, and the agency's fleet composition is included. The focus is on the internal operations of the organization's manual activities, especially those affected by the installation of the CASD system.

Except for billing and manifest printing, during the pre-automation period, DTD transit operations were supported entirely by manual activities. DTD's routine transit operations include receipt of service requests, scheduling, publishing of driver manifests, communication of enroute changes to drivers, customer problem resolution, and maintenance of primary billing records and of vehicles.

Scheduling and dispatch operations in a manual environment required expert level knowledge of the service area and a significant array of client characteristics. Routine operations for the dispatcher/scheduler required the ability to recall individual client characteristics that at minimum include client disability type and normal/alternative billing options. That level of expert knowledge was rarely developed except through assignment as a vehicle operator. This prerequisite experience limited all dispatcher/scheduler assignments to those personnel who had been former vehicle operators.

DTD's daily operations can be segmented into four distinct categories: service call receipt, scheduling, dispatch and vehicle operations. In the pre-implementation period, the amount of data potentially available for collection from paratransit operations was overwhelming in its volume. DTD took action to minimize a potentially paralyzing administrative burden by collecting no more data than necessary to provide required reports and to perform essential operational analysis. In summary, in the pre-implementation period, despite the determined effort to minimize administrative activities to its bare bones components, DTD generated a significant volume of paper records during routine operations.

The cost-effectiveness evaluation of the CASD system in Peoria has several components; a description of the computer equipment and software used at the study site; a description of data collection for the project and the implementation phases used to assess progress; a documentation of pre-implementation training methodology at the organization, impacts on scheduling, dispatching and management functions affected by the CASD system; a documentation of key productivity parameters monitored and analyzed in this study; a detailed analysis of effectiveness, efficiency and quality measures developed from performance attributes; a discussion of the impact of the CASD system on the potential for coordination; and finally, conclusions and recommendations of the study, including an assessment of the long-term value of CASD system implementation to the riding public and future paratransit operators.

Regarding feasibility: (a) CASD implementation is feasible in the paratransit environment. (b) CASD products are capable of supporting coordinated paratransit activity. (c) Personnel normally assigned to paratransit activity are capable of learning and effectively using current CASD products. (d) Current pricing of CASD products limits its availability to those transit operators able to secure adequate funding. (e) CASD implementation is a complicated and time-consuming process, often requiring more time and technology assets than available to small paratransit managers.

With respect to cost effectiveness issues: (a) CASD supported paratransit is potentially more efficient and effective than manually supported organizations. (b) Positive changes may be seen in vehicle optimization, on-time rates, and reductions in administrative activities, especially billing. (c) Customers may see potential efficiencies as negatives, more efficient use of vehicles translates to longer ride times for passengers. (d) It is unlikely that paratransit managers will experience personnel reductions because of CASD implementation, most are likely to increase personnel supporting CASD implementations. (e) Due to the short time duration of the post-implementation period, few changes in cost have been observed. If CASD were to result in reductions in cost of operations, then a longer time frame is needed to observe such changes. Cost reductions can take many years to realize, since organizational changes are required in order to reap such savings. In addition, the reduction in passenger trips in the post-implementation period did not provide the opportunity for management to utilize the CASD to reduce per unit costs as ridership increased.

Regarding scheduling and dispatching improvements: (a) Given unrestricted vehicle assignment, vehicle load factors may be significantly increased. (b) Administrative burdens associated with scheduling and dispatching are universally reduced because of elimination of redundant paperwork. (c) CASD systems dramatically increases the quality, timeliness and volume of management information from paratransit operations. (d) Average call length to schedule a pick-up will likely decrease because passenger ride data is stored in the CASD database with easy access by the dispatcher/scheduler

With respect to quality of service improvements: (a) The most significant impacts of CASD in this application have been on improving quality of service. A variety of service attributes have been positively affected by the CASD implementation. (b) Passengers will likely experience greater on-time rates at both pick-up and drop-off. (c) Overall satisfaction with the service has increased. (d) Customer reporting of ride denials have been reduced.

With respect to coordination potential: The CASD System has the potential to aid a service coordination effort. However, significant barriers to coordination exist which are not affected by CASD implementation. These include political, turf and personality issues. Until such issues are addressed, CASD will have little impact on coordination efforts.

Regarding report generation: (a) Report generation became one of the most significant failures of the CASD implementation. While holding the tremendous potential to give the manager access to real-time, high quality, easy to understand management information, CASD support in report generation was unexpectedly poor. (b) Reports are not formatted with a non-technical manager in mind. (c) Standard reports are far from "standard", and are difficult to reconfigure and interpret. (d) The most useful reports to managers are often ad hoc reports containing information useful only in answering a one-time question or of only local interest. Generating these kinds of reports requires the manager to develop knowledge of database report construction, often intimidating to a busy manager.

The study, finally, provides a number of recommendations for each area of operations examined. With respect to productivity, vehicle assignment limitations must be eliminated to allow the CASD system to optimize vehicle use.

With respect to management: (a) decision-makers must require well defined and pre-formatted training delivery schedules to be included in implementation. (b) As CASD systems are implemented state-wide, a user group of managers should meet periodically to exchange information, explain innovations, and discuss issues arising as the systems are used in paratransit operations.

With respect to training: (a) Each step of the preferred scheduling and dispatch process must be mapped and linked to the new CASD. (b) a pre-defined and formal training period must precede installation and "live" implementation of CASD. (c) Training and reference manuals must be distributed and prominently placed at each computer terminal. (d) Managerial training in developing and interpreting report data is the most often cited failure of CASD at the manager's level. Vendor training for this extraordinarily important task should become part of any implementation effort.

With respect to AVL and Mobile Data Terminals (MDT): Concurrent implementation of AVL/MDT overcomes the problem of run-posting in that no new personnel need be hired, manifest entries are out of the control of the driver, and no interpretation or data-entry mistakes will be entered into the system; all providing more accuracy and timeliness.

With respect to CASD technology in the long-term: (a) Contract administrators must implement fixes to ensure appropriate training is received by site managers to ensure management can access and understand CASD data. (b) Contract managers must ensure that project management support is provided to augment already busy paratransit managers. (c) The best evaluation of CASD will follow from implementation of AVL and MDT systems.

With respect to quality of service: Allowing unrestricted use of vehicles will impact passenger perceptions of on-time rates more favorably.

With respect to cost – effectiveness: Contract managers must enforce vendor accountability for training, report construction support and software documentation to ensure the potential CASD cost-effectiveness changes.

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DISCLAIMER

The contents of this report strictly reflect the views of the authors who are responsible for the facts and the accuracy presented herein. The contents do not necessarily reflect the official views of the Illinois Department of Transportation. This report does not constitute a standard, specification or regulation.

Acronyms Used in this Study

ADA –	Americans with Disabilities Act
APTS –	Advanced Public Transportation Systems
ATIS –	Automated Traveler Information Systems
AVL –	Automatic Vehicle Location System
CASD -	Computer Assisted Dispatch and Scheduling
CTA –	Chicago Transit Authority
CUTR –	Center for Urban Transportation Research, University of South Florida
DRT –	Demand Response Transportation
GPS –	Global Positioning Satellites
ITS-	Intelligent Transportation Systems
MMS –	Mobility Management System
WSTA –	Winston Salem Transportation Agency

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Chapter 1

Literature Review

1.1 Introduction

Advances in technology along with Federal and State transportation initiatives over the last decade have provided an impetus for paratransit operators to invest in technological upgrades such as computer assisted dispatching, automatic vehicle location and smart card systems. Based on research literature and other office automation experience, paratransit operators have expectations of increases in productivity and service quality following installation of computer assisted scheduling and dispatch software. Only a few operators have implemented the most sophisticated versions of any of the various software options. The most elaborate software systems are likely to have automated scheduling and dispatching software integrated with automatic vehicle location and advanced communications systems. Computer assisted scheduling and dispatch software has the potential to improve performance in a number of ways including increased vehicle load ratios, interagency connections, interactive voice driven reservation systems and dramatically streamlined billing operations (Goeddel 1996, Khattak and Hickman 1998, Kikuchi 1988).

This literature review is composed of eleven major sections. The first three sections of the report provide an overview of scheduling and dispatch systems and their main components. Included are descriptions of types of software available, features included in most packages, and possible benefits of implementation of computerized scheduling and dispatching systems. Sections four and five deal with methods of evaluation of these systems and possible effects of automation on organizations and employees. Strategies for dealing with the negative effects of computer automation are discussed.

The report then presents a variety of efficiency, effectiveness and quality of service measures found in the literature. While the emphasis is on measures that have been developed for paratransit services, those developed for fixed route transit, but also relevant to paratransit have been included. Finally, the report concludes with a discussion of measurement issues and sources of data in paratransit operation.

1.2 Advanced Public Transportation Systems

Scheduling and Dispatch systems are a subset of the Advanced Public Transportation Systems APTS). The APTS program is part of the U. S. Department of Transportation (DOT) Intelligent Transportation Systems (ITS) initiative to integrate several information technologies to improve public transportation and ridesharing. APTS includes but is not limited to the application and integration of technologies as follows (Goeddel 1996):

- Transit Management Systems - These systems integrate fleet based communication, Automatic Passenger Counting (APC), vehicle monitoring/location, and Computer Aided Dispatching (CASD) technologies that improve the overall planning, scheduling, and operations of transit systems.

- Automated Traveler Information Systems (ATIS) - These include a broad range of advanced computer and communication technologies designed to provide transit riders real-time information allowing better informed decision making regarding their mode of travel and planned routes and travel times. ATIS systems include in-vehicle annuciators/displays; terminal or wayside based information centers, kiosks, telephone information systems, cable and interactive TV, and the Internet. These systems give passengers projected travel times, directions and even vehicle load data.

- Electronic Fare Payment Systems – These are advanced fare collection and fare media technologies designed to make fare collection more efficient and more flexible for the transit provider. These systems include fare media ranging from magnetic strip to smart cards, and their associated fare collection and processing systems.

- Transportation Demand Management Systems - These systems include applications combining technologies and strategies that promote the use of existing transportation infrastructure to serve the increasing demand for transit. These applications include computerized demand responsive transit scheduling and dispatching systems and strategies to promote ride sharing and coordinated transportation services among transit and non-transit providers.

1.3 Computer Assisted Scheduling and Dispatch Systems

Computer Assisted Scheduling and Dispatching (CASD) systems are transit software packages that can perform and integrate many transit operations. CASD systems installation represents a first step towards integrating APTS technology into a transit agency. Although an "entry level" technology, Goeddel (1996) suggests that Computer Assisted Dispatching provides a variety of potentially important benefits, most related to reducing the complexities associated with vehicle optimization and billing in the demand response transit environment.

CASD scheduling of paratransit services entails the recording and scheduling of incoming passenger reservations for on-demand, real-time trips or for advance reservations for trips during the next day, week, or month. Passengers, vehicles, and in some cases, drivers are scheduled based upon the types of service required, time/day of week, and trip origin and/or destinations. Vehicle routes and schedules are optimized by minimizing travel time or distance subject to constraints of vehicle capacity and the passenger's desired pick-up and drop-off times.

Most paratransit agencies now using automated systems migrated slowly to automation of scheduling after first using some early version of billing software. Few paratransit agencies then controlled the financial resources necessary to finance the hardware and consulting fees necessary to embark on scheduling automation. Additionally, as Stone (1992) notes, no paratransit software was available that provided the combination of reliable scheduling and dispatch algorithms capable of running on affordable desktop machines until the end of 1992. Low demand for the software had further contributed to lack of availability in the marketplace.

The complexities of providing demand responsive transit are rarely appreciated by uninitiated observers. Even daily users of paratransit services are unlikely to understand the extraordinary effort preceding acceptance of a request for service. Demand response operators who rely on manual dispatch and scheduling operate at an extreme end of the labor-intensive scale in a complex and high tempo environment. Today's falling hardware prices, Advanced Public Transportation Systems (APTS) funding increases, and growing interest in providing service to the community have prompted a number of smaller demand response properties to consider one or more components of APTS technology, especially computer assisted dispatch systems.

1.3.1 CASD Software

Several paratransit dispatching and scheduling software packages are available. Table 1 displays representative examples of current CASD vendors. Almost all of the listed products has automatic vehicle location (AVL) capabilities, is able to schedule demand response requests in real time and includes a claim of significant experience in paratransit systems support. Each entry is MS Windows/NT compatible and possesses a wide range of functions that assist paratransit managers in tasks such as report generation, billing, and complaint and maintenance tracking, among others. All major systems are available in a base version that provides full scheduling, reporting and billing functions. Upgrades include Automatic Vehicle Location Systems (AVL), interactive voice response for customers and support for the owning agency in a Mobility Management System (MMS) role. In the MMS role, an agency owning automated software takes over scheduling and dispatching/billing functions for surrounding community or agency transportation systems.

The number of individual features available in the many versions of paratransit CASD systems can number in the hundreds, using many different names and with overlapping descriptions and functions. Lave, et al. (1996) suggest five categories of software functions: reservations, scheduling, dispatching, routing and reporting. In addition, automated vehicle location is another function that can be included in a CASD system. A short discussion of each functional category follows.

<u>Reservations Functions</u>
In this activity, a patron contacts a paratransit provider with a request for transportation. During this interaction, the paratransit representative collects and records information necessary to schedule the trip and bill for the service. Software packages are conceptually similar in construction of this module. All packages provide preformatted screens of electronic forms that automate and direct information collection. Many packages store previous customer information that is available in simple point and click mouse actions. This time saving feature allows the paratransit representative the option of simply reviewing previous trips and confirming information to be used on the currently scheduled trip. A trip request may be as simple as asking "Is it the same as yesterday?"

Table 1 Computer Assisted Scheduling and Dispatching Software Vendors

Vendor Name	Product Name	Vendor Name	Product Name
• Advanced Transit Solutions	Schedule Pro, Schedule Manager	• Management Analysts, Inc.	Rides, Newrides
• Computer Technology	SCOOTER	• Micro Dynamics Corporation	CADMOS Pro +, Dr. Dispatch
• CTS Software, Inc.	Rural Paratransit Scheduling and Info Management System	• Management Analysts, Inc.	Rides, Newrides
• Decision Science, Inc. (D.S.I)	Quick Route	• Multisystems, Inc.	MIDAS PT, DISPATCH-A-RIDE
• GIRO, Inc.	ACCESS Reservation System	• PC Solutions, Inc.	TransNet, TransNet Mobile
• Henson Consulting	Trip Management System	• RouteLogic	ParaLogic, RouteMap, ParaRoute
• IRD Teleride	TransView	• StrataGen Systems	ADEPT 2.0
• Intelitran	ParaPro	• Trapeze Software Group	PASS for Windows 95, Mini PASS

(Adapted from Dr. J. R. Stone's web site: www2.ncsu.edu/eos/service/ce/research/stone_res)

Another critical time saver is the automation of eligibility information. Many customers simply lack the cognitive ability to track their own sponsor and billing information. By storing this information in the computer, this process is dramatically streamlined. Additional timesaving is accomplished by using the step by step process imposed by the system's forms and self-checks.

Vehicle Scheduling

As Lave, et al. (1996, p.11) observes, "Scheduling is the core function which distinguishes [paratransit] systems from other transit." Scheduling takes the requests for service and fits these requests into a time line that allows the passenger and the provider to meet their often conflicting schedules. It is during scheduling that the customer receives approximate pick-up and drop-off times. With most CASD systems, the scheduling process is an interactive and dynamic process between the customer and the patron, requiring more than one cycle of proposed and rejected pick-up or drop-off times. The increased accuracy of a system's algorithm that may be able to project vehicle location greatly enhances the dispatcher's accuracy range.

Vehicle Routing

"The routing function finds the best route between pick-up and drop-off points in terms of the sequence of actual roads taken." (Lave, et al. 1996, p. 12). Vehicle scheduling and routing are perhaps the two most complicated parts of paratransit operations. The routing function (generally integrated into the same algorithm as the scheduling function) is based on sophisticated mathematical optimization techniques. It is one of the most protected parts of a vendor's software package. It is the speed and quality of output from the proprietary algorithms that are often used as primary selling features to potential clients. Scheduling and routing accuracy are dependent on vehicle location and passenger load factor inputs. Manual updates are potential causes of inaccurate or untimely information and may seriously degrade the system's potential to optimize fleet operations. Automatic vehicle location and passenger counting upgrades are offered as solutions to the drawbacks of manual input. Because of its increasing use in paratransit CASD, a separate discussion is provided for automatic vehicle location technology.

Vehicle Dispatching

Vehicle dispatching is the assignment of vehicles to previously scheduled requests for transportation. Software vendors have also followed generally similar strategies to accomplish this activity. The concept is to minimize the use of the paratransit provider's assets while maximizing the customer's perception of quality. It is in how the vendors develop their optimization algorithm that differences are seen between vendor offerings. Almost all software allows some degree of interaction between the paratransit operator and the system's algorithm. This interaction is likely to be an adjustment of the algorithm's weights for the several optimization steps. An operator may be able to assign greater weights to passenger ride time reduction, or to increase the use of vehicles by allowing greater loading per trip, as an example.

Automatic Vehicle Location

Automatic Vehicle Location (AVL) assists in locating vehicles in real time. Many of the newest systems integrate AVL and CASD systems, allowing the using agency to enjoy the benefits of both systems. Expected traveler benefits due to these technologies include: increased paratransit reliability, reduced frustration from uncertain wait times, travel time savings and reduced uncertainty in travel times due to improved content and quality of transit information. All combine to improve satisfaction with transit service (Khattak and Hickman 1998).

Four AVL technologies are proximity beacons (signpost technologies), dead reckoning, trilateration and satellite based AVL. Signpost technologies are a category of AVL systems that use fixed transmitters attached to overhead poles or wires that transmit codes unique to their individual location. Vehicles equipped with receivers interact and pass on a signal to a central facility that computes and tracks the location of the vehicles. Dead reckoning technology uses on-board compasses and vehicle odometers to track and compute a location relative to a known starting point. Trilateration uses radio frequency transmissions broadcast from three or more points to fix the vehicle location relative to a fixed point. LORAN-C is the most common trilateration technique.

Satellite Based Automatic Vehicle Location Systems are commonly known as global positioning satellite (GPS) technology. A GPS system is the most reliable and accurate of AVL systems. The Department of Defense maintains a number of satellites that serve a function similar to that of trilateration. On-board modules receive signals from several satellites simultaneously, allowing an algorithm to 'fix' the vehicle's location within a few yards. Because of various limitations in each technology, some organizations utilize more than one AVL system at a time. A common limitation is the interference from concentrations of tall buildings that disrupt satellite signals, making sign-post or dead reckoning technologies more appropriate in those high density urban areas.

Khattak and Hickman (1998) report that in 1997, 58 AVL systems were in operation, planning stages or under installation. He found 40 planned Global Positioning Satellite (GPS) installations and 10 operational GPS sites.

Reporting/Accounting

While many of the most dramatic claims of CASD improvements follow from optimization of vehicle routes and passenger loading, tremendous internal efficiencies are gained from automation of billing report generation. The ability to call up on demand reports to search for passengers with high no-show rates, average time to accomplish scheduling of passenger trip requests, and complaint follow-up can provide a quantum leap in management effectiveness.

1.3.2 Desired Features of Computer Assisted Scheduling and Dispatching Systems

Khattak and Hickman (1998) report the results of a poll that collected responses from paratransit software vendors and operators. Of the 29 operator respondents, 18 were in large urban areas, five were from small urban areas, and one was from a suburban area. Five respondents either operated in more than one kind of area or did not respond to this question. Vendors responded to questions in three general categories: vendor background, product technology attributes, and transit impacts as projected by the vendor. They found that on average, seven different technologies can be integrated with the various CASD systems (including AVL/CASD integration). The average transit agency has integrated four CASD technologies with their software package. Transit operators in Khattak and Hickman's (1998) poll also answered questions in three categories: transit agency background, technology implementations at the agency, and impact of the software implementation on their organization. When asked about which features they would like to add to their CASD packages, the most common response was automatic passenger counters. The polled managers indicated that other key system requirements included monitoring of schedule adherence, driver's performance, monitoring vehicle location, supporting dispatch decisions and providing consistently accurate information. Less important considerations include monitoring vehicle mechanical condition, in-vehicle security, directing enroute operations and monitoring passenger loads (Khattak and Hickman 1998).

When users were polled regarding the rationale for upgrading from existing dispatch systems, the most important factor leading to CASD implementation was that a member of the organization had become dedicated to implementing the new technology. Once an organization's upgrade advocate had appeared; the next upgrade hurdle became funding availability. Also rated as important was the need to upgrade obsolete equipment, and expand agency services (Khattak and Hickman 1998).

1.3.3 Benefits of Computer Assisted Scheduling and Dispatching Systems

The Khattak and Hickman (1998) poll also tabulated responses from transit agency staff members including general managers, boards of directors, dispatchers, telephone operators and drivers. The survey used a five point Likert scale to assess reactions to AVL/CASD implementation. The scale's highest (most favorable) score is 5 and the lowest is 1. In the survey, general managers and boards of directors gave the highest scores (2.62 and 2.53 respectively), while drivers, information system managers and maintenance staff gave the lowest scores to AVL/CASD implementation (2.00, 2.06 and 2.06 respectively). Dispatchers and telephone operators/customer service agents scored in the mid-range at 2.39 and 2.22 respectively. Table 2 lists the results of a Khattak and Hickman (1998) poll which asked the transit operators to rate how strongly they felt various categories of transit operations would be affected by implementation of AVL/CASD systems. This five point scale also rates "5" as highest and "1" as lowest. The scores in the table are the averages for each organization's responses. As can be seen from the table, improved ability to monitor vehicle location and schedule adherence were rated the most important benefits from introducing CASD.

Table 2 Expected Benefits From AVL/CASD – Average Organizational Response

Benefit	Avg. Score	Benefit	Avg. Score
• Improve ability to monitor vehicle location	2.92	• Improve ability to respond to crimes or other security incidents	2.54
• Improve schedule adherence	2.80	• Improve ability to direct enroute vehicles	2.46
• Enhance security for drivers and passengers	2.68	• Improve coordination with other transportation modes	2.15
• Improve ability to respond to breakdowns, accidents, schedule adjustment, etc.	2.68	• Reduce labor hours (e.g. on-street supervisor)	2.09
• Improve ability to monitor driver's performance	2.57	• Reduce number of vehicles as a result of better planning	1.95

(Khattak and Hickman 1998)

CASD should provide improvements in dispatching, scheduling, on-time performance, response to service disruptions and emergencies, enhanced driver and passenger safety/security; better ability to monitor driver and vehicle performance; and improved planning functions including selection of routes, stops and service frequencies. The following paragraphs summarize input from several sources (Khattak and Hickman 1998, Goeddel 1996, Stone 1994, Underwood, et al. 1995, Lave, et al. 1996, Kikuchi 1988)

Increased efficiency in paratransit operations should follow from efficient scheduling of vehicles/drivers to passenger trip requests; the validation of trip requests with provided services, and the certification of pre-approved (subsidized) fare payments. CASD systems can increase the utilization of vehicle fleets, reduce non-revenue vehicle miles (or vehicle hours), reduce the costs and time investment of fleet dispatching and the recording and billing of services provided.

CASD may also increase customer convenience and improve paratransit service through improved response time in the request process, more accurate pick-up and drop-off times, increased flexibility of scheduling and reduced travel times. Successful installation of CASD systems will allow the paratransit agency to comply more faithfully with both the spirit and letter of the Americans with Disabilities Act (ADA).

Once CASD is introduced into an organization, management is faced with the challenge of identifying change related to CASD implementation, exploiting increased volumes and quality of information and charting a course that maximizes the potential of both existing human and new technological assets.

This challenge is especially apparent when an organization is exposed for the first time to the vastly expanded reporting and tracking capabilities of CASD. A chief consideration of a transit manager is simply to decide just *what* information is important enough to analyze. The sheer volume of data available to management from CASD may easily overload the most competent of managers without some method to prioritize and use the available information.

From this research, it is clear that many researchers and transit managers have their "favorite" performance measures. Managers and researchers are familiar and comfortable with their use from long association. Also apparent from this research is that despite having favorites, actual on-site performance evaluation is limited to using data that is available, rather than the data which the evaluator/manager would prefer. These background issues create a diversity of reporting and measurement processes that do not contribute to effective monitoring of transit agencies.

CASD provides two other benefits: (1) it will allow a minimum level of uniformity across transit properties and (2) because CASD automatically and completely tracks all data, it will be possible to track performance across dimensions far more relevant to paratransit managers. An additional benefit is the tracking of some performance indicators that is impossible without automation (e.g. dispatcher effectiveness, call length, and no-show rates by customer to name a few). This will allow management of previously hidden burdens on efficiency.

Once uniformity and depth of reporting are the norm, attempts at comparing paratransit operations with one another will become far less difficult. Electronic archiving will make comparison of the same company to another time period far easier, and the accuracy of automation will make all comparisons more credible. Another point follows from the history of transit measures; virtually all measures of transit performance were developed before the introduction of automation and are focused on measurement of fixed route agencies from the providers' point of view. Automation opens the possibility of reorienting the performance measurement set to include larger numbers of quality of service indicators unique to paratransit.

1.4 Methods of Evaluation of Computer Assisted Scheduling and Dispatch Systems

Transit system evaluation and the development of appropriate indicators of system performance have been in development since the inception of public transit systems, but the first national level attempt at introducing uniform performance standards is attributed to the National Committee on Urban Transportation in 1958 (Tomazinas 1975). That meeting produced forerunners of many of the performance indicators still in use today. Tomazinas (1975) also suggested a conceptual framework that has evolved into the dimensions of efficiency, effectiveness, and quality. Pagano and McKnight's work (1983) expanded research in quality measures. Allen and DiCesare (1976) suggested that an evaluation framework is needed and Casey and Collura (1994) proposed such a methodology.

Casey and Collura (1994) proposed their framework in response to the need for consistent reporting during the evaluation of Advanced Public Transportation Systems. The work provides a common framework and methodology for the evaluation of APTS technology. The goal of the work is to structure published evaluations allowing easy transferability of lessons learned. Casey and Collura (1994) also suggest the use of six categories: APTS costs, APTS characteristics, user acceptance, transit system efficiency, transit system effectiveness, and impacts. While encompassing the evaluation of an APTS project from inception to completion, the report explicitly assigns responsibility for specific measurement development and other project unique factors to the on-site investigators.

Once a set of measures has been established, mangers must use them in the decision process. The best way of using the measures is in a comparison against some standard. Miller (1989) suggests that transit evaluation standards may be categorized into three groups; peer group comparison, arbitrary performance standards (either self-imposed or provided by governmental and other funding agencies) and time-series analysis. Each method presents a mix of trade-offs. The most effective manager/evaluator uses portions of each to monitor performance. A short description of each of the three groups follows.

1.4.1 Peer Group Evaluation

Most managers interested in getting a feel for how their organization is performing will at one time or another attempt to compare their team's performance against that of others. This is peer group evaluation. Some managers attempt to emulate best practice, others try to justify investment or even sub-optimal performance. In any case, an attempt is made to locate an organization that is similar enough to give credibility to the comparison. This task of identifying peer agencies is particularly challenging for small and medium demand response transit managers because of the lack of complete or reliable data. With the increasing reliability of the National Transit Database, the task of identifying peers is becoming somewhat less daunting. Peer group evaluation becomes far less challenging as more paratransit operations are automated with CASD. The increased accuracy and sample size of providers make the peer comparison ever more useful in locating similar agencies and accomplishing realistic analysis.

The variety of demand response missions, service areas and operational configurations complicate the use of peer group analysis. Some agencies operate as union free shops while others are fully unionized; some managers operate a fleet of private vehicles while others have varying numbers of municipal vehicles assigned to the pool. Revenue may come from as few as two agencies or as many as thirty.

Miller (1980) reports on the issue of dissimilar service areas and argues that peer comparison with performance data reliant on mileage or time is difficult except in the rare circumstance that properties are located in similarly developed geographic and demographic areas. Some transit managers have avoided the use of peer group comparison altogether for fear they may be compared to inappropriate peers using arbitrary standards over which managers may have little control.

Carter and Lomax (1992) and CUTR (1998) have introduced peer group selection and assessment methodologies. Carter and Lomax (1992) use seven performance variables in a methodology designed for small and rural transit operators in Texas. The CUTR (1998) work compares demand response properties based on nine variables. Both methods use a similar process to compare potential peers across a range of variables, using one or more variables as primary peer group identifiers and others as secondary indicators. Both methods use peak fleet size as a primary peer group choice factor. Miller (1989), who also investigated the viability of peer group comparisons, suggests that in addition to those variables introduced by CUTR (1998) and Carter and Lomax (1992), average trip length, population density and type of service provided may be good candidates for peer selection variables. Because the CUTR (1998) methodology is currently in use for annual evaluations of Florida paratransit operators, a more detailed description of their process is presented.

CUTR (1998) uses the nine variables of peak fleet size, passenger trips, revenue miles, revenue hours, average speed, total operating expense, geographic location, service area population, and service area density to select appropriate peers. The three primary peer selection determinants are population density, revenue miles, and average speed.

The first step in the CUTR (1998) methodology splits potential peers into groups by peak fleet size. Paratransit properties are grouped in ranges from 1 through 19 peak vehicles, 20 through 49, 50 through 99, and greater than 99 peak vehicles. Paratransit operations in the same size range as the property being evaluated are selected in the first round. Subsequent steps compare the potential peers across six measurements: passenger trips, revenue hours, total operating expense, geographic location, service area population, and service area density. Scores are developed by awarding one point for each variable that is within one standard deviation of the mean measure of that variable of the transit agency under consideration. An additional one-half point weight is added if the potential peer is within one standard deviation of the three primary measures of population density, revenue miles, or average speed. Agencies with the highest point value are selected as peers.

1.4.2 Industry/Government Norms

Industry/government norms are performance standards used as benchmarks. Most paratransit operators are subject to performance standards of this kind. The measures are common in contracts under which many private operators provide service. The contract may include ridership levels, revenue standards or a requirement to not exceed particular mileage or revenue hours ceilings. The tracking of subsequent measures such as load factors, variations of revenue hours or miles may also be required. The difficulty is that there are few industry norms or government standards provided as benchmarks. The few in use are commonly provided by funding agencies and are limited to the unique circumstances in which they were developed (Miller 1989).

Difficulties with norms or standards follow first from a lack of industry wide agreement either on which measures to use or what level of attainment of any particular measure is "average". As Miller (1989) points out, actual productivity rates *do* vary widely, depending on many factors including type of passenger being transported, trip length, and trip purpose. What may be a very productive ratio in one area may be sub-standard in another. Because of the arbitrary nature and limited use of these measures, they are of little value in evaluations of paratransit properties.

1.4.3 Time Series Analysis

Time series analysis is one of the most commonly used analysis techniques in paratransit management. Its high rate of usage is related to the ease of data collection and lack of need to collect similar data from other organizations. Time-series analysis compares changes in data from the same agency over time. Because of the uniqueness of the individual properties in terms of geography, demographics, funding, and reporting requirements, the time series analysis is often the simplest and most effective means of examining paratransit properties (Fielding 1978, Miller 1980, Carter-Goble and Assoc. 1982). A time-series analysis requires a similar data collection effort as peer group analysis, but does not take into account other agency performance, so it is significantly less time intensive.

1.4.4 Before and After Studies

Before and after studies are a special case of time series analysis. The difference is that a before and after analysis is predicated on some major event affecting the organization as a whole. The installation of CASD is the obvious application of the before and after study. In this kind of study, the full range of performance measures in the pre-installation period is compared to the same performance measures from the post automation period.

Investigations by Stone (1994), Khattak and Hickman (1998) and this study indicate that sparse literature is available reporting on before and after studies of the transition from manual to automated dispatch systems. This is because significant barriers to such studies exist. These barriers are: (1) the need for the large database required to document change and (2) lack of organizational stability in the dynamic paratransit environment. Dynamics in paratransit include high driver turnover and absenteeism rates, changes in vehicle fleet size or capacity and composition, and service area size and revenue changes. Lack of a database of previous operational information along with current reporting requirements have resulted in the retention of data relevant to reporting cycles rather than to in-depth analysis of the agency's productivity. Additionally, because most properties either accomplished automation incrementally or did so without public funding, few efforts were undertaken which follow the before and after effects of automation.

Stone's study (1996) of the Winston-Salem Transit Authority (WSTA) is the only known published work which documents the before and after effects of Computer Assisted Scheduling using modern software and hardware. The WSTA study documented many of the positive effects predicted by Goedell (1996) but the study's final results were not yet released at the time of this literature review.

Kikuchi (1989) did accomplish a before and after study of a paratransit property, but his software was experimental in nature, and used optimization procedures and software designed exclusively for the property evaluated in the study. He described the difficulties of tracking and related management requirements of paratransit operations. His study, completed as computer technology was just beginning to match the speed and memory needs of paratransit, developed background and criteria for future automated support of paratransit operations. A primary focus of the study was to endorse the applicability of automation to support paratransit organizations. Kikuchi (1989) concludes that paratransit operations will become far more productive by integrating computer technology into daily activities of scheduling, billing and reporting. The paratransit property in which Kikuchi's team installed his version of CASD reported gains in load factors for full-time drivers, the stated goal of the software development.

1.5 Effects of Automation

There are a wide range of positive outcomes that may occur following installation of computers in a work environment. The obvious gains are increased productivity, reduction in manual calculations, and increases in decision quality and speed, among many. Other less quantifiable changes may occur in the workforce, such as increases in job satisfaction and enhanced career opportunities.

There are also problems that may be associated with automation of the workplace. The introduction of computers to a work environment may produce a resentment of the new equipment because of the threat to job security. Some workers may simply resent the additional responsibility computerization may bring to lower levels of the organization. Others may resent the potential for work output monitoring that automation brings.

Pagano and Verdin (1987) recommend several strategies to overcome challenges of automation in the workplace. Table 3 contains a display of a range of problems and recommended solutions. The reader is directed to the original research for a more rigorous coverage of the subject. The authors published the matrix in Table 3 as part of an effort to address the potential problems being encountered in the transportation industry resulting from the implementation of workplace automation. Although twelve years have passed, the same issues are relevant in organizations experiencing the transition to computerized operations today. Table 3 lists potential problems across the top row and recommended solutions down the first column. A short discussion of the problems and solutions as proposed by Pagano and Verdin (1987) follows the table.

Table 3 Strategies for Mitigating Workplace Automation Issues

Potential Solution	Problem				
	Reduced Skill Requirements	*Resistance of Users and Specialists*	*Loss of Skilled Personnel*	*Short-term Loss of Productivity*	*Ineffective Use of Technology*
User Participation		X		X	X
Communication Programs		X			X
Gaining Management Support		X			X
Job/Workflow Redesign	X	X	X		X
Training		X		X	X
Incentives and Rewards		X	X		
Career Enhancement Programs			X		
Purchase Adequate Equipment					X

(Pagano and Verdin 1987)

1.5.1 Automation Challenges

The disparity in the valuation of new technology seen in the Khattak and Hickman (1998) poll (managers always rated automation higher than the staff who were to use it) may be related to the kind of resistance described in Pagano and Verdin's (1987) work. A major form of resistance is the lack of desire to implement technology because of fear of resulting job loss. Other forms of resistance may be related to self-confidence; some workers believe that they cannot master new skills such as keyboarding. Pagano and Verdin (1987) note that this last fear is most common in mid and late career male executives.

Another common problem affecting workplaces undergoing automation is what is called "deskilling" by Pagano and Verdin (1987). Deskilling is the kind of change in job skills that may follow installation of computers into a non-automated environment. The most destructive deskilling occurs when most or all of the activities normally handled by a human are replaced by a computer. This may be very apparent in automation of jobs like dispatchers, where the skill is comprised of a number of complicated and difficult to master competencies, such as spatial awareness (the ability to mentally place the position of enroute vehicles in a geographical context), service area geography and personal knowledge of the needs and idiosyncrasies of clients.

Possession of these skills/knowledge bases creates a knowledge hierarchy in the dispatcher/scheduler ranks. When this hierarchy occurs, an individual is able to control access to information. This fosters an environment where dispatchers and schedulers can command significant organizational power. The power accrues because no one else can duplicate the abilities of the dispatcher without significant investment in time and training. In this situation, the dispatcher is able to wield considerable leverage and reap esteem from all levels of the organization.

While automation has the potential to enhance the abilities of many users, the inherent ability of automation to store, access and display information represents a direct threat to many dispatchers by providing a cheap and reliable alternative to some human functions. Taking it a step further, installation of dispatching software can leave the dispatchers in the position of filling a monotonous clerk position where the computer has taken over most of the work for which the dispatcher had previously collected accolades. If not addressed correctly, the dispatcher may feel as if their most important contributions to the organization have been entirely replaced by automation.

In addition, the introduction of automation may have two opposite effects. For those which become proficient, the new technology may be used as a stepping-stone to a new position, but for those who are either unable or unwilling to embrace the new way of doing business, the next step may be to depart the organization in search of less technologically challenging employment.

Pagano and Verdin (1987) note that it is important to be prepared for a short-term loss of productivity following the initial introduction of new technology. The initial productivity reduction will likely be attributable to the requirement to run dual systems until the automated system is fully operational. Another reason for temporary productivity losses may be the ineffective use of the new technology, related to both lack of desire and to lack of understanding of the new equipment.

1.5.2 Strategies

Pagano and Verdin (1987) endorse the well known but difficult to implement strategy of encouraging the involvement of users of automation into the company's technology implementation decisions. Participative strategies are documented as having had dramatic successes in computer implementation.

Another strategy recommended by Pagano and Verdin (1987) is to increase the level of communication to company employees about plans and expected benefits of automation to both the individuals and the organization. It is important to implement a working two-way communication system that allows feedback up and down the organization structure.

Pagano and Verdin (1987) emphasize that not all management staff are automatically supportive of efforts to automate the workplace, so it is just as important to gain management support as it is to line up employee support. Employees often shape their response to workplace changes using their immediate manager as a role model, meaning advance training and buy-in must occur in the management ranks before introduction to the general workplace.

Because unexpected effects may occur in jobs not directly related to positions transitioning to computerized tasks, all positions should be reviewed thoroughly to ensure that workers in each position are aware of how the new technology will affect them. Pagano and Verdin (1987) offer an example of supervisors receiving increases in quality and quantity of information as an unexpected change for some managers.

Ongoing training is a necessary component of technology change. Training increases familiarity with the new equipment, removing both intimidation and frustration from workers' interaction with equipment. As confidence increases, innovation and productivity follows.

Pagano and Verdin (1987) also suggest that incentives, rewards and career enhancement programs may reduce workplace turbulence following the introduction of computers into the workplace. Incentives may include increased compensation for those most capable with the new technology. This strategy provides a foundation for recognizing employees possessing high potential for the organization who may then be oriented toward higher positions.

1.6 Efficiency Measures

One definition of efficiency is "...how well a system is using its resources to provide transit services. The ratio of output (e.g., level of service provided) to input (e.g., cost or resource usage), that is, providing the desired result with a minimum of effort, expense, waste, and so on (doing things right)" (Urban Public Transportation Glossary 1989).

Tomazinas (1975) documented 71 performance measures in his comprehensive transit measurement study. He argues that efficiency measures change according to the purpose of the analysis. In this view, the transit operator, the transit user, the government and society at large will each have differing measurement focal points. Table 4 illustrates his assignment into "points of view" from the operator and user and the particular focus implied by each viewpoint. This abbreviated table excludes both the views of government and of society at large, because of their inapplicability to the present study.

The contrasting values between user and provider associated with transit services is clear from a comparison of the two columns. In the view of many researchers, many of the values included in the point of view of users are more properly included in a discussion of quality, and so coverage of those issues is deferred until later in this paper.

Table 4 Transit Efficiency: Two Points of View from Tomazinas (1975)

Point of View	
Operator	*User*
• Unit Costs	• Cost of Travel
• Input of Resources	• Quality of Travel
• Relative Distribution of Costs	• Reliability of Service
• Provision of Service	• Safety and Security
• Collection of Revenues	• Availability of Service

Tomazinas (1975) collated and presented a wide range of efficiency measures with the intent to develop a conceptual framework and justification of their use as opposed to a rigorous development of which measure is "best" or most important. He explicitly warns against using any measure in a vacuum, without adding the context in which the agency is operating.

Tomazinas (1975) presents 27 efficiency measures, grouped into five categories, and these are shown in Table 5. These early measures are reflected in most of the work that follows Tomazinas over the last 25 years and so discussion of these are contained in the relevant studies in which they appear. The table is provided as a means of tracing the "lineage" of each measure as it developed through use and research.

Table 5 Efficiency Measures from Tomazinas (1975)

Unit Costs Measurements

- Total Operating Expenditure per Vehicle-Mile Operated
- Total Operating Expenditure per Passenger-Mile Carried
- Total Operating Expenditure per Passenger Carried
- Direct Cost of Conducting Transportation per Vehicle-Mile Operated
- Direct Cost of Conducting Transportation per Passenger-Mile Carried
- Direct Cost of Conducting Transportation per Passenger Carried

Input of Resources

- Total Labor Input per Vehicle-Mile Operated
- Total Labor Input per Passenger-Mile Carried
- Total Labor Input per Passenger Carried
- Total Energy Consumed per Vehicle-Mile
- Total Energy Consumed per Passenger Carried
- Total Energy Consumed per Passenger Mile

Relative Distribution of Costs

- Direct Costs of Conducting Transportation per Dollar of Total Operating Expenses
- Utilized Capacity per Available (peak) Capacity

Provision of Services

- Average Vehicle-Miles per Vehicle
- Passengers Carried per Vehicle (daily or annually)
- Vehicle-Miles Operated per Man Hour of Labor
- Passenger-Miles per Man Hour of Labor
- Passengers Carried per Man Hour of Labor
- Vehicle-Miles Operated per Passenger Carried
- Seat-Miles per Passenger Mile

Collection of Revenues

- Operating Revenues per Vehicle Mile
- Operating Revenues per Passenger Mile
- Operating Revenues per Passenger Carried
- Operating Revenue per Man Hour of Total Labor Input
- Operating Revenue per Dollar of Direct Cost of Conducting Transportation
- Operating Revenue per Vehicle

Fielding et al. (1978) contributed to transit measurement research by analyzing operational data from a group of individual transit properties in what seems to be the first effort of its kind. The project's goal was to develop an easy to use set of transit measures.

A significant hurdle preventing the kind of analysis the authors desired was the availability of operational data. Efficiency and effectiveness measures presented by the authors are based on data availability rather than their choice of ideal indicators. This lack of real data is a common thread running thorough most of the researched material. Fielding, et al. (1978) suggest that based on data availability, the indicators contained in Table 6 are very useful measures of a transit system's efficiency.

Table 6 Efficiency Measures from Fielding, et al. (1978)

- Revenue Vehicle Hours per Employee
- Revenue Vehicle Hours per Vehicle
- Operating Expense per Revenue Vehicle Hour

According to Fielding, et al. (1978), efficiency indicators are used to evaluate the process by which transit services are produced; that is, the relationship of inputs to outputs. The authors suggest that particular strengths of the first two measures in Table 6 are that they are measured in physical units, rather than dollar units. Fielding, et al. (1978) and Tomazinas (1975) argue that an advantage with this approach is that it allows comparison across properties, an early endorsement of the use of transit measures in peer group analysis. An emphasis on physical units also prevents differences in wages and prices from complicating peer comparisons. The following definitions are reproduced from the Fielding (1978) study:

1. *Revenue Vehicle Hours per Employee* - An efficiency measure of labor productivity. This indicator will be affected by the size of the administrative staff, its peak/off peak ratio, hours of service, and labor work rules. The use of "total" employees in this measure introduces some error as workday and workweek lengths may differ significantly between properties and yet appear similar in this measure. The authors argue for the use of total employee hours in the denominator if available.

2. *Revenue Vehicle Hours per Vehicle* - An efficiency measure of vehicle utilization. This indicator is affected by the service hours of the property, the peak/off-peak ratio, labor work rules, and the daily service vehicle/total fleet ratio. Since vehicle costs are a much smaller portion of operating costs than labor, a favorable score on this indicator is not as important in transit management as a high score on Revenue Vehicle Hours per Employee.

3. *Operating Expense per Revenue Vehicle Hour* - An efficiency measure of total inputs per unit of provided service. This indicator is affected by a property's peak/off-peak ratio, hours of daily service, and labor work rules. Properties which share support facilities with other organizations, e.g. a municipal operator whose maintenance and accounting is done by the larger municipal operator, may achieve somewhat inflated efficiencies on this indicator if costs of such services are not fully billed to the transit operation.

The measures contained in Table 7 are taken from Dave Consulting, Inc.'s analysis (1984) of the Chicago Transit Authority's Special Services Program, which had been started in 1981 without a standardized method of accounting for service performance in its target market. The study recommended 14 measures: 6 are efficiency measures, 4 are effectiveness measures and 4 are quality measures. The efficiency measures are:

Table 7 Efficiency Measures from Dave Consulting, Inc. (1984)

• Passengers per Service Hour
• Scheduled Trips as a Percent of Total Requests
• No-Show Passengers as Percent of Total Booked Trips
• Late Cancellations as Percent of Total Booked Trips
• Gross Operating Costs per Vehicle Service Hour
• Platform Hours as a Percent of Vehicle Service Hours

1. *Passengers per Service Hour* - A productivity measure indicating scheduling efficiency and level of individual demand being served. The authors suggest that group trips and system policies have the greatest effect on this measure.

2. *Scheduled Trips as Percent of Total Requests* - A measure of scheduling effectiveness versus demand for services, that is, how close the system is to meeting its actual demand for service.

3. *No-Show Passengers as Percent of Total Booked Trips* - Service policy indicator monitoring problems associated with no-show passengers.

4. *Late Cancellations as Percent of Total Booked Trips* - Service policy indicator monitoring problems associated with late cancellations.

5. *Gross Operating Costs per Vehicle Service Hour* - Cost-efficiency measure of total resources required (in dollars) to produce an hour of special transit service.

6. *Platform Hours as Percent of Vehicle Service Hours* - Labor efficiency measure indicating the productive time required for a trip. The measure is affected by size of service area or travel zones, trip making patterns and scheduling practice. "Total platform hours" is all the time during which an operator operates a revenue vehicle, either in service or in deadheading, including layovers, breaks (and lunch, if paid time).

Table 8 consolidates efficiency measures from a Carter-Goble and Assoc. (1982) project designed to assist small rural and urban transit system managers to monitor and evaluate their systems. The intent was not to create new measures, but to highlight the use of information already easily obtainable by the transit managers for use in their decision process. The authors suggest that the measures presented in their report are most effective if used with annual data because of fluctuations of cash flow and associated changes, although they acknowledge the need to do more frequent assessments.

The Carter-Goble and Assoc. (1982) study is oriented towards developing performance goals for the purpose of service enhancements. The efficiency, effectiveness and quality measures from their study are designed to support that objective. The report groups all measures into either financial or non-financial and then into seven "functional" categories which include three financial and four non-financial groups. Each of the seven categories are also reduced to smaller sets called "General", "Supplemental" or "Other".

The Carter-Goble and Assoc. (1982) authors argue that "General" indicators have the broadest level of measurement and are useful for either time-series or peer group comparisons. "Supplemental" indicators represent a more detailed level of analysis, especially for system-wide assessment of individual routes or different sub-components of service. The authors suggest that supplemental indicators are unique to individual transit properties and so are difficult to use for peer comparison purposes. In Table 8, general indicators are denoted with a "G", supplemental indicators with an "S", and other indicators with an "O".

The first two financial performance measures in Table 8, (Total Expenses ÷ Total Vehicle Miles and Total Expenses ÷ Total Vehicle Hours) are general indicators measuring how economically a system is providing service. "Total Expenses" means total operating expenses (operating and administrative) for the entire system, but excluding capital purchase expenses. "Vehicle Miles" equals all mileage, including deadhead. "Vehicle Hours" equals all vehicle time, including deadhead. The third general financial measure (Total Expenses ÷ Total Passengers) is a measure of cost effectiveness, or the extent to which a system is accomplishing its major purpose of moving people with specified resources.

The three supplemental financial indicators (Total Expenses ÷ Revenue Hours, Total Expenses ÷ Revenue Miles and Administrative Expenses ÷ Total Expenses) measure cost efficiency, or the economy of a system in providing service.

Table 8 Efficiency Measures from Carter-Goble, Assoc. (1982)

Financial Performance

- (G) Total Expenses ÷ Total Vehicle Miles
- (G) Total Expenses ÷ Total Vehicle Hours
- (G) Total Expenses ÷ Total Passengers
- (S) Total Expenses ÷ Revenue Hours
- (S) Administrative Expenses ÷ Total Expenses
- (S) Total Expenses ÷ Revenue Miles
- (O) Dispatch Cost ÷ Total Expenses
- (O) Dispatch Cost ÷ Total Vehicle Hours
- (O) Dispatch Cost ÷ Total Vehicle Miles
- (O) Driver's Wage and Fringe ÷ Total Vehicle Hours
- (O) Driver's Wage and Fringe ÷ Total Vehicle Miles
- (O) Fuel Cost ÷ Vehicle Miles
- (O) Maintenance Cost ÷ Total Vehicle Hours
- (O) Maintenance Cost ÷ Total Vehicle Miles
- (O) Overtime Pay ÷ Total Pay
- (O) Total Expenses ÷ Number of Employees
- (O) Administrative Cost ÷ Total Vehicle Hours
- (O) Administrative Cost ÷ Total Vehicle Miles
- (O) Administrative Staff ÷ Total Staff
- (O) Fuel Cost ÷ Total Expenses
- (O) Heating Fuel Consumed ÷ Area of Fixed Facility
- (O) Maintenance Hours ÷ Number of Revenue Vehicles
- (O) Vehicle Hours ÷ Number of Peak Period Vehicles
- (O) Vehicle Miles ÷ Employees
- (O) Vehicle Hours ÷ Pay Hours
- (O) Revenue Miles ÷ Vehicle Miles
- (O) Marketing Cost ÷ Total Expenses
- (O) Vehicle Miles ÷ Gallons of Fuel
- (O) Vehicle Miles ÷ Quarts of Oil
- (O) Number of Vehicles ÷ Number of Mechanics

Revenue

- (G) Revenue Miles ÷ Vehicle Miles
- (G) Total revenue ÷ Revenue Miles
- (G) Total Revenue ÷ Total Expenses

Subsidy

- (G) Subsidy ÷ Vehicle Miles
- (G) Subsidy ÷ Vehicle Hours

("G" – General, "S" – Supplemental, "O" - Other)

The large number of "Other" indicators are proposed for internal use by local management, usually in a time-series evaluation. The authors also suggest that these groups of measures are particularly susceptible to fluctuations of the economy, so that even internal, time-series comparisons should be made with caution.

The two 'Subsidy' measures explore the same kinds of efficiency as other revenue driven indicators, but focus on revenue derived from government financial support, and so indicate how efficiently the public's tax money is being spent. Subsidy measures are particularly difficult to use in peer comparison because of the number of different kinds of subsidy received from all levels of government. Time series analysis is likewise difficult because of the number of funding changes occurring each year during the government budget development process.

Kikuchi's (1988) report is the only before and after study focused on the transition from manual to automated operations found during this literature review. Regretfully, little is said about measurement development and rationale. The project measured performance across two dimensions: operating efficiency, and level of service (quality). Operating efficiency is said to be comprised of four components (1) workload distribution among drivers, (2) travel miles and time of empty vehicle, (3) level of passenger consolidation (load factor), and (4) vehicle travel speed (revenue travel and average daily travel).

In the Kikuchi (1988) project, the primary effort was to increase passenger loads on vehicles operated by full-time drivers. Passenger load levels were monitored by tracking the number of passenger trips per day and daily passenger distance. His measures are shown in Table 9.

Table 9 Efficiency Measures from Kikuchi (1988)

- Total Miles ÷ Revenue Miles
- Total Hours ÷ Revenue Hours
- Revenue Miles ÷ Revenue Hours
- Total Daily Passenger Trips ÷ Total Loaded Segments of Vehicle Travel ('loaded segment' is analogous to a revenue vehicle mile)

Miller (1989) developed efficiency measures specifically for paratransit operators. He argues that measures of vehicle and driver productivity should be given priority as efficiency measures because of the major impacts changes in these indicators represent. He argues that three efficiency indicators are most relevant: Operating Expense per Vehicle Hour, Administrative Expense as a percentage of Total Expenses, and Live Hours as a percentage of Paid Driver Hours.

Miller (1989) argues that Operating Expense ÷ Vehicle Hour is the most important indicator shown in Table 10 because it measures how efficiently or economically the paratransit system is providing service. The following two measures (Administrative expense ÷ Total Expense and Live Hours ÷ Paid Driver Hours) are indicators that may point to causes if the Expense per Hour figure is too high. He suggests that Live Hours ÷ Paid Driver Hours is a useful measure to explore the efficiency of dispatching and labor utilization, because it shows what percentage of time a driver is actually transporting passengers.

Table 10 Efficiency Measures from Miller (1989)

- Operating Expense ÷ Vehicle Hour
- Administrative Expense ÷ Total Expense
- Live Hours ÷ Paid Driver Hours
- Passenger Revenue ÷ One-Way Passenger Trip
- Operating Expense per One-Way Trip

Carter and Lomax (1992) introduce the seven performance categories of cost efficiency, cost effectiveness, service utilization/effectiveness, vehicle utilization/ efficiency, quality of service, labor productivity and accessibility. Those seven categories are measured by eight "indicators" of which two are efficiency measures, four are effectiveness measures and two are quality measures. InTable 11, the relationship of the two efficiency measures to their categories as assigned by Carter and Lomax (1992) is shown in parentheses. The authors provide the following discussion of the efficiency measures they present in their study:

1. *Total Vehicle Miles per Total Expense* – Measures the amount of output for each dollar of expense. This is the opposite of the more familiar cost per vehicle mile. The inverted form provides for a better graphic presentation and comparison. The authors indicate that Cost per Service Vehicle was considered and dismissed as a measure because Vehicle Miles per Expense is a more descriptive indicator of output per cost.

2. *Total Vehicle Miles per Vehicle* - Indicates the extent to which each transit vehicle is being utilized. This measure is used most effectively with annualized data, and must be used in the context of the agency it represents. Higher results may mean simply that the agency is operating with too few vehicles for its service area or demand.

Carter and Lomax (1992) developed the measures displayed in Table 11 to assist in the efforts then underway to create appropriate transit measures for small and rural transit systems. While proposing a peer evaluation methodology, their conclusions suggest that the time investment to track and calculate peer agency performance is counterproductive, and that time-series analysis or simple comparison against measures contained in current publications would provide adequate information for most assessments.

Table 11 Efficiency Measures from Carter and Lomax (1992)

• Total Vehicle Miles ÷ Total Expenses	(Cost Efficiency)
• Total Vehicle Miles per Vehicle	(Vehicle Utilization)

The Center for Urban Transportation Research, University of South Florida (CUTR 1998) developed measures of efficiency, effectiveness and quality in response to a set of Florida statutes (s.341.041, 341.071, 341.052) that require annual reporting of "productivity and performance measures" to remain eligible for state funding. CUTR selected these measures because they are required elements for submission to the National Transit Database. An interesting outcome of the reporting mandate is an ability for Florida paratransit operators to view and use relatively sophisticated annual peer and trend-line analysis without the time and labor investment required to do the analysis on their own.

CUTR makes a distinction between measures used for municipal transit agencies which operate their own paratransit fleets and those agencies which are contracted to provide service. In developing measures for these differing operations, CUTR acknowledges the difficulties in collecting data from privately owned contracted properties. When reporting on privately owned agencies, CUTR proposes reporting fewer efficiency measures for contracted services than for directly owned properties. In Table 12, those measures not used by private transit agencies are denoted with an asterisk - "*". The difference in use of measures follows from the difficulties encountered in collecting information from privately owned agencies.

Table 12 Efficiency Measures from the Center for Urban Transportation Research, University of South Florida (1998)

Cost Efficiency	*Vehicle Utilization*
• Operating Expense per Capita	• Vehicle Miles per Peak Vehicle
• Operating Expense per Peak Vehicle	• Vehicle Hours per Peak Vehicle
• Operating Expense per Passenger Trip	• Revenue Miles per Vehicle Mile
• Operating Expense per Passenger Mile	• Revenue Miles per Total Vehicles
• Operating Expense per Revenue Mile	• Revenue Hours per Total Vehicles
• Operating Expense per Revenue Hour	*Labor Productivity*
• *Maintenance Expense per Operating Expense	• *Revenue Hours per Employee
• *Maintenance Expense per Revenue Mile	• *Passenger Trips per Employee
Operating Ratios	*Energy Utilization*
• *Farebox Recovery	• *Vehicle Miles per Gallon
• *Local Revenue per Operating Expense	*Fare*
• *Operating Revenue per Operating Expense	• *Average Fare

("*" denotes measure not used for privately owned transit agencies)

CUTR has used measures taken directly from the National Transit Database (NTD) and so brings an element of standardization to their evaluation process. A review of select measures as taken from the CUTR (1998) report follows:

1. *Operating Expense per Capita* - Annual operating budget divided by the county/service area population; a measure of the resource commitment to transit by the community.

2. *Operating Expense per Peak Vehicle* - Total operating expense per vehicle operated in maximum service (peak vehicle); provides a measure of the resources required per vehicle to have a coach in operation for a year.

3. *Operating Expense per Passenger Trip* - Operating expenditures divided by the total annual ridership; a measure of the efficiency of transporting riders, one of the key indicators of comparative performance of transit properties since it reflects both the efficiency with which service is delivered and the market demands for service.

4. *Operating Expense per Passenger Mile* - Operating expense divided by the number of passenger miles; takes into account the impact of trip length on performance since some operators provide lengthy trips while others provide short trips.

5. *Operating Expense per Revenue Mile* - Operating Expense divided by the annual miles of revenue service; a measure of the efficiency with which service is delivered and is another key comparative indicator.

6. *Operating Expense per Revenue Hour* - Operating Expense divided by revenue hours of operation; a key comparative measure which differs from operating expense per vehicle mile in that the vehicle speed is factored out. This is often important since vehicle speed is strongly influenced by local traffic conditions.

7. *Maintenance Expense per Revenue Mile* - Maintenance cost divided by the revenue miles.

8. *Maintenance Expense per Operating Expense* - Calculated by dividing maintenance expense by operating expense; expressed as a percent of total operating expense.

9. *Farebox Recovery* - Ratio of passenger fare revenues to total operating expenses; an indicator of the share of revenues provided by the passengers.

10. *Local Revenue per Operating Expense* - Ratio of total local commitment with respect to total operating expense.

11. *Operating Revenue per Operating Expense* - Operating ratio calculated by dividing operating revenue by total operating expense.

12. *Vehicle Miles per Peak Vehicle* - Vehicle miles divided by the number of peak vehicles. It is an indicator of how intensively the equipment is used and is influenced by the bus travel speeds as well as by the levels of service in off-peak time periods. A more uniform demand for service over the day would result in a higher number.

13. *Vehicle Hours per Peak Vehicle* - Substitutes vehicle hours for vehicle miles and again reflects how intensively equipment is utilized.

14. *Revenue Miles per Vehicle Mile* - Reflects how much of the total vehicle operation is in passenger service. Higher ratios are favorable, but garage location, training needs, and other considerations may influence the ratio.

15. *Revenue Miles per Total Vehicles* - Total revenue miles of service that are provided by each vehicle available for maximum service.

16. *Revenue Hours per Total Vehicles* - Indicates total revenue hours of service provided by each vehicle available for maximum service.

17. *Revenue Hours Per Employee* - Reflects overall labor productivity.

18. *Passenger Trips per Employee* - Another measure of overall labor productivity.

19. *Vehicle Miles per Gallon* - Vehicle miles of service divided by total gallons consumed and is a measure of energy utilization.

20. *Average Fare* - Passenger fare revenues divided by the total number of passenger trips.

1.7 Effectiveness

Effectiveness is "...the use of output to accomplish goals, or the benefit the public actually receives from the service. [It is] the correspondence of provided service to intended output or objectives, particularly the character and location of service; in other words, producing the intended result (doing the right things). Also, the degree to which the desired level of service is being provided to meet stated goals and objectives ..." (Urban Public Transportation Glossary 1989).

Fielding, et al. (1978, p. 367) suggest that effectiveness is the "...comparison of produced output (provided services to intended output or objectives; that is 'doing the right things'. Measures of effectiveness are concerned with the extent to which the service provided – in terms of quantity, location and character – corresponds to the goals and objectives established for it by government and the needs of the citizens." They recommend four measures shown in Table 13 as a "first iteration" of measures of effectiveness and suggest that other more relevant measures may be introduced from further research. This early study noted the effect of politics on transit measures; reference to political issues is seen in two of the following four definitions for Fielding et al. (1978). This study is also one of the earliest works found addressing the unique needs of measures for demand response agencies. The effectiveness measures discussed in the Fielding et al. (1978) study are shown in Table 13.

1. *Revenue Passengers per Service Area Population* - An effectiveness measure of the penetration of transit into its potential market. Obviously, one important factor here is the definition of "service area"; a definition which is generally made by political agencies rather than by transit managers. To the extent that political agencies have a strong incentive to increase the size of the service area, this indicator may be unfair to some properties.

Table 13 Effectiveness Measures from Fielding, et al. (1978)

• Revenue Passengers per Service Area Population
• Percent of Population Served
• Total Passengers per Vehicle
• Revenue Passengers per Revenue Vehicle Hours

2. *Percent of Population Served* - The proportion of the service area population that has access to transit service. This indicator also has a potential problem with the political

definition of the service area. Another weakness is that it only measures whether someone is near (within one-quarter mile of) transit service, not how good that service is. For example, it ignores both frequency of service and circuity of routes. Demand-responsive systems will have scores of 1.00 because access is uniformly available throughout the service area.

3. *Total Passengers per Vehicle* - An effectiveness measure of system patronage and capacity utilization indexed to an average transit vehicle. This indicator is affected by average trip length, rate of transfers in the system, peak/off-peak ratio, and daily-service vehicle/total fleet ratio.

4. *Revenue Passengers per Revenue Vehicle Hour* - An effectiveness measure of system patronage per unit of produced service. This indicator is affected by the peak/off-peak ratio, hours of service, vehicle capacity and average trip length of a property.

Fielding, et al. (1978) also suggested two other measures they called "Overall Indicators", identified as such because they incorporate elements of both efficiency and effectiveness in a single indicator. These two measures are displayed in Table 14.

Table 14 Overall Indicators from Fielding et al. (1978)

- Operating Expense per Total Passenger
- Operating Expense per Revenue Passenger

1. *Operating Expense per Total Passenger* - An indicator of total resource inputs per trip. A system with an unusually high rate of transfers would look artificially good on this measure since it is based on total "unlinked" trips and is using too large a divisor. A further problem is that it ignores operating revenues. A system that charged extremely low fares, thereby attracting more passengers, would look very good on this measure even though its operating ratio was very poor.

2. *Operating Expense per Revenue Passenger* - An indicator of total resource inputs per trip. A system with an unusually high number of free-fare passengers would look artificially bad under this measure, because the divisor would be understated. A further problem is that it ignores the fare effects mentioned above.

Fielding, et al. (1978) raise the issue of data unavailability. They note that "very few data elements are widely available from transit operators." They suggest that many potentially valuable statistics are simply not collected in any standardized way. Of the potential data, the authors argue that two; 'Passenger Miles' and 'Employee Hours' may be the most valuable to start collecting. Primarily because of the lag time in measure response, Fielding, et al. (1978) argue against using measures of energy efficiency as performance indicators for transit agencies.

An argument for use of passenger miles over total passengers carried is based on the premise that Passenger Miles is a more accurate indicator of average vehicle occupancy (service consumed) than Total Passengers. Seat Miles is presented as a better indicator of service production than

Total Vehicle Miles. With these indicators, it is argued, highly significant measures of vehicle utilization and service consumption may be computed. The authors also advocate the use of Employee Hours when possible in labor input measures, because of the ability to strip out effects of part-time staff and overtime.

Another desirable measure suggested by Fielding, et al., but also unavailable during their study's publication because of missing data, is "Seat Miles". Seat Miles (Vehicle Miles × Seating Capacity) according to Fielding, et al. (1978), could provide a measure of the total service produced which is able to take into account seating capacity of the system's vehicle fleet. The authors argue that this is a more accurate measure of service produced than either total passengers or total vehicle miles. Additionally, Seat Miles provide a method of comparing systems using different vehicle capacities. The authors raise the potential problem though, that using seat miles ignores the standee capacity of most transit vehicles used in fixed route service. Two other desirable measures, unable to be used in the Fielding et al. (1978) study were "Operating Cost per Seat Mile" and "Operating Expense per Passenger Mile" both of which are dependent on collection of labor hours data. Using labor hours gives a far more accurate picture of labor input than simple personnel counts.

Carter-Goble and Assoc. (1982) also have developed measures of effectiveness for transit agencies. These are found in Table 15. The five supplemental measures using 'Passenger Revenue' as the numerator measure cost effectiveness by comparing effects (passenger revenue) to inputs and outputs (miles, passengers, etc.). These help pinpoint whether problems are related to passenger revenue versus total revenue, the fare collection system, etc. The authors suggest that revenue measures change more slowly than expense measures, because expense measures are far quicker to reflect economic changes (inflation). This prompts the authors again to caution that these measures must be adjusted either to ensure comparability or to be compared to a time period known to be similar. They note that these measures may be useful in measuring the results of a marketing campaign. The three supplemental 'Ridership' measures shown in Table 15 explore the societal impact of the service. "Elderly" in this context is defined as those passengers over the age of 65.

As in the previous Carter-Goble and Assoc. (1982) measurement set (Table 8), "O" denotes an 'Other' measure, likely to be relevant only in the system being evaluated; it would be too unique to use in peer group comparison. "S" denotes a supplemental measure; a more detailed look at subcategories of the system. "G" denotes a general, system wide measure, which is useful in comparison with other transit agencies.

Table 15 Effectiveness Measures from Carter-Goble and Assoc. (1982)

Revenue
- (S) Passenger Revenue÷ Total Revenue
- (S) Passenger Revenue÷ Revenue Hours
- (S) Passenger Revenue÷ Revenue Miles
- (S) Passenger Revenue ÷ Total Expenses
- (S) Passenger Revenue ÷ Total Passengers
- (S) Total Fare-Paying Passenger Revenue ÷ Total Revenue
- (O) Total Revenue ÷ Total Passengers

Ridership
- (G) Total Passengers ÷ Total Vehicle Hours
- (G) Total Passengers ÷ Total Vehicle Miles
- (S) Fare Paying Passengers ÷ Total Passengers
- (S) Current Year Passengers ÷ Previous Year Passengers
- (S) Elderly Passengers ÷ Total Passengers

("S" - Supplemental, "O" - Other, "G" – General)

Fielding, et al. (1983) have identified seven standard fixed route measurements that are reliable indicators of transit performance. The intent of the study was to identify which "Section 15" data now known as the National Transit Database (NTD), was most relevant to performance. While paratransit agencies may have different reporting requirements than the transit district which they service, the ability to standardize reporting by using the NTD indicators could allow for comparative peer data analysis. Fielding's (1983) research suggests the use of the seven attributes shown in Table 16, all elements of standard fixed route transit reporting:

Table 16 Attributes for Evaluating Performance (Fielding, et al. 1983)

- Revenue Vehicle Hours per Operating Expense (Output per Dollar Cost)
- Ratio of Operating Revenue to Operating Expense (Revenue Generation per Expense)
- Vehicle Miles per Peak Vehicle Requirement (Vehicle Efficiency)
- One-Million Vehicle Miles per Accident (Operating Safety)
- Passenger Trips per Revenue Vehicle Hour (Utilization of Service)
- Vehicle Hours per Employee (Labor Efficiency)
- Vehicle Miles per Maintenance Expense (Maintenance Efficiency)

Fielding's seven measures outlined in Table 16 have been refined by Miller (1989) so that they more closely reflect the needs of paratransit. This revised methodology increases the number of efficiency, effectiveness and quality indicators to ten (five efficiency, two effectiveness and three quality) and is derived from thirteen individual data elements that can be retrieved from two primary sources: the driver's log and the agency's financial records. The driver's trip sheet is the primary source document (six of the thirteen elements). Miller (1989) adds the factors "Financial" and "Safety" to the three measurement dimensions efficiency, effectiveness and quality. These include sub-elements measuring Complaints, On-Time vs. Total Pick-ups and "Avoidable Accidents". Because of the nature of the agency being studied, Miller's method emphasizes measurement of service to the senior citizen demographic; of the thirteen data elements proposed by Miller (1989), two are designed to measure service to just that population.

Miller (1989) proposes that the first measure in Table 17 (One-Way Passenger Trips ÷ Vehicle Hour) is the most important effectiveness measure, and further suggests that it is the single most important indicator in paratransit evaluation. He suggests that this measure is important above all others because it tracks how successfully the system is providing its product and how well the supply and demand for service are matched to each other. Senior Citizen One-Way Passenger Trips ÷ Senior Citizen Residents of Service Area is another, more specific measure of the same category as One-Way Passenger Trips ÷ Vehicle Hours. The author suggests that this measure may be modified to reflect any target population (such as low-income or disabled) to identify how well an agency is supporting its designated service groups. Miller (1989) also suggests that an additional use of this kind of measure would be to measure effects of advertising campaigns.

Table 17 Effectiveness Measures from Miller (1989)

- One-Way Passenger Trips ÷ Vehicle Hour
- Senior Citizen One-Way Passenger Trips ÷ Senior Citizen Residents of the Service Area

Table 18 contains the list of effectiveness measures suggested by Dave Consulting, Inc. (1984), following an analysis of the Chicago Transit Authority's Special Services program.

Table 18 Effectiveness Measures from Dave Consulting, Inc. (1984)

- Total Lift Users as Percent of Total Passengers
- Passengers per Vehicle Service Hour
- Gross Operating Cost per Passenger
- Total Wheel Chair Users as Percent of Total Passengers

1. *Total Lift Users as a Percent of Total Requests* – This is a measure of user characteristics. It indicates the percent of clientele that requires a passenger lift. The measure may explain low productivity due to the longer loading time required for lift access.

2. *Passengers per Vehicle Service Hour* – A productivity measure indicating scheduling efficiency and level of individual demand being served. It is affected by the extent of group riding in a system as well as system policies.

3. *Gross Operating Cost per Passenger* – A cost effectiveness measure of total resources required (in dollars) to produce one unit. This is a highly complex indicator affected by many facets of the system's operations including demand.

4. *Total Wheelchair Users as a Percent of Total Passengers* – This is also a measure of user characteristics. It indicates the percent of the clientele that requires passenger lift and securement. The measure may explain low productivity due to longer loading time and securement of wheelchairs.

Carter and Lomax (1992) have developed four measures of effectiveness. Each of these measures is assigned to one of seven performance categories. In Table 19, the relationship of the measure to its category is shown in parentheses following the measure's name.

Table 19 Effectiveness Measures from Carter and Lomax (1992)

• Passenger Trips per Total Expense	(Cost Effectiveness)
• Passenger Trips per Total Vehicle Miles	(Service Utilization)
• Passenger Trips per Employee	(Labor Productivity)
• Total Vehicle Miles per Capita	(Accessibility)

1. *Passenger Trips per Total Expense* – Indicates the number of passengers who are served per dollar of expense. As the authors note, this is the opposite of cost per passenger trip. They suggest that it is a more effective way of presenting and comparing this data. Because the measure is affected by length of trip and ridership, this measure may be biased against systems in rural areas.

2. *Passenger Trips per Total Vehicle Miles* – Indicates the extent to which transit service is utilized by patrons. The authors chose this measure over passenger trips per capita and passenger trips per hour because it is more representative of service utilization for nonurbanized areas. The underlying problem causing the choice was seen by the authors as inconsistency in the definition of a 'non-urbanized' area.

3. *Passenger Trips per Employee* – Although recommended, this measure is not used in the Carter and Lomax (1992) study because of data limitations.

4. *Total Vehicle Miles per Capita* – This accessibility measure indicates how available transit service is to the service area population. The authors chose Total Vehicle Miles per Capita instead of vehicle miles per square mile of service area because the population data had been adjusted in this case to reflect only the non-urbanized area.

The measures displayed in Table 20 are from CUTR's *Demand-Response Peer Reviews Analysis 1996 (CUTR 1998)*. In contrast to the efficiency measures in their analysis, the same sets of effectiveness measures are used for both directly operated and purchased demand response transit services.

Table 20 Effectiveness Measures from the Center for Urban Transportation Research, University of South Florida (1998)

Service Consumption	*Service Supply*
• Passenger Trips per Capita	• Vehicle Miles per Capita
• Passenger Trips per Revenue Mile	*Availability*
• Passenger Trips per Revenue Hour	• Revenue Miles per Route Miles

The following definitions, reproduced from CUTR's glossary, are provided for Table 20:

1. *Vehicle Miles per Capita* - Total number of annual vehicle miles divided by the service area's population. This can be characterized as the number of miles of service provided for each man, woman, and child in the service area and is a measure of the extensiveness of service provided in the service area.

2. *Passenger Trips per Capita* - Average number of transit boardings per person per year. This number is larger in areas where public transportation is emphasized and in areas where there are more transit dependents, and is a measure of the extent to which the public utilizes transit in a given service area.

3. *Passenger Trips per Revenue Mile* - The ratio of passenger trips to revenue miles of service; a key indicator of service effectiveness that is influenced by the level of demand and the supply of service provided.

4. *Passenger Trips per Revenue Hour* - The ratio of passenger trips to revenue hours of operation. This reports on the effectiveness of the service since hours are a better representation of the resources consumed in providing service.

5. *Revenue Miles per Route Mile* - Number of revenue miles divided by the number of directional route miles of service.

1.8 Quality Measures

For paratransit, quality is defined as: "A variety of measures meant to denote the quality of service provided, generally in terms of total travel time or a specific component of total travel time." (Urban Public Transportation Glossary 1989). As early as 1975, Tomazinas documented the importance of quality of service to users of transit services. He concluded that transit customers consistently rate quality attributes higher than standard efficiency or effectiveness measures. He also noted that traditional methods of measurement of efficiency and effectiveness are often inversely related to quality measures. This can mean that a system seen as perfectly efficient from the transit provider's point of view is completely inefficient from the users point of view.

As noted in Section 4, much of today's foundation in performance measurement was presented in Tomazinas' (1975) work which drew together nearly all of the measures still used today. Tomazinas argued for 14 quality measures, or in his terminology, efficiencies from "the point of view of the user". These are presented in Table 21, which is abbreviated to exclude three purely fixed route measures.

Table 21 Quality Measures from Tomazinas (1975)

Cost of Travel	*Comfort of Service*
• Direct Cost of Conducting Transportation per Vehicle Mile Carried	• Floor Area of Vehicle per Passenger Carried
• Total Travel Cost per Unit of Distance Traveled	• Ratio of Average Number of Seats Available to the Average Number of Passengers Carried
Quality of Travel	*Reliability*
• Proximity of Service	• Number of On-Time Arrivals per all Movements
• Frequency of Service	• Number of Major Delays in Performance per all Movements
• Ratio of Actual to Demand Frequency of Departure	
Safety and Security	
• Number of Miscellaneous Accidents per Vehicle Mile	• Number of Fatal Accidents per Vehicle Mile

Methodologies that assess quality necessarily reflect subjective standards and measurements. The question has been posed: "Which standards should be used?" The answer has been addressed by studying the opinions of the "experts", the users, service providers and through attempts to synthesize combinations of those responses. An analysis completed by Pagano and McKnight (1983) of the relationship between the range of quality measures contained in the three groups mentioned above documented a strong correlation between the views of those groups, with the strongest link between responses of users and providers of service.

The inescapable subjectivity of most quality measures has fostered arguments against the use of qualitative measures, although Tomazinas (1978), Pagano and McKnight (1983), and Casey (1994) acknowledge the value of subjective data, especially when linked to related quantitative measures. While on-time service is intuitively ranked as the most important attribute of quality service, surveys have identified several quality issues that cannot be derived from standard efficiency or effectiveness indicators. The list of these attributes includes: driver friendliness, feeling of safety, driver kindness, comfort, and courtesy of telephone operators (Dimension Research, Inc. 1998; Pagano and McKnight 1983).

Necessarily, most reporting is oriented toward revenue changes, and the majority of transit performance studies have focused on related efficiency and effectiveness measures. Stone (1994), Pagano and McKnight (1983), and Casey (1994) propose that those two dimensions alone are unable to fully describe agency performance, and endorse adding the subjective measure of quality to any realistic evaluation.

An effort undertaken by the Chicago Transit Authority (Mumayiz 1987) gives some comparative on-time data. An analysis of both objective data and customer attitude was completed in this effort. Table 22 displays customer perceptions of on-time performance in the study. "On-Time" here is defined as plus or minus ten minutes from the promised time.

Table 22 Customer Perception of On-Time Performance

Perception	Pick-up	Drop-off
Always On-Time	41.5%	39%
Usually On-Time	47.6%	48.6%
Seldom On-Time	7.0%	8.6%
Never On-Time	3.8%	3.8%

(Mumayiz 1987)

Table 23 displays Carter-Goble and Assoc.'s (1982) quality measures. Service quality measures in this category are an attempt to quantify a qualitative aspect of transit performance. These kinds of measures may be dependent on the use of passenger surveys to collect useable data. The authors note that quality data may be the least affected by external macroeconomic variables, since financial data is not involved.

The 'Level of Service' measures are some of the broadest indicators in the Carter-Goble and Assoc. (1982) study. The authors suggest that their best use is for goals comparison on an annual basis. The measure Revenue Miles ÷ Revenue Hours is equivalent to average speed and is a quality measure because it is a component of the calculation for time spent in the vehicle; slower average speeds may adversely affect passenger attitudes. It should be noted, though, that increases in average speed are not always a positive outcome: fewer boardings and stops (decreasing load factors) may indicate falling system productivity.

Under the 'Safety' heading, ‘avoidable vehicle accidents' mean accidents resulting from infractions of either a motor vehicle law or a system policy by the transportation system's driver. Safety measures are most often compared either to internal goals or to each other in a time-series analysis.

The 1982 Carter-Goble Associates report was submitted for use by rural and small urban transportation staff as a guide for evaluating their system's performance. The report is oriented toward fixed route service. In this study, Carter-Goble Associates (1982) suggest that "on-time" means zero minutes early and no more than 5 minutes late at least 90% of the time.

Their research lead them to suggest that the ideal complaint level is no more than three per individual driver per year. Carter-Goble and Associates (1982) present one of the few attempts to measure availability of accessibility features and vehicle cleanliness. A distinctive variance between Miller (1989) and Carter-Goble Associates (1982) is in safety measures; Carter-Goble Associates (1982) suggest one accident per 18,000 vehicle miles as a goal - Miller (1989) suggests one per 1,000,000 miles.

Pagano and McKnight (1983) developed a quantitative method to measure quality of service to disabled riders. The authors collected data from users of paratransit services, experts in special transportation, and service providers to develop an exhaustive list of both the important quality attributes and their relative importance. The study presented an index of measures based on information gathered from the experts and user questionnaires, and then an input utilization (production function) of the proportion of resources used by providers. The study found that measures of quality from all three groups (users, experts and providers) were highly correlated.

Table 23 Quality Measures from Carter-Goble, Assoc. (1982)

Service Quality
- (G) Stops On-Time ÷ Total Stops
- (G) Complaints ÷ Number of Drivers
- (S) Vehicle Miles ÷ Road Calls

Level of Service
- (G) Revenue Miles ÷ Revenue Hours (average speed)
- (G) Vehicle Miles per Year
- (G) Vehicle hours per Year

Safety
- (G) Vehicle Miles ÷ Number of Revenue Vehicle Accidents
- (S) Non-Vehicle Accidents per Year
- (S) Avoidable Vehicle Accidents per Individual Driver
- (S) Revenue Vehicle Accidents for Each Route
- (S) Revenue Vehicle Accidents for Each Vehicle

("G" – General, "S" - Supplemental,)

The potential weakness of utilizing judgment in quality assessments was addressed using a framework that incorporates judgment into a methodical decision process. A methodology used to quantify subjective input was based on Miller's (1978) work suggesting a five-step process. The model, combined with the Pagano and McKnight (1983) study is abbreviated as follows (from Pagano and McKnight 1983):

1. Establish a list of criteria, which is complete, mutually exclusive, independent, and of major significance. Accomplished through:
    - Literature Review
    - Experience
    - Expert opinions

2. Determine a hierarchical structure of successfully more specific criteria.
    - Grouped into eight categories (Table 24)

3. Select physical performance measures for each lower-level criterion.

    - Weighting to assign relative importance to both the category and individual attributes contained in the category.

    - Psychometric scaling

4. Establish a scoring function or means of evaluating each alternative for each performance measure attached to a criterion.

    - Designed to yield a score ranging from zero to one using a formula summing weights of categories (aspects) and attributes.

5. Validate weighting and scoring functions by applying them to real alternatives.

    - Expert review and customer survey

    - Apply to paratransit properties

By augmenting this framework with production function analysis and extensive personal interviews, the Pagano and McKnight (1983) study identifies eight general categories or aspects of quality Table 24) as it relates to the paratransit industry. Each aspect has associated with it from four to eight attributes.

Table 24 Eight Aspects of Quality

• Reliability	• Vehicle Access
• Comfort	• Safety
• Convenience	• Driver Characteristics
• Extent of Service	• Responsiveness

A major portion of McKnight and Pagano's (1984) and Pagano and McKnight 's (1983) studies were centered on the development and use of indexes of quality of service based on responses of paratransit users. The quality index was built on the eight aspects of paratransit service, shown in Table 24 and Table 25. Each aspect is listed in italics, followed by its associated attributes. Each aspect weight is listed in the 'Weight" column, also in italics, on the left side of the column in order of weight value. Attribute weights are listed along the right side of the column also in order of weight value. The weights are measures of the relative importance of the aspects and attributes of quality of service. The most important aspect is reliability and on-time performance with a 1.75 weight from the users point of view. Within that aspect, the attribute of arriving at destination on time had the highest weight. Attributes that are likely to be affected by computer assisted scheduling and dispatching are denoted by an asterisk. The authors used a survey of users and a psychometric scaling technique to assign the weights.

Ultimately, scoring functions were developed which measure the achievement of satisfaction for that attribute. Development of many scoring functions was a straightforward process; the measure of quality for instance for the existence of an open seat or appropriate wheelchair restraints is a simple "Yes" or "No". Some more difficult to quantify measures are courtesy, cleanliness and friendliness of the driver.

The measures were then applied to forty-two paratransit operators in the Chicago area. An interesting outcome of the Pagano and McKnight study (1983) was that larger private paratransit providers scored higher on quality measures, while publicly managed properties score generally lower on the same measures. The project incorporated substantial analysis and development of several new measures of quality.

Table 25 Aspects and Attributes of Paratransit Quality (Pagano and McKnight 1983)

Weight	Aspects and Attributes
1.75	*Reliability and On-Time Performance*
*3.9	Arriving at destination on time or within a few minutes of scheduled time
*2.9	Notification of delays or cancellations of service
*1.3	Wait time (from time of reservation or schedule) for pick-up <u>at</u> home
*1.2	Wait time (from time of reservation or schedule) for pick-up <u>away from</u> home
*0.7	Few delays while on vehicle
1.61	*Safety*
4.4	Safe driver/Low probability of traffic accident
2.7	Low probability of falling
2.5	Low probability of personal assault
0.2	The type of tie-down
0.2	The position of the wheelchair in the vehicle
1.36	*Vehicle Access*
1.9	Height of first step
1.8	Short distance from house or destination to vehicle
1.4	Number of steps
1.4	Assistance in getting from vehicle to destination
1.2	Assistance in carrying packages
1.2	The width of the isle
1.1	Presence of wheelchair lift or ramp
1.31	*Driver Characteristics*
2.9	Knowledge of general needs of elderly and disabled users
2.6	Courtesy an friendliness
3.0	Ability to handle medical emergencies
1.6	Neatness and professionalism
*0.9	Familiarity with habits and needs of individual user

1.29	*Convenience of Making Reservations*
*2.9	Being picked up at times selected by traveler rather than at preset times
*2.6	Shortness of reservation time
*2.3	Convenience of return reservation procedure
*2.1	Accommodation to changes in reservations
1.07	*Extent of Service*
2.7	No or few restrictions on where vehicle will go
2.6	Total number of hours during which service is available
*1.8	Low rate of turning down reservations because of limited capacity
1.6	Service on weekends
1.3	Service in evening
0.87	*Responsiveness to User*
*3.9	Courtesy and friendliness of telephone operators
*3.7	Ease of getting clear information on service
*1.9	Receptiveness to complaints and user suggestions
*0.5	Procedure for following up on complaints
0.74	*Comfort*
2.5	A guaranteed seat or location for wheelchairs
1.9	The condition and cleanliness of the vehicle
1.4	The smoothness of the ride
1.4	Air-conditioning and good ventilation
1.4	Sheltered waiting areas for pick-ups away from home
1.4	Seats in waiting areas for pick-ups away from home

(Adapted from Pagano and McKnight 1983 and McKnight and Pagano 1984)

("*" denotes that attribute may be affected by Computer Assisted Scheduling and Dispatch)

A short discussion of selected individual attributes and their scoring functions is provided below. These attributes were chosen on the basis of the likelihood of being affected by the introduction of a computer assisted scheduling and dispatching system (CASD). The scoring functions are grouped under their respective aspect of quality in the same way as in Table 25.

<u>Reliability and On-Time Performance</u>

1. *Arriving at destination on time or within a few minutes of scheduled time* – The authors of this study note the lack of accurate and/or complete records useful for evaluation of transit properties. Due to the lack of useable data, this study used the observations of the transit manager obtained through interview and researcher observation. Measures were developed using the following scale:

Measure of attainment		*Score*
Good	– 90% or over within 5 minutes	0.85
Fair	– 80% to 90% within 5 minutes	0.65
Poor	– Less than 80% within 5 minutes	0.35

2. *Notification of delays or cancellations of service* – Pagano and McKnight (1983) found that providers' attention to this quality issue ranged from no notification (especially during inclement weather) and in the case were no reservation is taken, to those who make every effort to notify passengers in case of delay. The greater the effort, the higher the score, which is computed using the function:

   Score = 1-0.02(x-5 minutes)

   where: x = minutes from pick-up time or window that vehicle is expected to be late in order for the provider to notify.

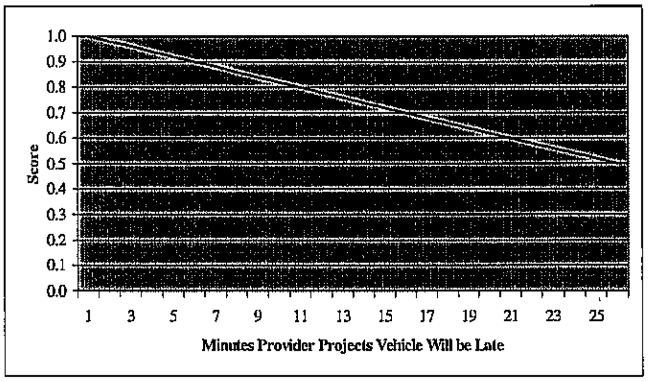
   Figure 1graphically illustrates the scoring function for Notification of Delays or Cancellations.

3. *Wait time (from time of reservation or schedule) for pick-up <u>at</u> home* – Because no measure of actual wait time was available, the base for the score is the score for arriving on time. Each minute of window allowed for arrival time reduces the on-time score by 0.01. This means that if a provider is "Good" (90% or better on-time rates), and has a 15-minute window, then the score of 0.85 is reduced by 0.15. The complete score is: 0.85 – 0.15 = 0.70.

4.

5. *Few delays while on vehicle* – The authors suggest that most delays occur either from pick-up and drop-off actions or from mechanical breakdowns. Scores for the two potential delays (delays due to passenger pick-up/drop-offs and breakdown delays) are calculated separately using the following scoring functions:

Figure 1: Scoring Function for Notification of Delays or Cancellations



(Pagano and McKnight 1983)

a. *Expected delay due to passenger pick-ups/drop-offs:* Calculated as the average occupancy minus 1, times the estimated time per pick-up. Estimated pick-up times are given for group pick-ups (30 seconds), door to door service (three minutes), lift passengers (one minute). This scoring function is:

$$S(P) = 1 - 0.045\,((\text{occupancy} - 1)(ET_P + P(WC))$$

where: occupancy = average occupancy

S(P) = score for delays due to picking up other passengers

P(WC) = percent of ridership using wheelchairs

ET_P = estimated time per pick-up

b. *Expected delay due to breakdowns:* Based on the history of the provider. Breakdown probability was estimated as the average number of in-service breakdowns per year divided by the total vehicle days per year. This function requires computation of both an estimated time per breakdown and probability of breakdown. The delay time was estimated with the following function:

$$ET_b = 15 + 1.5\left(\frac{A}{3}\right)^{.5} + 15(1-R) + 30(1-B)$$

where: ET_b = estimated time per breakdown (in minutes)

A = size of service area in square miles

R = 1 if vehicle is radio equipped, zero otherwise

B = 1 if they have a back-up vehicle, zero otherwise

Expected delay: the probability of a breakdown times the estimated time per breakdown.

$$S(B) = 1 - 0.5\,(Pr(BD))\,(ET_b)$$

where: S(B) = score for delays due to breakdowns

pr(BD) = probability of breakdown

Overall Score = .5 S(P) + .5 S(B)

6. *Wait time (from time of reservation or schedule)for pick-up away from home* – same as waiting at home.

Driver Characteristics

7. *Familiarity with habits and needs of individual user* – While suggesting that this attribute has value in assessing a paratransit agency, Pagano and McKnight (1983) where unable to accurately score this function because of the difficulty in measuring the driver's attitude. They developed a rough scoring function using driver turnover rates as a way to estimate the relative familiarity a driver might have based on the number of times a driver comes in contact with a passenger through normal scheduling. The authors developed three functions, one each for low, medium and high driver turnover rates. Because the ideal driver – passenger assignment is a permanent arrangement where the same driver transports the same passengers, those that do so are given a score of 1. When dispatchers cannot always assign passengers to the same driver, but try to do so, an extra 0.1 is added to the score. These scoring functions are shown below:

(Low Turnover Rate – 5 or more years of service per driver)

Score = 1-0.05(D-1)

where D = number of drivers

(Medium Turnover Rate – 2 to 4 years of service per driver)

Score = 1-0.1(D-1)

(High Turnover Rate – less than two years per driver)

Score = 1-0.2(D-1)

<u>Convenience of Making Reservations</u>

8. *Being picked up at times selected by traveler rather at preset times* – A demand responsive service receives a score of 1.0, otherwise the score is computed using the following scoring function:

Score = 1-Pr(R)

where: Pr(R) = probability that passenger will not be able to take trip at preferred time. Pr(R) was estimated as the average number of trip requests turned down or scheduled at another time of week divided by average weekly ridership.

9. *Shortness of reservation time* – Figure 2 shows the relationship between advance notice required for a reservation and the function "length of reservation". Providers able to accept reservations in 30 minutes or less are given a score on "1"; those requiring seven days or more receive a zero. Because same day reservations are significantly better than a seven-day reservation requirement, a step function was used.

(Same Day)

Score = 1-0.075 (RH)

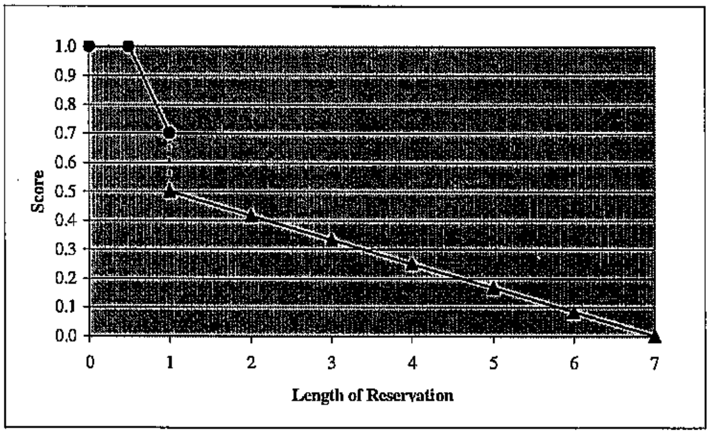
(One Day or More)

Score = 0.583-0.083(RD)

where RH = reservation time in hours

where RD = reservation time in days

Figure 2: Scoring for Length of Reservation



(Pagano and McKnight 1983)

10. *Convenience of return reservation procedure* – This scoring function gives a score of 0.8 for an agency that accepts a reservation for both the pick-up and return at the same time and a score of 0.4 when customers are only able to make reservations for one way at a time. The authors note that the most convenient system is for no reservation to be required (e.g. fixed route); this receives a score of 1.0.

11. *Accommodation to changes in reservations* - This scoring function takes into account both the probability of being able to make a change and the shortness of the reservation because being able to change the time or location becomes more important as the length of reservation time increases. This interaction in represented by the function:

Score = 1 – (1-(P(A)) (1-S(R))

where: P(A) = probability of making changes

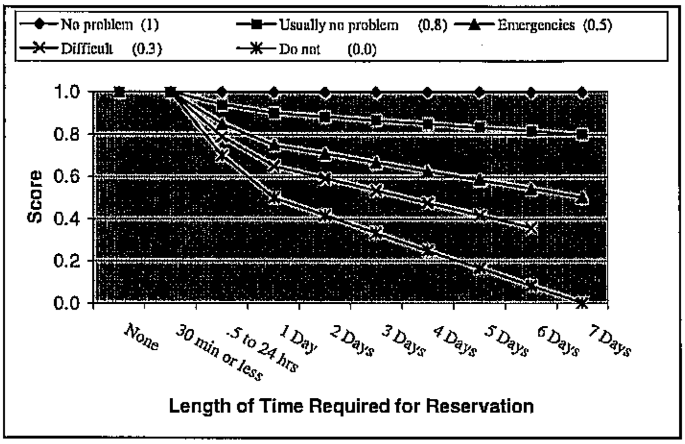
S(R) = score for length of reservation

The development of the scoring function for accommodation to changes in reservations necessitated the use of estimates derived from operator interviews for accommodating change. The scale used to estimate the frequency for accommodating change, P(A) (based on operator interviews) was:

No problem in accommodating changes	1.0
Usually no problem	0.8
Will take emergencies	0.5
Try, but it's difficult	0.3
Do not accommodate change	0.0

Scoring for Accommodation to Change is graphically displayed in Figure 3.

Figure 3: Scoring for Accommodation to Change



(Pagano and McKnight 1983)

Extent of Service

12. *Low probability of being turned down because of limited capacity* – This score is based on the service's turndown rate, so that zero turndowns are scored with a one. The authors used their estimates of worst case turndown rates to develop the lower boundary at about 18%, or in the 10th percentile nationally. Using those criteria, the function is:

Score = 1-5 TDR

where: TDR is the turndown rate (number of potential passengers turned down per week ÷ ridership per week).

Responsiveness to User

13. *Courtesy and friendliness of telephone operators* – For this attribute, the authors assigned a subjective score based on their observations. An excellent score of 1.0 was assigned to an operator who is friendly and polite and who attempts to resolve all customer problems and complaints. An intermediate score of 0.5 is awarded if the operator is judged as "always polite … and does job." The worst score, a zero, is assigned if the operator is "rude, impatient or grouchy".

14. *Ease of getting clear information on service* – This attribute is scored by assigning sub-scores to each of three methods of information dissemination: printed flyers,

telephone, and outreach/personal explanations. The maximum score is not to exceed 1.0, assuming that no agency will score a perfect score on all three sub-attributes.

15. *Receptiveness to complaints and user suggestions* – The authors assigned five ranges for measuring this attribute:

Actively seeking user suggestions	1.00
Consulting an advisory committee	0.75
Encourages suggestions	0.75
Reviews all suggestions and complaints	0.50
No active program or signs of resistance	0.00

16. *Procedure for following up on complaints* – This attribute scores the agency's follow-up policy for complaints using three categories:

Follows-up on all complaints and considers all suggestions	1.0
Follows-up on all complaints judged to be serious and legitimate	0.5
No consistent follow-up	0.0

The quality measures in Table 26 are from Dave Consulting, Inc.'s (1984) analysis of the Chicago Transit Authority's Special Services Program. The study assessed service issues with a focus toward assignment of paratransit operations to contracted providers.

Table 27 Quality Measures from Dave Consulting, Inc. (1984)

- Total Vehicle Miles per Roadcall
- Percent of Pick-ups on Time
- Average Trip Travel Time
- Accidents per Million Total Vehicle Miles

At the time of the study, no standard reporting system for tracking system performance had been developed. An emphasis of the analysis was to provide some standards for use as benchmarks and to assign future performance goals. In this study, an important quality measure, percent of pick-ups on time was measured based on the Chicago Transit Authority's 20-minute window rather than the (then) industry standard of 15 minutes. With this 20 minute standard, the CTA on-time rate was calculated at 73.7%.

1. *Total Vehicle Miles per Roadcall* - Maintenance performance indicator of effectiveness of regular and preventative maintenance. Measure is affected by age of service fleet, operating conditions, and defined practices regarding roadcalls
2. *Percent of Pick-ups On-Time* - Service quality measure of effectiveness and reliability of scheduling and dispatch processes. To some extent, measure may explain no-show performance and long trip times.
3. *Average Trip Travel Time* - Service quality measure of average time required for a trip. Measure is affected by size of service area or travel zones, trip making patterns, and scheduling practices.
4. *Accidents per Million Total Vehicle Miles* - Measure of overall system safety. Affected by operating conditions, extent and type of exposure.

Mumayiz's 1987 working paper was part of an overall evaluation of the Chicago Transit Authority's (CTA) mobility limited special services program designed to assess the post privatization of the CTA's special services transit programs. This study also noted the lack of established, common measures of quality among demand response providers. In developing these measures, the author drew from Pagano and McKnight (1983) and Dave Consulting, Inc. (1984). His measures are shown in Table 27.

Mumayiz (1987) chose a seemingly arbitrary on-time standard defined "as pick-up or drop-off anytime early to 10 minutes late". He also used the now ADA standard trip time threshold of 90 minutes. Despite the long list of potential quality measures noted in Pagano and McKnight (1983), only a select few were chosen to evaluate the private carriers. Mumayiz (1987) opted to focus on the performance measures cost to users, extent of service (hours of operation and trips serviced), and reliability (on-time performance and delays enroute).

Table 28 Quality Measures from Mumayiz (1987)

• On-Time Performance	• Extent of Service
• Notification of Delays in Service	• Capacity (likelihood of getting a trip)
• Wait Away from Home	• Ability to Select Trip Time
• Wait at Home	• Reservation Length
• Delays Enroute	• Total Trips Serviced
• Extent of Service	• Accommodation to Changes to Trip Plans
• Ease of Making Return Reservations	• Restrictions on Trip Purpose or Destination

Figure 4 and Figure 5 display data derived from the results of over 422,000 rides provided from February 1986 through January 1987 from the Chicago area. The chart shows early and late performance across eight time ranges, from greater than thirty minutes early to over sixty minutes late (Mumayiz 1987). The data is an aggregate of the original four independent properties contracted for paratransit service in Chicago. This data represents the first year of operations post privatization. In this case, the common performance goal was to operate within a window of no more than ten-minutes early or late. Here, the organizations were able to make the goal only about 51% of the time.

Figure 4 CTA Paratransit On-Time Performance by Time Increment, February 1986 - January 1987 (Mumayiz, 1987)

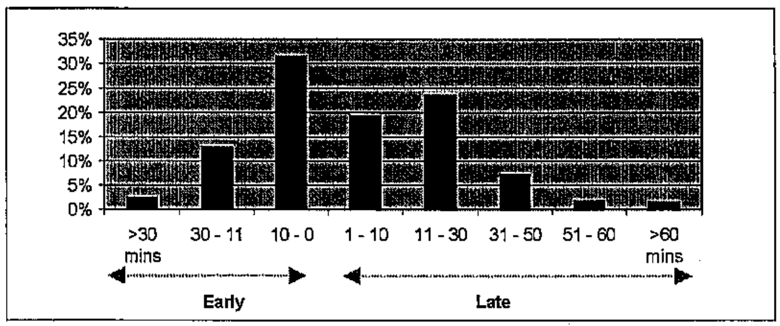
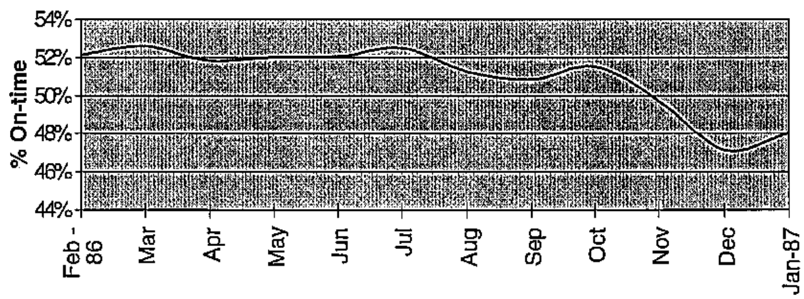


Figure 4 graphically displays Mumayiz's data (1987) for the CTA from February 1986 through January 1987. Only about 20% of all vehicles arrived 10 or less minutes late and just over 30% of arrivals were 10 minutes early.

Figure 5 depicts the data shown in Figure 4 by month for comparison. The Dave Consulting (1984) study and the APTS evaluation guide (Casey 1994) each suggest that seasonal weather variation should be factored into on-time performance data analysis. Figure 5 displays a range of 5.4% between the best and worst months, with the dip corresponding with winter weather, although factors such as employee vacation, trip destination changes or personnel turnover may have been contributing factors.

Figure 5 CTA Paratransit On-Time Performance by Month



Derived from Mumayiz, 1987

Kikuchi (1988) presents the quality measures shown in Table 29. These reflect the author's before and after study of an agency transitioning from manual to automated operations, and did not fully describe the development or background for choice of particular measures. One measure described in the Kikuchi (1988) study is passenger travel speed. This measure was computed by using the ratio of on-board travel distance to time. As expected, averages varied according to the number of intermediate stops the vehicle made during its route. Kikuchi (1988) noted the trade off that must be considered when attempting to optimize paratransit travel; as more customers are added to a vehicle, increasing efficiency, passenger ride times are extended, decreasing quality of service.

Table 29 Quality Measures from Kikuchi (1988)

- Passenger Travel Speeds
- Passenger Wait Times
- Number of Intermediate Stoppings
- Vehicle Standing Time at Stops

In his 1989 study, Miller suggests specific quality goals for demand response operators. He suggests that operators should experience no more than 1 complaint per 1,000 one-way passenger trips and that 95% of all pick-ups should be made within ± 15 minutes of the promised time. He also suggests that the entire system should have no more than one avoidable accident per 100,000 miles.

Table 30 Quality Measures from Miller (1989)

• Service Related Complaints ÷ 1000 One-Way Passenger Trips
• On-Time Pickups ÷ Total Pickups
• Avoidable Accidents ÷ 100,000 Vehicle Miles

Miller (1989) notes that his goals are not comprehensive and are primarily designed for ease of measurement. It is this issue of the difficulty of measuring quality that is addressed by Pagano and McKnight (1983).

The quality measures developed by CUTR (1998) are contained in Table 1. CUTR notes that many very important quality measures are not included in the analysis, because the survey was dependent on National Transit Database submissions that do not require reporting of some significant quality measures.

Table 31 Quality Measures from the Center for Urban Transportation Research, University of South Florida (1998)

• Average Speed (Revenue Miles ÷ Revenue Hours)
• Average Age of Fleet (years)
• Number of Incidents
• Revenue Service Interruptions
• Revenue Miles Between Incidents
• Revenue Miles Between Interruptions

Some measures listed by CUTR that may be critical to measuring a transit agency's quality performance might include: passenger satisfaction with levels of service, community attitudes toward the service agency, vehicle cleanliness and comfort, operator courtesy, on-time performance, quality of passenger information support, frequency of service, and others.

The following quality definitions are provided from the CUTR analysis.

1. *Average Speed* - Average speed of vehicles in operation (including to and from the garage) calculated by dividing total vehicle miles by total vehicle hours.

2. *Average Age of Fleet* - Traditionally, a standard transit coach is considered to have a useful life of 12 years. However, longer service lives are not uncommon. The vehicle age and the reliability record of the equipment, the number of miles and hours on the equipment, the sophistication and features (i.e., wheelchair lifts, electronic destination signs, etc.), and operating environment (weather, roadway grades, and passenger abuse) all affect the maintenance needs and depreciation of the bus fleet.

3. *Number of Incidents* - Total number of unforeseen occurrences resulting in casualty (injury/fatality), collision, or property damage in excess of $1000. For an incident to be reportable, it must involve a transit vehicle or occur on transit property.

4. *Number of Service Interruptions:* A revenue service interruption during a given reporting period caused by failure of some mechanical element of the revenue vehicle or for other reasons not included as mechanical failures.

5. *Revenue Miles Between Incidents* - Number of revenue miles divided by the number if incidents; reports the average interval, in miles, between incidents.

6. *Revenue Miles Between Interruptions* - Number of revenue miles divided by revenue service interruptions; an indicator of the average frequency of delays because of a problem with the equipment.

1.9 Measurement Issues

Central to any evaluative framework is the selection of measurements on which to base the evaluation. Researchers and consultants have used a variety of measures to evaluate transit properties. Evaluators are often forced to use measures reflecting data availability rather than researcher preference. This is especially true at properties with manual operations, where only the most basic and necessary data will be maintained. The range and accuracy of available data is also related to agency size. The smaller the organization, the less likely that rigorous data collection will be the norm. In this section, two measurement issues common to paratransit will be discussed, these are the definition of Deadhead and Cost Allocation.

1.9.1 Deadhead

During the course of this literature review, a number of different definitions for the key transit measure, deadhead, were discovered. As paratransit agencies move toward computer assisted scheduling and dispatching systems, this critical measure becomes easier to track and more useful as a management tool. However, a common definition has not been adopted by all agencies. The following paragraphs outline a selection of variations for the term "deadhead" uncovered during this study:

- The Urban Transportation Glossary (1989) lists deadhead as moving "a revenue vehicle in other than revenue service, for example, from one garage to another or from the end of the line to a garage".

- Demand responsive deadhead is mileage driven from the last passenger's destination to the vehicle's stand, garage or headquarters (Carter-Goble, 1982).

- A common measure of paratransit productivity is passengers carried per vehicle service hour. The most common definition of a vehicle service hour includes the time the vehicle leaves the garage until the time the vehicle returns. Unlike fixed route operations where exact deadhead can be calculated, a paratransit vehicle is considered in service from the time it leaves the garage until the time it returns (Dave Consulting 1984).

- The APTS evaluation guideline (Casey 1984) addresses deadhead for demand responsive agencies this way:

In service:

- In motion with one or more passengers aboard
- In motion with no passengers on board and in the act of picking up one or more passengers

Non-Service:

- Garage to first pick-up point
- Last drop-off point to garage
- Between first pick-up point and the last drop-off point with no passengers onboard and not in the act of picking up one or more passengers

The number of definitions associated with deadhead may cause some confusion among demand response managers, and the installation of automated software may add to the problem of deadhead definition, because software packages may be programmed to track deadhead in at least as many ways as shown above. Two paratransit software vendors report deadhead as the sum of all revenue vehicle travel without revenue passengers, tracking deadhead minute by minute.

The National Transit Database Reporting Manual (NTDRM) acknowledges this issue: "The concept of deadheading is not as well defined for non-scheduled, non-fixed route services" (NTDRM 1998). The NTDRM endorses measuring deadhead as only that time or mileage preceding the first pick-up or following the last drop-off. Variations seen as conforming to this rule and counting as deadhead include fueling trips and operator lunchtime.

1.9.2 Cost Allocation

One of the more difficult items to quantify in demand responsive transportation is allocation of costs for comparative uses. Because of the large variations in cash flow, any attempt at measuring financial attributes should be annualized over a twelve-month period. Financial performance data may also be affected by insurance premiums, cash inflows from charitable organizations and late payment of receivables (Carter-Goble 1982).

Miller (1980) presents a simple method of cost allocation called the "three-variable unit cost model". This method distributes costs into three service variables: vehicle hours, vehicle miles, and vehicles. It is based on the assumption that the cost of operating a shared ride system is directly related to the number of vehicle hours of service provided, the number of miles traveled and the number of vehicles required to provide service. Miller's model attempts to represent the total shared-ride operating expenses in an unambiguous manner. His model is shown below:

Annual total expenses = (Vehicle hour related expenses x Vehicle miles) + (Vehicle mile-related expenses x Vehicle miles) + (Fixed expenses per vehicle x Vehicles)

1.10 Data Sources

The choice of measure selected to evaluate a property is constrained by the property's record keeping policies. As noted earlier, the less automated a property, the more limited the choice of measures. In demand response transportation, the vast majority of operational information must be drawn from driver's run sheets (manifests). Additional information may be collected from complaint logs, customer satisfaction surveys, related agency records, personal interviews and financial documents. The typical driver's run schedules offer twenty-three separate elements.

Table 32 displays the partial list of potential driver's log elements. Although the driver's log contains a wealth of data, the accuracy of the information contained on the driver's trip sheets has been questioned. Because of a mixture of time constraints, (self-imposed or agency) pressure to inflate on-time performance and lack of training or sometimes initiative, the driver logs are subject to significant quality variations. A common problem is manifested in a long stream of drop-off or pick-up times logged as occurring at precisely the scheduled time. Without automatic vehicle location systems that independently update vehicle location and time, this problem is nearly unavoidable. The pressures of fighting the time schedule given the daily challenges drivers face while transporting paratransit passengers make it a struggle to maintain the driver's manifest above minimal accuracy levels (Dave Consulting 1984).

If peer evaluation is desired, a data collection source (although reporting accuracy is sometimes less than ideal) may be the NTD (Formerly Section 15) database. In the case of small paratransit agencies, reports often suffer from inaccurate and incomplete data, although with time and increasing automation, the data will become more refined. CUTR has established an effective evaluation process (discussed in section 4.1, Peer Group Comparison) using information extracted from the National Transit Database and submitted during standard reporting cycles.

Table 32 Potential Data Elements Contained in the Driver's Run Schedules

Data Element	Will contribute to:
Van ID	Allows computation of total ride time by vehicle
Beginning/Ending mileage per run	Average speed and travel times Cost per vehicle mile Cost per passenger mile Miles per vehicle Vehicle Miles per peak vehicle Vehicle between pick-ups (Deadhead) Vehicle Miles between accidents Passenger trips per mile Vehicle Miles per roadcall
Total number of trips	Cost per passenger trip Passenger trips per vehicle hour Scheduled trips as percent of total trips Passenger trips per mile Passenger trips per vehicle Average trip time Service related complaints per 1000 trips
Beginning /Ending time per run	Average speed and travel time Passenger trips per vehicle hour Vehicle hours per peak vehicle Passenger trips per hour Passenger trips per vehicle service hour In vehicle ride time

Data Element	Will contribute to:
# of ambulatory passengers per run	Total lift users as percent of total passengers
# of wheelchair passengers per run	Total lift users as percent of total passengers
Total Passengers	Total Users
Passenger name/counts	Total riders Cost per passenger mile, passenger trip Farebox recovery per trip Gross operating costs per passenger Late cancellations as percent of total passengers No show passengers as percent of total passengers Passenger trips per hour Passenger trips per mile Passenger trips per vehicle Revenue passengers per service area population
Scheduled Pick-up/Drop-off time	Average wait time at or away from home On-Time pick-up variation
Actual Pick-up/Drop-off time	Average wait time at or away from home In vehicle ride time Vehicle Revenue hours Deadhead time On-Time percentages Percent of over ADA maximum travel time
Amount paid (farebox receipts)	Farebox revenue
Cancellations	Cancellations as percent of total passengers
No-shows	No-shows as percent of total passengers
Rescheduled	Rescheduled as percent of total passengers
Demand response/Subscription	Variations by service

Chapter 2

Paratransit Environment

2.1 Service Area Characteristics

Door to Door Inc.'s operating area is contained within the boundaries of the three county region of Peoria, Tazewell and Woodford counties. The estimated 1998 combined population of the tri-county area was 346,000 (Economic Development Council for the Peoria Area 1998). The city of Peoria, IL is in the center of the three county region and is located approximately 160 miles from St. Louis, 140 miles from Chicago and 200 miles from Indianapolis. The city of Peoria and its Metropolitan Service Area (MSA) have developed into the region's focus of population and economic growth for the three county area. Several smaller population areas ring the Peoria metropolitan area; Chillicothe and Rome are two growing northern communities; East Peoria and Washington are the major outlying eastern communities; Morton, Pekin, Marquette Heights and Bartonville are the Southern outlying population centers.

The Western section of Peoria and SW Tazewell counties have geographically dispersed populations, Woodford county has the lightest population density, and Peoria County leads in population figures (53% of the total service area) with 183,600 residents. Tazewell's population represents 37% of the area with 128,000 residents. Woodford county's population represents the lowest percentage at just 10% of the total tri-county population (34,700 residents) (Economic Development Council for the Peoria Area 1998).

The Economic Development Council for the Peoria Area (EDC) estimated in 1998 that approximately 77% of the workforce were employed in non-manufacturing occupations. Manufacturing and government employment represented about 16% and 9% respectively of the total employed residents (EDC 1998). The population is predominately white (89.5%), and claims a median 1997 estimated household income of $46,000 (EDC 1998). The latest reported annual unemployment rate (1998) for the greater Peoria region was estimated at 3.8% (Peoria Chamber of Commerce 1999)

The elderly population represents a primary customer base for Door to Door, Inc. Tables 1 and 2 summarize census data for over age 65 residents and their respective rural/urban populations (U. S. Bureau of the Census and www.census.gov 1990). 'Urban' and 'rural' in this report are used in the convention described in *Urban and Rural Definitions*, U. S. Census Bureau (1995). In this publication, "urban" is defined as:

> 1. Places of 2,500 or more persons incorporated as cities, villages, boroughs (except in Alaska and New York), and towns (except in the six New England States, New York, and Wisconsin), but excluding the rural portions of "extended cities."
>
> 2. Census designated places of 2,500 or more persons.
>
> 3. Other territory, incorporated or unincorporated, included in urbanized areas.

Table 33 Age/Rural Population Distribution for the Extended (Tri-County) DTD service area*

Area	Total 1990 Population	% > age 65	1990 Rural Population	% Rural > age 65
Peoria County	182,827	14.2	29,652	11.1
Peoria City	113,504	14.4	-	-
Tazewell County	123,692	13.2	28,598	11.5
Woodford County	32,653	14.1	25,655	12.6
Illinois (statewide)	11,430,602	12.6	1,762,050	15.4

Rural areas are any areas outside of the definitions contained above. Slightly greater percentages of the over age 65 population reside in the urbanized areas of the tri-county region, and each of the three counties have slightly higher percentages of elderly residents than the state as a whole. Figure 6 shows estimated changes in the over age 65 category between 1990 and 1997. Population data suggests that the rate of population change in the over 65 age group is changing at about the same pace as overall population growth in each of the three counties. Peoria County's population remained nearly stable during the period, while Tazewell County's over age 65 and general population growth essentially mirrored the State's.

Woodford County, while the lowest in population density, has been the fastest growing of the three counties. Woodford County's overall population increased by 6 % compared to the State of Illinois' 3.9%.

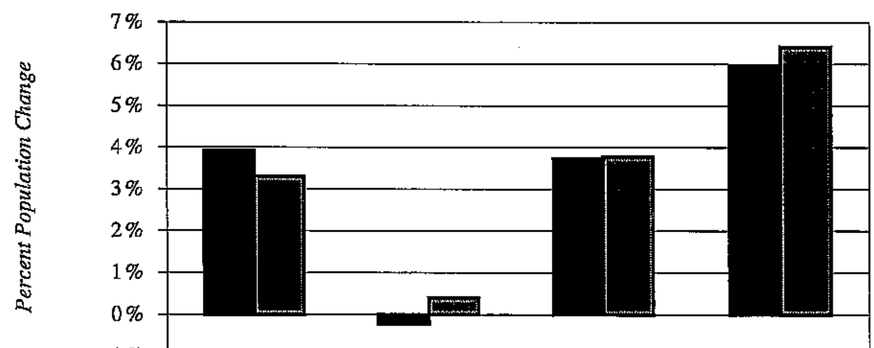
Although Woodford County is experiencing the greatest rate of growth, it is still the most lightly populated area with only 9.4 people over the age of 65 per square mile, creating a significant obstacle to cost effective paratransit service in that region. Both Peoria and Tazewell counties have higher densities of elderly than the State average.

Table 34 Population Density by County (estimated 1997)

Area	Square Miles	1997 Total Population (est.)	Population Density p/Sq. Mile	1997 Population > Age 65 (est.)	> Age 65 Population Density p/Sq. Mile
Illinois	57,918	11,446,412	197.6	1,481,303	25.6
Peoria County	649	182,657	28.7	26,073	40.2
*City of Peoria	40.9	113,504	2775.2	16,325	399.1
Tazewell County	620	128,521	207.2	17,055	27.5
Woodford County	528	34,776	65.9	4,945	9.4

(*1990 census data)

Figure 6 Door to Door, Inc. Service Area Population Change 1996-1997 (estimated)



	Illinois	Peoria County	Tazewell County	Woodford County
Total Pop Chg	3.9%	-0.2%	3.7%	6.0%
> Age 65 Pop Chg	3.3%	0.4%	3.8%	6.4%

2.2 Transit District

The Greater Peoria Mass Transit District (GPMTD) serves the transit needs of the four communities of Peoria, West Peoria, East Peoria and Peoria Heights. The district operates an all fixed route service using 53 vehicles for one express and ten regular routes. One regular route is contracted service to the city of East Peoria located adjacent to the eastern Peoria City limits. The Greater Peoria Mass Transit District operates Monday through Saturday in their defined service area; the Peoria Urbanized Area.

The transit district has experienced an increase in ridership during the study period from approximately 1.8 million passengers in their FY1998 to a projection of 2 million passengers in 1999 (Greater Peoria Mass Transit District 1999). The transit district also provides limited park and ride transportation, charter, and a downtown trolley service.

2.3 Door to Door

Door to Door, Inc. (DTD), is the current five-year cycle bid winner, and will reenter the bid process in June of 1999. Door to Door, Inc. provides service with thirty-four personnel, including twenty drivers, four dispatchers, a four person management and administrative staff and six part-time employees.

Door to Door, Inc. operates twenty-five vehicles including nine provided by the transit district in support of their complementary paratransit obligations. The Greater Peoria Mass Transit District performs all service and fueling for their nine vehicles. The requirement to perform maintenance of the vehicles at the GPMTD facility with GPMTD personnel is provided by the current service agreement between DTD and the GPMTD.

2.3.1 History

Door to Door, Inc. was established in 1981 in response to the Greater Peoria Mass Transit District's need to provide paratransit service to the transportation disadvantaged population in the district's service area. Paratransit service provides access to services long enjoyed by more mobile, but non-disabled residents. The requirement to provide this complementary service is contained in the Rehabilitation Act of 1973 and the 1990 Americans with Disabilities Act (U. S. Congress 1990 and 1973).

2.3.2 Community Governance

Door to Door, Inc. is governed by a board consisting of no less than twelve members and no more than twenty. Each board member is a volunteer recruited from a community in the service area and must be nominated by members of the current board.

2.4 Other Providers

The tri-county area is served by three paratransit agencies. Two service primarily rural areas; Door to Door, Inc. provides both rural and urban services.

2.4.1 Rural Peoria County Council on Aging, Inc.

The Rural Peoria County on Aging, Inc. (RPCCA) services residents of rural areas of Peoria County. This agency was established in February 1982 to provide service to senior citizens outside of the City of Peoria. The agency's charter provides services ranging from chore assistance through respite care, and includes transportation services. RPCCA's transportation services are provided to the general public, without age restriction, for trips to medical appointments, adult day care, employment, grocery shopping, and other necessary trips. Medical appointments are given highest priority.

During 1998, the organization provided 12,314 passenger trips and logged 137,633 miles. The agency operates five lift-equipped vans with a maximum capacity of 7 ambulatory and 2 wheelchairs. An all ambulatory configuration allows for up to 11 passengers per vehicle. RPCCA transit operations are largely funded by a grant from the Illinois Department of Transportation, including fuel, maintenance and administrative costs (RPCC Overview 1999)

2.4.2 We Care, Inc.

We Care, Inc. is also a non-profit organization dedicated to providing services to enable many people to live independent, fulfilling, safe, and healthy lives at home. Services range from home-delivered and congregate meals to transportation services. Service is restricted to passengers whose trip either originates or terminates in the We Care, Inc. service area. We, Care Inc. operates in both rural Woodford and Tazewell Counties through separate contract arrangements. We Care, Inc. operates 22 vehicles between the two counties and provides a total of 92,521 one way trips to passengers during FY 1998 (Thompson 1999; and Tri-County Regional Planning Commission 1999).

2.4.3 Central Illinois Agency on Aging, Inc.

The Central Illinois Aging on Aging (CIAA) is not a provider of transportation services, but rather disburses funds for several projects, including transportation for the elderly. The CIAA provides services to older persons residing in the six county area including Stark, Marshall, Fulton as well as the tri-county areas of Peoria, Woodford and Tazewell Counties. The CIAA provides funding to DTD and We Care in support of their charter to develop community resources for residents over age 60. During FY 1998, the CIAA provided funding assistance for more than 27,300 one way trips for senior citizens among the three transit providers (CIAA Brochure 1999).

2.5 Coordination Potential

Computer assisted scheduling and dispatch systems are designed to support coordinated transit activities and provide the technological solution to the multi-agency brokerage concept. Because of some overlap of service area and other long-standing customer arrangements, there are frequent occasions when vehicles from the three agencies cross paths while providing transportation to Peoria area residents. This overlap occurs almost exclusively in the boundary area between the officially designated Peoria urbanized and rural areas. It is likely that such coordinated transit will result in more efficient utilization of vehicles.

At present, no formal coordination exists between the three providers in the Tri-county region. Issues of funding, organizational longevity, and politics are major barriers to efforts at coordination of paratransit and other demand response transportation activities. Until these issues are addressed, it is unlikely that coordinated activities will occur.

Chapter 3

Pre-Implementation Activities

3.1 Overview of Operations

This report contains a description of daily operations of Door to Door, Inc. (DTD); a medium sized paratransit property located in central Illinois. The following sections provide an overview of the organization's personnel structure, a detailed description of the agency's manual operations from receipt of a request for service to dispatching, and a brief description of vehicle operations and the customer complaint process. The agency's financial environment, service area and characteristics are briefly outlined, and the agency's fleet composition is included. This report is focused on the internal operations of the organization's manual activities; especially those affected by the installation of computer assisted scheduling and dispatch software.

Except for billing and manifest printing, during the pre-automation period, Door to Door Inc. transit operations where supported entirely by manual activities. Door to Door's routine transit operations include receipt of service requests, scheduling, publishing of driver manifests, communication of enroute changes to drivers, customer problem resolution, and maintenance of primary billing records and of vehicles.

Scheduling and dispatch operations in a manual environment require expert level knowledge of the service area and a significant array of client characteristics. Routine operations for the dispatcher/scheduler require the ability to recall individual client characteristics that at minimum include client disability type and normal/alternative billing options. That level of expert knowledge is rarely developed except through assignment as a vehicle operator. This prerequisite experience has so far limited all dispatcher/scheduler assignments to those personnel who are former vehicle operators.

Door to Door's daily operations can be segmented into four distinct categories: service call receipt, scheduling, dispatch and vehicle operations. These activities are discussed in additional detail below.

The amount of data potentially available for collection from paratransit operations is overwhelming in its volume. The literature review lists several dozen potential measures of productivity and quality and it is possible to add a nearly unlimited range of measures from dispatcher/scheduler efficiency to maintenance hours per arbitrary unit of passenger travel. At Door to Door, Inc., the management's decision has been to balance reporting requirements with the core activities required to provide service in the community. This action has minimized a potentially paralyzing administrative burden by collecting no more data than necessary to provide required reports and to perform essential operational analysis.

Despite the determined effort to minimize administrative activities to its bare bones components, Door to Door, Inc. still generates a significant volume of paper records during routine operations. These records are composed of driver manifests, passenger tickets (pre-paid fares), cash receipts, and associated records.

3.2 Personnel

Door to Door's routine personnel structure includes thirty-four personnel assigned in ten separate job titles (Table 1). For purposes of discussion, the job titles shown in Table 1 are distributed into three categories: Management, Union/Non-Management and Non-Union/Non-Management. All Union/Non-Management personnel share union affiliations with the district employees union; Amalgamated Transit Union Local 416.

Table 35 Door to Door Personnel Assignments

Management		*Union/Non-Management*	
Executive Director	1	Vehicle Operators	
Administrative Assistant	1	Regular	8
Director of Operations	1	Non-regular	12
Director of Maintenance	1	Ambulatory	3
Total Management	**4**	*Total Vehicle Operators*	**23**
Non-Union/Non-Management			
Maintenance helpers	2	Scheduler/Dispatchers	3
Part-time Van Assistant	2	*Total Scheduler/Dispatcher Staff*	**3**
Part-time Clerks	2		
Total Non-Union	**6**	**Total Personnel**	**36**

3.2.1 Executive Director

The Executive Director is overall manager of all operations and administrative activities of Door to Door, Inc. He formulates and recommends strategic policy to the board and implements the board's decisions. The Executive Director manages development and dissemination of all agency information (annual reports, budgets, personnel policies, reports to the board, etc.). He also represents the agency in all contracting or coordination meetings with all outside organizations. This individual makes all hiring and firing decisions and approves all personnel scheduling decisions. He ensures appropriate marketing/public affairs activity is generated and interacts with all outside funding agencies. Major portions of the Executive Director's responsibilities include generation of funding sources.

3.2.2 Director of Operations

The Director of Operations supervises, coordinates and directs the day-to-day delivery of service within the service area. This individual acts in the place of the Executive Director in his absence and supervises the schedulers/dispatchers and vehicle operators on a daily basis. He is directly responsible for maintaining the on-time performance of the fleet. This individual is responsible for training all new scheduler/dispatchers and vehicle operators when necessary. Additional duties include investigation of accidents/incidents and ensure data accuracy for operations reports.

3.2.3 Director of Maintenance

The Director of Maintenance is responsible for the maintenance of all Door to Door, Inc. vehicles (excludes GPMTD leased vehicles), Door to Door, Inc. equipment and facilities. In the absence of the Director of Operations, he assumes responsibility for Scheduler/Dispatcher operations. The Director of Maintenance is assisted by two part-time maintenance assistants. This individual maintains all repair and safety records. Because of previously developed computer skills, an additional responsibility includes the maintenance of computer software and hardware for the organization.

3.2.4 Scheduler/Dispatcher

The Scheduler/Dispatcher receives, processes and enters all requests for transportation on Door to Door, Inc. fleet vehicles. The Scheduler/Dispatcher interacts with the public, the agency vehicle operators and management. Four Scheduler/Dispatchers are assigned at Door to Door, Inc. The Scheduler/Dispatcher manages vehicle assignment, enroute communications with drivers, and serves as the first contact for passengers attempting to follow-up with service complaints or compliments. The Scheduler/Dispatcher must have a high threshold for conflicting priorities, a deep sense of commitment to customer support, and above average interpersonal skills. Because of the prerequisite that dispatchers have in-depth knowledge of the service area, to date, no Scheduler/Dispatcher has been assigned without first having served in the capacity as vehicle operator.

3.2.5 Administrative Assistant

The Administrative Assistant manages the office and provides administrative support to the Executive Director and the organization. This individual collects, records and deposits all cash receipts for the organization, and administers the agency's accounts payable and receivables. The Administrative Assistant prepares all reports and statistical output on behalf of the Executive Director.

3.2.6 Maintenance Helpers

The Maintenance helpers assist in any task associated with maintenance of Door to Door, Inc. vehicles, equipment or facilities. Maintenance helpers are assigned directly to the Director of Maintenance and perform such tasks as he assigns.

3.2.7 Part-time Van Assistants

Van assistants assist vehicle operators in configuring the assigned vehicles to accommodate projected passenger needs. These individuals add or remove seats to allow wheelchair space and often travel with the vehicles to assist in securing wheelchairs inside the vehicles prior to departure.

3.2.8 Part-time Clerks

Clerks assist in general office duties as assigned by the Administrative Assistant or management staff. They may provide data entry and telephone support as well as filing and other assistance as needed.

3.2.9 Vehicle Operators

Driver assignments vary by load requirements, but generally are distributed in three shifts; the majority work straight 30-hour weeks Monday through Friday. Two to three additional drivers assist during peak hours in part time status, and a single driver works the late shift. Two drivers handle Saturday runs.

DTD drivers are required to possess a commercial drivers license (CDL) and to comply with the requirements imposed by its assignment, including criminal background checks, drug testing, etc. Additional orientation and testing is required and provided by both DTD staff and contracted personnel, in areas such as sensitivity training, cardiopulmonary resuscitation, and service area familiarization. Drivers who will be transporting mobility disabled passengers are required to attend a workshop/orientation at a local hospital where the drivers are introduced to issues surrounding transport and implications of wheelchair usage. During this time, drivers are temporarily "confined" to a wheelchair, trained to maneuver a loaded chair through a number of small obstacles, and demonstrate strength adequate to move a loaded wheelchair into a vehicle. Drivers incrementally expand driving responsibilities and passenger loads based on both positive evaluator observation and length of employment, until the driver demonstrates competency.

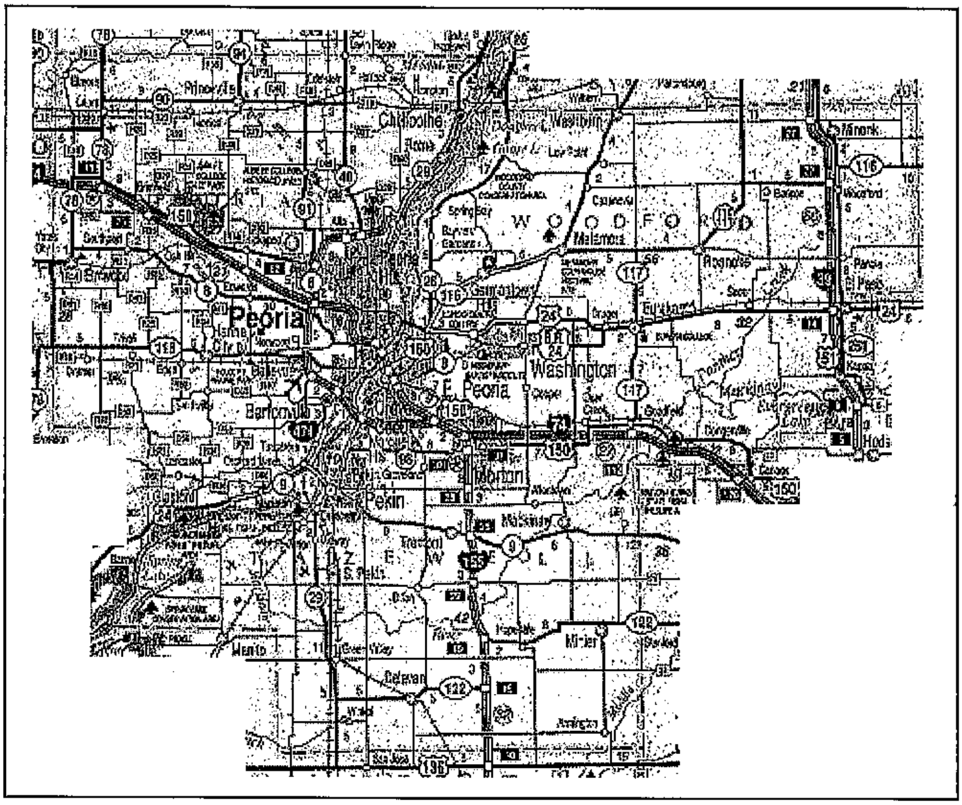
3.3 Fleet Composition

Door to Door's normal fleet is composed of 29 vehicles (Table 2). The fleet count includes 11 GPMTD leased vehicles (normal operations require use of no more than 9) and three vehicles received when Door to Door, Inc. acquired responsibility for runs formerly accomplished by the Rural Peoria County Council on Aging (RPCCA). The three vehicles received to support the RPCCA routes are owned by the Central Illinois Agency on Aging through a grant received from the Illinois Department of Transportation. Using the convention established in the Transportation Research Board's TCRP Report 18 (Lave, et al 1996), Door to Door is a medium size paratransit organization.

Table 36 Door to Door, Inc. Fleet Composition During Pre-implementation Phase

Vehicle Type	# Vehicles	Passenger Capacity	Wheelchair Capacity	Ambulatory Seating	Passenger Capacity
Van	8	8	4	4	64
Van (GPMTD lease)	11 (max)	12	8	4	132 (max)
Van	2	20	0	20	40
Minivan	4	5	1	4	20
Raised Roof Van	1	6	1	5	6
School bus (All wheelchair)	1	12	12	0	12
Standard City Coach (GPMTD Lease)	1	35	0	35	35
Van	1	10	6	4	10
Total	**29**				**319 (max)**

Figure 7 Door to Door, Inc. Service Area



3.4 Service Area

Door to Door, Inc. operates within a primary service area contained within a thirteen-mile radius of the center of the city of Peoria. A regular run to Chillicothe is the major exception. Chillicothe is located approximately 23 miles to the north of Peoria, making this run the longest distance routinely traveled in paratransit service by DTD vehicles (Figure 7).

The primary service area includes all of the major urban area in the Tri-county region and is estimated at over 346,000 residents (Economic Development Council for the Peoria Area 1998). In addition to providing contracted service for the transit district, Door to Door, Inc. provides non-profit service using a separate rate structure for transportation to virtually any point in the Tri-county area. If a passenger has the means to pay and the need to travel outside of the primary service area, Door to Door, Inc.'s vehicles are authorized to operate anywhere within the state of Illinois.

When providing complimentary paratransit service for a passenger under contract to the GPMTD, the service area for that passenger is restricted to the Peoria metropolitan service area. Two paratransit operators; Rural Peoria County Council on Aging, Inc. and We Care, Inc. are the primary rural transit providers in the Tri-county area. We Care, Inc. services Woodford and Tazewell counties, Rural Peoria Council On Aging (RPCCA) operates in rural Peoria County.

Figure 7 illustrates the Tri-county regional boundaries. Peoria county is located to the north-west, Woodford to the north-east, and Tazewell to the south. The Peoria urban area clearly dominates the central area, located along the boundaries of the three county region and representing over 30% of the region's population. Three transportation providers operate in the three county area; Door to Door, Inc. provides transportation in the urban areas of Peoria and Northern Tazewell counties. We Care, Inc. and Rural Peoria County Council on Aging provide transportation in the rural areas of the three counties.

3.5 Service Characteristics

The majority of Door to Door's service is provided by the vans listed in Table 2. The total fleet provides an average of three hundred passengers per day with an average of six hundred daily trips. The total number of passenger trips in FY 1998 totaled 143,573. The system's dispatch is almost exclusively reservation driven (24-hour advance notice), with the exception of nearly real time response provided to those passengers returning from medical appointments. Those requests usually require the dispatch of an empty vehicle to pick up an individual passenger. Most of these trips are funded by grants from the United Way and the City of Peoria Community Development Block Grant (CDBG).

Most passengers have schedules which parallel normal business hours, so peak travel hours match rush hour traffic patterns, extending the average peak trip time to one hour. Average non-peak travel time is approximately twenty minutes. Because most passengers are "regulars" with essentially regular schedules, the dispatch system has well-developed routines which take on characteristics of fixed route systems.

The Door to Door, Inc. system experiences two major peaks in daily service. These A.M. and P.M. peaks occur between 7:00 - 9:00 am and 2:00 - 4:00 p.m. While the Door to Door, Inc. fleet is large enough to handle most peak loads, the system is occasionally unable to accommodate all wheelchair patrons because of insufficient wheelchair stations in the Door to Door, Inc. fleet.

Potential customers are required to establish eligibility for service under provisions of the Americans with Disabilities Act through the completion of an eligibility form that may be completed manually or on-line at GPMTD's web site.

Door to Door, Inc. is contractually required to provide service during the same hours as the Transit District. This arrangement provides paratransit service on Monday through Friday from 6:00 am to 10:00 p.m. Saturday service is provided from 9:00 am to 6:00 p.m. No Sunday service is provided. When service is provided outside the GPMTD service area, transit hours are 6:00 am to 6:00 p.m. Door to Door, Inc. provides <u>door to door</u> as opposed to <u>curb to curb</u> service to most of its customers. This means that drivers provide assistance from the client's door to the destination's door.

3.5.1 Fare structure

Authorized riders transported within GPMTD's service are charged $1.50 per one-way trip. Transportation outside of the GPMTD service area is charged one of a number of rates depending on distance from the City of Peoria, sponsor relationship and time requirements of the trip. Billing for trips outside of the Peoria urbanized area is based on individual arrangements with separate human service and charitable agencies. A common billing arrangement is based on mileage from the city of Peoria. Current rates are listed as $8.00 for trips within a radius of approximately 6 miles. For trips beyond the six-mile radius, but less than a radius of approximately 13 miles, rates are charged at a flat rate of $18.00. Trips outside of the outer radius are charged an additional $0.50 per mile in addition to the $18.00 flat rate. Agencies may negotiate a range of options that allow billing for mileage only, time only or combinations of both. Authorized GPMTD riders traveling outside of the GPMTD service area pay rates based on distance traveled.

Trips outside of the service area may be reimbursed by one of the many social service agencies that provide program support to various segments of the disabled and senior population. Examples of sponsor agencies who will support travel needs for those passengers not covered by other funding sources include United Way and the Central Illinois Agency on Aging (CIAA), and the City of Peoria CDBG.

3.5.2 Major Destinations

A 1993 study completed by CGA Consulting Services, Inc. presented survey results of area paratransit riders. Surveyed Door to Door Inc. riders listed travel to and from work as their primary trip purpose, followed by school and medical appointments (Regionalized Transit Feasibility Study for the Peoria Urbanized Area 1993). A review of FY 1998 driver's manifests indicates the most common destinations by volume are a work/education and therapy program administered by the Peoria Association for Retarded Citizens (PARC), and the Community Workshop Training Center (CWTC), both located in the City of Peoria.

3.6 Revenues and Costs

Operation of a not for profit paratransit agency requires tracking a complicated set of expenses and revenues. Revenue and other funding may be collected from twenty or more separate agencies and are received in the form of direct payment, fare-box receipts, donations and in-kind services.

Due to various restrictions in area coverage, trip purpose and membership, combinations of two or more billing agencies or categories are possible. For instance, DTD operates the transit district's vehicles, while the district provides all maintenance and fuel used in day to day operations of those vehicles. Organizations such as United Way provide direct contributions to Door to Door Inc., for billing not covered by other funding sources. This mix of operations revenue and contributions create an extraordinarily difficult billing challenge.

3.6.1 Revenue and Expenses

Nearly 50% of Door to Door's operating revenue is earned from contract services with the transit district. In FY 1998, 81% of all revenue was generated through ridership fees collected from participating agencies. Salaries and wages represent the greatest expense categories, followed by expenses associated with repairs & maintenance and fuel & lubricants. Only 11% of overall costs are paid as management wages. Human resources costs represent the largest overall expense category at 64% (Table 3).

Figure 2 graphically displays the distribution of total expenses as detailed in Table 3. From the chart, it is seen that Door to Door, Inc. is a lean organization, with only 19% of total expenditures in non-operational costs.

Table 37 FY 98 Expenses by Percent of Total Expenses

Human Resources	
Salary/Wages Vehicle Operators & Dispatchers	45%
Salary/Wages Mgmt & Other	11%
Payroll Taxes (Total)	4%
Fringe Benefits (Total)	3%
Employee Physicals	<1%
Total HR Expenses	64%
Administrative Costs	
Supplies	1%
Legal & Accounting	1%
Printing & Advertising	<1%
Postage/Dues/Subscriptions/Travel	<1%
Total Administrative Costs	2%

Vehicle Operations	
Fuel & Lubricants	6%
Repair & Maintenance	10%
Total Vehicle Operations	16%
Misc. Expenses	<1%
Total Insurance costs	6%
Utilities & Telephone	1%
Rent	1%
Interest Expense	1%
Depreciation	8%

Figure 8 Door to Door, Inc. Expenses by Source

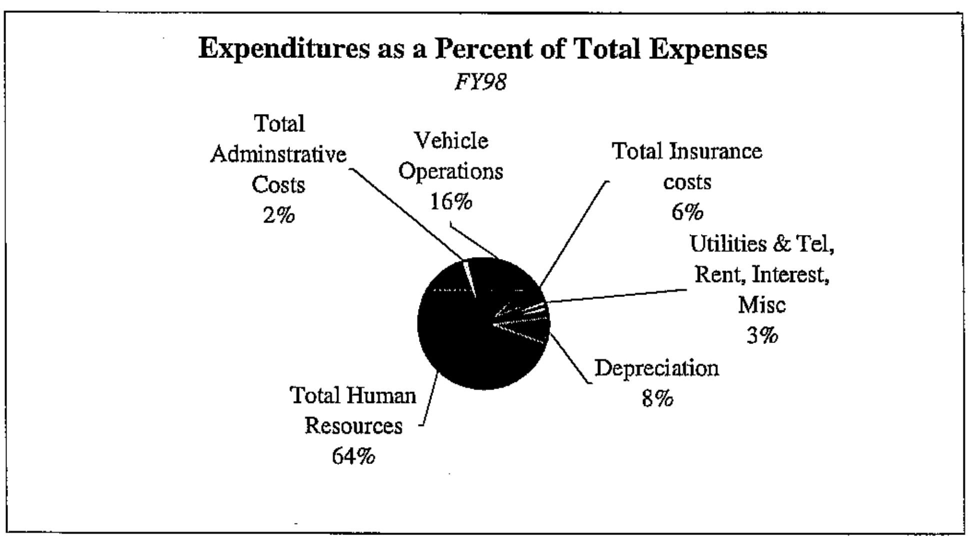
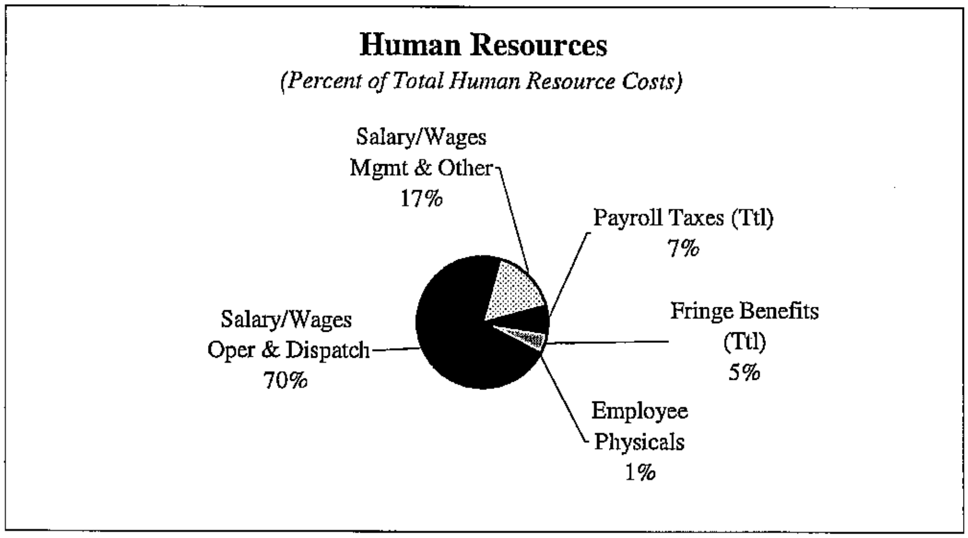


Figure 9 Human Resource Expense Detail



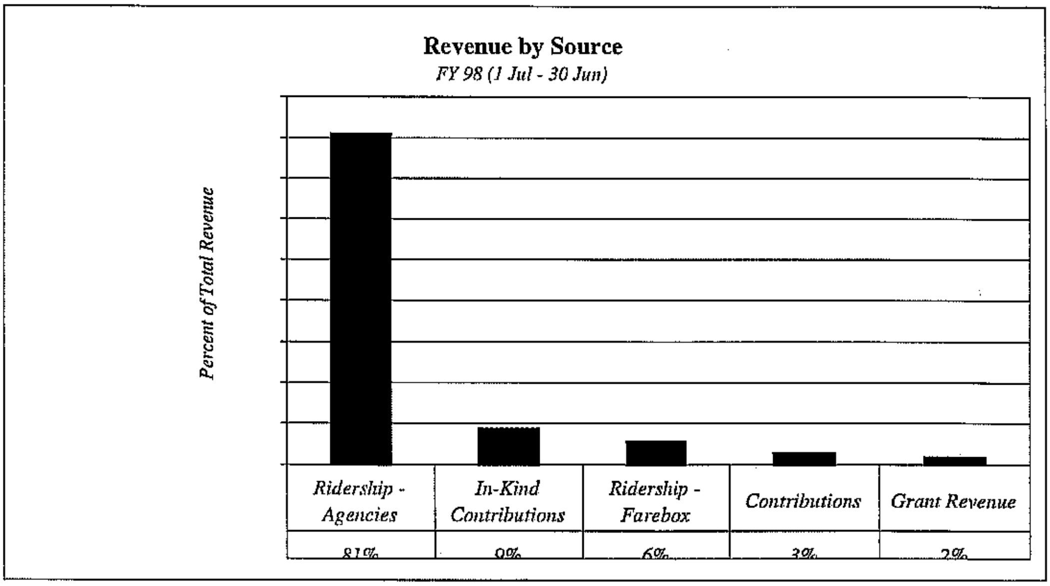
As shown in Figure 3, salary and wages of non-management personnel represent the lion's share of all human resource costs (70%) and 12% of all personnel costs are dedicated to payroll taxes, fringe benefits and employee physicals (mandatory drug testing). Because all full-time maintenance is accomplished by the Director of Maintenance, "Management and Other" includes all wages and salary of maintenance activity for the organization.

The dependence on subsidy income is clearly seen in Figure 4. Eighty-one percent of all revenue is generated through billing of sponsor organizations. Only 6% of total revenue is received through the farebox. This dependence requires extraordinary attention to maintaining positive relationships with regional sponsors and other contributors.

3.7 Receipt

To initiate a service request, customers may call any of Door to Door Inc.'s (DTD) published numbers 24 hours a day. As with most demand response agencies, Door to Door, Inc. requires a 24-hour advance reservation for guaranteed service. Customers may call after hours to add or modify a request for service. However, during non-business hours, calls are routed to an answering service which collects all after hours calls for later forwarding to the Door to Door, Inc. premises using a facsimile machine. The first shift dispatcher takes action for all call requests and modifications with urgent and time sensitive changes. The first shift dispatcher/scheduler modifies schedules as required to delete cancellations and if possible, by adding new ride requests to existing driver manifests. Actions on service changes for later periods are generally deferred until the full complement of dispatchers are available.

Figure 10 Door to Door, Inc. Revenue by Source



3.7.1 Screening/Vehicle Assignment

Because of a complicated set of billing and vehicle assignment options, customers are screened for eligibility before any scheduling actions are initiated. Client eligibility is determined through a screening process designed to assign a billing sponsor, ensure an appropriately configured vehicle arrives for the patron, and determine that the driver assigned is capable of providing any required special support.

The screening phase of the process includes steps that identify the correct billing sponsor for each caller. In addition to the Greater Peoria Mass Transit District (GPMTD), a variety of non-profit institutions serve as sponsors for Door to Door, Inc. patrons. The United Way and the Central Illinois Agency on Aging, and the City of Peoria CDBG are three major sources of funding. Nineteen additional agencies currently provide rider subsidies for Peoria area paratransit riders (Table 4).

DTD is the non-profit agency currently contracted to provide complimentary service to the disabled for the Greater Peoria Mass Transit District. GPMTD contracted riders are scheduled on and transported by vehicles operated and leased by DTD, and maintained by the transit district. Transit district vehicles are normally restricted for use by passengers designated as qualified riders by the district contract. Overflow district passenger volume is accommodated by scheduling. on DTD vehicles. Riders not covered by the transit district contract are designated by DTD personnel as "Outside" riders and are scheduled on available and appropriately equipped DTD vehicles.

Riders claiming eligibility for services on district vehicles using a GPMTD sponsor code are required to provide a current GPMTD registration number during scheduling. Individuals gain eligibility by indicating that they possess a disability that prevents use of GPMTD's regular services.

Assigning accurate sponsor codes is sometimes a daunting task requiring the use of three or more agencies. Sponsor code assignment is complicated by restrictions on various elements of the individual trips imposed by sponsor agency charters. Some agencies will fund trips by elderly (over 60 years of age) to medical facilities, but not to shopping destinations. Agencies may also restrict trips by using mileage or fiscal constraints. A complicated trip may include funding agency A sponsoring the portion of a trip through one geographic zone (mileage restrictions), while sponsor B would fund the trip to the final destination if to a medical facility (trip type restriction), and sponsor C might then be used to transport the passenger back to the mileage limit of sponsor A. Nearly all of the billing goes on behind the scenes, and is invisible to the customer.

Some trips are not eligible for any current sponsor code if the patron is not a member of a sponsoring agency's service group. Many of these trips are charged to funds provided by United Way and other contributing agencies and individuals. Asking the right questions of the calling patrons and knowledge of the many agency restrictions are essential skills for dispatchers who must correctly assign billing codes in high tempo situations.

A routine challenge is provided in attempting to explain to patrons possessing failing mental capacities that the requested trip today is not authorized to the store across from the hospital because the trip purpose is different now from yesterday's trip to the doctor. This situation may significantly increase the amount of time to service a call. Despite these challenges, and time pressures, dispatchers often take extraordinary steps to contact various agencies searching for funding of a patron's trip.

3.7.2 Time Negotiation

In the case of either the contracted rider, or the "Outside" rider, the time requested for pick-up or delivery may not be compatible with previously scheduled vehicle operations. In this case, a negotiation process is entered where alternate times are offered by the scheduler/dispatcher in an attempt to accommodate the customer. If a mutually satisfactory schedule can be arranged, the time(s) for pick-up and/or drop-off are noted on internal documentation and confirmed with the caller. Due to high volume telephone traffic combined with simultaneously occurring dispatching operations, customers are sometimes given either an extended window (more than 10 minutes) for arrival time or the option to have a time confirmed with a telephone call at a later time.

Table 38 Door to Door, Inc. Pre-implementation Passenger Sponsor Agencies

Agency Name	*Number of Codes*	*Agency Name*	*Number of Codes*
• PARC (Peoria Association of Retarded Citizens)	8	• Peoria School District	2
• Door to Door, Inc (Internal codes)	5	• Proctor Hyperbaric	2
• Central Illinois Memorial Kidney Fund	4	• Human Service Center	2
• Central Illinois Council on Independent Living	4	• Crossroads	1
• Peoria Senior World	4	• Department of Human Services	1
• Camp Free to Be	2	• Foster Grand Parents	1
• Community Workshop and Training Center	2	• CAP	1
• Even Start	2	• Catholic Social Services	1
• Peoria Department of Rehabilitation Services	2	• St. Francis Hospital	1
• Special Recreation Association	2	• Illinois Mentor	1
• Illinois Department of Mental Health and Developmentally Disadvantaged	2	**Total Codes**	**50**

3.8 Scheduling

Scheduling is a multi-step process comprised of the development of the sequence of passenger pick-up and drop-offs, the recording of the pick-up and drop-off order in a format useable by the operators, and the maintenance of the most visible component of the manual process - the wall mounted scheduling boards. Scheduling is one of the more complex tasks undertaken by the scheduler/dispatcher. The next several sections detail the scheduling process.

3.8.1 Run Development

A large number of Door to Door Inc.'s daily ridership is composed of return patrons. Because of the large number of repeat riders, most customers are actually being fit into pre-configured vehicle patterns called "runs" during their scheduling process. A run is the route recommended by the scheduler/dispatcher that attempts to minimize the expenditure of organizational assets and maximize the service quality received by the passengers.

When a run is composed of a high volume of return riders travelling to and from the same locations on a regular schedule, scheduling becomes more a confirmation process rather than a scheduling process, since all optimization decisions have been completed during previous scheduling efforts. Most of the daily activity of the scheduler/dispatcher team is oriented toward maintenance of pre-configured lists of passengers. When working with these kinds of runs, a passenger is presumed to be riding on the scheduled run unless the rider takes action to cancel their seat.

The use of runs allows for a high level of predictability for vehicle arrival times. Even in the case of no-show patrons at several pick-ups, the vehicle will travel a route essentially as if the no-show passengers had boarded, and will arrive very close to the originally scheduled time. This predictability, along with a sense of the day's no show rate, allows experienced dispatchers to confidently accept ride requests without cycling through the entire scheduling process while the customer is on the telephone. Accepting a reservation for a customer who is a return rider on a regularly scheduled run is actually *not* changing an existing run.

The most difficult part of scheduling is the first time development of a run. In normal operations, this task is reserved for the most experienced dispatcher/scheduler. The task of run development requires that each ride request be optimized in terms of ride time, distance and vehicle assignment. While some choice is removed because not all vehicles are available for assignment, even the optimization of two vehicles in an urban area can be enormously complicated. Run development for non-urbanized areas become less complicated as entry and exit routes to individual patron residences become more limited.

3.8.2 Pick-up and Drop-off Times

When scheduling a ride request, the focus in scheduling may be either on the drop-off time or on the pick-up time. When assigning the time for pick-up and/or drop-off, time of day and type of trip requested determine the scheduling orientation. During morning hours, when most people are departing from their residence, the dispatcher is focused on arranging a drop-off time. This is in consideration of the comfort provided to the passenger who may await pick-up in the comfort of home, and the common need to *arrive* at a destination at a particular time. These arrival times are generally common to groups of riders and correspond to routine working hours or doctor's office hours. Most morning requests schedule riders to arrive at a place of employment, rehabilitation, medical appointment, etc.

During afternoon hours, most requests are oriented towards returning patrons to their residence. During these hours, dispatchers reverse their scheduling focus, with an effort now to minimize the wait time away from home, making pick-up time the more important scheduling issue.

Some passengers may have special circumstances requiring a specific pick-up and/or drop-off time anchored to accommodate appointments or other circumstances. Each of these requests introduces more complexity into the scheduling process by forcing all other trip requests to be scheduled around the anchored times. Some other common special circumstances requiring extra scheduling effort may include a requirement to separate particular passengers because of significant personality conflict, inflexible doctor's appointment hours or behavioral disorders.

3.8.3 Request for Service Sheet

Once the billing sponsor is established, the appropriate scheduling focus is implemented, and a projected time for pick-up or drop-off is established, the process of recording and tracking scheduling events begins. During the negotiation/confirmation process, the call taker begins recording customer information. One of the first documents used is the *Request for Service* sheet. This sheet is used to record much of the information discussed above, such as the customer's name, the date, ID/agency affiliation (billing agency), pick-up/drop-off times/locations and a record of the time negotiation if the initial customer request was unavailable.

3.8.4 Paper Tickets

While customer information is recorded during the call receipt process, the most often used resource is the paper ticket that is used to represent the individual passengers of each run. These tickets are approximately 1 by 3-inch rectangles of various colors on which all information necessary to schedule and dispatch is recorded for that customer. The tickets are reusable, and are retained from day to day. If a ticket had not been completed during a previous request, a paper ticket is created during this phase. The ticket holds the customer's name, disability, pick-up and drop-off address, sponsor codes and any special notes. Information may be recorded on both sides of the ticket. The paper ticket is affixed to a magnetic holder allowing the ticket to be attached to metal faced display boards. The display boards and the magnetically attached tickets represent the most critical non-human elements of the scheduling and dispatch process. The labels are designed using nine separate colors representing the range of possible billing, vehicle and run assignments. Table 5 lists those color and category assignments.

Table 39 Pre-Automation ticket and color assignments used on wall displays

Vehicle Assigned (*All are operated by DTD drivers*)	*Description*	*Ticket Color*	*Funding Agency*
GP Transit District	Scheduled, occasional (non-repeating) district contract passenger	Blue	Transit District
GP Transit District (DTD backs up w/own vehicles)	Same day service, "Will call"	Yellow	Transit District
Door to Door, Inc.	Same day service, "Will call"	Green	Various Agencies
SST (DTD back up)	Scheduled Senior Citizens	Salmon	SST
GP Transit District	Routine GP riders	Red	Transit District
Door to Door, Inc.	Routine Door to Door riders	Pink	Various Agencies
SST	Routine SST/Permanent Pick-up Schedule	Cream	SST
Door to Door, Inc.	Public aid riders	Gray	Public Aid
Door to Door, Inc.	Door to Door, Inc. Charters	Purple/Green	Various Agencies

3.8.5 Scheduling Boards

The scheduling boards are the most visible components of the manual system. When completed, they visually represent all planned trips during the current and following five-day period. Because the board system is arranged to visually represent each day of the operational week (Monday through Saturday) in fifteen minute intervals, the act of placing the ticket on the board is in its simplest form, scheduling. In a simplistic scenario, if there is a space in one of the board's intervals (representing available time), large enough to "fit" the proposed trip, then the trip can be scheduled.

The decision process executed in placing a magnetic ticket onto the board represents the most complicated dispatcher task. The process includes consideration of a large number of variables, including vehicle availability, customer idiosyncrasies, weather, and knowledge of the service area. Service area knowledge is the primary skill allowing the scheduler/dispatcher to assign a time interval to each travel segment. Only encyclopedic knowledge of the area and customer base allows for inclusion into the travel time equation such factors as length of time to move a wheelchair from door to vehicle in different facilities, and the use of "short-cuts" not obvious to casual travelers.

The combination of tickets and boards allow a graphic representation of every group of individual trips. These collections of individual trips are called 'runs'. The boards are configured such that strips of colored paper may be attached representing pre-scheduled trips (runs) which must be accomplished on a daily basis. Driver lunches and breaks are displayed using the same visual method used for reserving time for runs, using a different color strip of paper. When the colored strips are attached to the board, it represents a length of time that must be protected to keep the time slice open for scheduled activities during that day. The boards are wide enough to allow for space representing the total possible time allocation of a day in fifteen minute increments for every assigned vehicle, meaning several columns are displayed for each day. The boards require the use of two of the four walls in the dispatch office.

3.8.6 Driver Manifests

At the end of each day, the scheduling/dispatch staff uses the now updated wallboards to create the driver manifests for the next day. In this process, the information is simply transferred from the tickets onto the paper manifest. The manifest assigns a particular route to each driver, creating the stop by stop schedule for each vehicle. Once completed, the manifest becomes an essential document, because it will contain all pick-up/drop-off times and names, fare collection data, cancellations, and additions for each stop.

The driver manifest is the most important document created during the operating cycle because of the amount of data contained within the document, and the number of management and accounting actions dependent on it. This single document reflects input from all four operations categories; call receipt, scheduling, dispatch and vehicle operations. Once the manifest is completed by the driver and reviewed by the scheduling and dispatch team, information recorded on the manifest provides input to the billing process and quality control activities. Because the manifest is a primary source document containing on-time performance, cash receipts and customer show/no-show results, once completed, it becomes a keystone for all future organizational analysis.

3.8.7 Dispatcher Boards

On the day of the trip, the magnetic labels are moved from the wallboards to the dispatcher's desk and arranged on smaller boards; one for each vehicle dispatched. The smaller boards are rectangular strips of wood approximately 1 and 1/2 inches wide and twenty inches long. Tracking of both vehicle and individual rider status is accomplished by placing the tickets on the board (held in place by rubber bands running vertically along the board) in time sequence from earliest at top to latest for that run at the bottom. When augmented with an aggressive dispatcher and cooperative driver, these dispatcher boards allow near real time monitoring of the trip status for each passenger and vehicle.

The smaller boards are updated continuously by the dispatchers in response to radio communications with the drivers regarding location and passenger status. Two sets of lines are inscribed onto the boards which allow the dispatcher to identify the general status of each passenger as awaiting pick-up, onboard, or dropped off. Any tags above the top line represent customers waiting for pick-up, those between the two lines represent customers who are onboard the vehicle and tags below the bottom line represent passengers already dropped off.

With experience, most dispatchers are able to project arrival time deviation, projected vehicle load factor and visually place every dispatched vehicle on a mental map of the service area by using the boards and radio contact. Because the smaller boards provide instant visual clues about passenger loading, route progress or schedule deviation, the dispatchers are able to make real time corrections to the enroute vehicles, adding or subtracting riders as it becomes necessary.

While all dispatchers demonstrate notable competency in the use of this system, dispatchers admit that high tempo peak dispatching periods seriously degrade the quality of passenger and vehicle monitoring. During these peak times, clients can "get lost" while awaiting assignment to the next open vehicle, drivers may be forgotten after having been authorized a break, and a larger number of incoming calls may not be scheduled at all.

3.9 Dispatching

For the purpose of clarity, dispatching has been defined as all activities between the generation of the final manifest issued to the driver and the receipt of the completed manifest by the dispatcher staff from the driver, following run completion. This includes vehicle/driver assignment, communications with enroute drivers, real-time modification of enroute manifests, and collection of driver provided information while away from the dispatch facility.

3.9.1 Vehicle and Driver Assignment

Vehicle/driver assignment is accomplished using a simple first come first serve process within constraints imposed by run requirements and driver classification. For example, runs that provide service to disabled clients using a wheelchair require both a lift equipped vehicle and a driver classified in the "regular" category, so that the driver is qualified to provide assistance in boarding and unloading of wheelchairs. Other constraints in vehicle assignment are imposed by agency requirements mandating vehicle use. Both the Central Illinois Agency on Aging and the Greater Peoria Mass Transit District provide vehicles reserved for primary use by their agency's passengers. These assignments are managed using sponsor codes collected during the call receipt and certification process outlined above. In the case that more than one vehicle is available following the previous criteria, the driver is free to take the vehicle of his choice. The transit district maintains and stores their vehicles at a nearby facility where DTD operators pick-up and return the vehicles.

3.9.2 Driver Communications

Once departed from the dispatch facility, both dispatchers and drivers maintain routine contact with one another through their dedicated radio channel. Drivers are routinely queried by dispatchers regarding current location, vehicle loading and projected arrival times. Drivers are required to report their passenger count and mileage at several prescribed times of day.

Drivers routinely call the dispatch staff for passenger updates, cancellations, and to ask for telephone assistance to contact no-show passengers. The radio also provides emergency communication in case of accident, breakdown, and passenger health or other issues. A very common communication requests assistance with locating a customer residence. This kind of assistance may require that the dispatcher speak to both the customer who is providing directions and to the driver who is navigating with voice commands from the dispatcher.

3.10 Real time scheduling

During many runs, passengers may either be added or deleted due to cancellations or additions initiated by the passenger or the dispatcher. In either case, the dispatcher notifies the affected driver using the radio and requests that the run manifest be updated to reflect the change. Each driver carries a "Demand Response Trip" manifest on which additions are noted. The dispatcher maintains similar forms that are used to verify the driver's copy. Total vehicle loading and agency billing are derived from these two documents.

3.11 Customer Complaints

During the course of the dispatching day, it is possible that a number of clients may be inconvenienced through late arrivals, passenger misconduct or even incorrect drop-off location. In these or other customer service issues, the dispatcher is the primary arbiter and resolution specialist. This is unavoidable because of the direct telephone link between the passenger still waiting for a pick-up and the dispatcher. When a receiving a call from a distressed client, the dispatcher is able to choose from a wide range of options. On one extreme, the dispatcher simply receives the call and notes it in a logbook provided for that purpose, leaving it for later management disposition. When using greatest latitude, the dispatcher interacts with the client, accomplishes problem resolution and makes no formal record of the action. The latter method is common because many calls are related to late arrivals or no-shows, meaning that the dispatcher reacts by locating the nearest vehicle and reroutes it to the calling client. In some cases the event is closed with a simple "I'm sorry" while the pick-up is canceled because of vehicle unavailability or because the customer's schedule no longer allows for travel that day.

3.12 Dispatcher Interviews

In depth surveys of the dispatch team were conducted through private, face-to-face interviews using a structured format. The dispatchers answered questions from a series of open-ended questions designed to allow each to respond freely. No attempt was made to limit responses. Three interviews were conducted in a one-day session at the transit property. The individual interviews ranged in length from one and a half to just over two hours.

The purpose of the interviews was to obtain information from the dispatch team developed through individual experience and not represented explicitly in other objective measurements. These initial responses will allow a comparison of attitude change toward the automation process related to each of the installation phases. Additional interviews will be accomplished in the during and post-implementation phases. Results will be combined in a separate document containing a thorough discussion of attitude change.

The pre-implementation survey uncovered significant factors that may be directly affected by the installation of computer-assisted dispatch and scheduling software. The most important issues likely to be affected by the automated system include resolution of customer complaints, coordination of dispatcher activities and agency training requirements.

Descriptions of the dispatch process provided by the respondents highlight significant levels of stress and frustration during normal operational tempos in the pre-automation phase. The dispatchers attributed much of the high stress levels to their inability to efficiently coordinate the scheduling activities during daily peak service periods. As an example, during peak service hours, the manual process requires individual dispatchers to schedule incoming requests simultaneously. This often results in overlapping and mutually exclusive promised pick-up or drop-off times. The inability to coordinate scheduling during peak periods accentuates an already hectic environment by requiring additional work to resolve scheduling conflicts.

3.12.1 Skills

Dispatchers were asked to describe the competencies they feel are necessary attributes of a skilled dispatcher. The brief results are displayed as Table 6. Responses in this category ranged from map reading skills to situational awareness. The common theme is the emphasis on communications skills and knowledge of the service area. Every dispatcher agreed that a fundamental prerequisite for dispatch assignment is previous driver experience. Given that a dispatcher possesses the necessary driving experience, two of three dispatchers identified communications skills as the most important attribute; the third dispatcher chose organizational skills.

The driver knowledge base all dispatchers refer to as a prerequisite is comprised of geographic orientation (street layout, relative distances between common pick-up and drop-offs), a "feeling" of how long it takes to complete assigned runs, vehicle and passenger idiosyncrasies and spatial skills which allow the dispatcher to visualize the location of each dispatched vehicle.

Two of the three dispatchers indicated that administrative skills associated with paperwork maintenance are least important in dispatcher operations. This is a reference to the daily necessity of catching up on trip requests received during peak hours, but which have been unable to have been acted on immediately. The administrative process in this case is the backtracking required to complete log entries and to reconcile conflicts between scheduling assignments. The third dispatcher declined to identify any skill as "least important", preferring to allow that all skills are important, but at different times of the day.

The dispatchers believe that the most important skill sets required in the post automation period will not change. The two dispatchers who chose communications skills as the most important skill requirement were adamant on this subject.

In response to questions regarding transferability of skills developed from dispatch/scheduling automation, all respondents agreed that the new computer skills would be valuable in any new workplace. Skills in this context are basic MS Windows fundamentals. This response is to be expected because of the very limited exposure to other than the DOS based system used in daily operations. The dispatchers noted that none had significant exposure to computer applications outside of the current work environment. None had previous computer experience preceding their current employment and all rated their current computer skills as average or worse.

3.12.2 Overall job evaluation

The dispatchers unanimously agreed that they "like" their job. Two of the three framed their positive comments in terms of enjoying the job's responsibility; the third noted satisfaction with the humanitarian aspects of assisting the disadvantaged clientele. Negative responses to other questions such as those related to development of transferable skills and high stress levels indicate significant dissatisfaction with other job responsibilities.

Every dispatcher believed that automation of the dispatch process would significantly reduce workload and its related stress. Indications of high stress levels were contained in responses from every dispatcher. Some stress generation was attributed to a high workload resulting from a management decision to not replace a dispatcher who had departed the week before the system installation began.

3.12.3 Expectations

The entire dispatch team and all others in the organization perceive that dramatic changes will take place in terms of both internal administrative and external operational efficiencies, meaning higher vehicle load factors and increased quality of service to the customer. All of the respondents also had positive expectations regarding the automated system (Table 7), and reinforced their opinions again that the upgraded system will significantly reduce workload and stress. Two of the three saw the greatest value of automation in reducing the complexity of the manual system's administrative requirements. Dispatchers expressed their hopes that the new process would reduce paperwork, therefore increasing dispatcher focus on the more important task of providing service.

Table 40 Most Important Pre-Automation Skills (Pre-implementation)

Communications	• Telephone, radio, interpersonal communications skills • Humor
Service Area Knowledge	• Knowledge of area and clients • Map skills • Driver skills
Administrative	• Caller information transcription • Working the scheduling board
Organization	• Computer skills
Situational Awareness	• Spatial orientation to synthesize status of scheduling board, vehicle location, and integrate driver/vehicle abilities • Identifying and prioritizing task precedence • Knowledge of personal limitations
Other	• Patience • Memory • Aggressiveness

Table 41 Pre-Automation Expectations

• Efficiency increases (e.g., more service)	• Less complicated process
• Increased driver availability and control	• Reduce workload and related stress
• Control of sign-off and break times	• Reduced administrative requirements

One response focused on the hope that the new system would allow greater control of driver break/sign-off times. The issue with driver sign-off and break revolves around the practice of the driver calling in for sign-off to break, when the driver had actually been on break for an extended period following early or canceled drop-offs. This happens most during peak times when dispatchers forget to whom they have given run changes. During high tempo periods, cancellations may have been given to a driver significantly shortening the run. Without dispatcher intervention, some drivers may take advantage of the "extra" time, and park the vehicle awaiting instructions instead of apprising the dispatcher that the vehicle is available. During the period when the dispatcher had lost track of a vehicle's load status, the dispatcher had been unnecessarily forced to assign the idled driver's potential passenger load to other vehicles.

While all think that dispatching efficiency will increase, one respondent was convinced that the automation would limit the "human touch" of dispatchers. This is reflected in another dispatcher's comment that the system interaction necessary to enter dispatcher input is too much trouble. Because of the difficulty involved in not accepting the software's solutions, dispatcher sentiment was that most would ignore the option to do so.

All dispatchers believed that the system would make them reduce ineffective, redundant paperwork and increase dispatcher effectiveness. One of the dispatchers feared that increased reliance on the program's display window might require additional skills to the detriment of situational awareness. All dispatchers agreed that the program would develop additional computer related skills that would be useful in the future.

3.12.4 Training

Lack of training is the single greatest dispatcher concern. With the imminent "live" date so near, every dispatcher expressed concern that no relevant training had yet been received. The dispatch team's concern follows from the group's near complete lack of exposure to computer applications in either personal or professional environments. The team's concerns seemed to be more that they lacked general computer training as opposed to training on the particular software being installed. Far from feeling intimidated with the new program, the concern was with how to handle the most basic of computer issues: back up, what to do "if the mouse doesn't work", or the computer "crashed".

3.12.5 Additional Information

The last question allowed the participants to add any information they felt as important. The responses to the question "Is there anything else you'd like to add" yielded several responses, ranging from questions about their future if they did not "pick-up" the new system, to specific observations of current and future property operating issues. The most significant issue in this category is related to the potential usefulness of dispatchers to the organization if either they are unable to master the new program or if the new system "replaces" them.

Chapter 4

Cost Effectiveness Evaluation

4.1 Introduction

This chapter is composed of nine major sections. Following this introduction, Section 2 is a description of the computer equipment and software used at the study site. Section 3 contains the description of data collection for the project and the implementation phases used to assess progress. Section 4 documents pre-implementation training methodology at the organization impacts on scheduling, dispatching and management functions affected by the computer assisted scheduling and dispatch (CASD) system. Section 6 documents key productivity parameters monitored and analyzed in this study. Sections 7 through 9 present a detailed analysis of effectiveness, efficiency and quality measures developed from performance attributes contained in previous sections. Section 10 discusses the impact of CASD on the potential for coordination, and sections 11 and 12 contain the conclusions and recommendations of the project, including an assessment of the long-term value of CASD implementation to the riding public and future paratransit operators.

4.2 CASD System Description

Door-to-Door, Inc.'s CASD implementation included the purchase of both hardware and software components. All hardware (computers, monitors, printers and other peripherals) were purchased locally, taking advantage of the fast response times for repairs when needed and of local pricing. All software was provided by the paratransit software vendor, who also installed the hardware, the local area network, and necessary software support packages.

4.2.1 Equipment

Door-to-Door, Inc.'s computer hardware was comprised of one server, five workstations and a printer connected via a local area network. The Greater Peoria Mass Transit District installed a single workstation giving them dial-in access to the server. Table 42 shows the basic hardware installed during pre-implementation.

Table 42 Implementation Hardware

Hardware	Description	Qty	Location
Server	266 MHz, Tape Back-up, Hi-Cap Dual Drives	1	Door to Door, Inc
Workstation	300 MHz	5	Door to Door, Inc
Workstation	300 MHz	1	Transit District

All hardware components were obtained from a local retail franchise and represented average hardware capabilities at the time of purchase. The server was purchased with two high-capacity hard drives and a tape back-up system. The server contained a (then) relatively fast 266 MHz

CPU, while each of the initial workstations was configured with 300mhz processors and single hard drives. The server and workstations were linked in a local area network (LAN) providing server access from any connected workstation and to a laser printer.

The software package is compatible with the Windows© operating system and is designed to allow a maximum of interaction with simple "point and click" mouse actions. Except for direct data entry, virtually all activities are accomplished using the computer's mouse controls. The software's features are divided into two broad categories, scheduling and dispatching, described in more detail in the following sections.

4.2.2 Software

The organization's software package consists of a semi-customized, commercial paratransit management software package. The software was provided and installed by a major, established vendor. Although the software package installed at the study site is a relatively basic configuration, the software was upgradable, allowing the addition of automatic vehicle location devices, mobile data terminals and other related modules.

The installed software package is designed to store, tabulate and report a wide range of performance measures, including odometer readings, time stamps for various legs of each trip, dispatcher and driver efficiency measures and a large number of passenger data elements. The CASD system calculates and reports complicated billing transactions involving multiple agencies.

More complex or ad hoc report generation capabilities are available with either the purchase of a report writing module designed to create custom reports or by accessing the system's database directly with any of several commercial database or spreadsheet applications capable of reading standard database files.

4.2.3 Scheduling Functionality

The study site installed paratransit software designed to support all of the most common actions taken in paratransit scheduling operations. Table 43 contains a listing of the basic scheduling functions of the software.

Table 43 Site Scheduling Software Features

Feature	Implemented	Feature	Implemented
Landmarks/Common Addresses	Partially	Rider Statistics	Partially
Automatic Geocoding	Yes	Brokering	No
Mapping	Partially	Run Posting	Partially
Run Definitions/Registered Trips	Partially	Batch Trips (optimization)	Partially
Scheduling Elements	Partially	Feeder Trips	No
Rider Information Elements	Yes	Complaints	No
Automatic Vehicle Location	No	Mobile Data Terminals	No

Landmarks/Common Addresses

The "Common Address" feature in the site's version of the CASD software allows the scheduler/dispatcher to abbreviate scheduling activities by using a code to represent frequent origins and destinations such as medical facilities, common shopping destinations and any other pick-up or drop-off locations frequently used by schedulers. In the version installed at the study site, schedulers are able to add specific locations at the destination or pick-up location such as "Main Entrance", etc. to further speed ride-booking transactions. When the code used to designate the common address is used in a field, the software automatically enters the entire address. Advantages of using common address codes include increased accuracy of information entry and prevention of duplicate ride assignment resulting from two riders traveling to the same location who have slightly different spellings of drop-off or pick-up locations.

This feature allows the software to use internal databases to automatically assign the mapping coordinates used by the scheduling module. This module uses TransCAD© to assign and display mapping information. The site's software version uses latitude and longitude information as input to route solution algorithms for optimization of vehicle trips.

TransCAD is a geographic information system (GIS) designed primarily for transportation uses that graphically displays coded geographic data. A geographic information system (GIS) is a computer-based information system designed for the input, manipulation, management, and analysis of spatial (geographic) data. Components of a GIS include, software, and a Relational Database Management system (RDBMS). A GIS models the real world as a series of 'layers' that are linked together by geography. GIS allows for the analysis of geographic relationships between the features stored in the data layers. It is the GIS system that actually produces the map output seen on the CASD display.

Mapping

Mapping features allow users to dynamically interact with the geocoded customer database. Other mapping features allow point and click assignment of rider pick-up and drop-off locations and the addition of new streets to the database. Dispatchers also use the function to give real time directions to drivers. The CASD map allows dispatchers to interact with the underlying mapping system by using the mouse and adding additional data to the system's mapping database.

Users in most CASD installations must enter new streets that have been constructed since the mapping database was produced or to correct a mapping error introduced in the original dataset. The CASD at this site allowed users to essentially "target" a geographic position with a mouse cursor and then to "draw" a street on the CASD map. Additions using this drawing and mouse action were automatically loaded as geographic coordinates in the GIS database, making the new street available in future run solutions.

Run Definitions

This feature allows assignment of predefined vehicle routes to particular segments of the service area and also to designate service for unique contractors. This option allows CASD users to enter subscription routes, or those service routes that are performed in regular cycles. When operators use this option, the group of regular riders are grouped together and assigned a route using the system's scheduling algorithm. Once defined, this route remains essentially unchanged from one use to another. DTD implemented this feature, but only for a portion of the GPMTD subscription routes.

Scheduling Elements

Scheduling elements include provisions for trip reservations, automated trip scheduling, brokering and cancellation/confirmation actions. Trip reservation actions may include entry of subscription, advance but not routine schedules, and same-day reservations.

Rider Information Elements

Rider information is collected and maintained in the system's database allowing a one-time entry of rider information. Rider information includes disability information, emergency contact information, mobility aid identification and sponsor codes. Disability information allows automatic assignment to vehicles with lifts and wheelchair configurations, and to drivers trained with special skills. In addition to rider specific information, the system can store information about personal care attendants, and the rider's past trip activity. Previous trip activity can be used later as a template for automatically scheduling a future trip.

Rider Statistics

The system collects a huge amount of information about each passenger. In addition to the basic information required to initiate a system entry for a first ride, the system can collect and report passenger no-show rates, ride-times, frequency of visits to zones, ride frequency with particular drivers and/or vehicles and associates each run, and each unique passenger-trip.

Brokering

The brokering feature allows the system to track billing and performance data separately for other providers, allowing for centralized scheduling and dispatch support to geographically distant operations. This feature is designed to allow a central scheduling/dispatch office to handle all scheduling, dispatching and billing activities for other agencies, allowing those other agencies to benefit from the potential of CASD while avoiding the necessity of investing their own capital assets in a new system. This was not implemented by DTD.

Run Posting

Run-posting is an activity required in CASD equipped organizations that have not installed automatic vehicle location devices and/or mobile data terminals, which is the case at Door to Door, Inc. This activity manually reviews passenger manifests for driver entries to record arrival and departure times, mileage and passenger counts in the CASD database. Run-posting may become a significant time investment in that every passenger action, completed trip, no-show, pick-up and drop-off time, must be manually entered into the CASD database. Lag time between run completion and run posting prevents accurate real-time assessment of system performance and opens the door to data inaccuracies from manual data entry.

Batch Trips

Trip batching is the optimization of passenger trips into efficient pick-up and drop-off times along the most suitable routes, and in the most suitable vehicle. This feature allows designated requests for service to be assigned to the route and vehicle most appropriate to ensure that the passenger arrives at their destination at the time they desire while still minimizing fleet mileage and time. When using this feature, all requests for service are held in an unassigned status, until some pre-determined cut-off time. At the pre-determined time, all designated riders are individually considered for assignment by the scheduling algorithm to any available vehicle. After computing scores considering various weights for length of ride-time and difference from promised pick-up or drop-off, the riders are presented in various run assignment schedules for dispatcher selection. The dispatcher may either choose a configuration suggested as most "feasible" or any of the other provided options. The dispatcher may also manually select any or all of the riders and assign as they feel necessary.

This feature has not yet been implemented by DTD. Only individual routes have been optimized.

Feeder Trips

Feeder trips allow passengers to schedule pick-up and drop-off times that coincide with other transit providers, ensuring that the pick-up or drop-off time coincides with the schedule of the other provider. This may be used to link a rider with a mass transit system, or any other mode of transit. This feature was not implemented by the study organization.

Complaints

This feature allows rider complaints to be registered in the CASD database, linking the complaint to all the database fields tracked for normal record keeping, such as driver, time of day, route, vehicle ID, etc. This allows management to link customer service issues with individual drivers, dispatchers, or other system components. This feature was not implemented.

Dispatching Functionality

Table 44 lists basic dispatching features provided in the base CASD system. Dispatching includes all actions taken by scheduler/dispatchers after the vehicle has left the garage. This includes enroute schedule adjustment – adding or removing passengers from the passenger manifest, redirecting drivers around obstacles/traffic, scheduling breaks and retrieving and entering odometer and time stamps as drivers complete the runs listed on their assigned passenger manifest.

Table 44 Site Dispatching Software Features

Features	Implemented
Automatic Schedule Adjustment	Yes
Same-Day Trips	Yes
Identify Standby Vehicles	No
Track Dispatcher Performance	Yes
Track Vehicle/Driver Performance	Yes
Manifest Generation	Yes

Automatic Schedule Adjustment

The software allows real-time input of schedule changes to already issued manifests. Schedule changes may then be sent to drivers, allowing dynamic use of the software's optimization algorithm. Real time input of vehicle location information allows the scheduler/dispatcher to alert passengers to early and late vehicle arrivals.

Same Day Trips (Demand Response)

This CASD system allows the dispatcher/scheduler to assign new riders to manifests as drivers follow their existing passenger manifest routing. When using this function, the software automatically updates the pick-up and arrival times of future passengers, assigning the new rider if rider schedule changes are not pushed beyond the early or late arrival windows established by management.

Identify Standby Vehicles

The version of software installed at the study site is designed to project many items of interest such as projected vehicle location, idle vehicles and passengers awaiting assignment to a vehicle on the computer screen. Use of this function was troublesome to the site's dispatchers who described it as contributing to a "cluttered" screen making dispatch actions more confusing.

Track Vehicle/Driver Information

When properly configured and with proper data entry, the system is capable of providing a wide range of performance reports. Standard reports include most formats familiar to paratransit managers who report to the National Transit Database. With extra modules or commercial database or spreadsheet software, the system can provide a full range of ad hoc reporting capabilities. When configured to do so, the software can track individual productivity of drivers, dispatchers, schedulers, and vehicles. This feature allows management to view statistical data that rates scheduler/dispatcher production by individual, call taking time, and on-time performance of vehicles and drivers. The system is also configured to track such information as driver license information, training requirements, and related data. The CASD is also capable of tracking maintenance events for vehicles, and removing vehicles from service when scheduled maintenance is due. DTD had limited use of this feature.

Manifest Generation

The system generates a paper manifest for issue to drivers. The manifest provides drivers with optimized route schedules (if the feature is used), and all necessary information to direct the driver to each rider pick-up or drop-off location. The manifest is used by the driver to record all activity during the day, providing a permanent record of pick-up and drop-off times, passenger no-shows and on-time rates.

4.3 Data Collection Effort

The data collection effort spanned both qualitative and quantitative dimensions of paratransit operations. Qualitative data includes hundreds of hours of interviews collected from face-to-face and telephone interviews of the site's manager and dispatchers in real time as they experienced the transition from manual to CASD operations, and a survey of passengers taken as they used the paratransit service. Quantitative data has been collected from elements contained in the passenger manifest used in the pre and post-implementation periods. Pre-implementation data was manually keyed into a useable database. Post-implementation data was extracted directly from the agency's new CASD equipment.

Dispatcher interviews were completed in each of the implementation phases to assess changes in attitudes toward the new technology, job satisfaction and changing skill sets. The interviews were accomplished in single face-to-face settings asking identical questions in each session. Only two of the dispatchers interviewed in the pre-implementation period were still working at the site in the post-implementation period. However both of the new dispatchers had experienced the transition to CASD as drivers in the same facility.

Implementation Phases

The project investigated changes during three pre-defined periods. The pre and post-implementation periods were designed to encompass equal six-month time increments. The implementation period was defined so as to begin after all manual dispatching activities had ceased and the CASD was used to accomplish as much of the day to day activities as possible. Table 45 illustrates the implementation phases. Pre-implementation activities included customer data entry, geo-coding, sponsor code assignment, training, system shakeout and hardware/support systems installation. The following sections discuss the implementation activities in detail.

Table 45 Implementation Phases

Phase	Dates	Length
Pre-Implementation	Jun 1998 – Nov 1998	Six Months
Implementation	Dec 1998 – Jul 1999	Eight Months
Post-Implementation	Aug 1999 – Jan 2000	Six Months

4.4 Implementation Problems

Installation of CASD introduced substantial problems and changes throughout the organization, from top management to dispatchers to the occasional rider. Perceptions of change where observed in terms of service quality, job satisfaction, inter-office communications and interaction with political entities. This section discusses the problems that occurred and how the organization attempted to deal with each.

4.4.1 Scheduler/Dispatchers

Scheduler/Dispatchers bore the brunt of almost every CASD related implementation problem and were faced with the challenge of providing uninterrupted service even when CASD hardware and software were not operational. Weekly follow-up conversations during the implementation period provided a long list of problems attributed to CASD implementation. Almost all implementation issues can be classified into one of three categories (1) Learning/Training issues, (2) Resistance to Change issues, and (3) Technological Limitations.

<u>Learning/Training Issues</u>

Examination of interview data shows that the vast majority of problems attributed to CASD implementation can be more properly classified as learning or training issues. Items classified in this category range from long-term problems following improper geocoding, expedited entry of sponsor codes, and failure to consult help menus/manuals when appropriate.

<u>*Geocoding problems*</u> with rider pick-up and drop-off locations contributed to an extended period of turbulence during both pre and implementation periods. Geocoding assigns latitude and longitude information used by the scheduling algorithm. When a small portion of the pick-up or drop-off location is incorrect or when two addresses for the same location are entered with slightly different formats, the CASD system may produce wildly inaccurate scheduling output. Examples of address differences implicated in output problems are as small as the period "." following the compass direction "E.". Another example is "1st" and "First". Although routinely handled by manual dispatching, CASD software is unable to distinguish between those simple variations.

The underlying problem was discovered and understood only after months of frustrated efforts of dispatchers and management. Inaccurate data input contributed to negative perceptions of CASD capabilities. Ultimately the staff invested hundreds of person-hours of time to review and correct all addresses in the CASD database. This problem was exacerbated by a lack of report generation expertise, which could have produced ad hoc reports of addresses having similar street names.

Sponsor code assignment caused internal conflict similar to that associated with geocoding, and contributed to another round of person-hours investment to correct what could have been avoided had the staff been aware of the consequences of their decision to streamline the process. Sponsor code assignment links pay rates with different sponsoring agencies. A single agency may have several codes corresponding to different payment levels and programs. A rider may have been assigned any one of a combination of fifty sponsor codes. The CASD system uses these codes for report generation, billing and in cases of restricted vehicle use, for vehicle assignment.

Sponsor code problems were created when the staff, already behind the implementation schedule from problems with geo-coding and a myriad of other issues, decided to "streamline" client entry by minimizing sponsor code assignment, often using only two codes. This solution allowed the staff to accomplish what they considered their primary mission – providing rides to those who need it – but it created havoc when attempts were undertaken to use the CASD system for billing and reporting. Because the sponsor codes are primary fields used to generate billing reports, this single action snowballed eventually limiting the value of virtually every report generated by the software. This problem was still in the final stages of resolution during the post-implementation period requiring a manual review of every record in the database.

A particular challenge for this property was the need to manually create new records for more than half of their rider base. This effort required that the dispatcher staff work several weeks of overtime. After as long as eighteen months after implementation, sponsor codes for some passengers were unresolved, leading to inaccurate reporting and billing. Because DTD staff knew these inaccuracies, parallel manual billing processes were maintained to ensure accuracy, increasing the time required to complete every task.

These and many other implementation problems were intimately related to funding decisions that minimized training and did not account for the need to have a dedicated project manger with experience in this kind of environment. When asked about the best way for dispatchers to develop the necessary skills to be an effective scheduler/dispatcher, comments centered on training methodologies. All dispatchers would have hoped for a slower training cycle, noting the volume of material needed to operate the new CASD.

It is notable that through post-implementation, dispatchers did not have operating manuals or system notes binders for reference at their desks. A lack of reference sources contributed to a steep learning curve, marked with several periods where months of work had to be redone to accomplish what should have been a simple data entry process

Dispatchers/schedulers who did not have previous training in computer skills were not prepared to move directly into daily interaction with CASD. Aggressive implementation of CASD does not mitigate apprehension of the implementation process by shortening the "pain" associated with change. Our survey results indicate that a relatively inflexible learning curve is associated with technology implementation. The learning curve is affected most efficiently through well-prepared training and the close planning and interaction of management, dispatchers and vendors.

The staff, management and vendor all provided opposing viewpoints toward training. When asked, the vendor claimed to have given all relevant and necessary training, the manager claimed that the staff spent significant time involved in training, and the staff claimed that little or no real training was given at all.

Of note is that through the date of this writing, no training or reference manuals have ever been in evidence at the site for either manager or staff, and that both manager and staff repeat the phrase "I haven't had time to use the 'Help' menu, and it's too hard to use anyway."

Resistance to Change

Another category of problem is strongly related to an organization's innate desire to embrace or reject change. In this case, significant problems were encountered during all phases of implementation because some staff members did not always see value in changing from the pre-implementation scheduling/dispatching methodology to automated operations. Resistance to change can be seen in how little staff was compelled to search for answers to problems by either looking up answers in the online help facility or pushing to have reference books at each terminal.

Early expectations of CASD value mirrored the comments of the vendor representatives. This early optimism carried the staff through turbulent periods of pre-implementation that required long periods of overtime and harried workdays entering and correcting geocodes and customer information. Many expectations never materialized leading to a boomerang effect on attitudes, generating negative attributions toward the CASD system, and ultimately to a slow down in innovation and the learning cycle in late implementation and much of the post-implementation phases.

While dispatchers said that the new CASD performed to their expectations, they were also anxious to add qualifiers such as " ... when properly implemented", and "It will be great when it's fixed", indicating that dispatchers still viewed the system in terms of its potential even in late implementation phases. Comments were frequently modified with statements such as "The [CASD] is great, but I thought things would be more organized than they are now", and "I love it, but I thought [the CASD] would do automatic and easy scheduling".

Many dispatcher complaints were often related to the way dispatchers attempted to mimic "the old way" of dispatching using CASD. As an example, when in the manual process, dispatchers inserted each request into a specific opening in a particular run. This was done visually, so that an open physical space on the wallboard meant that a passenger could be fit in. When using the wallboard system, scheduling was customarily focused on arranging for the vehicle to arrive at the customer's pick-up location at the arranged time. Drop-off time was implicitly recognized in the pick-up time schedule -- pick-up time was drop-off time minus the dispatcher's best estimation of ride-time.

When using the CASD system, the dispatcher orientation was forced to change to a focus on drop-off times instead of pick-up times. Dispatchers did not totally accept this change in focus until the beginning of the post-implementation period.

Technological Limitations

Some problems were related directly to software and hardware limitations. One significant technological issue is the size of the database created by the site's CASD system. An unexpected problem arose as a result of the large amount of information generated from each trip action by the CASD. The enormous volume of data creates a database large enough to require archiving several times a year in order to preserve the CASD system performance levels. The problem is two-fold – (1) the growing database requires significant space to store a year's worth of performance data, (2) the larger the database files, the slower the access to data becomes (compiling a standard, built-in report for a year requires up to ten full minutes, and often resulted in a crash). Access speed is independent of the time period requested for the report – a request for a one-week time period requires the same length of time to compile as the same report spanning several months.

The vendor recommends a two-part solution (1) archive data more frequently and (2) splitting the request into smaller time "chunks", both introducing complexities to a system billed as simplifying paratransit management. When data is archived, it becomes unavailable for comparative purposes unless it is unarchived. Unarchiving and accessing this database is a cumbersome operation, and for less savvy paratransit operators, far from intuitive. The difficulties associated with accessing archived data limit the potential analysis benefit of comparing previous and present years, making it unlikely that any but the most sophisticated users will utilize this potentially significant tool.

4.4.2 Drivers

In contrast to initial expectations, drivers seem to have accepted the CASD more readily than any other employee group in the organization. Early concerns had been voiced indicating that drivers may resent additional oversight with what had been an extremely independent job. Because the CASD provides more detailed routing and time information than previous manifests, an expectation was that drivers would resent detailed and seemingly inflexible routing plans. In fact, drivers indicated they have seen little change at their level, noting that they actually like the new CASD generated manifest better than the old manual version because it contains more rider information. Additional rider information includes where to pick up the passenger e.g., at the rear screen door, at the garage, etc, and fewer scheduling mistakes requiring drivers to respond to failures of dispatching.

4.4.3 Management

Changes to management's skill sets included a requirement to learn and master a wide range of report development and production skills. These skill sets required management to use relatively complex database tools in a self-taught environment. Because manuals were less than user friendly at best and often simply unavailable for the level of expertise brought to the subject, learning was a time consuming and frustrating experience.

The CASD system was programmed with limited self-reporting capabilities. Reports have limited flexibility in terms of format of content, meaning that most reporting not specifically identified before implementation must be accomplished through the use of an add-on module or other commercial database/spreadsheet program. Use of any of the options necessary to produce ad hoc report output can require substantial extra time investment for an already busy manger. Report production problems substantially reduced the value of the CASD to management through mid post-implementation.

Management was also severely impacted by the difference between expectations and actual results. Because of the continuing problems associated with entering correct information into the database, no accurate reporting was available until late in the post-implementation period. Management had been expecting report output since the beginning of the implementation period. However, the delays imposed dual reporting requirements until accuracy of the system could be guaranteed. Dual reporting required administrative support staff to audit system performance twice during each period, increasing daily workloads and further degrading attitudes toward the CASD system. Management brought expectations of route optimization, system efficiency gains and possible personnel reductions to the pre-implementation phase. By the end of post-implementation, hopes for optimization and personnel reductions had vanished totally.

The manager at this site entered the transition period having made the decision to moderate change related problems by migrating from a manual to an automated system over a period of approximately sixty days. As it was planned, a phased approach would allow all staff an opportunity to familiarize themselves with the system, its features and capabilities. The implementation period included the entry and upload of passenger data, creation and updates of electronic maps and billing codes for the large number of sponsor agencies served by the Door to Door, Inc. fleet.

Implementation was scheduled to last no more than ninety days. However, the series of challenges outlined above eventually extended the period to more than nine months. By the close of the study, significant portions of CASD technology remained unimplemented. Almost two years after the pre-implementation phase, most routes and passenger pick-up and drop-off decisions are completed without taking advantage of the system's optimization algorithms. Instead of full system optimization, only individual route optimization was implemented. Reasons for not using major features of the software include client idiosyncrasies, intro-organizational turf battles, organizational culture, politics and training issues.

Operator surveys indicate that managers often simply do not have the kind of time necessary to monitor all phases of the implementation process. Even given the expertise to manage the process, time limits imposed by an already full schedule prevent the kind of involvement needed to manage the entire implementation process. This is especially problematic for smaller, non-profit agencies that have no support from transit districts. The study site manager's comments mirrored those of operators across the country, strongly advocating the use of a project manager, even in a temporary assignment to assist in implementation.

The ability to generate reports had been billed as one of the more useful components of the CASD, however, reporting was not available even in rudimentary form until late in 1999, almost a year after installation. Report generation was available from two methods – *Crystal Reports*, an add-on for custom reports and a built in report generator that produces pre-formatted reports. Reporting was seriously degraded by the incredible errors interjected by sponsor coding and geocoding problems.

4.4.4 Customers

Dispatchers presented differing accounts of how customers perceive effects related to CASD implementation. A dispatcher who noted that customers have "been told that they can't have a ride at the time they asked because the 'computer' says it's not feasible" demonstrates how customers can be affected by CASD without ever being exposed to CASD activities.

By saying that "We now use drop-off time instead of pick-up time", one dispatcher raised a change in scheduling procedures that is certainly affecting customers. This scheduling change is a fundamental way in how CASD scheduling differs from the organization's previous method. This change requires a different focus on how pick-up times are assigned and transmitted to the customer. In the old system, dispatchers most often communicated with riders in terms of the time the organization's vehicle would arrive at the caller's pick-up destination. The new CASD is seen as forcing all scheduling communication to be in terms of arrival at the rider's drop-off destination. This conflict resulted in another major implementation problem. If a dispatcher constructs runs on the CASD, using pick-up times for each rider just as they did for manual scheduling in pre-implementation, the times became "anchored" in the CASD schedule, negating the optimization features of CASD. This problem alone accounted for several months of lost time.

No consistent outcome was provided by dispatchers on the impact of CASD on the call-intake and ride booking processes. This anomaly may be a reflection of individual learning curves and desire to implement the new system. Comments regarding training lead us to hypothesize that the range of times required to accomplish CASD scheduling may also be a result of inconsistent training.

4.4.5 Implementation Costs

Additional time was invested by both salaried and wage administrative employees, although additional salary and wage costs were managed by limiting overtime and deferring attention normally given to routine tasks to accomplish duties required to support CASD implementation.

Additional tasks included double-checking manifests, billing documents, and assisting in run posting support.

Total hardware, software, licensing and training costs totaled approximately $87,190. Installation costs were split in a cost share arrangement between IDOT, the transit district and the study site. Although additional overtime costs were incurred in the implementation of the system, these were not reflected in the financial statistics for the eight-month implementation period. Possibly, in order to stay within budget, management trimmed salary costs to reflect the overtime expense. This could have lead to some of the problems and impacts discussed previously.

4.5 Post-Implementation Organizational Impacts

Scheduler/Dispatchers have been affected most dramatically by the CASD implementation. CASD implementation touches virtually every area of scheduler/dispatcher activities, leaving only customer interaction on the telephone essentially unchanged in the post implementation period.

Administrative staff provided positive comments regarding the potential and actual changes occurring as a result of CASD installation. The staff responsible for billing provided the most substantial positive comments, most focused on reductions in time required to process billing documents for the fifty plus sponsors.

All levels of the organization reported increasing comfort and often expressed reliance on the new system by the end of the post-implementation period. Scheduler/dispatchers and management felt the greatest impact was on skill set development.

Table 46 illustrates dispatcher responses when they were asked which skills were most important for an "ideal" dispatcher. Responses varied little between implementation phases. While computer skill requirements are admittedly more apparent in the post-implementation phase, dispatchers stated, "The basic foundations of dispatcher knowledge – area, clients and drivers, remain the same".

Because the CASD requires most scheduling activities to be completed in a single cycle of activities, most dispatchers indicated a feeling that time management may have increased in importance in the post-implementation phase.

Dispatchers in all implementation phases noted a fear of errors introduced by computer "glitches", arising because of the inability to visually confirm the result of each action. CASD requires output reports to give a complete picture of completed scheduling and optimization results. These fears lead dispatchers to emphasize the importance of interpersonal skills because they are often faced with responsibility of explaining CASD errors to customers.

Table 46 Dispatch Skills Categories

Communication
• Telephone, radio, interpersonal communications skills and humor
Service Area Knowledge
• Knowledge of geography and clients
Administrative
• Caller information transcription
Organization
• Computer skills
Situational Awareness
• Spatial orientation to synthesize status of scheduling board, vehicle location and integrate driver/vehicle capabilities
• Identifying and prioritizing task precedence
• Knowledge of personal limitations

Dispatchers often reported that they feel as if they are the buffers between CASD problems, customers and drivers whenever CASD output was inaccurate or unavailable. Dispatchers soothed drivers with no-show or fractious passengers, defused customer complaints and gave "best guess" estimates of vehicle arrival times. Dispatchers noted that compared to the manual way of scheduling, they now use *more* memory skills, because they can not use the same visual aids as before (wallboards, paper manifests, etc.) to track operations.

The greatest positive comments from dispatchers are associated with the client database component of the CASD. In the words of a pleased dispatcher, "The [CASD] keeps records of what kind of ride, and all of the client information on hand without having to reenter it every time". This dispatcher added, "I thought it might be hard to understand, but it has enhanced performance". Other dispatchers had more conventional expectations - "running reports and keeping billing up to date", and getting a "better sense of lateness" (vehicle on-time rates).

Dispatchers noted that in post-implementation they spent more time at their desks, although they were split at this point about how much more time was saved in the call-in and ride booking process. Dispatchers noted with satisfaction that redundant administrative tasks were far less demanding when using the CASD. Compared to the old, manual system, redundant record keeping was slashed.

4.6 Efficiency and Effectiveness - Key Productivity Variables

Productivity parameters have been drawn from the literature and developed during the course of this study. The project's study site presented challenges to data collection, verification and classification. Challenges arose with identifying seemingly simple measures as load factor and revenue hours, because pre-implementation data was insufficient to support meaningful comparison with the post-implementation period.

Measures in this study have been split into three categories - Efficiency, Effectiveness and Quality. The following sections first outline the measures used in this study, and then display the before and after comparisons using the study site's data.

4.6.1 Base Financial Indicators

Table 47 contains the basic financial variables used in this study's efficiency and effectiveness measures along with their respective pre and post-implementation changes. Base variables used include all salaries and wages, operating expenses and total costs. Other cost categories demonstrated unacceptable variation linked to exogenous influences. Financial variables falling into this category were not considered. All variables in Table 47 are monthly averages of each six-month implementation period. The post-implementation data were adjusted for changes in the Consumer Price Index and for additional personnel that were unrelated to the implementation of the CASD.

Table 47 Average Monthly Financial Variables

Category (Average Monthly)	**Pre** (Avg. Monthly)	**Post** (Avg. Monthly)	**Avg. Monthly Post-Imp** (Less CPI and Adt'l Pers)	**Pre to Post Adj. % Change****
• Administrative Salary	$10,246	$11,780	$10,244	0.0%
Driver Salaries	$36,876	$38,094	$37,280	1.1%
Dispatch Salaries	$8,692	$8,554	$8,372	-3.7%
Maintenance Salaries	$1,930	$2,979	$1,975	2.3%
Total Salary	$57,744	$61,407	$57,871	0.2%
Operating Expenses*	$ 23,761	$ 23,644	$ 23,139	-3.0%
Other Costs	$18,634	$22,888	$22,399	20.21%
Total Costs	$ 100,139	$ 107,939	$ 103,409	3.27%

* - Operating Expenses = Fuel and Lubricants, Vehicle Insurance, and Vehicle Maintenance (Only)

** - All adjusted financial data reflects a reduction of 2.1348% CPI and appropriate reductions of increases due to additional personnel not associated with CASD implementation.

<u>Administrative Salary</u>

Administrative salaries include only those salary expenses directly related to staff not performing driving, maintenance or dispatch/scheduler duties. During the course of this study, the administrative staff was augmented by adding an operations manager. This manager was required by the new contract with the Greater Peoria Mass Transit District and was not related to the implementation of the new CASD. The salary of the operations manager was deducted from the adjusted totals before CPI adjustments were applied. After salary and CPI adjustments, administrative salary remained unchanged (a difference of less than $3.00) between the pre- and post-implementation periods.

Driver Salaries

Driver salaries include only those costs of paying permanently assigned drivers (full and part-time), excluding the salaries of dispatchers who occasionally provide driver support. Driver salaries increased by 1.1% over the test period, despite total vehicle hours actually decreasing slightly during this period, and no additional driver positions being opened. Although nearly 20% of the driver staff turned-over during this period, total driver staff numbers remained essentially unchanged. Temporary, unfilled positions were covered by existing drivers using overtime and dispatch staff. The slight increase in driver salaries despite reduced miles and vehicle hours seems to reflect additional overtime of those drivers who extended their working days to cover routes for absent drivers.

Dispatch Salaries

This cost item includes only those expenses paid to personnel filling permanent dispatch/scheduler positions, excluding the occasions when drivers may substitute for or augment dispatcher/schedulers. Observed salary changes are linked to a combination of reductions in overtime for senior scheduler/dispatchers and lower wage rates for newly assigned dispatchers in the post-implementation period. Only two dispatchers were still employed at the site at the close of the post-implementation phase. Salary changes were not linked with any organizational or procedural changes resulting from implementation of the CASD.

Maintenance Salaries

Maintenance salaries were increased by the addition of both a part-time and full-time employee in the post-implementation period. The additional maintenance cost is not related to installation of the CASD.

Total Salary

Total salary includes only direct salary expenses excluding FICA and associated salary/wage costs. Adjusted average total salary remains essentially unchanged over the pre and post-implementation periods, increasing only 0.22%. Driver and dispatcher salaries represent about 79% of total salaries in both implementation periods, representing the largest cost components of salary.

Operating Expenses

Because of tremendous variations in the study site's financial data, "operating expenses" has been modified to include only the three major contributors to the category, vehicle insurance, vehicle repairs and fuel & lubricants. The balance of operating expenses has been included in "other costs". Operating expenses fell by 3% in real terms from $23,761 to $23,139. A decrease in operating costs follows a decrease in vehicle miles and hours, lower fuel prices and a reduction in total passengers in the post-implementation period.

Other Costs

Other costs include non-vehicle insurance, depreciation, and worker's compensation, none of which are affected directly or indirectly by CASD installation. This category also varies significantly by month preventing meaningful analysis. Of the balance of cost categories included in other costs, salary related expenses and specifically, worker's compensation has contributed most to pre and post-implementation change, adding an average change of nearly $5,000.

Total Costs

Total costs include depreciation, rent, legal fees in addition to the major categories listed above. Dispatch salaries, operating costs and other costs show the greatest change, however none of these changes can be directly connected to CASD implementation.

4.6.2 Base Non-Financial Variables

The basic set of non-financial variables is listed in Table 48. Non-financial base measures include employee counts, Passenger hours, One-way passenger trips, Peak vehicles, and vehicle hours/miles. The following discussions describe pre- and post-implementation changes. All figures in Table 48 are monthly averages, of two-month periods from each of the implementation periods except peak vehicles, which is the average maximum number of vehicles dispatched during weekday periods. Pre-implementation system performance data is an average of March and June 1998; post-implementation data is an average of September and November 1999.

Table 48 Base Average Monthly Non-Financial Measures (Average Monthly Weekday)

Category *(Average Monthly Mon. – Fri)*	**Pre** *(Avg. Mo.)*	**Post** *(Avg. Mo.)*	**Post Adjusted** *(Avg. Monthly less-Adt'l Pers)*	**Pre to Post Adj. % Change**
Employees	34	37	34.5	1.5%
Passenger Hours	8,334	8,026	-	-3.7%
One-Way Passenger Trips	11,793	11,021	-	-6.5%
Peak Vehicles (Avg. Weekday)	20	20	-	0.0%
Vehicle Hours	3,287	3,188	-	-3.01%
Vehicle Miles	42,498	39,532	-	-6.97%

Employees

This is the average employee count in each implementation period. Pre- and post-implementation employee levels changed with the addition of a full-time operations manager, and one full-time and one part-time maintenance employee. One additional part-time employee has been added to assist in run posting, augmenting permanent staff when needed. The operations manager position was added as a result of a change in the transit district's contract requirements, while maintenance personnel were added to assist an already over taxed maintenance staff. No direct or indirect CASD influences were observed in the operations manager or maintenance personnel additions. The part-time run-posting position is a direct result of CASD implementation, reflecting the added task of updating the CASD database with every passenger manifest. CASD operations require run-posting activities to update projected database arrival/departure times, passenger loading, no-shows, etc.

Run posting is a process change directly related to CASD installation. The CASD must be updated with accurate odometer, time stamp and rider no-show information to produce reports and billing data. Run posting transfers passenger manifest data entered by the driver to the CASD system. Run posting is a particularly important task in that the input accuracy at this point has direct impact on all CASD performance reporting.

Passenger Hours

Passenger hours were calculated as the product of passenger trips and mean passenger ride time. Calculated average monthly passenger hours decreased 3.9% in the post implementation period to 8,026, following a slight increase in passenger ride time and a decrease in the number of passenger trips.

One-way Passenger Trips

One-way passenger trips is a count of one-way weekday trips. Holidays falling on weekdays have been excluded as have days where significant weather events seriously degraded performance. Total one-way passenger trips dropped from 11,793 reported in the pre-implementation period to 11,021 in the post-implementation period. This 6.5% reduction reflects changes in contract service agreements between Door to Door, Inc. and its many contract agencies rather than any influence of CASD implementation.

Peak Vehicles

Peak vehicles are an average count of vehicles dispatched during the busiest part of the study site's days. Fleet peak numbers follow the service area's local work schedules, as a significant proportion of Door to Door, Inc. passenger trips transport riders to work sites. Peak vehicle data fluctuates within a narrow range because of contractual prohibitions limiting the use of some vehicles, reducing the potential optimization of those vehicle assets.

Peak vehicles are limited by the following constraints:

- Contract for the part of the customer base represented by the district contract. A maximum number of vehicles are allowed in service at any one time,

- Contract with both district and certain sponsor agencies. Passengers may not normally be mixed on vehicles operated with certain funds, restricting optimization,

- Potential vehicle availability in the DTD fleet. Few spares are available, limiting maximum dispatched vehicles,

- Service area restrictions. A large part of the service area is non-urban, with lighter population and limited access routes. As the passenger pick-up or drop-off location is scheduled farther from the central business district, progressively fewer roads access the area, requiring more vehicles and drivers, and ride time.
- Driver availability (chronic driver shortages reduce maximum fleet size)

Due to these constraints on vehicle usage, average vehicle fleet size remained essentially constant between pre and post-implementation periods.

Vehicle Hours

The vehicle hours variable is the difference between reported last drop-off and reported first pick-up times on the manifest. Vehicle hours decreased by approximately 3%, likely driven by the reduction in ridership described above. Vehicle hours were also likely influenced by demographic changes in the ridership base due to service contract changes; riders living in more rural areas or having more severe disabilities require longer ride or loading times.

Vehicle Miles

The vehicle miles measurement is a monthly average of all odometer miles reported on the passenger manifest during each implementation period. Vehicle miles (difference between last drop-off and first pick-up odometer readings) decreased nearly 7%, following the change in ridership volume and demographics associated with changing contracts with the service agencies.

4.7 Efficiency Analysis

Table 49 illustrates the efficiency measures used in this analysis. The analysis compares a number of relevant expense categories with fleet size changes, average fleet hours, miles and one-way passenger trips. Table 50 displays pre and post-implementation comparisons of measures used in this study.

Table 49 Efficiency Measures

Efficiency Measures	
Administrative Salaries/Peak Vehicles	Total Expenses/One-Way Passenger Trips
Administrative Salaries/Vehicle Hours	Total Expenses/Vehicle Hours
Administrative Salaries/One-way Passenger Trips	Total Expenses/Vehicle Miles
Administrative Salaries/Vehicle Miles	Total Salaries/One-Way Passenger Trip
Dispatch Salaries/Vehicle Hours	Total Salaries/Vehicle Miles
Dispatch Salaries/Vehicle Miles	Vehicle Miles/One-Way Passenger Trips
Driver Salaries/Vehicle Hours	Vehicle-Miles/Total Expenses
Driver Salaries/Vehicle Miles	Vehicle Hours/Vehicle

The first set of columns in Table 50 show efficiency measures per average peak vehicle in the pre- and post-implementation periods. Because average peak vehicles remained constant between the two periods, the peak vehicle column shows only the relative difference between the respective financial variable in each row. Salaries, except for dispatch salaries were relatively stable between the two periods. Salary and operating expenses fell slightly. Total expenses per peak period vehicle grew 3.3%, reflecting other, not CASD related factors. Vehicle hours per peak vehicle fell 3 percent.

Table 50 Efficiency Measures Matrix (Average Monthly Values*)

	Avg. Monthly Peak Vehicles			Avg. Monthly Vehicle Miles			Avg. Monthly Employees		
	Pre	Post	% Chg	Pre	Post	% Chg	Pre	Post	% Chg
Administrative Salary	$512	$512	0.0%	$0.24	$0.26	7.5%	$301	$297	-1.5%
Dispatch Salary	$435	$419	-3.7%	$0.20	$0.21	3.5%	$256	$243	-5.1%
Driver Salary	$1,844	$1,864	1.1%	$0.87	$0.94	8.7%	$1,085	$1,081	-0.4%
Driver & Disp Salary	$2,278	$2,283	0.2%	$1.07	$1.15	7.7%	$1,340	$1,323	-1.3%
Total Salary	$2,887	$2,894	0.2%	$1.36	$1.46	7.7%	$1,698	$1,677	-1.2%
Salary & Oper Exp	$4,075	$4,051	-0.6%	$1.92	$2.05	6.8%	$2,397	$2,348	-2.0%
Total Expenses	$5,007	$5,170	3.3%	$2.36	$2.67	11.0%	$2,945	$2,997	1.8%
Vehicle Hours	164	159	-3.0%	0.077	0.081	4.2%	96.7	92.4	-4.4%

* - All financial data are averages of six-month pre and post-implementation periods; non-financial data are averages of a two-month period from both the pre and post-implementation periods.

Efficiency measures per average monthly vehicle mile in Table 50 illustrate the effect of a reduction in fleet vehicle miles. Although dispatch salaries fell, and other salaries changed only slightly between evaluation phases, the decrease in recorded mileage forced an increase in all efficiency measures.

A 1.5% increase (from 34 to 34.5) in employees along with small expense gains overall along with reductions in dispatch and operating expenses underlies the negative changes in financial to employee ratios.

Table 51 displays the relationship between salary variables, one-way passenger trips and vehicle hours. The minimal gains and small negative changes in salary components are overwhelmed by the 6.5% decrease in passenger trips. The decrease in passenger trips, unrelated to CASD implementation, allowed all salary to passenger trip ratios to show relatively significant increases.

A drop in vehicle hours, also related to a decline in ridership supported an overall increase in salary to vehicle hour ratios. The decrease in both vehicle miles and vehicle hours shows a slight decrease in average speed from nearly thirteen to just over twelve miles per hour.

A decrease in miles per hour in this case is an ambiguous indicator, in that changes in ridership demographics (disabilities, traffic patterns, etc) all impact how quickly the vehicles move from point to point. Average speed decreases can also be a negative quality indicator, and in this case corresponds to a calculated mean ride time increase per passenger ride of approximately one-minute.

Table 51 Efficiency Measures Matrix 2 (Average Monthly Values*)

	Avg. One-Way Pass Trips			Avg. Monthly Veh Hours		
	Pre	Post	% Chg	Pre	Post	% Chg
Administrative Salary	$0.87	$0.93	7.0%	$3.12	$3.21	3.1%
Dispatch Salary	$0.74	$0.76	3.1%	$2.64	$2.63	-0.7%
Driver Salary	$3.13	$3.38	8.2%	$11.22	$11.69	4.2%
Driver & Disp Salary	$3.86	$4.14	7.2%	$13.86	$14.32	3.3%
Total Salary	$4.90	$5.25	7.2%	$17.57	$18.15	3.3%
Salary & Oper Exp	$6.91	$7.35	6.3%	$24.80	$25.41	2.5%
Total Expenses	$8.49	$9.38	10.5%	$30.47	$33.14	6.5%
Vehicle Miles	3.60	3.59	-0.5%	12.9	12.4	-4.1%

* - All financial data is average of six-month pre and post-implementation periods; non-financial data is average of two-month period from both the pre and post-implementation periods.

4.8 Effectiveness Analysis

Table 52 illustrates effectiveness measures used in this study. Examination of salary to passenger related ratios provide a sense of how inputs are related to system outputs. The lower the ratio, the better the system is distributing its outputs. Table 53 shows the results of the small changes in salaries and wages and larger decreases in one-way passenger trips between the pre and post-implementation periods. The greater decline in passenger trips drives all salary per passenger trip ratios upward. The similar magnitude of change in dispatcher salary and passenger hours results in a near zero change in that ratio, showing that on average, one dollar of dispatcher time is invested for each hour of passenger time in both the pre- and post-implementation periods.

Table 52 Effectiveness Measures

Effectiveness Measure	
Administrative Salaries/Passenger Hours	One-Way Passenger Trips/Vehicle Hours
Administrative Salary/One-way Passenger Trips	Passenger Ride-Time
Dispatch Salaries/ Passenger Hours	Total Expenses/ One-way Passenger Trips
Driver Salary/Passenger Hours	Total Salaries/ Passenger Hours
One-way Passenger Trips/Employees	Vehicle Miles/One-way Passenger Trips

Vehicle miles per passenger trip changed imperceptibly, from 3.60 miles per passenger trip to 3.59 miles per trip. The negligible change in this measure is the result of simultaneous reductions in both passenger trips and vehicle miles. Reductions in this measure would have been expected as a result of route optimization algorithms. However, incomplete implementation of this feature prevented accurate assessment of its impact.

Overall effectiveness measures have declined between the pre- and post implementation periods as a result of the measure's underlying linkage with ridership levels that have declined due to non-CASD related reasons.

Vehicle productivity, passenger trips per vehicle hour, declined slightly from 3.6 to 3.5. This reflects the reduction in passenger trips on overall effectiveness of the system.

4.9 Quality Analysis

Table 54 illustrates the quality measures used in this analysis. These measures were chosen as those most likely to be affected by changes in the CASD. On-time pick-up/drop-off data and total trips serviced are taken from passenger manifest counts. Average speed is computed from total vehicle hours and miles. The balance of the measures listed in Table 54 are the result of analysis of pre and post-implementation passenger surveys. Pre and Post-implementation on-time arrival analysis is contained in section 4.9.1, passenger ride time is examined in section 4.9.2, and rider survey results are found in section 4.9.3.

4.9.1 On-Time Analysis

Pick-up Definition

On-time pick-ups have three components: "Early" pick-up rates, "Late" pick-up rates and "On-time" pick-up rates. On-time data is computed from the differences between the agency's promised and actual pick-up times. An arrival is "early" if the manifest time stamp is posted as earlier than fifteen minutes before the promised pick-up time. "On-time" is defined as the interval between fifteen minutes before the promised pick-up and fifteen minutes after the promised pick-up. "Late" is defined as any manifest time stamp more than fifteen minutes after the promised pick-up.

Drop-Off Definition

On-time drop-offs have three components: "Early" drop-off rates, "Late" drop-off rates and "On-time" drop-off rates. On-time data is computed from the differences between the agency's promised and actual drop-off times. A drop-off is "early" if the manifest time stamp is posted as earlier than fifteen minutes before the promised drop-off time. "On-time" is defined as the interval between fifteen minutes before the promised drop-off and fifteen minutes after the promised drop-off. "Late" is defined as any manifest time stamp more than fifteen minutes after the promised drop-off.

Table 53 Effectiveness Measures Matrix (Average Monthly Values*)

	One-way Pass Trips			Passenger Hours			Vehicle Hours			Employees		
	Pre	Post	%Chg	Pre	Post	%Chg	Pre	Post	% Chg	Pre	Post	%Chg
Admin Salary	$0.87	$0.93	7.0%	$1.23	$1.28	3.8%	$3.12	$3.21	3.1%	$301	$297	-1.5%
Dispatcher Salary	$0.74	$0.76	3.1%	$1.04	$1.04	0.0%	$2.64	$2.63	-0.7%	$256	$243	-5.1%
Driver Salary	$3.13	$3.38	8.2%	$4.42	$4.64	5.0%	$11.22	$11.69	4.2%	$1,085	$1,081	-0.4%
Total Salary	$4.90	$5.25	7.2%	$6.93	$7.21	4.1%	$17.57	$18.15	3.3%	$1,698	$1,677	-1.2%
Total Expenses	$8.49	$9.38	10.5%	$12.02	$12.88	7.2%	$30.47	$32.44	6.5%	$2,945	$2,997	1.8%
One-way Pass Trips	-	-		1.42	1.37	-3.0%	3.6	3.5	-3.6%	347	319	-7.9%
Vehicle Miles	3.60	3.59	-0.5%	5.1	4.9	-3.4%	12.9	12.4	-4.1%	1,250	1,146	-8.3%

* - All financial data is average of six-month pre and post-implementation periods; non-financial data is average of two-month period from both the pre and post-implementation periods.

Table 54 Quality Measures

Quality Measure
On-Time Drop-Off-Rate
On-Time Pick-Up Rate
Average Passenger Ride Time
Average Speed
Convenience of Return Reservation Procedure
Courtesy and Friendliness of Telephone Operators
Shortness of Reservation Time
Ease of Getting Clear Information
Accommodations to Changes in Reservations
Notifications of Service Delays, Cancellations

System Definition

System on-time rates are the aggregated on-time rates of both pick-up and drop-off manifest time stamps. System rates are computed in the same fashion as pick-up and drop-off rates; any manifest time-stamp (pick-up or drop-off) more than fifteen minutes before the promised pick-up or drop-off time is "Early", any pick-up or drop-off time stamp between fifteen minutes before and fifteen minutes after the promised pick-up or drop-off is "On-Time", and time stamps later than fifteen minutes after the promised pick-up or drop-off is late. On-time pick-up and drop-off analysis examined data from individual passenger records as shown on passenger manifests. No distinction was made between trips to or from either home another destination. Data were aggregated to include all pick-up and all drop-off observations in only two categories. "Pick-up" refers to the portion of the trip either at home or at the return trip were the rider waits for the vehicle to arrive. "Drop-off" refers to the portion of the trip when the rider is being dropped off at either home or another destination.

Table 55 Pre vs. Post Implementation On-Time Performance Test of Proportions

	Sample Proportions					
	Pick-Up		Drop-off		System	
	Pre - Impl	*Post - Impl*	*Pre - Impl*	*Post - Impl*	*Pre - Impl*	*Post - Impl*
Early	12%	12%*	18%	13%	14%	12%
On-Time	72%	81%	65%	78%	69%	80%
Late	17%	7%	17%	9%	17%	8%

(*All pre to post-implementation changes except "Early Pick-up" are statistically significant at α =.05)

Table 14 illustrates on-time ratios Analysis of before and after sample proportions reveal significant change occurring in all but one category of on-time performance measures. On-time pick-ups changed a statistically significant (α =.05) percentage from 72% to 81% in the post-implementation period. Early pick-up rates remained constant at 12% in both the pre- and post-implementation periods. The ratio of late pick-ups decreased dramatically from 17% in the pre-implementation period to 7% in the post-implementation period. Although the mean late pick-up difference between promised and actual time was less than a minute, mostly due to a peak at the twenty-minute range, from the rider's perspective, post-implementation vehicles are late far less often.

Drop-off on-time ratios followed the same trend as pick-up proportions – early pick-ups decreased, on-time ratios increased dramatically and late arrivals decreased from 17% to only 9%. Overall system on time ratios also display this same pattern. This same information is also shown in Table 15 in which mean differences from on time in minutes are shown. All differences except "Early Pick-Up" are significant at the .05 level.

Table 56 Pre vs. Post Implementation On-Time Performance

	Mean (Minutes)					
	Pick-Up		Drop-Off		System	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Early	-30.10	-29.67*	-31.59	-29.47	-31.44	-29.62
On-Time	0.318	-0.437	-0.106	-0.328	0.061	-0.414
Late	31.79	30.93	31.68	29.97	32.00	30.77

(*All differences *except* "Early Pick-Up" are significant at α =.05)

Figure 11 displays pre- and post-implementation promised vs. actual pick-up time differences. The figure shows the most distinct change from the pre and post-implementation periods in the time increments between five minutes early and five minutes late. Pre-implementation data in this range is just over 30%, while post-implementation data shows an increase to just under 70% in the same range. The change in on-time arrival deviations is driven almost entirely by a reduction in arrivals between five and fifty minutes after the promised time. The overall percentage of early arrivals (greater than 15 minutes early) has remained almost constant between the pre and post-implementation periods.

Figure 11 Promised vs. Actual Pick-Up Differences

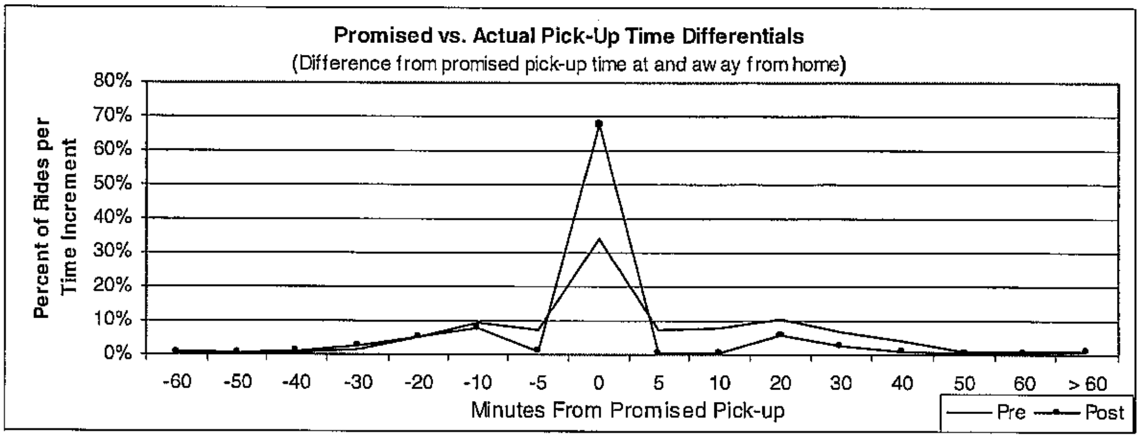


Figure 12 Promised vs. Actual Drop-Off Differences

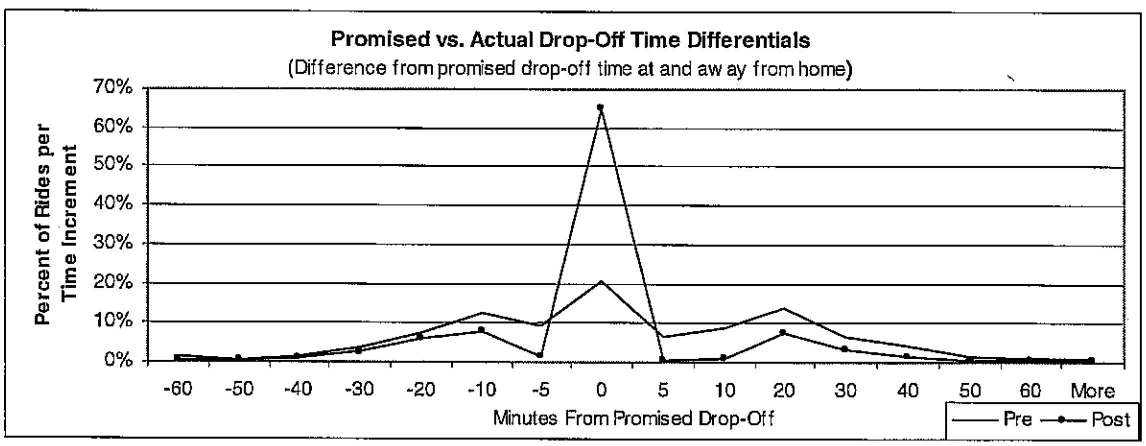
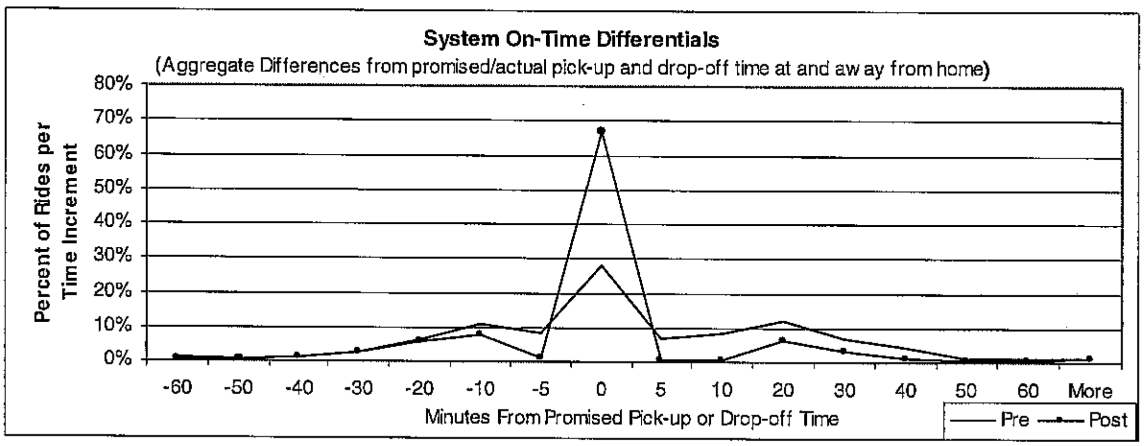


Figure 12 displays promised vs. actual drop-off time differences between the pre- and post-implementation periods. This figure shows similar changes in on-time performance observed in pick-up data. Both early and late drop-offs have been reduced. The change in arrival time rates reflects a fundamental change in how dispatching and scheduling has been modified because of CASD implementation.

Pre-implementation manual scheduling operated with an emphasis on pick-up arrival time; CASD scheduling places the emphasis on drop-off arrival time. In practice, this means that scheduler/dispatchers who previously arranged times with riders and spoke in terms of arrival time at the pick-up location, must now convert to a specific drop-off time. This basic change in operations has resulted in significantly tighter pick-up and drop-off time windows.

Figure 13 displays aggregated system wide on-time rates for both ends of a rider's trip. The figure shows total on-time rates for both pick-up and drop-off. The figure shows a system that has been overall positively impacted by CASD implementation, providing more predictability in both pick-up and drop-off times and simultaneously providing measurably fewer late and early vehicle arrival experiences to riders.

Figure 13 Aggregate On-Time Rates



4.9.2 Passenger Ride Time

Table 57 displays passenger ride time data taken from the pre and post-implementation passenger manifests. Ride-time is calculated by subtracting the actual passenger drop-off from the actual passenger pick-up time.

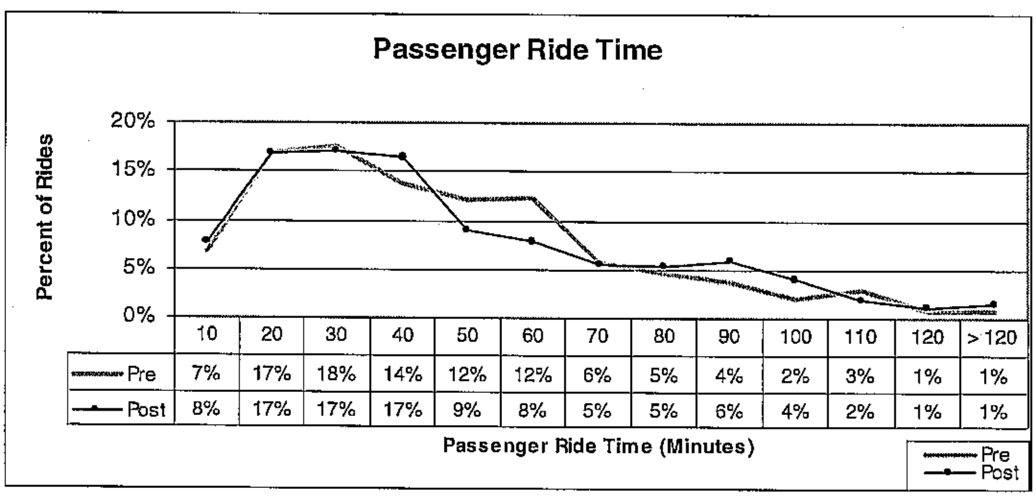
Table 57 Passenger Ride Time

Mean Passenger Ride Time (*Minutes*)	
Pre	**Post**
42.3	43.7

Figure 14 shows a slight increase in average passenger ride time from 42.3 minutes, to 43.7 minutes. An increase in passenger ride time is consistent with efficiency gains in passenger loading. An increase in average ride time is a double-edged transit attribute; increases in ride time are a positive efficiency indicator, and a negative quality indicator. An increase in perception of ride time length has been noted in the passenger surveys, where post implementation riders indicated that they felt they were riding in the vehicle for more than one-hour more frequently than in the pre-implementation period.

Figure 14 illustrates changes in passenger ride times between pre- and post-implementation periods. Changes include a small increase in passenger ride times between thirty and forty minutes and a somewhat larger increase between eighty and one hundred minutes. The figure shows the most substantial changes occurring in passenger ride times were a decrease in the percentage of riders between fifty and seventy minutes and an increase between 80 and 100 minutes. It is interesting to note that the proportion of ride times in the range between one and thirty minutes, comprising 42% of both pre and post-implementation riders remained essentially unchanged.

Figure 14 Passenger Ride Time



	10	20	30	40	50	60	70	80	90	100	110	120	>120
Pre	7%	17%	18%	14%	12%	12%	6%	5%	4%	2%	3%	1%	1%
Post	8%	17%	17%	17%	9%	8%	5%	5%	6%	4%	2%	1%	1%

4.9.3 Rider Survey Analysis

A survey was completed three months before the start of the pre-implementation period, in March 1998. The survey, commissioned for the Greater Peoria Mass Transit District, was completed by Dimension Research Incorporated (DRI) and entitled *Americans with Disabilities Passenger Survey*. Survey respondents were polled by telephone, allowing for survey responses from 257 registered riders. An additional set of forty-three responses was collected from care-givers for those physically or cognitively disabled riders unable to answer questions on their own behalf. The DRI survey polled riders with seventeen major questions and nine sub-questions for a total of twenty-six separate responses. Six questions collected responses to open-ended probes used to augment scaled question responses.

The post-implementation rider survey asked questions identical to the 1998 DRI survey, allowing direct comparison of before and after results. The post-implementation survey was administered in person to registered riders of Door-to-Door, Inc, and the Greater Peoria Mass Transit District. Riders were surveyed while enroute on paratransit vehicles and at their pick-up or drop-off location. Sixty fully completed surveys where administered in the post-implementation period. Copies of pre and post implementation survey questions are in the Appendix A to this report.

Demographics

Table 58 Demographics displays demographic data for pre and post implementation respondents. Post implementation respondents were proportionally younger (under age 65) and composed of more male respondents.

Table 58 Demographics

		Mean Response		Response Proportions	
Ques	**Response**	**Pre**	**Post**	**Pre**	**Post**
Q19	Age 65 or less	2.56	2.37	0.40	0.63
Q20	Male = 1, Fem = 2	1.73	1.63	0.26	0.37

Q19: Respondent's age 1 = Under 18 years of age; 2 = 18 to 65 years of age; 3 = Over 65 years of age.

Q20: Respondent's gender

Service Recency

Table 59 displays recency of last service use responses. Pre-implementation respondents were evenly split between those who used the service one month ago or less and those who used the service two or more months ago. Post-implementation respondents were all at least monthly riders, and a majority used the service several times a week. The increased recency of service results is likely a result of surveying riding passengers; those riding during any survey period are most likely to constitute the subset of passengers who ride most often. A positive result of this response set is a respondent much more knowledgeable about changes in the transit service.

Table 58 Recency of Service

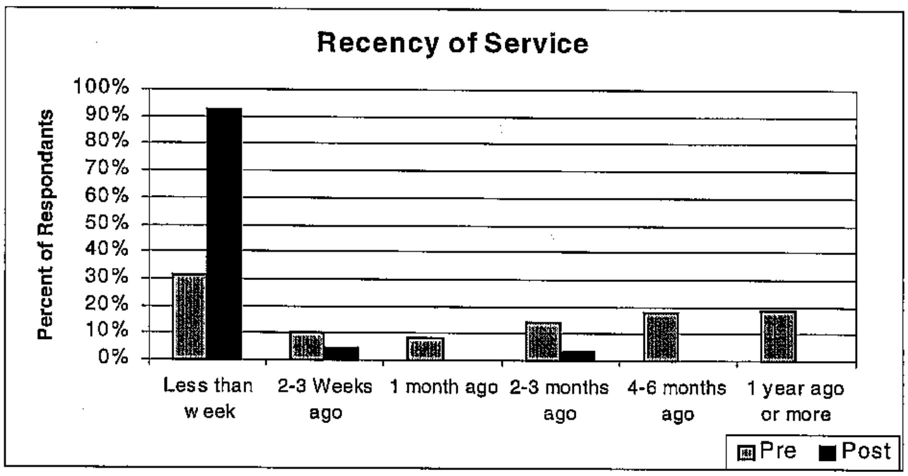
		Mean Response		Proportion	
Ques	Time Increment	Pre	Post	Pre	Post
Q1	1 month ago or less	3.323	1.142	0.50	0.97
Q2	3 times per month or less	2.343	1.218	0.43	0.86

Q1 – When was the last time you used the service provided by Greater Peoria Mass Transit or Door to Door, Inc?
Q2 – How often do you use the service?

Scale: 1=Within the past week; 2=Two to three weeks ago; 3= One month ago; 4=Two to three months ago; 5= Four to six months ago; 6=One year ago or longer.

Figure 15 graphically illustrates the recency of service use in the pre- and post-implementation samples. The graph shows the significant change in respondent recency of service use – over 90% of riders in the post-implementation period have used the service less than a week before the survey.

Figure 15 Recency of Service



Overall Satisfaction

Table 60 illustrates respondent's overall attitudes toward the service. 95% of the post implementation respondents rated the service more favorably in the post-implementation period, compared to only 79% in the pre-implementation period. The post-implementation mean score is 1.365 compared to a pre-implementation mean score of 1.875, corresponding to a change in user perspective that has moved from only "Somewhat Satisfied" in the pre-implementation period to "Very Satisfied" in the post-implementation period. Figure 16 graphically illustrates the change in attitude between the pre and post-implementation periods. The trend toward more positive responses is clearly seen in that negative responses in the post-implementation period are virtually non-existent, representing only 5% of total responses.

Table 60 Satisfaction with Service

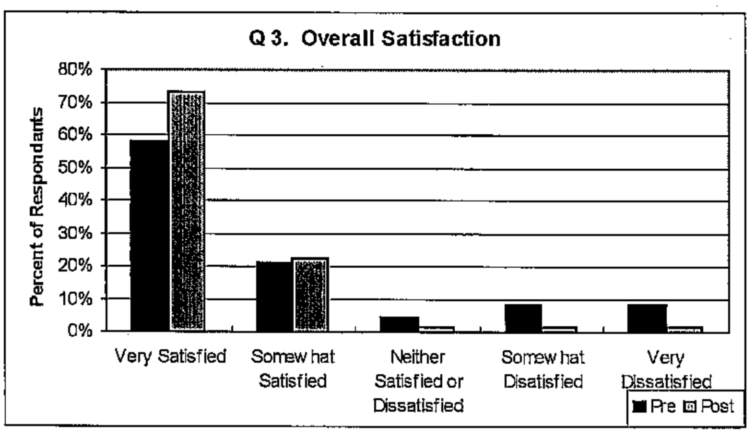
		Proportion		Mean Response	
Ques	Rating	Pre	Post	Pre	Post
Q3	Very/Somewhat Satisfied	0.79	0.95	1.875	1.365*

*= Significant at $\alpha = .05$.

Q3: Overall, how satisfied are you with the service?

Scale: 1=Very satisfied; 2=Somewhat satisfied; 3=Neither satisfied nor dissatisfied; 4=Somewhat dissatisfied; 5=Very dissatisfied.

Figure 16 Satisfaction with Service



Reservation System Attributes

Table 60 contains a consolidated list of reservation system attributes. Questions 6.1 and 6.2 ask about telephone reservation qualities. Question 6.1 responses: examining promptness of answering the telephone, are statistically significant at the 10% level. Frequency of being put on hold responses are less ambiguous and indicate a statistically significant negative change, indicating that callers are experiencing longer or more frequent periods of being placed on hold in the post-implementation period.

Questions 6.3 and 6.4 examine the respondents' attitudes towards the individual who answers the telephone. Neither perceptions of dispatcher/scheduler friendliness or perceptions regarding scheduler/dispatcher attempts to assist the caller generated statistically significant attitude change.

Responses to question 12, ride denial, show a statistically significant positive attitude shift. Ride denial perceptions have dropped from 14% to 4% in the post-implementation period. Questions 13 and 14 indicate a non-statistically significant shift toward increases in the frequency of passengers being not picked up after ride scheduling. Analysis of question 13.1, asking about explanations offered for not being picked up was equally ambiguous.

Figure 17 graphically displays respondent's perception of how promptly the telephone is answered when attempting to arrange a ride reservation. The figure shows a post-implementation increase in the length of time required for scheduler/dispatchers to answer the telephone.

Figure 18 displays respondents' perceptions about how often they are put on hold after they have contacted a scheduler/dispatcher. The figure illustrates that respondents perceive that they are put on hold more often in the post-implementation period. Table 19 illustrates respondents' perceptions toward ride denial occasions. Fewer respondents reported ride denial experiences in the post implementation period.

Table 61 Reservation System Attributes

Ques	Response	Response Proportion		Mean Response	
		Pre	Post	Pre	Post
Q6.1	"Yes" = 1, "No" = 2	0.94	0.87	1.06	1.13#
Q6.2	"	0.15	0.31*	1.85	1.68*
Q6.3	"	0.95	0.98	1.05	1.02
Q6.4	"	0.93	0.96	1.07	1.04
Q12	"	0.14	0.04*	1.86	1.96*
Q13	"	0.18	0.21	1.82	1.78
Q13.1	"	0.19	0.13	1.81	1.86
Q14	"	0.08	0.11	1.92	1.89

Scale (for all questions): 1=Yes; 2=No.

= Significant at $\alpha = .10$.

* = Significant at $\alpha = .05$.

Q6.1: Is the telephone answered promptly?

Q6.2: Are you put on hold often?

Q6.3: Is the person who answers the telephone usually friendly?

Q6.4: Does the person who answers the telephone usually try to do everything they can to help you?

Q12: Have you ever been denied a ride for any reason?

Q13 Have you scheduled a ride and then have the service not pick-you up?

Q13.1 (If "Yes" for Q13) Where you contacted and given an explanation?

Q14 Have you ever been dropped off at a location and then had the service not pick you up?

Figure 17 Promptness of Answering Telephone

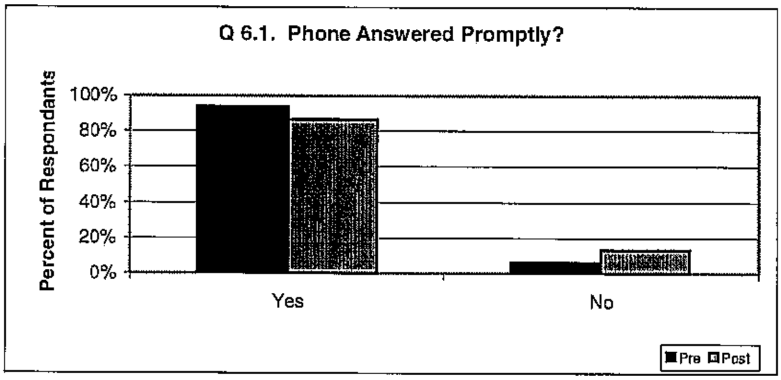


Figure 18 Perception of Being Put on Hold

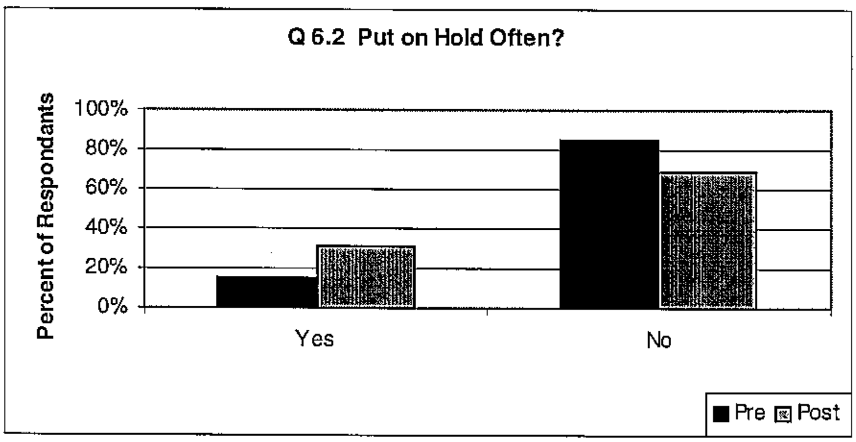
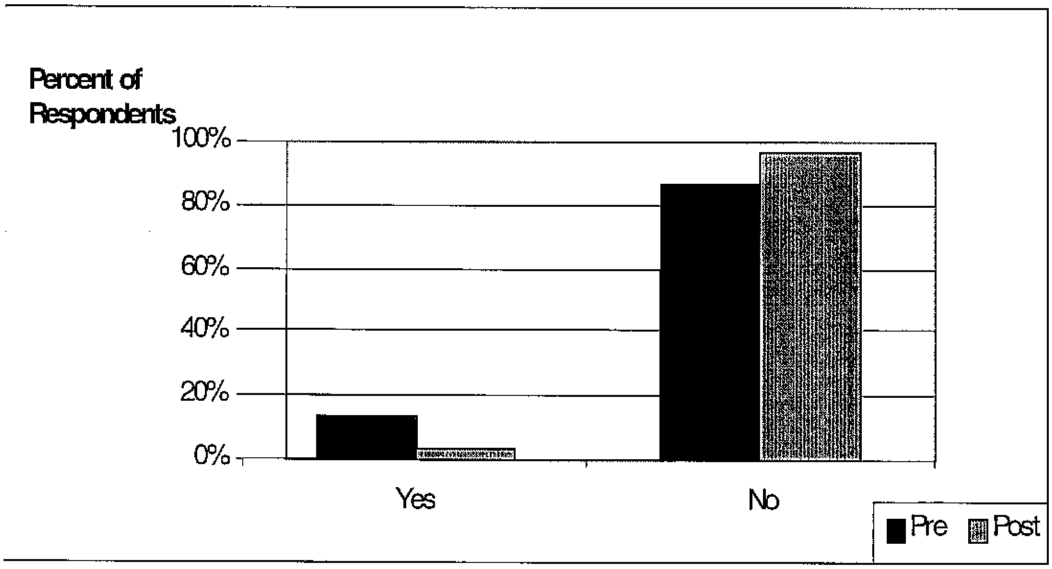


Figure 19 Ride Denial Perceptions



<u>On-time Perceptions</u>

Table 62 displays a consolidated list of statistical tests for the survey categories grouped together to show changes in vehicle on-time performance. Four of the five categories of on-time performance have shown statistically significant change.

The table indicates that riders strongly believe the service has been operating at a higher on-time pick-up and drop-off rate. Although pre and post-implementation responses to question 7.2 are not statistically significant, those responses follow the same trend as the remaining three questions in this category. Analysis of manifest data shown earlier corroborate the respondents' perceptions of increases in on-time performance, showing slight reductions in lateness overall, and a more significant reduction in lateness of drop-offs. Figure 20 illustrates respondents' perceptions of on-time arrival rates.

Table 62 On-time Perceptions

Ques	Response	Mean Response		Response Proportion #	
		Pre	Post	Pre	Post
Q7.1	"Yes" = 1, "No" = 2	1.21	1.08*	0.79	0.92*
Q7.2	"Never" = 1, "Always" = 5	2.00	2.05	0.77	0.87
Q11	"Yes" = 1, "No" = 2	1.39	1.19	0.61	0.81*
Q11.1	"Never" = 1, "Always" = 5	2.41	2.06*	0.62	0.77*
Q15	"Yes" = 1, "No" = 2	1.85	1.73#	0.14	0.27*

* = Statistically significant at $\alpha = .05$.

= Proportions for Q7.2 & Q11.1 represent the proportion of responses indicating either "Never" or "Almost Never".

Q7.1: Does the bus usually arrive at the scheduled time?

Q7.2: How often are you picked-up after the scheduled time?

Q11: When you are picked-up for your return ride, are you usually picked-up the scheduled time?

Q11.1: How often are you picked up late for your return trip?

Q15: Have you been left on a vehicle more than an hour, while other riders were taken to their destinations?

Figure 20 Perceptions of Bus On-Time Arrival

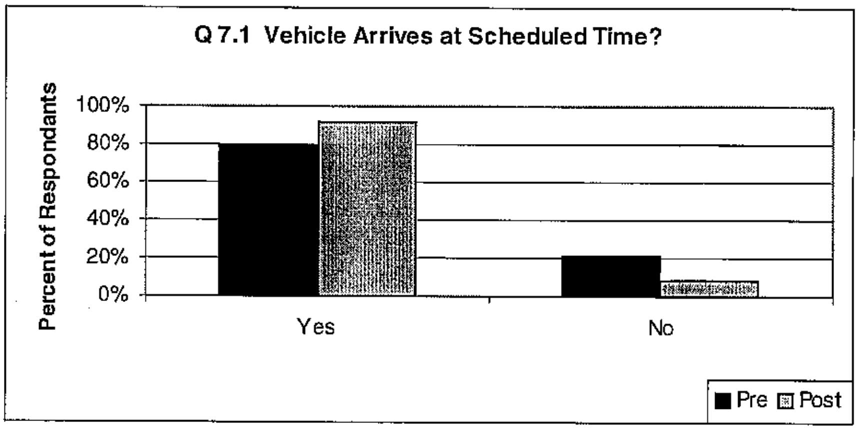


Figure 21 Lateness Perceptions at Pick-Up

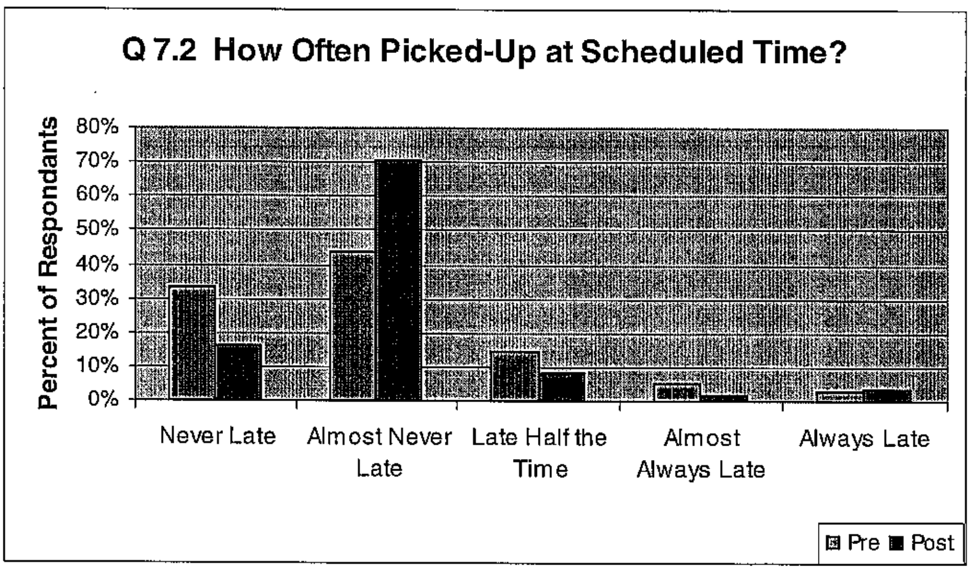
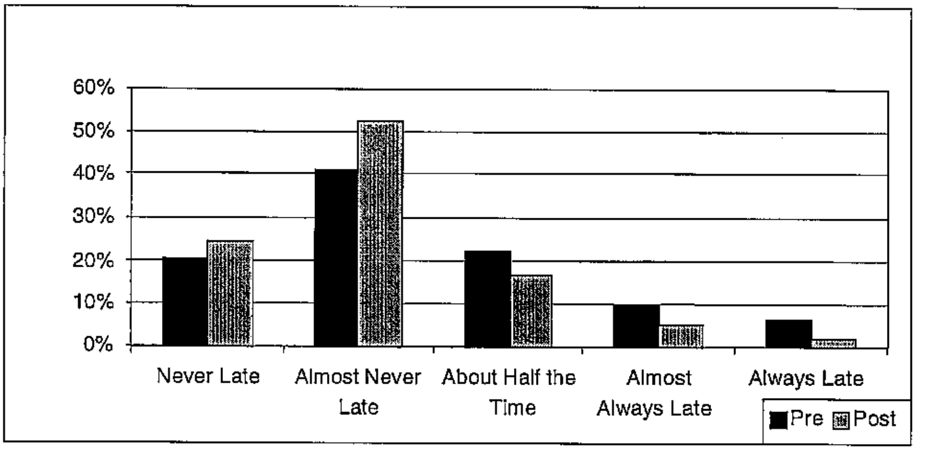


Figure 21 illustrates perceptions of how late the vehicle arrived beyond the promised time. The figure shows that respondents believe vehicles are late about as often now as in the pre-implementation period, the mean pre-implementation response scores of 2.00 is nearly identical to the post-implementation response score of 2.04. Positive changes are observed in the category of "Almost never late". In this category, responses increased more than 25%, driven by reductions in all three negative response categories. The typical respondent perceived a statistically identifiable improvement in the post-implementation period in the timeliness of the bus arrival for the return ride. Figure 22 illustrates the same trend toward positive responses for on-time arrival as seen in other on-time responses.

Figure 22 Lateness Perceptions for Return Trip



Question 15 asked if the passengers experienced ride times of more than one-hour. The results are shown in Figure 13. Responses indicate that proportionally, passengers experienced ride times of greater than one-hour almost twice as often in the after period. While approximately 14% of respondents experienced ride times in excess of one hour in the pre-implementation period, nearly 28% of respondents had over one hour ride times in the post-implementation period. This result is consistent with manifest data analysis showing that a proportion of riders have experienced increased ride times, although the data suggest that those who do experience ride times in excess of one hour were those already riding the longest of any other group. The data indicate that post-implementation riders who had previously been experiencing ride times between fifty and seventy minutes are most likely to have been affected by post-implementation ride-time increases.

Figure 23 Perceptions of Ride Times of More Than One-Hour

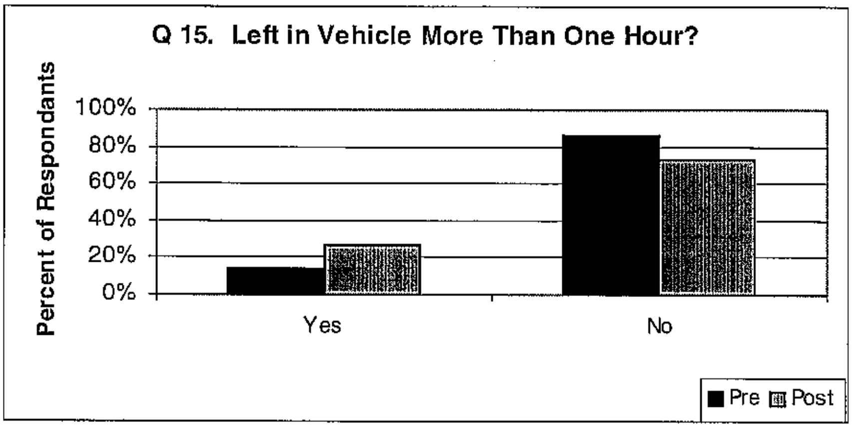


Table 63 displays responses to questions about driver friendliness, vehicle cleanliness and safe driving procedures. No statistically significant change is identified between pre and post-implementation responses. It is notable that no responses in this category experienced observable change. These categories had no obvious connection to CASD implementation.

Table 63 Driver/Vehicle Attributes

		Mean Response		Response Proportion	
Question	**Response**	**Pre**	**Post**	**Pre**	**Post**
Q8	"Yes" = 1, "No" = 2	1.02	1.03	0.98	0.97
Q9	"Yes" = 1, "No" = 2	1.06	1.10	0.94	0.89
Q10	"Yes" = 1, "No" = 2	1.02	1.05	0.98	0.95
Q17	Excellent - Good	2.15	1.91	0.89	0.91

Scale for questions 8-10:
1=Yes; 2=No.

Scale for question 17:
1=Excellent; 2=VeryGood; 3=Good; 4=Fair; 5=Poor.

Q9: Is the vehicle usually clean?

Q8: Is the driver usually friendly?

Q10: Does the driver follow safe driving procedures?

Q17: How do you rate the value of this service?

Accommodations to Changes in Reservations

This attribute is very difficult to quantify without direct observation of a large sample of actual dispatcher – customer interactions. Funding and time constraints prevented formal, long-term assessments of the kind of sample data required to evaluate this important quality attribute. This study was able to informally observe a small sample of dispatcher – customer interactions, and additionally performed personal, on-site interviews with the scheduler/dispatch staff and a representative sample of riders. Using the results of pre and post-implementation interviews of both groups, some sense of this attribute can be inferred.

Pre and post-implementation riders responded to the question "When the service number is called: does the person who answers the telephone do everything they can to help you?" Although testing did not show a significant difference between pre and post-implementation periods (Prob >|T| = 0.3696, $\alpha = .05$), this is likely because the ridership was already at a very high level of agreement on this subject; 93% of pre-implementation riders gave positive responses to this question, compared to 96% in the post implementation period.

Dispatcher interviews were also accomplished during each phase of implementation. During these often-lengthy interviews, dispatchers reinforced repeatedly that they spent significant time every day accommodating their customers. Because of the high rate of passengers who ride daily, dispatchers quickly become very familiar with the ridership they schedule, often becoming so familiar as to be privy to medical conditions and other personal attributes of riders. The combination of personal interaction and a stated desire to help a clientele dependent on transportation pushes scheduler/dispatchers to frequently take extraordinary steps to provide service.

Taken together, survey and interview results lead to a conclusion that the attribute is very important, however, linking this attribute's change to CASD is difficult.

Notifications of Service Delays, Cancellations

To assess change in rider perceptions in this attribute, customers who indicated that they had not been picked-up despite having a reservation, answered the question "Were you contacted afterwards and given an explanation?"

Survey responses were slightly more negative in the post-implementation period; however, the change was not significant in statistical testing (Prob >|T| = 0.5419, $\alpha = .05$). This ambiguity in response change is also likely due to an extreme in both the pre and post-implementation phase responses. Only 19% and 13% of riders gave positive responses to this attribute in the pre and post-implementation periods, respectively. While the difference is not significant statistically, the extremely low positive responses in both periods point to a failure to notify missed customers in either period. Rider responses to open-ended questions asking about potential service improvements also frequently mention the need to notify customers of late or no-show vehicles.

Dispatcher interviews reinforce the lack of attention given this attribute – dispatchers unanimously agree that they "would like" to notify customers whenever the vehicle is late or did not show, but that the dynamics of the position prevent investing time in that manner. While expressing a strong desire to notify in advance, dispatchers list time constraints as a significant barrier. All evidence points to the conclusion that no effort is taken to notify customers of changes in vehicle arrival times or to explain no-show vehicles to stranded customers. This did not change with the implementation of CASD.

4.10 Coordination Issues

Computer Assisted Dispatch and Scheduling (CASD) offers the possibility of efficiency and effectiveness increases resulting from reductions in duplicated activities and optimization of vehicle and personnel assets. An optimal CASD configuration will streamline scheduling and dispatching activities by allowing multiple fleets to be coordinated by a single set of dispatcher/schedulers, while simultaneously reducing vehicle deadhead time by increasing vehicle loading.

Modifications to the ideal may include geographically distant vehicle fleets and customer service operations supported by a single centralized CASD system. A centralized system offers the possibility of a central call receipt center responsible for manifest optimization and associated billing actions, and the potential to release employees previously involved in tedious manual administrative and support activity to customer support.

In practice, coordinated activity between paratransit sites is rare and influenced by significant political infighting, preventing meaningful cooperative efforts.

The study site's potential has been overshadowed by political challenges, preventing a fuller implementation of coordinated activities. Recent agreements, allowing the study site to generate manifests and billing for another service provider in the area, have allowed a first step toward coordination. Actions initiated after the study conclusion have authorized a one-year experiment to assess the potential of coordinated activities, and deserves follow-up to document progress.

4.11 Conclusions

Feasibility

- CASD implementation is feasible in the paratransit environment. Technology is sufficiently represented in vendor product offerings to support current and future paratransit operations.
- CASD products are capable of supporting coordinated paratransit activity.
- Personnel normally assigned to paratransit activity are capable of learning and effectively using current CASD products.
- Current pricing of CASD products limits its availability to those transit operators able to secure adequate funding.

- CASD implementation is a complicated and time-consuming process, often requiring more time and technology assets than available to small paratransit managers.

Cost Effectiveness

- CASD supported paratransit is potentially more efficient and effective than manually supported organizations.
- Positive changes may be seen in vehicle optimization, on-time rates, and reductions in administrative activities, especially billing.
- Customers may see potential efficiencies as negatives, more efficient use of vehicles translates to longer ride times for passengers.
- It is unlikely that paratransit managers will experience personnel reductions because of CASD implementation, most are likely to increase personnel supporting CASD implementations.
- Due to the short time duration of the post-implementation period, few changes in cost have been observed. If CASD were to result in reductions in cost of operations, then a longer time frame is needed to observe such changes. Cost reductions can take many years to realize, since organizational changes are required in order to reap such savings. In addition, the reduction in passenger trips in the post-implementation period did not provide the opportunity for management to utilize the CASD to reduce per unit costs as ridership increased.

Scheduling and Dispatching Improvements

- Given unrestricted vehicle assignment, vehicle load factors may be significantly increased.
- Administrative burdens associated with scheduling and dispatching are universally reduced because of elimination of redundant paperwork.
- CASD dramatically increases the quality, timeliness and volume of management information from paratransit operations.
- Average call length to schedule a pick-up will likely decrease because passenger ride data is stored in the CASD database with easy access by the dispatcher/scheduler

Quality of Service Improvements

- The most significant impacts of CASD in this application have been on improving quality of service. A variety of service attributes have been positively affected by the CASD implementation.
- Passengers will likely experience greater on-time rates at both pick-up and drop-off.

- Ovearall satisfaction with the service has incareased.
- Customer reporting of ride denials have been reduced.

Coordination Potential

- The CASD System has the potential to aid a service coordination effort. However, significant barriers to coordination exist which are not affected by CASD implemention. These include poltitical, turf and personality issues. Until such issues are addressed, CASD will have little impact on coordination efforts.

Report Generation

- Report generation became one of the most significant failures of the CASD implementation. While holding the tremendous potential to give the manager access to real-time, high quality, easy to understand management information, CASD support in report generation was unexpectedly poor.
- Reports are not formatted with a non-technical manager in mind
- Standard reports are far from "standard", and are difficult to reconfigure and interpret.
- The most useful reports to managers are often ad hoc reports containing information useful only in answering a one-time question or of only local interest. Generating these kinds of reports requires the manager to develop knowledge of database report construction, often intimidating to a busy manager.

4.12 Recommendations

Productivity

- Vehicle assignment limitations must be eliminated to allow the CASD system to optimize vehicle use.

Management

- Decision-makers must require well defined and pre-formatted training delivery schedules to be included in implementation. An "Up-front" training prerequisite ensures that the accountability and funding necessary for successful implementation will be contractual requirements.
- As CASD is implemented state-wide a user group of managears should meet periodically to exchange information, explain innovations, and discuss issues that have arisin as CASD is used in paratransit operations.

Training

- Training package construction is far from ideal. Operators and funding administrators should not leave this important implementation aspect to chance or "The unique dynamics of the organization. Each step of the preferred scheduling and dispatch process must be mapped and linked to the new CASD. Once mapped, so that each "old" step of the agency scheduling/dispatching cycle is linked to a specific step in the CASD, each must be assigned as a distinct training goal. Once each step of the scheduling process is identified and made a mandatory training accomplishment, both vendor and paratransit staff will take ownership of respective tasks.

- Dispatchers identified two distinct training tracks – general computer skills, and CASD specific training. General computer training covers information related to such issues as crash recovery, operating system strengths and weaknesses, and error message resolution. CASD specific training is tightly focused on CASD features and benefits. Training that is limited to bringing a dispatcher to minimum performance in common tasks was described as restrictive and prevented exploitation of the CASD synergy possible if the total system had been introduced. The lesson from this is that a pre-defined and formal training period must precede installation and "live" implementation of CASD. Despite initial negative comments from all participants, formal, detailed training is a prerequisite to effective use of the CASD.

- Training and reference manuals must be distributed and prominently placed at each computer terminal. Dispatcher comments indicate that manuals have not been in the hands of dispatchers months after implementation.

- Managerial training in developing and interpreting report data is the most often cited failure of CASD at the manager's level. Vendor training for this extraordinarily important task is virtually non-existent in our polled managers, but should become part of any implementation effort.

AVL and Mobile Data Terminals

Requirements for run-posting of every transaction degrade data accuracy and prevent real-time assessment of system performance. Allowing both the run-posting and vehicle/passenger time stamps to be accomplished manually works in opposition to the kind of accuracy and data reliability expected of computer generated reporting and tracking. Allowing manual time stamps means that system performance statistics are nearly as suspect as in the pre-implementation period – the CASD in this role becomes simply a more sophisticated data storage device instead of the revolutionary management tool it potentially represents.

Concurrent implementation of AVL/MDT overcomes the problem of run-posting in that no new personnel need be hired, manifest entries are out of the control of the driver, and no interpretation or data-entry mistakes will be entered into the system; all providing more accuracy and timeliness.

- AVL/MDT should be implemented a part of a CASD.

CASD Technology in the Long-Term

- Contract administrators must implement fixes to ensure appropriate training is received by site managers to ensure management can access and understand CASD data.
- Contract managers must ensure that project management support is provided to augment already busy paratransit managers.
- The best evaluation of CASD will follow from implementation of automatic vehicle location devices and mobile data terminals. Lacking those two important CASD modules, CASD is little more than a customer database, limiting significant productivity changes to administrative reductions.

Quality

- Allowing unrestricted use of vehicles will impact passenger perceptions of on-time rates more favorably.

Cost – Effectiveness

- Contract managers must enforce vendor accountability to training, report construction support and software documentation to ensure the potential CASD cost-effectiveness changes.

Chapter 5

Operator Survey

5.1 Introduction

As part of this project, a survey of paratransit operators across the Country was conducted to provide insights into the processes used, problems encountered and benefits and costs experienced. This survey was initiated to create a primary data source of expert knowledge. The instrument for this survey was designed to exploit significant, but widely dispersed experience in paratransit automation. While a number of automation efforts have been implemented, at best few, if any implementation processes have been observed and methodically described. The purpose of the survey was to collect responses from paratransit operators who have experienced the transition to Computer Aided Scheduling and Dispatch (CASD) systems, including key productivity measures of passenger trips/vehicle hour, costs per service hour, total vehicle miles and many quality of service measures. The survey was designed to collect a range of qualitative information found to be important during research on this project. Areas of interest include general descriptive information for each operator (e.g. peak vehicles and employees), major software features, transition to automation issues, training and support, and productivity/quality changes.

5.2 Sample Selection

Our initial sample was developed from lists of sites at which computer aided scheduling and dispatching (CASD) had been installed. These lists were provided by three CASD vendors. Two respondents representing separate vendors were located through referrals while prospecting from the original lists. In total, the implementation experience of four different vendors' systems was included in the study. We ultimately collected responses from fourteen operators. Our initial sample set was chosen to reflect fleet size and trip volume attributes similar to Door to Door, Inc.

Vehicle fleet size and average daily ride volume were obtained from operators using self-reported estimates. Even these seemingly simple attributes are subject to considerable interpretation. Some vehicles are in dual ADA/Non-ADA use; others are in restricted use as prescribed by a sponsor agency or local transit district rules. Some managers count "trips" as round-trip, while others use the more common, "one-way" trip definition. The many variations on the ability of agencies to contract vehicle services for one-time events and even the use of volunteer vehicle services further complicated the consolidation of these attributes.

We considered and rejected a handful of operator selection methodologies. Among those not chosen is the peer selection methodology used by the Center for Urban Transportation Research (CUTR) at the University of South Florida. This methodology selects peers using some basic statistical comparisons. The complete description of this process is contained in this study's literature review. Geography, trip volume, and fleet size among other attributes are compared in this methodology, and those within one standard deviation of the target agency are first cut candidates for consideration as peers.

Many, if not most paratransit agencies have separate reporting requirements for contracted ADA service, and service provided under contract to their respective transit districts. In addition, they do not routinely or completely report operating statistics to central repositories such as the FTA database. Because of the difficulty in collecting the detailed information necessary for the CUTR technique, we chose to forgo this possibility.

We also attempted to choose operators based on population density (population divided by square miles of service area). This was also rejected because "service area" is not always clearly defined. Some operators provide service in portions of several geographic areas that are hard to break out separately; others have no restrictions on area and are limited only by client or sponsor ability to pay. In the end, vehicle fleet size and daily ride volume were used as sample selection criteria. Agencies were selected if their size and average daily ride volume were in a similar range to Door to Door, Inc.

The survey process was accomplished in three phases:

Operators received a letter of introduction, a description of the study and were asked to participate.

Each operator identified from step one was called and offered an opportunity to participate. Those who agreed were offered a copy of the survey results as an incentive to participate. During this step, most operators scheduled a day and time to provide their verbal responses. The survey instrument was then faxed to the participant.

On the prearranged date and time, the operator's responses were recorded during a forty to ninety minute telephone interview.

5.3 Survey Instrument

The survey was divided into five major sections:

Sample Characteristics. Collected comparative data such as fleet size, daily trip volume, employee counts, date of installation of CASD, and major features of the system installed at the site.

Implementation. This section describes the respondent's general experience with the early phase of CASD implementation.

Productivity and Quality Changes. This section collected more specific observations related to changes in the respondent's operations, such as on-time performance, vehicle usage, and related measures.

Organizational Changes. In this section, operators described morale, retention and structural changes resulting from introduction of CASD.

Coordination Issues. Here, an attempt was made to collect information about site specific issues related to brokerage or coordinated efforts to manage transportation services in physically separate, but geographically associated demand response agencies.

Sample Characteristics

The average operator in this survey used thirty-three vehicles to provide service to their customer base. The median number of employees involved in this service is thirty-five, and those employees provide an average of 639 one-way trips per day (Monday through Friday). This includes both patrons serviced under the provisions of the Americans With Disabilities Act (ADA) and non-ADA riders on vehicles in demand response service only (this excludes both fixed route and route deviation service from trips per day counts). Table 64 is a summary description of the sample.

The median trip to employee ratio is approximately fifteen, and the group's measure ranged from a high of forty to a low of four. With over 160 paratransit employees, one agency operates with a trip to employee ratio of nearly nine, low compared to the group mean of fifteen. The site with the highest trip to employee ratio (40) is the third largest by fleet size. The respondent claiming the highest average vehicle load ratio (45) was in the middle range of fleet size. The standard deviation of average daily vehicle loads is ten.

The disparity in these measures illustrates the problem with paratransit performance management. Differences in organization structure, geography and local policies are often responsible for differences between two seemingly comparable agencies. In this sample, the agency with the highest volume of trips per day is a department in a municipal transit district. A majority of the other operators are not for profit, and usually smaller, stand-alone organizations.

Figure 24 illustrates the distribution of one-way trips per day for the sample. In this figure, one-way trips per day are grouped into categories of 400 or fewer trips per day, 401 to 700 trips per day, and over 700 trips per day. Four of the seven large operators (> 30 vehicles) provide one-way trips at rates of 701 or more per day. Despite providing significantly higher daily volumes, larger operators were not proportionally more productive in terms of average daily vehicle load (average trips per day/vehicles). The median load ratio for the sample is twenty with a range from 5.4 to 45. The average vehicle load ratio is just over twenty-one passengers per day, with a range from five to forty-five. Figure 25 graphically displays groupings of the operator's average daily vehicle loads.

Very few agencies in the sample had implemented automated scheduling or dispatching before 1997. Nine of the fourteen operators installed their systems between 1997 and early 1999. The systems are approximately evenly distributed between four vendors.

Table 64 Sample Description

Trips per Day	Vehicles	Average Vehicle Load Ratio[1]	Trip to Employee Ratio[2]	Total Organization Employees	Number of Paratransit Employees	Level of Automation[3]
1500 (high)	63	24	9	2000 (high)	167 (high)	S, D, MDT
1400	50	28	40 (high)	45	35	S,D
1300	65 (high)	20	15	9 (low)	85[4]	Roster Only
850	31	28	26	120	33	S, D
700	58	12	17	60	42	S
700	36	20	13	170	55	S, D
600	32	19	19	31	31	S, D
500	11	45 (high)	20	100	25	S, D, Billing
325	30	11	8	50	43	S, D
250	10	25	16	16	16 (low)	S
250	13	20	14	18	18	Billing Only
250	23	11	7	150	38	S, D
180	6 (low)	30	4 (low)	76	43	S, D
150 (low)	28	5 (low)	5	30	30	S, D
Mean 639	*33*	*21*	*15*	*205*	*47*	
Median 550	*30.5*	*20*	*14.5*	*55*	*37*	

1 *Average Vehicle Load Factor = Trips per day÷Vehicles*

2 *Trip to Employee Ratio = Trips per day ÷ Number of Paratransit Employees*

3 "S" = Scheduling, "D" = Dispatching, "MDT" = Mobile Data Terminals

4 *Contracts out all vehicle operations. Count includes contracted drivers. This operator consolidates rides requests and forwards passenger lists to contracted vehicle operators*

Figure 24 Distribution of One-Way Trips per Day

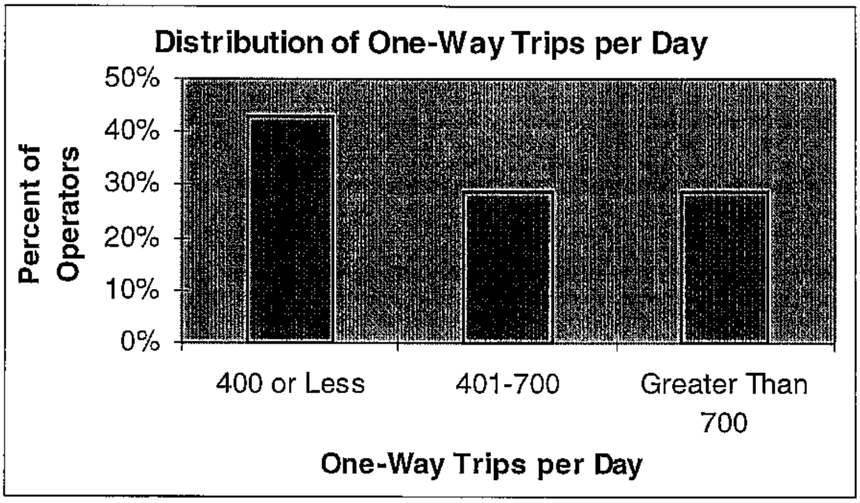
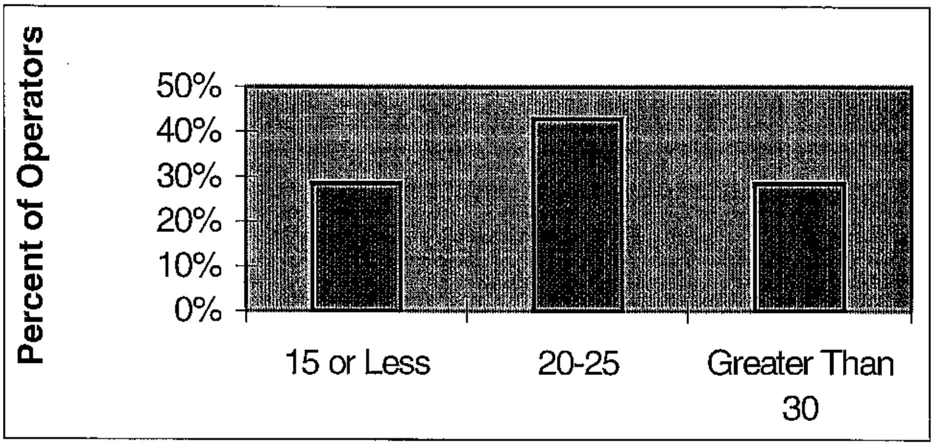


Figure 25 Frequency Distribution of Average Daily Vehicle Loads



5.4 Implementation

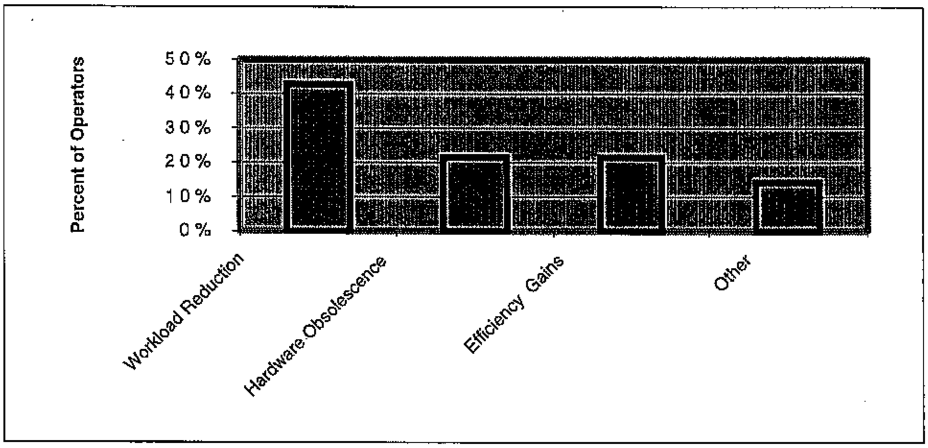
Rationale for Implementation

The sample of operators responded to an open-ended question asking why they had implemented a computer assisted scheduling/dispatching (CASD) system. Their responses ranged from a fear of Y2K issues, through a desire for internal efficiencies, to a need to decentralize organizational knowledge. Figure 26 displays these results.

Figure 26 Rationale for Implementing an Automated Scheduling and Dispatching System

- Facility chosen as a test site
- Overworked staff
- Internal efficiencies
- Outdated equipment
- Decentralize organizational knowledge

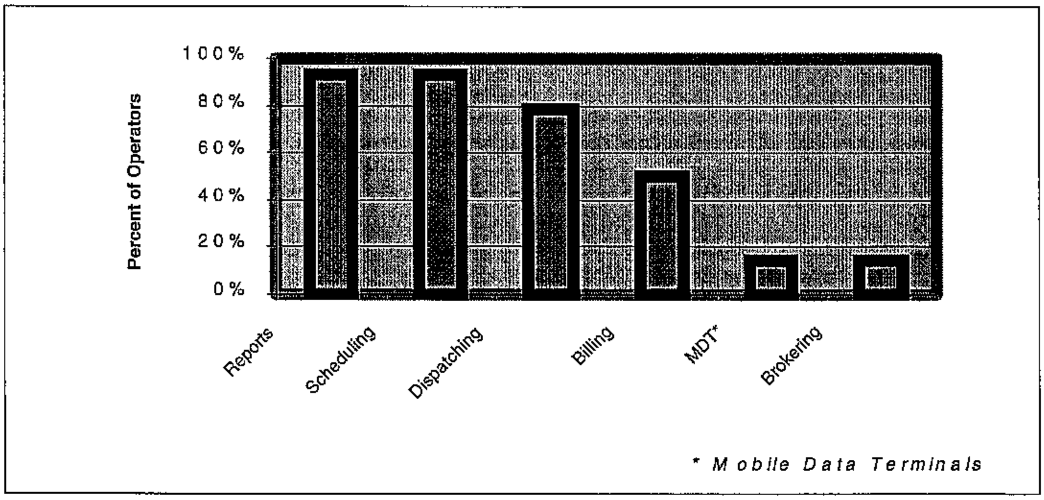
Figure 27 Rationale for Installing CASD



The results were compressed into four major categories; workload reduction, hardware obsolescence, efficiency gains and other. "Other" includes being a test site selection, and an operator who implemented CASD to incorporate the collected knowledge of his only dispatcher prior to retirement. Figure 27 illustrates the distribution of these categories. By far, the most cited reason to upgrade is to reduce workload on an overworked dispatch and scheduling team.

Decreasing the workload has the dual effect of eliminating the need for additional personnel, and streamlining internal operations, both primarily financial considerations. Financial issues were major themes behind many responses. Operators hoped to increase ride volume while holding or reducing associated costs. One reason cited as an incentive to upgrade was maintenance cost. The respondent citing this reason was using a mainframe version of an older commercial scheduling system costing nearly $40,000 a year in maintenance (hardware and software) alone. The same operator estimated maintenance for the new system at only $9,000 per year. The words "overloaded", and "overwhelmed" in connection to administrative requirements were common among most operators. A strong majority included the expectation that many of the reporting and record keeping functions of their organizations would be significantly reduced. A minority of respondents planned to upgrade further to include automatic vehicle location (AVL) and/or mobile data terminals (MDT) and wanted to lay the groundwork with their present upgrade to move towards those more advanced goals.

Figure 28 Distribution of Features Used in CASD



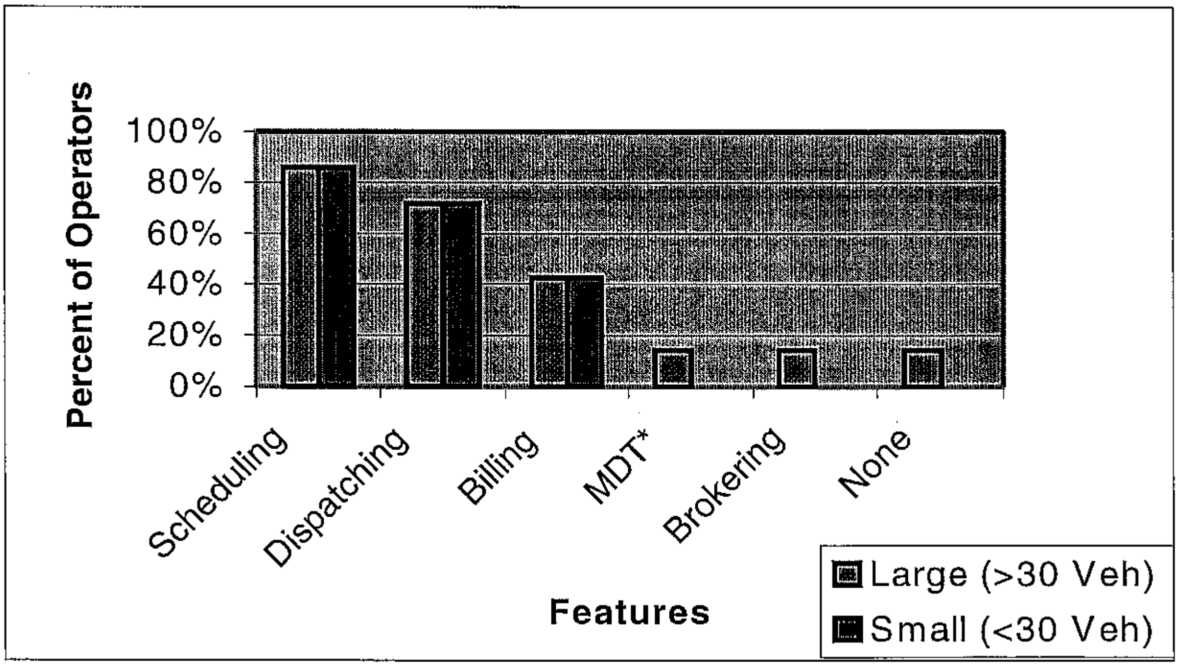
5.4.1 Features Used

While the importance of even the most obvious CASD features are debated by some users, the four most used "parts" of a CASD package are Report generation, scheduling, dispatching and billing support. Even in our small sample, we discovered tremendous variation among users' dependence on the available features of their CASD systems. Figure 28 displays the most commonly used features represented in the survey.

Operators used the features of the CASD in many combinations. Some generally used scheduling capabilities more often than others for instance, but operators used features of the CASD in differing feature configurations, even in their own operations depending on the client and run. As an example, if a route consists of a pre-configured and relatively simple manifest, it is less likely that the CASD will be used for more than manifest printing for that run. Some operators have contracted all transportation requirements to taxi companies or other demand response providers. These agencies simply "pass along" a list of clients to the contracted transportation agency and have no need for any major features of the CASD. The agency in this last case does not employ any drivers, dispatchers or schedulers, so no of the major features are needed in this agency model.

There was no difference in feature use when compared to agency size. Large (greater than thirty vehicles) operators were just as likely as small operators to have or to not have implemented the features of scheduling, dispatching or billing. Figure 29 displays the percentage of operators by fleet size and feature implementation.

Figure 29 Feature Implementation by Fleet Size



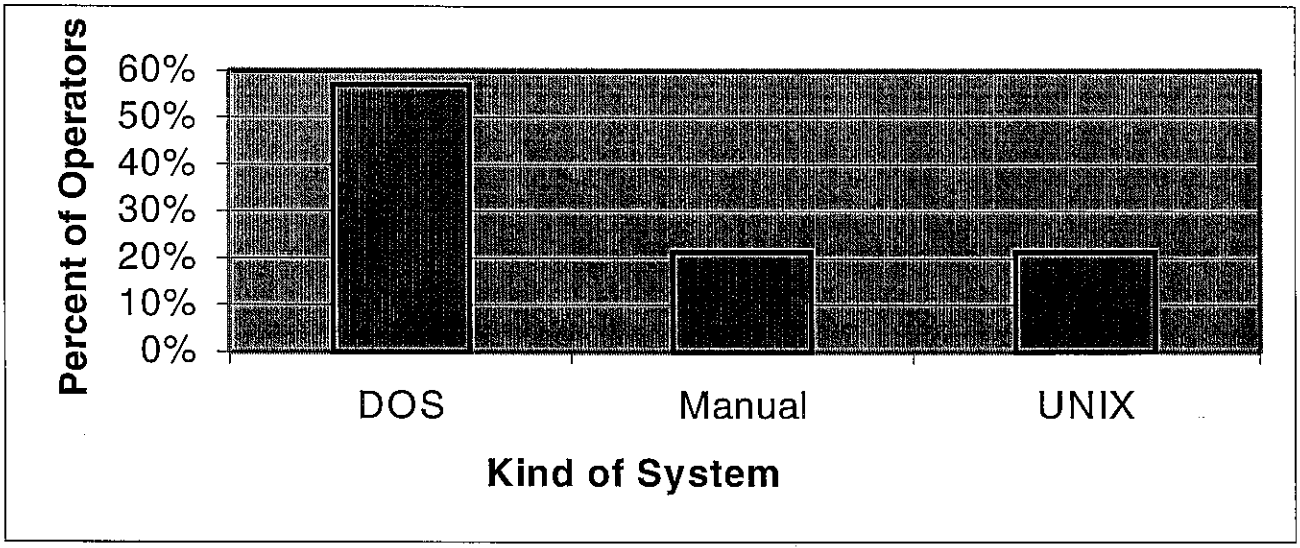
Very few respondents indicated that they are using the system's full potential. Most note that they use only a few of the many system features. Suprisingly, not every respondent uses the scheduling and dispatching features of their new software. Reasons include that the agency serves as a broker who simply passes off names to contracted vehicle operators, and that ride volume is low enough to still be handled by manual scheduling/dispatching. In organizations that experience resistance to automation, conscious decisions by some staff members prevent complete implementation of features.

At least four of the respondents do not use the optimization features built into all of the software packages, meaning that they have simply moved the old dispatcher schedules onto the computer platform, essentially relegating the new systems to manifest printers and customer database management tools.

5.4.2 Description of Old Scheduling/Dispatch Technology

None of the respondents upgraded from a previous Windows based platform, and 20% of the operators were using a totally or mostly manual system when they began installation of the new system. Seven of the operators were using some DOS based version of either a locally or commercially developed database. Two of the operators were using a mainframe (Unix) based commercially developed program. Figure 30 shows this distribution.

Figure 30 Distribution of Previous Dispatching System

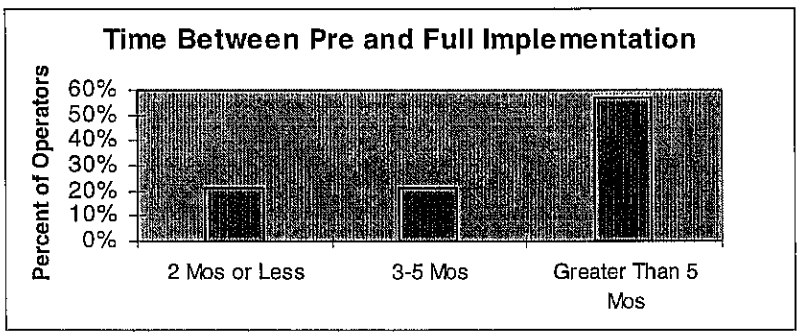


A majority of operators with previous versions of CASD installed at their site had still been augmenting their systems with manual administrative support. Operators with previous non-Windows (DOS, Unix) systems supplemented CASD report output with manually produced reports. These manually generated reports may have come from either pencil and paper calculations transferred to spreadsheet applications (especially for presentation) or reports generated from those (Dbase, Lotus, Excel) applications that are updated weekly or daily. The operators were generally disappointed with the complexity (number of steps required to complete scheduling, call intake, etc.) of DOS based systems, although some operators were vigorous advocates for the "simplicity" of DOS applications as compared to Windows based systems.

5.4.3 Time to Implementation

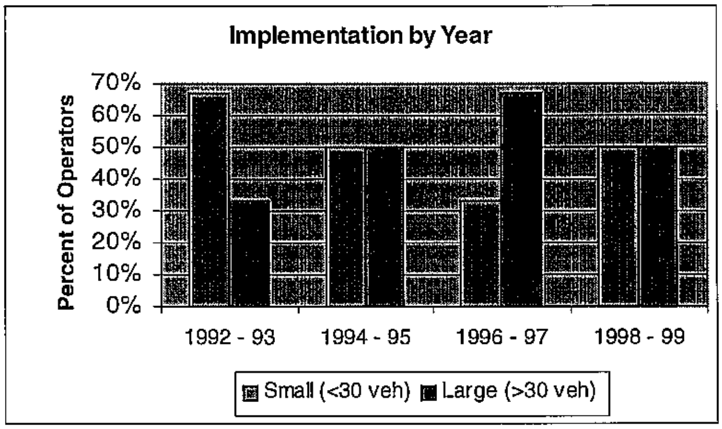
"Pre-Implementation" in this context was defined as the time required from the day requests for proposals where released (if required), or funding was requested. For the purposes of this survey, "Transition" is defined as the time beginning when some portion of the new CASD is used in training or "live" operations. "Full-implementation" means that the "old" system has been essentially abandoned and that the new hardware and software has substantially begun to support daily operations. There was no clear trend in length of time used for pre-implementation tasks. It is just as common to find operators who move from pre-implementation to full-implementation in less than five months as to find an operator who used five or more months. For those in the category of "greater than 5 months", a majority used more than nine months. See Figure 31 for a complete distribution.

Figure 31 Distribution of Time Periods Used for Pre Through Full Implementation



Between 1992 and 1997, large and small operators in our sample implemented new systems in opposite cycles; smaller operators implemented earlier, larger operators later. This meant that in our sample, by 1997, smaller operators had older versions of CASD systems in relation to larger operators. Figure 32 graphically illustrates this relationship.

Figure 32 Implementation by Year and Fleet Size



5.4.4 Transition Time

During the implementation period, many operators decide to operate both the new and old systems simultaneously. This is thought to give the operator's staff time to transition more comfortably and to ensure that even in the case of an unrecoverable system failure during the first weeks, that operations will continue with minimum interruptions. A drawback of this technique is the tremendous stress caused by simultaneous maintenance of both systems. An operator who transitioned overnight, without any back-up system noted that using the old system was already a full-time job, and that adding another set of requirements onto an already overloaded workforce was out of the question.

The average operator used seven weeks to transition from the old, existing scheduling and dispatch system (whether manual or automated) to the automated/new version. The majority of sites (8 of 14) experienced transition rates shorter than seven weeks; the median time was three weeks. Figure 33 illustrates the range of periods used by respondents to transition to their new system.

Although small sample size prevents accurate projections, mean implementation times seem to follow type of previous system. Operators using either DOS or Unix systems before transition to a new system had shorter implementation times than those transitioning from a manual system. On average, those using DOS systems used 4.8 months to transition, Unix based operators used 5.7 months, and manual to automated systems used 6.3 months.

The majority of respondents indicated that the transition rate they experienced was quicker than they would have liked. Fifty percent rated the transition experience as "Too Fast", 25%

indicated the pace was "About Right", and the remaining 25% indicated the pace of transition was "Too Slow".

Thirty-six percent of the operators cited lack of adequate personnel as the major reason behind their feeling that the rate of change was too fast. In those cases, the site simply didn't have enough staff on hand to field both the old and new systems, attend training and continue daily operations. Figure 34 illustrates the operators' responses by fleet size.

Figure 33 Time to Transition to Automated/Upgraded System

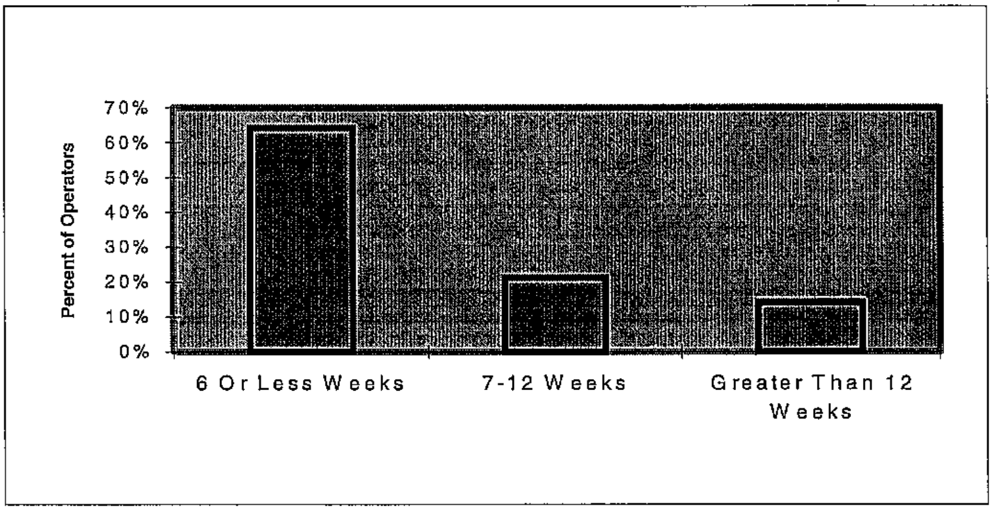
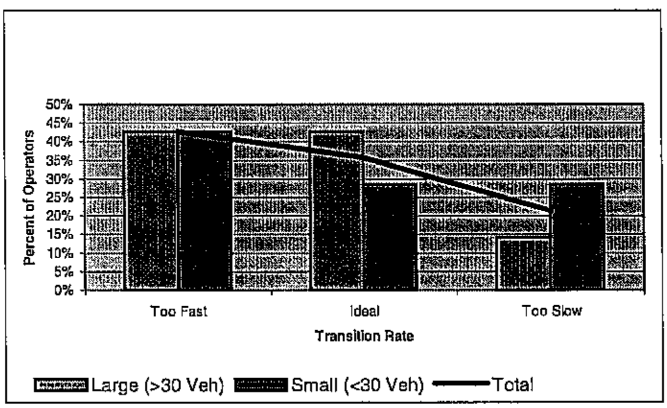


Figure 34 Transition Rate vs. Fleet Size



Four of the site representatives indicated that their displeasure with the pace of implementation was related directly to poor training efforts on the part of the vendor. Operators cited both extremes of not enough information and too much information as reasons for displeasure with the transition rate. Three operators cited information overload as a reason for believing that the rate of change was too fast. These respondents would have preferred to spend an extended training period to introduce their staff more slowly to the volumes of information associated with the new system.

5.4.5 Data Entry

A common problem encountered during pre-implementation is entry of or conversion of data for the new system. For those transitioning from a manual system, the initial entry of the data used for geocoding addresses and the confirmation process required is far more effort than they had bargained for. Operators often noted that if they could revisit the transition period again, data entry is the point at which they would intercede. A common solution offered by the respondents was to hire a temporary worker to key in the data. For those transitioning from an existing database to another, both the vendor and the site manager always underestimated the effort required to translate from one data format to another. While a seemingly simple task, this step (translating addresses to map coordinates) has been responsible for an unexpectedly large number of problems. Errors at this step generate a long list of potential problems from erroneous manifests to inaccurate time projections for scheduling.

5.4.6 Resistance

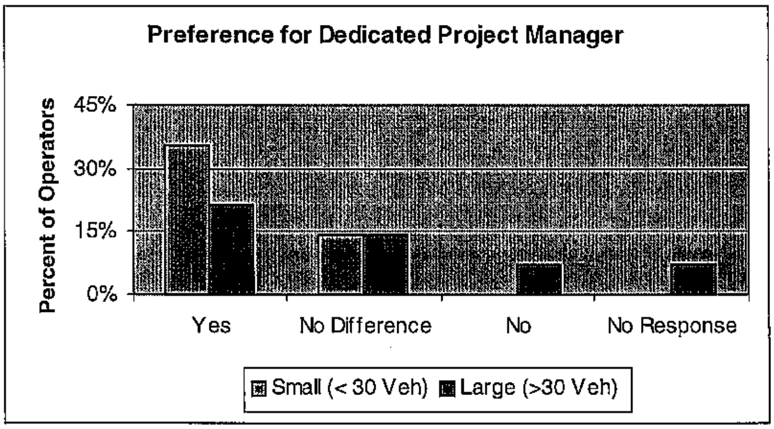
Only three operators noted that they did not have problems with resistance. All other respondents cited varying levels of resistance. Only four of the respondents noted a fear of computers as the main issue and four of the respondents noted that their staff resisted change simply because it *was* change. These managers indicated that the issue at their site was not necessarily that new technology was intimidating, but that the staff felt that the present way of doing business was adequate, and questioned the need for changing what seemed (to the dispatcher/scheduler) to be working well. For those who indicated that they experienced no resistance, managers cited intensive interaction between staff, managers and their respective vendors as a reason for the positive attitudes toward change.

Variations of the phrase "fear of computers" arose during responses to this question, with that attitude most prevalent in previously all manual operations. For some, having "hard" copies of records was far preferable to use of the database integrated in all CASD systems. One operator related the story of how he had to constantly pressure his dispatch staff to access the computerized database when needing information. His employees had been using paper records taken from a file cabinet to answer questions when the same (and presumably more accurate) information was available with a query to the database located on the employee's desktop. Some employees expressed resistance because they felt too much was required of them at once. When in this "overload" state, employees simply balked at using the new system.

5.4.7 Dedicated Project Manager

While no one had a full-time, on-site project manager, many noted that the vendor or in house information technology personnel served in that capacity in at least some degree. Most site general managers served as the lead for all implementation decisions. Eight of the respondents agreed that an on-site, full-time project manager would have made a positive contribution to the implementation process, but three indicated that a project manager would not have made a difference. One respondent indicated that an on-site project manager would have only complicated the process. Figure 35 summarizes the responses.

Figure 35 Preference Towards a Dedicated Project Manager



A strong inverse relationship exists between size of fleet and desire for an on-site, full-time project manager. Depth and availability of organizational computer support is related to agency size. This is especially true when an agency is co-located with its sponsoring transit agency. When such co-location occurs, organizational support from resident information technology personnel at the transit district often take significant burden from the paratransit manager. Managers of smaller and off-site organizations often bear the entire extra burden of implementation planning, monitoring and training. In large or small organizations, the more experience with technology a manager possessed, the less intimidation they felt with implementation planning and execution, and so consequently, felt less strongly about the need for outside help.

5.4.8 Training and Support

Responses to questions about training were consistent among both large and small operators. Even when the training was rated as good (seven of the respondents rated the training as generally positive), respondents were rarely content with the training location or length. Training content was noted as a problem less frequently. Only four of the respondents rated training negatively, although these comments were the most candid and strongly stated of the survey.

Operator experiences with training ranged from exceptionally good to abysmal. While one operator could claim training of more than eighty-hours over eight months, a significant number of the respondents felt as if they were sole providers of their training, noting that they were forced to use help menus and poorly written manuals. One site manager quoted his vendor representative's response to a request for assistance as "Read the book".

Most vendors will construct training in a package defined by the site management. In one case, this was a regrettable error. This respondent designed the training to support a transition to doing his old operations on the new CASD, attempting to mirror past operations. This operator strongly regretted not researching other ways of "doing business" which may have resulted in changing roles and responsibilities to match the new system's potentials.

Managers offered strikingly different attitudes about training content and volume. One respondent cited displeasure with the "overwhelming mountain of knowledge" required to learn how to operate the new system, while another described training length and content as "not much". It is important to note that the same respondent quoted as saying "not much" also said that they spent "as much time as they could" on training, illustrating the dilemma of balancing the needs of continuing operations with the implementation of new technology.

The balancing act is addressed again in statements that indicate that at least one manager felt "chained" to the desk during training, and this from a manager who rated the training in this the second implementation of CASD as "useless". The managers variously described their training as "disjointed" with another manger adding that yet another vendor trainer had said, "Here's the book, read it".

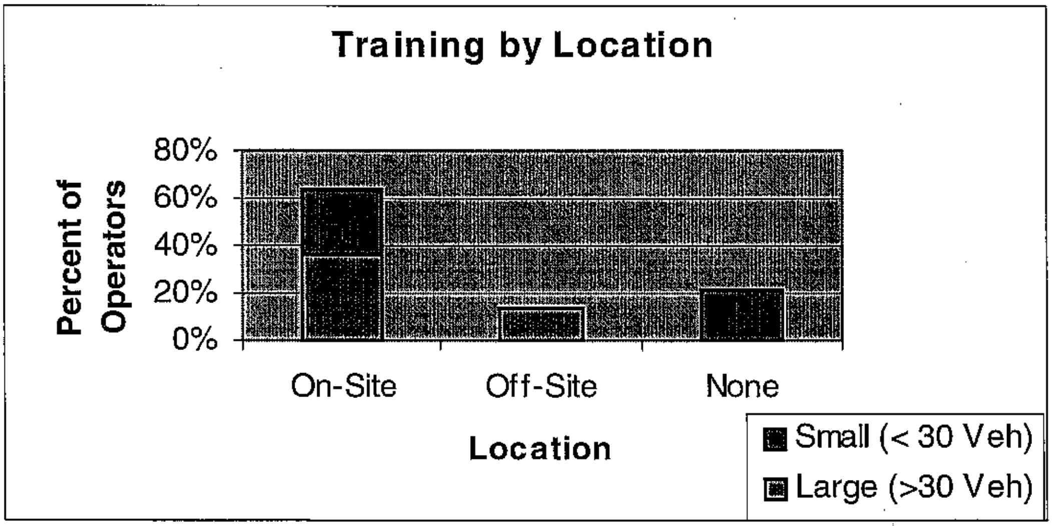
Positive comments include "Generally good", "Very good to excellent" and "Great", although when asked how they would change "Very beneficial" training, the respondent added "more staff training" as a more useful product.

The respondents described an ideal training program as being located away from the work site, given on equipment/software mock-ups identical to those at their site and customized to give separate training to management, dispatch/scheduling/call-intake and other office staff. A consistent theme noted by respondents is that very little training is provided for management that is designed to create the kind of familiarity with report generation and analysis they would like. Respondents almost universally note that they are left to their own methods to create and deliver management training in those areas. One manger's opinion was that lack of training for management is related to less effective use of the installed CASD.

Experiences with training are related to pre-implementation funding decisions. Some software vendors allow for configuration of CASD installation with varying levels of training and support. Extended training requires substantial investment by the operator, both in fees paid to the vendor and loss of productivity/payment of overtime for the operator's staff. Almost all respondents related a story of how difficult it was to implement a satisfactory training program. Formal training is often pushed to the far end of the training program in favor of on-the-job training with the idea that "live" experience will be more valuable than classroom training. This leaves formal training to be squeezed into the last days or even hours of the software vendor's site visit, and is probably a contributor to the "overwhelmed" feeling cited by many operators. The inability of management to fund adequate training is the most cited reason for not designing what an operator would call an "ideal" training environment. One operator noted that the representative sent to conduct the site's training was too new to provide the kind of training they needed.

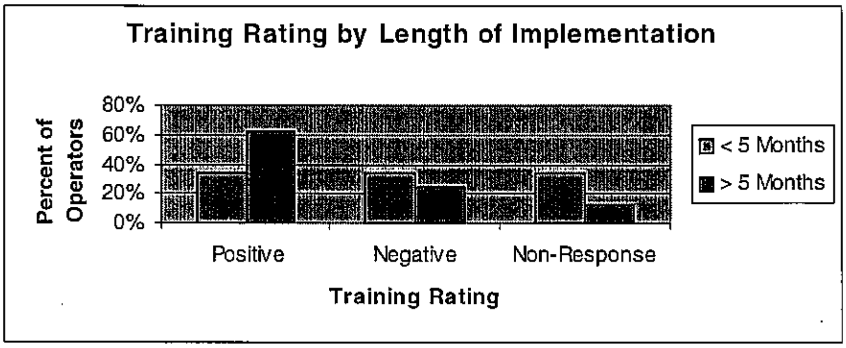
Smaller sites are far less likely to have off-site training, in fact, in our sample; no small operator had experienced off-site training. Three small operators had received no vendor training at all. Figure 36 and Figure 37 illustrate responses about operator's training by location and length of implementation.

Figure 36 Training by Location and Fleet Size



Training ratings seem also to be affected by length of time spent in implementation. Longer implementation times seem positively correlated to more positive training ratings. Figure 37 displays the respondents' feelings about training when compared to implementation length.

Figure 37 Training Rating by Length of Implementation



5.4.9 Reporting

All major "Section 15" reports are provided as basic output from the four vendor packages included in this survey. Use of these reports is related to the agency's reporting requirements. Every site uses these basic reports to some degree. Interestingly, every site manager uses some form of ad hoc reporting or custom designed reports to supplement their standard selection of reports. One manager still uses a standard commercial spreadsheet to upload raw data from his new system. He maintains that it is far easier to endure the extra effort this requires, because it is still easier than using the system's built in report generation capability. The inability to use, understand or "believe" the data from the system is a recurring theme in the survey.

Custom management reports are frequently designed (at extra cost) by the vendor on behalf of the operator. Custom reports are used by most mangers to fulfill local reporting requirements and to allow presentation of data deemed important by the manger, but not provided in standard reporting.

Some software packages are designed as modular units to which additional modules may be added at any time, increasing the package's overall usefulness to the operator. A common addition to standard CASD systems is a report generation module that allows ad hoc report generation. Despite this option's obvious utility, many operators do not have funding allocated to support purchase of this option, or if installed, do not use it because of unfamiliarity with the system. A list of some of the most often used reports is contained in Table 65.

Nearly all respondents use some variation of load factor (passengers/vehicles) as a primary measure of productivity. Far fewer use traditionally defined quality measures such as on-time performance or ride time as a day to day management tool.

Respondents were far more likely to claim that their custom and ad hoc reports were most valuable in making the most important decisions in their organizations. When asked about their "most helpful" reports, the respondents generated the list in Table 66.

Table 65 Most Often Used Reports

• Total rides per day	• Route performance statistics
• Total rides booked	• On-time reports
• No-shows	• Farebox reports
• Total cancellations	• Trip purpose
• Summary of ridership	• Accounts receivable
• Billing codes	• Vehicle loading
• Daily costs	• Driver performance
• Deadhead	• Passenger list
	• Riders by pick-up location

Table 66 Most Helpful Reports

• Ad hoc reports	• Subscription runs
• Average trips per hour	• Disabilities list
• Average mileage	• On-time performance
• Summary run analysis	• Total ride time
• "Quick schedule" report – (load factor, average MPH/passengers per hour, etc)	• No-shows
• Pre-trip edit list	• Revenue hours
• Productive hours	• Total trips

5.5 Productivity and Quality Changes

When asked about expectations and actual results, most respondents indicated that they got what they wanted from the new systems. Table 67 lists general categories of expectations. Several respondents listed more than one category of expectation. Table 68 lists results as described by the operators.

Table 67 Respondent Expectations

Expectation	Responses
Increased Trips per Hour/Ridership/Vehicle Optimization	8
Reduced Cost per Trip or Reduced Trip Time	2
Reduced Call Intake/Scheduling Time	2
Improved On-Time Performance	2
No Expectations	1
Track Driver Productivity	1
Easier Reporting	1

Only two operators indicated that they do not now use their vehicle fleet more effectively, but they added that the reason is that they were already "about as effective" as they could be. Managers implemented their CASD systems and frequently cited increased "trips per hour" and "cost per trip" as an expected outcome of the post-implementation period. A high percentage had noted that administrative burdens were crushing the staff to the point that more time was spent on administrative details than actually providing services. A hope was that the CASD would reduce the administrative burden imposed by the many layers of reporting requirements.

Virtually all respondents indicated that they expected to gain increases in ridership after installation of the new CASD. One respondent noted that vehicle optimization was a goal of the new system, one of the only times this feature was explicitly mentioned. Operators also indicated that efficiencies should follow "Less time spent on scheduling".

Operator comments indicate that most sites actually received the benefits the mangers had hoped for, although the magnitude of change was often far less than they had expected. Operators cited changes in passengers per hour, customer base and overall monthly ridership, although few operators were prepared to give singular credit to the new system. Respondents often cited a synergy of inputs that contributed to the productivity changes, both good and bad.

Table 68 CASD Results

Results	Responses
Better Vehicle Optimization and Scheduling	11
Increased Trips per Hour	9
Reduced Administrative Time	9
More Efficient Dispatching and More Relaxed Atmosphere	9
Easier Scheduling – Reduced Reservation Time Requirements	6
Increased Driver Productivity	5
Increased Customer Satisfaction	3

One site manager attributes changes simply to increased attention by all staff to productivity as a reason for change. Another operator noted that geographic responsibilities with concurrent population increases were major change factors. One operator, giving direct credit to the new system, stated that passengers per hour increased to 2.2 from 1.9.

An interesting comment gives an indication of how difficult it may be to track overall transit community changes following CASD implementation: "...There is no way to compare pre-implementation time with post implementation times...we didn't track those numbers before".

Eleven of the fourteen operators said that they were better able to utilize their vehicle assets. One operator cited more "constructive grouping" as a factor for increased fleet utilization, although one operator who agreed that he was seeing increased vehicle use noted that the increase was only marginal, because they had yet to become a "true demand response" agency.

When asked about changes in the capacity of the overall organization resulting from CASD implementation, ten of the operators provided positive comments, one by adding that the capacity had changed "quite a lot".

When asked about the most important productivity and quality changes, operators cited a range of items, including the one operator who said "everything" that changes is important. Other operators indicate that internal operations such as the ability of dispatchers and/or call takers to enter information in a single screen "while the customer waits" is very important. Speed of entry in this operator's estimation is the equivalent of an enhancement in quality of service.

On-time performance, another quality issue, was cited as the most important change; this was the first time for some managers to see "real" on-time ratios. Previous manual operations especially had no way to tabulate total on-time performance because of the tremendous time investment required to track that kind of data.

One operator, especially pleased with a change in capabilities noted that the CASD "...opened up the entire county ...clients can now travel to where they want and they spend less time on the phone ...".

Nine of the operators indicated that quality of service has improved, while three did not see any changes. One respondent noted that the "system can't impact quality". Of those who indicated a quality change, some noted more than one category, but all can be grouped into five major groups:

- More service to community (more rides in less time)
- Faster or more efficient reservation system
- Improved on-time performance
- Fewer turn-downs (service denials)
- Real time information to customers (arrival time projections, etc.)

Additional changes in quality include extra information added to the manifest, such as rider pick-up information: "Pick-up behind house", or "Ring door bell twice". These extra notes allow more personalized service and increased perceptions of driver friendliness. Despite these changes in quality, most operators indicated that their level of complaints did not change dramatically. Nine of the fourteen respondents did not show a change in complaint levels, although they noted that the levels were generally low before the system implementation. Seven of the respondents indicated that their on-time response rate increased, but no clear trend of comments is evident to account for the change.

Respondents claim that they are able to reduce their turn-down rates because of their CASD while at the same time reducing the required advance reservation window from as long as a week to as short as same-day service.

Ten of the respondents noted that the scheduling/call intake process is more efficient. Most of those in this category note that the increase in scheduling and call intake speed is related to having all client information available in front of the scheduler as the client calls. This means that call intake has been reduced from as much as ten minutes to two or less in some cases. It is notable that two respondents indicate that it now takes more time to schedule than before. In these cases it is because of either the low volume manual system was easier to use or the staff is still on the learning curve integrating the new process into daily tasks.

It was notable that very few of the operators had current or reliable data at hand to back-up claims of increases in productivity. When a measurement was offered describing how performance had changed, "Trips per hour" and "Cost per trip" where the most cited examples. Another operator focused on how little the actual tasks had changed from the "old" way to the "new" way. This operator noted that internal efficiency remained unchanged because "The old system (manual) required humans to assign requests ...to vehicles. The new system is no better and sometimes worse." An issue raised by the same operator is that "dispatchers walked into" the transition with the idea that the new system would be error free. Because of the many ways that errors may be introduced into the system, this is far from the case, negatively affecting morale, discussed below.

5.6 Personnel Management Changes

Most (9 of 14) cited management changes as a result of CASD implementation. Among those changes were enhanced abilities of management to monitor driver performance and call booking by period. Table 69 lists major changes cited by respondents.

Table 69 Management Changes

- Hired more personnel
- Pushes drivers harder
- Provides more data for management decisions
- Morale increases from increased productivity
- Can post group performance for competitive atmosphere

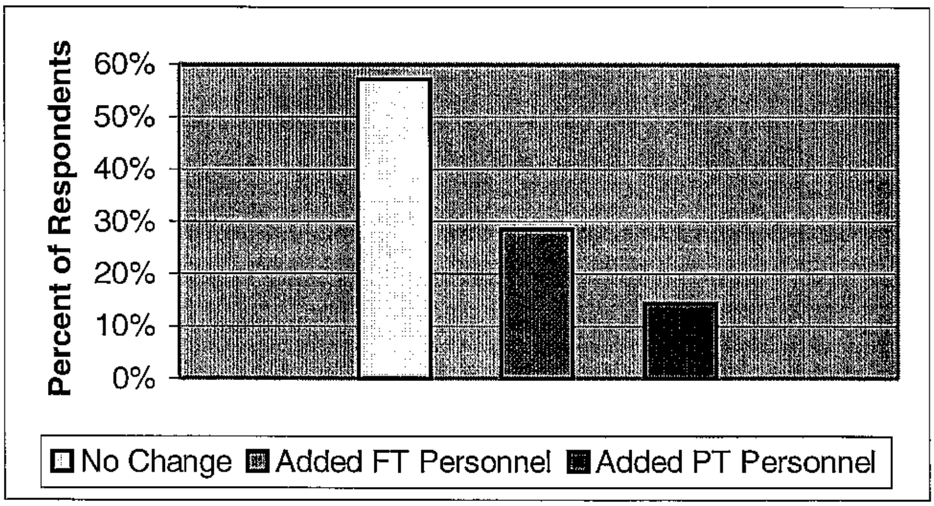
Nine of the fourteen respondents said that the way they manage people has changed because of the new system, while two noted that "Nothing has changed". The responses of those who said that they have changed management techniques ranged from equitable distribution of workload to drivers, to increased data for decision making to tracking on-time performance. Most comments focused on the increased access to data. These managers noted that they are able to look simultaneously at all levels of the organization to both reward and reorient performance.

Some comments from the survey indicate a range of opinions about how the management of personnel has changed since installation of CASD. While one manager does not see any change in the way his organization is managed, another cites improved use of data and higher driver productivity. The increase in productivity was linked to higher levels of morale in the driver workforce. Another manger noted that the ability to track on-time performance allowed interaction with drivers using timely and specific information, allowing a more productive relationship.

No manager was able to reduce staff size, and one manager noted that increased staff was a significant change at that facility. Over 41% of managers made the decision to hire more personnel during one of the phases of CASD implementation. Nearly 28% added more full-time staff, and more than 14% hired more temporary staff. Figure 38 displays these changes.

Five of the respondents noted personnel changes, but only one manager changed employee levels because of personnel unable or unwilling to embrace the new technology. In that case, the manager released three dispatchers/schedulers and hired four new staff members. Other respondents added personnel to handle extra volume, but only one operator noted that the extra volume was a direct result of the new system. One site added a new position (systems maintenance) to handle the increased technology requirements of the new system. Four of the respondents reorganized or renamed jobs in their organization. These changes are intended to allow more people to share in the workload of scheduling and dispatching. No operator was able to reduce the number of personnel on staff as a result of CASD installation.

Figure 38 Personnel Changes

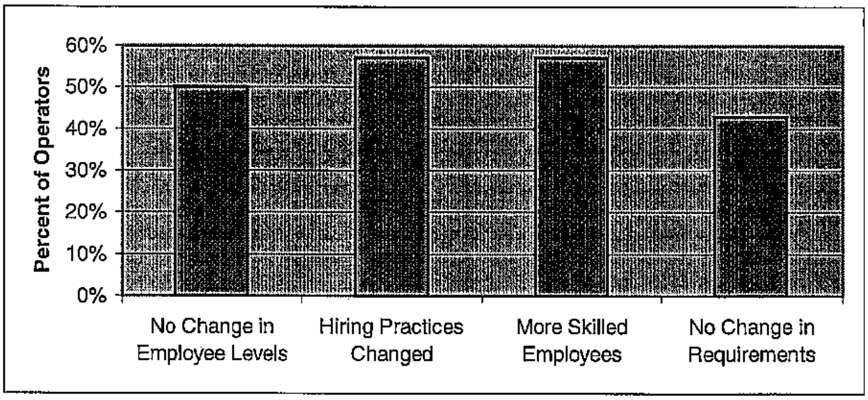


Every respondent indicated that morale has in some way been affected. Only one respondent indicated that the system had negative effects on morale. The negative morale in that case resulted from increased workload that was a direct result of higher volume following from greater use by the community. No respondent cited the system as having any effect on overall retention levels.

Other reasons cited for morale changes include frustration with the new system's complications, but the vast majority indicated very positive morale impacts following CASD implementation. One respondent noted that his staff has been "cheered" because of rider's comments with respect to on-time performance. One group of employees was initially resistant, but later became excited as they began to understand the potential of the new system. Another manager noted that his "People liked the new system because it is easy and intuitive, very productive and very fast". Another manager said that with this new tool, nearly anyone could be a "great" dispatcher or scheduler (a reference to the difficulty in finding capable dispatchers). A real sign of how morale has changed, said one operator, is heard, rather than seen, in the radio comments between dispatchers and drivers that are now far friendlier.

Although no respondent has undergone dramatic changes in hiring patterns, most managers believe that one result of the new system is to increase the level of technological understanding required of incoming employees. Most will ask for at least some familiarity with the MS Windows operating system. Figure 39 summarizes respondents towards hiring practices.

Figure 39 Employment Changes



5.7 Coordination Issues

Very few respondents operate in the brokerage/mobility management environment and so less useful information was developed from this group of questions. Nine of the operators were not using any of the brokerage features of their CASD; none were using the features enough to say that they are really doing "brokerage. When asked, most operators agree that "turf wars" and a desire to protect ongoing operations will always be barriers to coordination efforts. As one operator noted, a major problem in many rural areas is simply that vast geographic areas are not serviced at all by any transit services. Others note that "exclusivity" problems; operators or agencies not wanting to share the potential population are major barriers to incorporating brokerage. This theme is noted in another operator's comments that "politics and border protection" are serious impediments to consolidated transit efforts.

A common problem is the restrictions imposed on particular vehicles. When an organization initially sets up a paratransit service, it frequently chooses not to operate the service itself, preferring to contract out services to an existing transit provider. In many cases, the agency will lease their vehicles to the contracted agency. As part of the service contract, a significant number of agencies will restrict the use of their leased vehicles only to the support of their targeted population. This may mean that an empty vehicle already on the road, and in the immediate area of a rider needing transportation, may not be authorized to pick up that passenger.

Nearly all of the operators agreed that political issues override many common sense solutions. "Ownership" and "exclusivity" are often the most contentious issues. Others noted that municipal officials are always "all for an idea so long as the cost is free".

5.8 Overall Themes

Few overall themes emerged from the operators when asked how they would approach the implementation process "all over again". Some general responses are noted below:

- Choose a more "user friendly" system
- Change contracting to allow for hardware upgrades as they occur between pre-implementation and actual installation
- Include temporary hires in pre-implementation budgeting
- Run "dual" systems longer
- Create a "new paradigm" that takes advantage of technology instead of doing the same thing on the new platform
- Clearly define report requirements before implementation
- Better training
- Hire programmer to handle data conversions
- Dedicated project manager

Operators indicate that they would "shop around more" to locate more "user friendly" or "less costly" systems if they could revisit the pre-implementation process. These operators were generally happy with the system, but remain convinced that other systems must be more capable and flexible. Two operators indicated that considering more choices in the bid process would have resulted in better choices.

Another operator said, "You need analysts to decide on a new paradigm for the system instead of doing the same thing all over" on the computer. A caution was also offered against speeding up the installation and implementation process because of a manager's personal decision that it has to be done "Right now". For that manager, speeding up the process up front extended the total time to fully implement the CASD system.

5.9 Major Findings

1. Fully half of the operators do not use major features of their new CASD. Importantly, most operators do not use one of the most lauded features, optimization. It is evident that many operators have transitioned to CASD technology in a way that does not position the organization to take full advantage of the newly acquired technology. For the vast majority, the way that operators conduct business has not changed to match the capabilities of the new system. Previously constructed subscription trips are still configured the same way; vehicles still travel the same route and dispatchers still place drivers and passengers as they did before automation.

2. Operators have noted gains in efficiency, effectiveness and quality, with some reporting significant changes, but on the whole, pre and post implementation comparisons do not show the kind of dramatic efficiency changes operators have hoped for. By far, the most significant changes have occurred in the reduction of administrative time related to manifest preparation and passenger information record keeping. This survey indicates that the most likely non-administrative effect experienced by operators regardless of size or mission is reduction in call intake time.

3. Training issues are significant and have seriously degraded potential positive impacts at most sites. Training is a variable dependent on both the desire of the site manager to fund, and the vendor representative's experience level. Training efforts are likely to become a lightning rod for discontent as the staff transitions to the new system, and management should make every effort to ensure that funding and time are allocated for training as early as possible.

4. This survey indicates that no vendor has provided satisfactory report generation capabilities or the training required to create and interpret the report output. Vendors and funding agencies must be made aware of this shortfall early to allow for custom reports to be added to the initial pricing model, and that separate, focused training is provided for management.

5. Operators are strongly in favor of adding a dedicated project manager to the CASD implementation process. Very few transit managers have the time or training to handle the increased responsibilities associated with implementation of CASD systems. While the vendor has performed admirably in some cases in this capacity, their vested interest and limited ability to integrate the unique needs of each site limits their effectiveness.

6. Overall, the implementation of CASD has been positively welcomed in this survey sample, but few operators are able or willing to fully exploit the power of CASD technology. Both policy and personnel issues limit full implementation of CASD systems. As long as agencies restrict use of their vehicles to certain groups of passengers, optimization algorithms can not reduce vehicle usage, and as long as training and attitudes does not match needs, personnel problems will persist.

Appendix 1

Rider Survey

Rider Survey

1. **When was the last time you used the service provided by Greater Peoria Mass Transit District and Door to Door, Inc?**

- ☐ Within the past week
- ☐ Two to three weeks ago
- ☐ One month ago
- ☐ Two to three months ago
- ☐ Four to six months ago
- ☐ One year ago or longer

2. **How often do you use this service?**

- ☐ Once a week or more often
- ☐ Two to three times a month
- ☐ Once a month
- ☐ Once every two to three months
- ☐ Less often than once every two to three months

3. Overall, how satisfied are you with the service? Would you say that you are

- ❑ Very satisfied *(Please proceed to Question 4)*
- ❑ Somewhat satisfied *(Please proceed to Question 4)*
- ❑ Neither satisfied nor dissatisfied *(Please proceed to Question 5)*
- ❑ Somewhat dissatisfied *(Please proceed to Question 5)*
- ❑ Very dissatisfied *(Please proceed to Question 5)*

4. What do you like about this service?

____

____

____

____

____

____

5. **What, (if anything) do you not like so well about this service?**

____

____

____

____

____

____

6. **When the service number is called to schedule a pick-up:**

6.1 Is the phone answered promptly .... ❑ Yes ❑ No

6.2 Are you put on hold often? .... ❑ Yes ❑ No

6.3 Is the person who answers the telephone usually friendly? .... ❑ Yes ❑ No

6.4 Does the person who answers the telephone do everything they can to help you? .... ❑ Yes ❑ No

7. On the day of the scheduled pick-up:

7.1 Does the bus usually arrive at the scheduled time? ....❑ Yes ❑ No

7.2 How often are you picked up after the scheduled time?

❑ Never late

❑ Almost never late

❑ Late about half the time

❑ Almost always late

❑ Always late

8. Is the driver usually friendly? ....❑ Yes ❑ No

9. Is the vehicle usually clean? ....❑ Yes ❑ No

10. Does the driver follow safe driving procedures? ....❑ Yes ❑ No

11. When you are picked-up for your return ride, are you usually picked up at the scheduled time?

❑ Yes ❑ No

11.1 How often are you picked up late for your return trip?

- ❑ Never late
- ❑ Almost never late
- ❑ Late about half the time
- ❑ Almost always late
- ❑ Always late

12. Thinking again about when you call to schedule a pick-up, have you ever been denied a ride due to over-scheduling or some other reason?

- ❑ Yes *(If "yes", proceed to Question 12.1)*
- ❑ No

12.1 If "Yes", Please describe the situation

____

____

____

____

____

____

____

13. Have you ever scheduled a ride and then had the service not pick you up?

- ❑ Yes *(If "yes", proceed to Question 13.1)*
- ❑ No

13.1 If "Yes", Please describe the situation.

____

____

____

____

____

____

____

13.2 Where you contacted afterwards and given an explanation?

- ❑ Yes
- ❑ No

14. Have you ever been dropped off at a location and then had the service fail to pick you up?

- ❑ Yes
- ❑ No

15. Have you ever been left on a vehicle more than one hour while other riders are taken to their destinations?

- ❑ Yes
- ❑ No

16. What improvements, if any, would you like to see made to this service?

____
____
____
____
____

17. Thinking about the cost of this service, would you say the service is:

- ❑ An excellent value for the money
- ❑ A very good value for the money
- ❑ A good value for the money
- ❑ A fair value for the money
- ❑ A poor value for the money

Appendix 2

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