

# AUTOMATED COST RECOVERY: *A FEASIBILITY STUDY*

FHWA/MT-08-004/8186

*Final Report*

*prepared for*  
THE STATE OF MONTANA  
DEPARTMENT OF TRANSPORTATION

*in cooperation with*  
THE U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL HIGHWAY ADMINISTRATION *and*  
RESEARCH AND INNOVATIVE TECHNOLOGY  
ADMINISTRATION

*August 2008*

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RESEARCH PROGRAMS

Montana Department of Transportation



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# **Automated Cost Recovery: A Feasibility Study**

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Funding for this project was provided by the Montana Department of Transportation (MDT), the Western Transportation Institute, and the Research and Innovative Technology Administration of the U.S. Department of Transportation.

July 2008

**TECHNICAL REPORT DOCUMENTATION PAGE**

1. Report No. FHWA/MT-08-004/8186	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Automated Cost Recovery: A Feasibility Study		5. Report Date July 2008	6. Performing Organization Code
		8. Performing Organization Report No.	
7. Author(s) David Kack, Amanda Jorgensen, Richard Hodges		10. Work Unit No. (trais)	
9. Performing Organization Name and Address Western Transportation Institute - Montana State University (WTI) P.O. Box 174250 Bozeman, MT 59717-4250 Tel: 406-994-6114 Fax: (406) 994-1697		11. Contract or Grant No. 8186	
		13. Type of Report and Period Covered Final, 11/06 – 3/08	
12. Sponsoring Agency Name and Address Research Programs Montana Department of Transportation 2701 Prospect Ave PO Box 201001 Helena, MT 59620-1001		14. Sponsoring Agency Code 5401	
		15. Supplementary Notes: Research performed in cooperation with the Montana Department of Transportation and the US Department of Transportation, Federal Highway Administration. This report can be found at <a href="http://www.mdt.mt.gov/research/docs/research_proj/cost_recovery/final_report.pdf">http://www.mdt.mt.gov/research/docs/research_proj/cost_recovery/final_report.pdf</a>	
16. Abstract Public and specialized transportation (transit) providers in Montana and other states use a variety of methods for collecting fares from riders, invoicing agencies for rides, and collecting ridership data. The purpose of this project is to determine the feasibility of implementing various technologies in transit systems within Montana to assist in the collection and accounting of passenger fares. Specific components of the research included reviewing the state of the practice in the transit industry, reviewing current technologies in Montana, conducting a requirements analysis, reviewing Americans with Disabilities Act (ADA) issues, conducting a benefit/cost ratio analysis, and providing an implementation plan. Based on the findings from these tasks, researchers also developed recommendations for MDT, which included procurement of a high-value customer data reporting system, development of a pilot program for additional technologies, and development of a one-stop center that would leverage technologies implemented to support transportation (transit) providers and provide a "one-call, one-website" portal for customers and clients.			
17. Key Words Automated fare collection, data collection, smart cards, ridership, demand responsive transportation, freight and passenger services, public transit providers.		18. Distribution Statement Unrestricted. This document is available through the National Technical Information Service, Springfield, VA 21161.	
19. Security Classification (of this report) Unclassified	20. Security Classification (of this page) Unclassified	21. No. of Pages 141	22. Price

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## **Acknowledgements**

Funding for this project came from the Montana Department of Transportation, the Western Transportation Institute, and the Research and Innovative Technology Administration of the U.S. Department of Transportation.

The authors thank Craig Abernathy, the Montana Department of Transportation's project manager, and the project panel: Audrey Allums, Bob Burkhardt, Chuckie Cramer, Marlene Disburg, Chris Dorrington, Steve Earle, Lyn Hellegaard, June Hermanson, Steven Potuzak, and Cynthia Whitbeck.

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## INTRODUCTION

The purpose of this project is to determine the feasibility of implementing various technologies in transit systems within Montana to assist in the collection and accounting of passenger fares. The research included the following objectives:

1. Review the state of the practice in the transit industry of automated cost recovery systems, and their applicability in Montana.
2. Review current technologies in Montana, such as Montana Access, to see if these systems/technologies could be expanded to include automated cost recovery in Montana's transit systems.
3. Complete a requirements analysis that reviews the business practice of transit systems to determine what issues might affect implementing an automated cost recovery system.
4. Review potential technologies/systems to determine if there would be any issues relating to the Americans with Disabilities Act (ADA).
5. Develop a benefit/cost ratio to determine if implementing an automated cost recovery system in Montana is feasible.
6. Provide an implementation document that will highlight any key barriers, hurdles or issues that would need to be addressed, should a decision be made to implement an automated cost recovery system.

Public and specialized transportation (transit) providers in Montana and other states use a variety of methods for collecting fares from riders, invoicing agencies for rides, and collecting ridership data. In urban areas, electronic passes may be used, while in rural areas a simple "paper and pencil" method may be used. While simpler methods may require less infrastructure (computers, communications equipment, etc.), they may actually be less efficient, requiring more time for personnel to consolidate data, invoice for services, and complete other data management tasks.

Many larger urbanized transit systems are using automated (electronic) methods of collecting fares, tracking ridership data, and invoicing agencies/organizations for rides. Methods may include magnetic strip cards, smart cards, or stored value cards. In addition, some states have implemented statewide software solutions to automate as much data collection, analysis and reporting as possible. The Client Ridership Referral and Financial Tracking (CRRAFT) system used in New Mexico is one example of this type of software. In addition to customized software packages, commercial off-the-shelf (COTS) systems are available.

In an earlier project, the Western Transportation Institute (WTI) worked with MET Transit of Billings to identify the benefits of Computer-Aided Scheduling and Dispatching Software. These software packages not only assist with the scheduling of demand-responsive systems, but can also help with data analysis, invoicing, and other planning and management requirements. These software systems can be integrated with fixed-route transit systems to provide an integrated solution for a transit system. Based on the first WTI report, MET Transit put out a Request for Proposals, and selected RouteMatch Software as the new provider of software for MET Special Transit (MST). WTI was subsequently asked to complete an analysis of MST before and after the implementation of the RouteMatch software. This project served as foundational research for conducting a benefit/cost analysis of an advanced public transportation system.

The following sections describe the information gathered with regard to the six objectives noted above and are presented so that the Montana Department of Transportation (and potential partnering agencies) can determine whether or not to move forward with the implementation of automated cost technologies. In addition, the report includes the following reference materials in the Appendix: the survey distributed to Montana transit providers (Appendix A) and a summary of the results (Appendix B); background material on mobile data computer systems (Appendix C), and a copy WTI's report on the analysis of MET Special Transit (Appendix D).

## **AUTOMATED COST RECOVERY & FARE PAYMENT TECHNOLOGIES**

The United States transit industry has a long and, at times, varied record with automated fare-collection systems. Every day, hundreds of thousands of U.S. transit customers use various passes and cards to pay for their transit trips. Across the world in Europe, Asia, the Americas and Africa, millions of customers are able to access and benefit from public transportation every day. Increasingly, payment devices like credit cards, debit cards, cellular telephones and other tags and devices are being used that provide inexpensive, secure and accurate transactions for customers and operators alike. Through the use of electronic fare payments, interoperability is fast becoming the norm, enhancing the ability of different agencies to coordinate and share information so that passengers can travel in a seamless fashion.

There are numerous rail-, bus-, transit- and paratransit-based examples around the world of interoperable systems. These systems integrate payment methods and devices that link separate operators, allowing for revenue sharing among providers and giving customers seamless, single payment solutions for their transportation options. In the United States, notable examples of large automated fare systems include the San Francisco Bay area, Washington D.C., Boston and Chicago. Other systems in development or deployment that deserve study include those in Houston, the Puget Sound area, Los Angeles and Salt Lake City. This list is not exhaustive but will serve to provide examples of important opportunities and lessons for the state of Montana.

As will be noted later, the electronic payment industry and the transit industry are both changing rapidly. New payment approaches from the banking and card payment industries are converging with new needs from the transit industry to “do more with less,” improve measurable efficiency and create new opportunities for both. This section will review existing and emerging technologies for electronic and automated payment systems, review some existing applications of those technologies in the transit industry, examine similar technology and business management approaches in other industries, and look at the role of the private payment industry in the development of tools and applications.

### **Current Transit Technologies**

Traditionally, a majority of transit operations have relied on cash- and pass-based systems to collect revenue from their passengers. Fareboxes currently in use range from very simple “drop” fareboxes that merely collect and securely hold payments, to more sophisticated “registering” fareboxes that count the fares, validate currency and passes, and record transaction information (Figure 1).



Source: (Diamond Manufacturing 2008; GFI GENFARE 2008)

**Figure 1: Basic and Advanced Fareboxes**

There are two main types of fare media: smartcards and magnetic stripe cards (Figure 2). Both allow easy passenger identification and payment of fare without using cash. Magnetic stripe cards typically only allow the fare (value) to be deducted from the card, while smartcards deduct fares from a cash value stored on an imbedded microchip. Smartcards typically also allow value to be added to the card, while this is not typical with magnetic stripe cards, although this is changing.



Source: (Hodges 2007)

**Figure 2: Magnetic Stripe and Smart Cards**

Many regional systems within the United States are using smartcards, but most of these systems are large metropolitan systems. There are, however, many large and small systems using magnetic stripe cards. There are two basic types of magnetic stripe media: read-only swipe cards and read-write, stored-value cards. The read only technology is similar to that used for credit or debit cards, and allows the automatic determination of the validity of an unlimited-ride pass.

There are also machine-readable paper tickets that are printed with specific ink that makes counterfeiting very difficult. These tickets offer a possible replacement for paper transfers or single-ride fare tickets. The read-write technology, used with a ticket processing unit (TPU) or bus ticket validator (BTV), can accommodate stored-value and other automated payment options. The use of magnetic farecards on bus systems is a more recent development, but as of late 2002, read-write technology had been implemented by more than 30 U.S. bus operators.

There are many multi-operator systems utilizing smart cards. Some examples include: the New York City Transit Metro-Card system; the state of Connecticut, with services in Hartford, New Haven and Stamford; and southern California, where five operators accept the Metrocard.

Farecards have proven very popular among customers. The greatest benefit magnetic stripe cards have had for customers is a wider variety of convenient payment methods. Many magnetic stripe card programs offer “rolling passes,” which free the customer from being constrained to a particular calendar timeframe. Unlimited, 30-, or 31-day passes are easily purchased, and do not require a rider to have to “pay with cash” each time they board a vehicle. Magnetic stripe cards can reduce the cost of travel for many riders through the availability of one-day passes or stored-value cards (Figure 3).



Source: (Kack 2007)

**Figure 3: Fare- and Time-Based Pass Options**

The cost of these collection approaches varies greatly and depends primarily on the level of complexity that the transit operator is willing to pay for. Transit operators tend to adopt one type of equipment and then stay with the specific manufacturer for decades. This can lead to significant technical, physical and institutional barriers when considering whether to change or upgrade existing revenue collection systems. Technical challenges can include system hardware and software changes, staff training and other agency impacts. Physical challenges can range from installation of new equipment on vehicles to reconfiguring cash counting rooms to adapt to new or different equipment. Institutional barriers can include cost, perceived benefits, actual

benefits, the existence of long-standing vendor relationships, and a general reluctance to change equipment and procedures.

Many older, card-based fare collection systems are based on magnetic stripe cards that are physically and functionally similar to well known credit cards and products such as gift cards. The systems can be either account-based, which means that there is a background account balance that the card draws against, or they can be card-based, where the cash value is stored on the card in what can be referred to as an “electronic purse.” There are numerous examples of each approach. The business, privacy and security standards of the transit operator play a significant role in the decision whether to employ the account-based or card-based approach. It is important to note that the same type of card can be used in either approach; it varies by the amount of information with which the card is encoded when it is issued.

The payment card industry and the security card industry have adopted full standards that govern the structure, type and security of the card data, while the transit industry has yet to adopt either those or their own standards. The Payment Card Industry (PCI) standards have been agreed upon and widely adopted by all major financial institutions in the United States. The card-issuing companies require vendors to meet those standards or risk fines and/or transaction refusals. As a result of not having widely accepted standards, fare vendors in the transit industry have tended toward proprietary standards and approaches that are specific to the vendor and not easily transferable to other vendors or customer needs.

Closed or proprietary systems tend to be linked via hardware or software as integrated systems and are often sold as complete packages to operators. There are advantages and disadvantages associated with either approach that should be a large part of any procurement consideration. The typical transit or other small dollar purchase (less than \$50) is exemplified by the current marketing of “tap and go” or “touch and go” (proximity card) purchases at convenience stores and fast food restaurants (Figure 4).



Source: (MasterCard 2008)

**Figure 4: Proximity Card**

Other contactless technologies include building access cards, student identification cards, business identification cards and others. All of these cards can be purchased and encoded to meet current payment industry standards and can be read by commonly available, off-the-shelf card readers made by a variety of manufacturers. Most of the existing card types can be read by off-the-shelf multi-function card readers that meet PCI standards for data transmission and security. Adapting these existing card types to proprietary transit card systems is possible, but relies on the transit operator and vendor to coordinate with the third party to modify their systems to allow the use of the cards in their payment network.

### **“Smart Card” Or Radio Frequency Identification (RFID) -Based Applications**

Travelers are familiar with numerous successful electronic card-based systems throughout the world. Increasingly, transit customers and travelers are seeing these systems spread across the country as systems become slightly less expensive to implement and the need to improve revenue management, collect accurate data and build customer relationships increases for transit operators. Hundreds of systems across the world employ electronic cards to collect and manage millions of transactions every day. Famous and heavily used card systems include the “Oyster” card in London, the “Octopus” card in Hong Kong, the “Suica” card in Tokyo and multi-use cards like the “Amsterdam Card” in Amsterdam (Figure 5).





Source: (Hodges 2007)

**Figure 5: International Fare Cards**

All of these large card systems reflect the high-end extremes of implementation and revenue management, but can also provide valuable lessons for smaller deployments. A key element of each of them is built around a strong business case for the program. Those cases range from regional coordination and revenue management to improved usability for customers and visitors.

Because of the short time frame and limited scope of all the programs to date, it is difficult to identify significant actual impacts and benefits of smart card technology. Contactless cards allow faster boarding or throughput than do fare media that have to be inserted or swiped. Higher data capacity and processing capabilities of smart cards make innovative types of fare options more attractive.

There are a number of issues related to the use of smart cards that a transit agency must consider. The smart card is intended to supplement the agencies' existing paper or magnetic fare media. The primary reason for this use of multiple technologies is that smart cards are currently much more expensive than magnetic cards or tickets. In order to encourage retention of the smart cards, as well to defray their cost, some agencies have imposed a card issuance charge. The fee charged by the Washington (D.C.) Metropolitan Area Transit Authority (WMATA) has not proven to be a barrier to demand for smart cards to date. According to the agency, sales have been evenly distributed among various purchaser income levels, including those with very low incomes. High card cost also makes it difficult for an agency to consider providing smart cards to one-time or occasional riders, since these people will certainly resist paying a purchase fee. To address this issue, much less expensive smart cards, as well as card recycling strategies, are currently being developed by the technology vendors.

One of the key smart card-related concerns in the transit industry has been how to promote standardization and interoperability among different technologies. Agencies want to facilitate the availability of multiple sources of cards as they introduce smart card systems. In regional systems, the integration of fare payment among multiple agencies requires each of the participants to be able to accept cards issued by the other participating agencies. Thus, it is essential that all participating agencies agree to procure the same system or agree on a common technology standard that insures interoperability if agencies select systems from different vendors. The contactless card systems implemented to date have utilized several different types of contactless interface. Cubic Transportation System, based in San Diego, California, began marketing a smart card upgrade for its magnetic systems in the mid-1990s. During this time,

Cubic used its own proprietary Go-Card as the basis for upgrading fare systems. The WMATA SmarTrip and Chicago smart card systems utilize the latest version of Cubic's contactless communications interface. Cubic has also been awarded contracts to provide cards and equipment for several other systems, including those in Los Angeles and San Diego. Regional systems now in place or being implemented in San Francisco, Ventura County, Seattle, Berlin, Rome and elsewhere are using cards based on a contactless chip developed by Motorola. These systems are being implemented in conjunction with ERG, a Cambridge, Massachusetts based firm that focuses on several issues, including information technologies.

Contactless card standards have been the focus of the International Organization for Standardization (ISO) 14443 standards development group. Sony, Cubic, and several others have sought to have their cards adopted as additional ISO contactless standards, but these proposals have not been accepted thus far. In light of the lack of a single technology, or even a single standard, vendors have addressed the interoperability issue by developing both cards (actually, chips) and readers that combine multiple interfaces. Sharing a common low-level interface does not, however, guarantee interoperability. Software communications must also be compatible, and there must be shared security data. At the software communications level, different suppliers are rarely compatible.

Major transit card deployments and projects in the United States include Boston's Charlie Card, the Washington, D.C. SmarTrip card, the Chicago Card Plus, the Translink card in the San Francisco Bay area, Sound Transit in the Puget Sound region and the TAP card in the Los Angeles region. All of these projects have gone through a traditional development process and have been issued through large private transit-fare vendors. Each of the cards has unique applications and characteristics that have lessons for other deployment projects. As a group, the Translink, Sound Transit and TAP projects have several unique challenges that serve as valuable examples for multi-agency or regional cards.

The Translink card has attempted to link regional transit fares on nearly every mode of public transportation in an area served by 27 separate agencies from very large to very small. The Los Angeles card is attempting to link at least 12 agencies and multiple modes. As shown in the Puget Sound region as well, establishing business agreements, coordinating services, and agreeing to fare arrangements have been significant challenges to the timely implementation of the projects. The cards in Washington D.C., Boston and Chicago are primarily single-agency cards in their early phases. This has allowed a more concentrated effort toward their deployment and a relative streamlining of the business processes.

Recently, New York's Metropolitan Transit Authority, Washington D.C. Metro and the Utah Transit Authority in Salt Lake City have undertaken trials and limited deployments of systems that accept payment with standard American Express, Visa and MasterCard RFID chip cards. These new approaches appear to promise much lower installation costs, higher levels of transaction security and greater customer convenience. These new approaches, based on recent industry bids, also offer unique opportunities for sponsoring agencies to explore outsourcing of back office, customer support and card distribution functions. Indications are that significant operating cost savings, beyond the lower costs associated with the bankcard-based approach, may be possible.

There are several smaller transit agencies that have deployed smart card applications for their customers. Ventura County transit in California developed a "home-grown" Go Ventura card

system a decade ago in conjunction with the state university. This program was limited in scope, but included seven small agencies and is considered to be very successful in the industry as an original approach. The program is expected to be folded into the larger Los Angeles system in coming years.

There are numerous other public applications of card technology that directly relate to electronic payment business practices and technology. Automated roadway toll collection and settlement technologies provide a range of alternative approaches outside the traditional transit industry. Numerous standards have been developed in the tolling industry to improve multi-state and regional payment settlement and provide customers a seamless trip. The building access and security card segments have made huge efforts in improving the security and ease of use for card systems. There are several standard cards that are widely available that can be read in an account based system and reconciled by a back office operation. Universities, colleges and large employers also provide significant opportunities for cooperation in card deployments. All of these card-based applications can be integrated into a common, widely distributed and relatively inexpensive solution for customers and agencies.

Numerous opportunities are also present in the public assistance payment arena. Many states, including Montana, have issued stored value payment cards that make card accessibility easier for customers who may not have available bank resources or debit/credit cards. Various technical approaches can be used to improve the payment and record keeping for public assistance programs, Medicaid transportation, social services transportation, and senior and disabled transportation that leverage existing programs. These technical approaches include using systems with open architecture (not linked to the specific vendor), or having the State require new systems use common components (such as magnetic stripe versus radio frequency identification cards). However, the largest challenges in having common (or flexible) payment/identification systems are not technical, but institutional. In many instances, it is the relationship between agencies, either at similar levels (Federal, state, regional, etc.) or at different levels, that act to prevent coordination and cooperation between service providers.

It is very important to note that the payment card industry (PCI), led by the large private card issuing companies, has developed new card, payment and security standards for small or “micro” purchases that provide new opportunities for transportation providers. These standards allow immediate verification of small purchases made with American Express’ “Expresspay,” Visa’s “payWave” and MasterCard’s “PayPass” cards. The financial services industry is providing a new avenue for transit operators to develop electronic payment programs using open card architectures, widely available readers, secure transactions and opportunities for out-sourcing of program operations. None of these areas is new in the payment card industry, but the convergence of technology, customer convenience and institutional need is opening up the transit payments industry to a higher level of vendor competition.

## **Technology and Business Convergence**

As mentioned briefly above, the convergence of technology opportunities in the payment card industry and the growing challenges of technology deployments in the transportation and transit industries has provided a unique opportunity for several agencies to conduct trials and plan for major deployment of electronic payment programs that fall outside of existing vendor offerings and may provide major improvements in customer service, transit system management, revenue

enhancement and cost savings. There will be some risk as these programs develop, but the opportunities provided by lower-cost, more easily managed card systems have triggered a wave of interest across the country.

There are three major pioneering deployments along this line. Washington Metro has fitted its subway with RFID card readers that will accept the MetroCard as well as payment with selected credit cards directly at the turnstile. The New York MTA is conducting a trial with several card vendors using the same approach on New York subways. The most dedicated approach has been made by the Utah Transit Authority (UTA) in Salt Lake City. Beginning in 2006, the UTA started a demonstration program on its fleet of ski buses to accept payment for transit trips by credit card, ski resort employee identification cards, ski season pass holders and a third party (Ski Utah) card issued by a separate vendor. The simple intent was to prove that the technology for reading and reconciling RFID cards was available and ready for deployment. The demonstration was successfully completed in April of 2007. In May of 2007, UTA began a process to issue a Request for Proposals for a complete, open source based RFID fare system. This deployment will ultimately cover commuter rail, light rail, bus and paratransit services for the entire service district. Customers will be able to use their standard credit/debit cards, use cards issued through UTA (or a vendor), or use their student and/or employee electronic identification cards for fare payment. The open architecture and widely adopted standards are anticipated to save the UTA millions of dollars in development and deployment costs over its system network. UTA accepted proposals from various vendors and will be announcing which vendor is selected in early 2008.

### **Payment System Challenges**

The transit industry has a long history with a small number of vendors. Most systems currently in place are tied to specific vendors, specific hardware and specific software. Often these systems are closed, meaning that the vendor has included special coding or contractual arrangements that preclude the customer (transit operator) from using cards or hardware from other vendors. For some agencies, this has been a very attractive and useful arrangement. For others it's seen as a barrier to deploying lower cost or more widely sourced systems. Working with a single vendor or working with a system you already know has its appeal, and changing systems or vendors can be difficult. Locking into a specific vendor's product can mean being tied to that vendor's development and upgrade cycle, which can be costly. There are few incentives for competitive procurements when major system components can only be supplied or modified by the existing vendor. This can lead to product obsolescence and significant risk if the sole vendor has production or financial challenges. Standards-based open-architecture systems reduce that risk by allowing numerous vendors to compete to provide system components. It places a larger burden on the management of contracts and business relationships for the transit provider, but opens up opportunities for cooperation.

Another deployment challenge is institutional relationships and system integration. It is not common for transportation, social services, medical and disabled service providers to work together in coordinating fares and transportation links. Numerous examples exist of revenue collection programs that have been delayed or suffer cost overruns because of an inability to resolve institutional issues. It is critical that all parties involved in a multi-agency procurement or program agree to a common set of business goals and rules during the earliest stages of any project.

In reviewing some of the projects that have had planning and/or implementation issues, Mr. Hodges explains that, “There are usually many fingers to point when large projects fail or are delayed. Vendors tend to over-promise technology, software and delivery. Agencies tend to have unrealistic expectations about complexity, schedule and cost. Weak project management is widely prevalent in the industry and is compounded by poor contracting approaches. Often, projects are visualized and agreed to with very little objective analysis and are then later expected to perform to a standard that was set after procurement” (Hodges 2008). In Table 1, Mr. Hodges noted some of the projects that have not started, or have been significantly delayed, and explains his thoughts on the issues of the projects (Hodges 2008).

**Table 1: Technology Deployment Issues**

<b>Project</b>	<b>Issue</b>	<b>Discussion</b>
Translink – Bay Area	The Translink card is entering a second stage of acceptance testing with two more operators. The initial project was supposed to have been completed with all 27 operators about 5 years ago. Full system deployment (including Bay Area Rapid Transit [BART] and San Francisco Municipal Transportation Agency [MUNI]) could be further years away.	The project started out as a Metropolitan Transportation Commission (MTC) project because they had money and were a neutral “third party” between big and small operators. Numerous contractor delays occurred when Motorola dropped out of the business mid-project and ERG was put in the position of technical lead instead of supplier. Political conflicts and weak project management allowed the program to drift for years. Communication also drifted between sponsors and agencies as time went on. Staff changes and political pressure in recent years have gotten the program going, but delays have been enormous.
Puget Sound	When will it happen?	Political and financial wrangling in Washington state and the Seattle area have whipsawed this project. Financial condition of the contractor may be a serious issue. It represents another ambitious regional plan that tried to do it all at once rather than step by step.
Houston - Metro	5+ years of delay led to contractor firing for cause and damages. Replacement contractor is performing well.	Failure of original vendor to deliver and less than optimal contracting from the agency let the project drift into a political mess. Vendor over-promised technology and software, agency neglected to control project until it was too late.
Minneapolis - Metro	Over one year delay in successful installation, testing and acceptance of ticket vending machines for light rail line. Deadline was opening day.	The project had overly optimistic schedule from vendor, especially given the project’s technical requirements. Metro was busy building the line and did not dedicate the effort to identify and correct vendor until too late. Back office software was a major headache beyond the technical issues with machines.

**Table 1: Continued**

<b>Project</b>	<b>Issue</b>	<b>Discussion</b>
Salt Lake City - UTA	Project bidding and contracting delayed nearly 8 months on ambitious schedule and new technology approach.	Work in progress. Delays in vendor selection threatened ambitious schedule from the start. Contract negotiation took months longer than scheduled, initial start date of April 2008 (from early 2007 procurement start) will be missed – originally scheduled to coincide with commuter rail opening. Vendor financial position may be an issue.
Los Angeles, San Diego	San Diego and TAP cards several years behind schedule.	Overly ambitious schedule that was originally tied to success of Bay Area Translink. Vendor software issues, problems with project management and buy-in from agencies.
Sydney, Australia	In courts after vendor terminated in December 2007. Originally scheduled for installation and operations prior to 2000 Sydney Olympics. Contracted in 1998.	Ambitious early schedule. Currently in court both sides suing for damages. Vendor failed to delivery complex product, agency made several changes along the way. Vendor in serious financial condition as a result.
City in Ohio	Mid-sized city exploring card options.	Unrealistic financial and technical expectations from agency have led to a two year postponement of procurement when industry vendors could not provide a service at the requested cost.

The issue of consumer privacy and transaction security is another area where the payment card industry and transit providers share a common interest. Transportation providers generally have no interest in becoming bankers, and banks usually have little interest in providing transportation services. However, both parties are legally and ethically bound to protect the privacy and security of their customers. The payments industry has stringent standards to protect transaction data that no transit provider could easily adopt as its own. To be a card issuer and transaction processor would require a major commitment from a transit provider, but could be a task that is readily outsourced. Outsourcing of that specific task would also help insulate the service provider from any other privacy or security risks.

Transit providers have different means for collecting fares, billing client agencies, and reporting ridership data. In large urban areas, a transit system may use advanced public transportation systems (APTS), including fare collection systems that utilize smart cards or stored value cards. In small rural areas, transit providers may use cash fares, tokens or punch cards, with information recorded manually by the drivers.

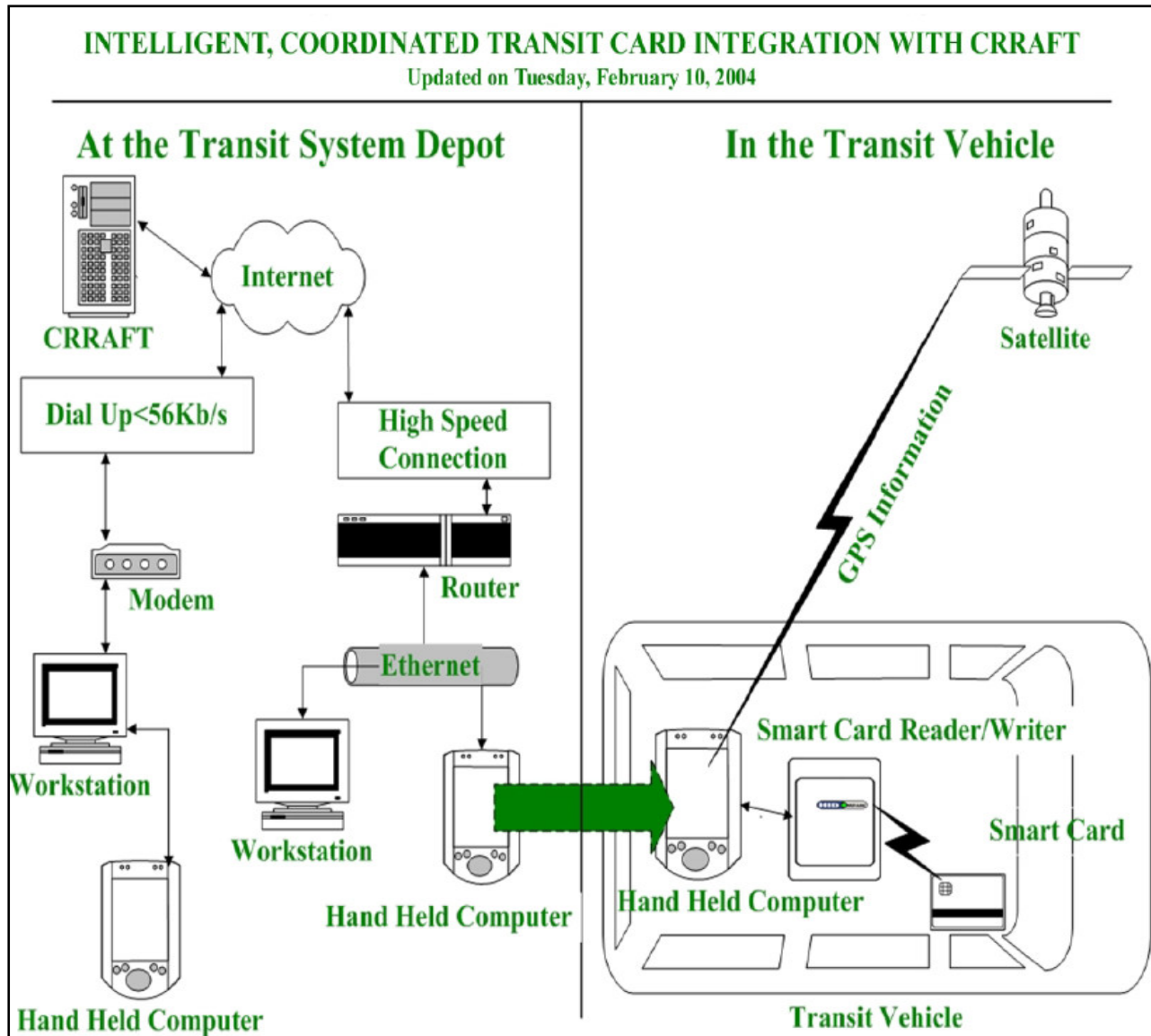
## Rural Technologies

In rural areas, there have been several different approaches to automated cost recovery technologies. In New Mexico, a software system was created to deal with invoicing and other issues. In Texas, a transportation provider added on to its existing software to enhance its ability to track payments for transportation services.

In the late 1990s, the Alliance for Transportation Research Institute (ATRI) at the University of New Mexico was working with the New Mexico Department of Transportation's Public Transportation Programs Bureau (PTPB) on issues such as public and specialized transportation funding and coordination. Through this process, it was decided that ATRI would create a software program that would allow transit providers, as well as funding agencies such as the New Mexico Department of Transportation and New Mexico Department of Labor, to better link the payment of rides to their funding source.

The Client Referral, Ridership and Financial Tracking software known as CRRAFT began development in 2000, with initial deployment among a select number of transit providers in 2002 and 2003. In 2004, the New Mexico DOT required that all rural general public transit providers (known as Federal Transit Administration [FTA] Section 5311 providers) use the CRRAFT software for invoicing for federal funds obtained through the DOT. ATRI has continued to enhance the CRRAFT system to make it more useable for the transit providers, including the addition of a Smart Card module to the software in 2005 (the Smart Card module was planned/developed in 2004, and implemented in 2005).

The Smart Card enhancement used off-the-shelf components, and was created to further automate the process of tracking ridership and payments. The system (Figure 6) is being used by six out of twenty-seven providers in New Mexico (Espinoza 2004). Current information from New Mexico indicates that the size of the systems using CRRAFT varies from two to seventeen vehicles; with annual ridership from 4,500 to 80,000; operating the spectrum of demand response, modified fixed route and fixed route services, or a combination of those services (Martinez et. al. 2008 and NMDOT website 2008).



**Figure 6: CRRRAFT System Schematic**

While the Smart Card enhancement was being added to the CRRRAFT system, an evaluation was taking place to determine the usefulness of the software. This evaluation provides some insight as to whether or not the CRRRAFT system may be a viable alternative for Montana.

Twelve hypotheses were developed and tested during the evaluation process. The findings (Sanchez 2005) are shown in Table 2.



**Table 2: CRRRAFT Evaluation Analysis**

<b>Hypothesis</b>	<b>Results</b>
Use of the system saves transit providers time invoicing and reporting to funding agencies.	Not True. On average, the use of CRRRAFT has not saved transit providers time invoicing and reporting to the PTPB. In fact, transit agencies with higher ridership and demand responsive service may have had the opposite experience and are spending more time preparing invoices after the implementation of CRRRAFT.
Use of the system results in funding agencies having faster access to reports.	Not True. On average, the use of CRRRAFT has not resulted in funding agencies having faster access to invoices and reports. With the online system however, funding agencies may be able to monitor the numbers that transit agencies are entering into the system during the month.
Reports created by the system are accurate and reliable. Use of the system reduces the time funding agencies spend checking and correcting reports and reduces money incorrectly allocated or invoiced.	True. The use of CRRRAFT has resulted in more accurate invoices and has saved time for funding agencies during the reviewing process. The fact that transit agencies know at all times their remaining balance in each line item seems to have helped reduce the number of incorrect amounts on invoices.
Use of the system reduces the time funding agencies spend researching and collecting information.	True. The use of CRRRAFT has in fact reduced the time funding agencies spend researching and collecting information.
Use of the system reduces the overall time required for transit providers to schedule demand response trips.	Not True. The use of CRRRAFT has increased the time to schedule demand response trips for a majority of transit agencies, and the impact is particularly evident for agencies entering schedule data for many trips.
Use of the system results in more efficient schedules for demand response trips.	Mixed. For most users CRRRAFT did not have a positive impact on the efficiency of the scheduled route or the development and use of the demand response schedule, but may have improved the efficiency for a few smaller transit agencies.
Use of the system reduces the number of unauthorized trips.	Mixed. CRRRAFT did not have a clear and decisive impact on the number of unauthorized trips.
Use of the system reduces the number of in-service breakdowns.	Little/no impact. CRRRAFT did not have an impact on the number of vehicle breakdowns.

**Table 2: Continued**

<b>Hypothesis</b>	<b>Results</b>
Use of the system reduces the operating cost of transit services.	Mixed. For the providers, CRRRAFT may result in higher operational costs for larger transit agencies that enter many demand response trips. However, the data analysis did not provide conclusive results about the relationship of CRRRAFT with changes in operating cost alone or operating cost per trip.
Use of a web-based system has minimized the time and cost of deployment, support, and maintenance.	Mixed. CRRRAFT appears to be useful for generating invoices and supporting auditing activities, but has resulted in many transit agencies doing additional work to use CRRRAFT in support of NMDOT reporting/invoicing requirements.
Transit providers and funding agencies perceive that the benefits of the system outweigh its costs.	Mixed. NMDOT and New Mexico Human Services Department (NMHSD) are generally pleased with the benefits of CRRRAFT and generally agree that the benefits outweigh the costs. The transit agencies have mixed views. However larger agencies, particularly those providing demand response service, were more likely to indicate that CRRRAFT has been unsuccessful and that the costs outweigh the benefits.
Use of a single system improves communication between diverse agencies.	True. For NMDOT, CRRRAFT has resulted in better communication and coordination with transit agencies. For transit agencies, communication and coordination remained about the same or better.

Funding agencies, including the New Mexico DOT, generally believed that the CRRRAFT system was an improvement over previous invoicing methods. However, those transit agencies which provided a higher number of rides generally believed that the CRRRAFT system added to their burden, instead of making their operation more efficient. In discussions with several agencies, the authors found that those systems that used software to schedule rides felt CRRRAFT was a burden, although they acknowledged that CRRRAFT was easy to use for invoicing, and provided lots of reports (Martinez et. al., 2008).

CRRRAFT did not set out to be a computer-aided scheduling and dispatching software, such as RouteMatch or Trapeze. The Capital Area Rural Transportation System (CARTS) in Austin, Texas, however, designed a system around its Trapeze software. The CARTS system is based on adding Smart Card and other technologies to the Trapeze computer scheduling and dispatching software that was in place in the organization. The objectives of the project (Marsh 2007) are:

- Automate fare collection by employing magnetic stripe/smart card readers.
- Move to paperless, personless reporting and data collection.
- Integrate Texas “Lone Star” benefit card.
- Initiate direct billing reporting for Medicaid, etc.
- Transition to seamless fare media coordination with Capital Metro Transit in Austin, Texas.

Figure 7 and Figure 8 (Mitchell 2007) provide schematic diagrams of the CARTS systems.

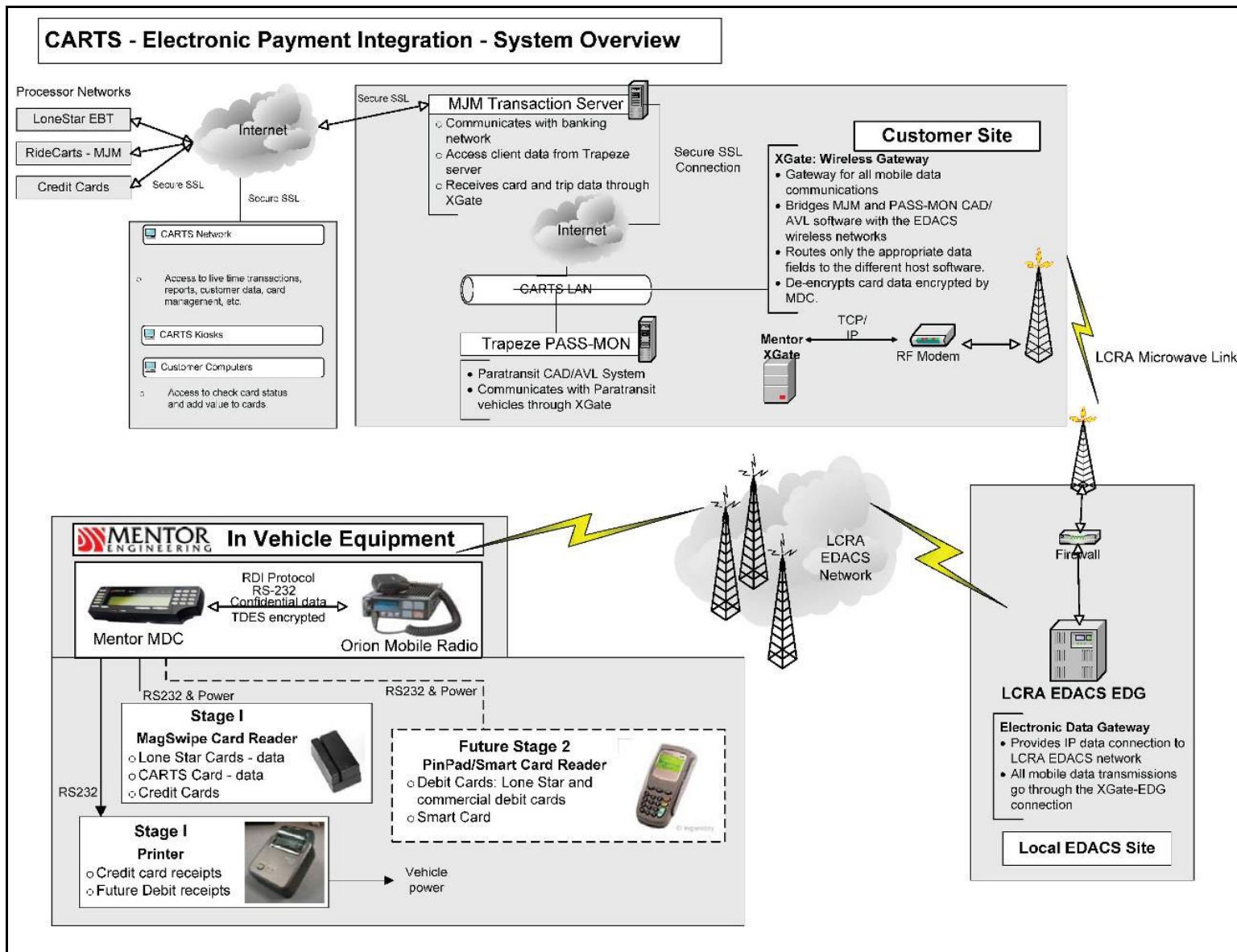


Figure 7: CARTS Communication Schematic

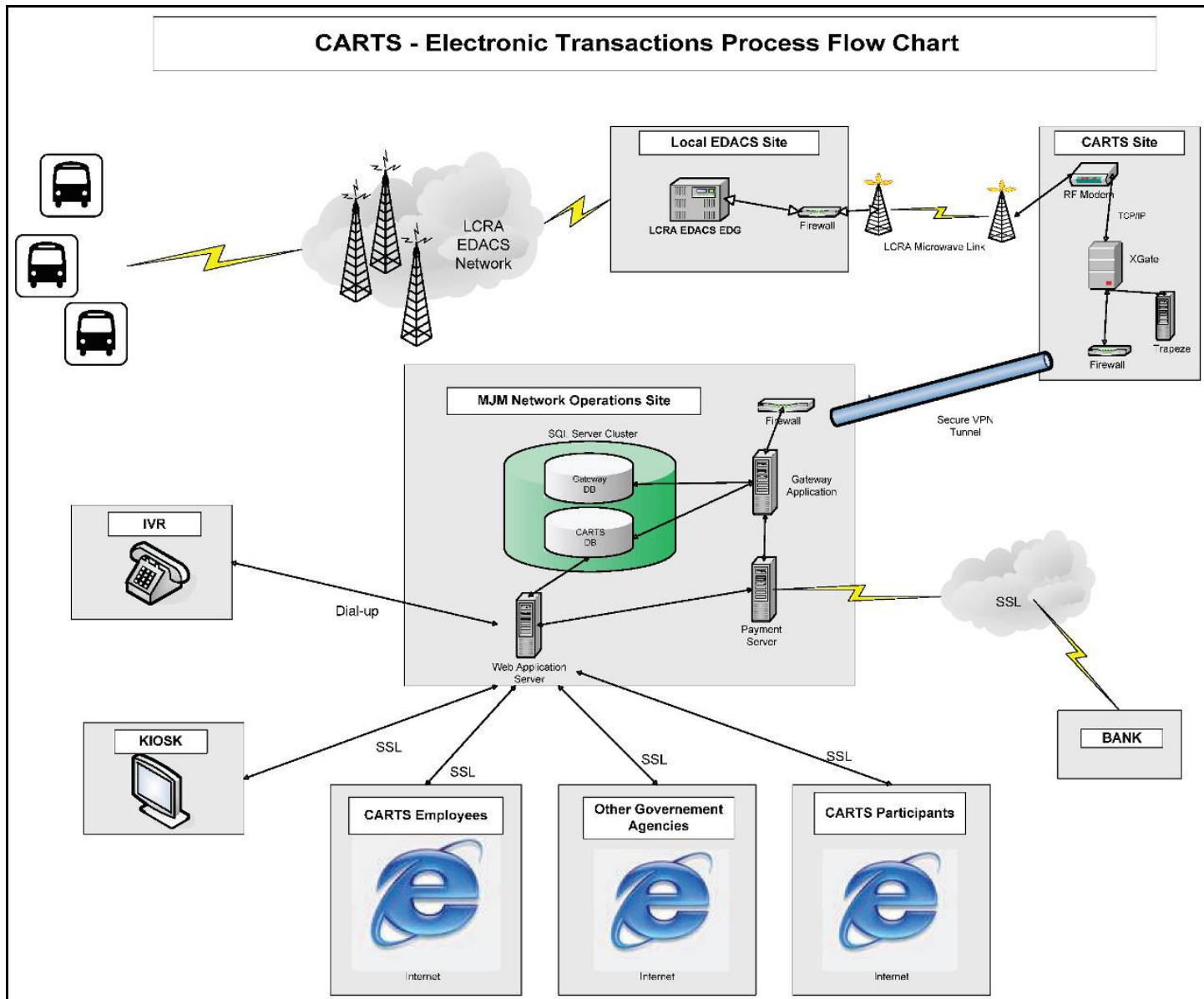


Figure 8: CARTS System Schematic

The CARTS project was expected to begin system-wide operation in September of 2007, with an evaluation of the project to begin six months after full implementation. The evaluation will consider the following (Cherrington 2007):

- Operational efficiency,
- Data collection, management and reporting,
- Revenue invoicing and collection,
- Effectiveness of scheduling,
- Customer satisfaction,
- Ability to coordinate services, and
- Use of swipe card technology.

While the evaluation of CARTS has yet to begin, the process leading up to the system-wide deployment has yielded some valuable lessons (Hosen 2007):

- Walk, Don't Run—Implement one technology at a time, master it, then take the next step. Take your time!
- A Solution In Search Of A Problem—Have a vision and goals. What do you want to accomplish with this technology? What are your technology goals?
- Purchase For The Future, Not The Present—Think five to ten years into the future and ensure that your software will work with any new technologies that may be available.
- Demonstrations Do Not Really Count—Demos are nice, but you must see the technology working in the real world before you purchase.
- Seek Out The Best Communications Option—In the CARTS case, a local power authority was bringing a state-of-the-art system on line.
- It's Still The Staff—Success depends on staff willingness and ITS capabilities. The best technology requires willing and able staff to maximize performance.

This section reviewed automated cost recovery technologies on a national and international scale, including very large (urban) systems, as well as rural systems. The following section describes technologies that exist in Montana that could possibly be leveraged as part of an automated cost recovery system.

## CURRENT TECHNOLOGIES IN MONTANA

There are several magnetic stripe and/or smart card technologies in Montana that could be used as the basis for an automated cost recovery system in Montana. However, before a review of the cards, it is important to review the purpose of an automated cost recovery system, and how it would work in a Montana transit system.

The purpose of the technology is to automate the collection of fares, and automate (or vastly simplify) the process of recording ridership, fare payment, and the processing (or invoicing) of those various payments. This focus on the purpose is important, because in Montana the vast majority of public transportation (transit) systems are demand-responsive, as opposed to fixed-route systems (only 25 percent, or 8 of the 32 public transit systems, have a fixed-route component). This difference is important because, unlike a fixed-route service where the rider is anonymous, in a demand-response system the ride is scheduled beforehand, so the dispatcher/scheduler who schedules the ride knows who is taking the ride and whether there is more than one funding source for the ride. In these instances it is not necessary that there be a smart card or magnetic stripe card, and a basic computer-aided scheduling and dispatching software may be all that is necessary.

Most computer-aided scheduling and dispatching software programs greatly simplify the process of managing customer/rider data, and can easily determine how many rides were provided from a given funding source or through a particular payment method. There are two transit systems, MET Transit in Billings and the Great Falls Transit District, that are using current computer-aided scheduling and dispatching software. MET Transit acquired RouteMatch software (Atlanta, GA) within the past three years (Appendix D), and Great Falls Transit uses Shah software (Midland, TX). Mountain Line in Missoula currently uses Paralagic software (Orlando, FL) although there is discussion that Mountain Line may issue a Request for Bids for new software within the next year or two.

Because RouteMatch software has been used in a statewide application, it is known that the software could be leveraged to a statewide system (though with additional costs). It is not known at this time whether or not the Paralagic or Shaw software systems could be leveraged to create a statewide network. The decision on which software to select would be based on creating specifications that were not part of the scope of work of this project. However, if the decision is made to move forward to further investigate automated cost recovery technologies, it would be wise to further investigate the three software systems being used in Billings, Great Falls and Missoula.

In addition to the transit/paratransit software systems, the WTI team identified several other technologies in Montana that could be utilized for automated cost recovery purposes. These technologies include the *Montana Access Card* and the “Griz” and “Cat/One” cards that are associated with the University of Montana and Montana State University, respectively. Even the Montana state driver’s license could be used as a fare card for an automated cost recovery system. These cards could be employed in such a way that they are the only card accepted by a system, or an automated cost recovery technology (card reader) could be designed to read a number of different cards.

In Missoula, the Mountain Line system uses GFI Genfare fare boxes that can read a number of different magnetic strip cards, including the Griz card and the passes that are produced by GFI

Genfare. Additional cards could be read by the system, as long as GFI Genfare knew where the information was coded on the particular magnetic strip. If a card system was implemented in a particular area, or on a statewide basis, it would be possible to read a number of different cards, if that were deemed desirable.

The requirements analysis conducted, and discussed in the next section, considered these cards and used a survey to determine what additional technologies may already be in use by transit systems in Montana. The purpose of the requirements analysis is to ensure any future systems/technologies that are defined for automated cost recovery systems (a potential follow-on project) are interoperable, expandable, and compatible to the maximum extent possible with current technologies that may be deployed (or soon deployed) in transit systems in Montana.

## REQUIREMENTS ANALYSIS

The WTI team conducted a survey that documented payment methods and invoicing/reporting requirements of public and specialized transit providers across the state. The survey also examined current technologies used by providers, and funding sources related to current passengers. This process helped define what systems/technologies may be implemented in the future by transit agencies. These systems/technologies may assist with a number of functions, including fare payment, cost recovery, ridership tracking, automated reporting to agencies such as MDT and the Department of Public Health and Human Services (DPHHS), etc.

The survey was mailed to 73 public and specialized transportation (transit) systems in Montana to collect information that would be used in the cost/benefit and implementation tasks within this project and report. The survey consisted of four sections: organizational characteristics, reporting requirements, organizational business practices, and organizational use of technology. The questions in these sections were intended to collect information on transportation (transit) agencies in Montana to determine how transit operators are tracking ridership, fare payment, and what technologies are being used in their operations. Thirty-four surveys were returned for a response rate of 46 percent, which is a high return rate for a mail survey, considering no follow-up was made after the surveys were initially mailed. Based on the responses from a range of providers, we believe that the survey results are representative of all transportation providers in Montana. A copy of the survey instrument is included as Appendix A, while a summary of the responses is included in this section, with detailed responses provided in Appendix B.

The percentages associated with the various answers to each question are based on the total responses to the question, not the number of surveys received. Therefore, if only 20 organizations responded to a question, the percentages of the various answers are based on a total of 20 answers and not the total of 34 surveys returned, unless otherwise noted. The summarized responses of each question are shown in Table 3. The detailed list of all responses to each question, along with any comments is included in Appendix B.



**Table 3: Questionnaire Responses**

<i>Organizational Characteristics</i>	
<b>Question</b>	<b>Response Summary</b>
Does your organization collect fares (payments) from any individual who rides your vehicles?	Yes: 65% No: 35%
How are fares collected	Most systems use a variety of methods, including cash fares, punch cards and (monthly) passes.
Does your organization collect ridership data?	Ninety-seven percent of the respondents (33 out of 34) indicated that they do collect ridership data.
How is data collected?	The majority of the systems have the driver collect the information on either a tally sheet, or with a mechanical counter/clicker.
How does your organization define a 'ride' (e.g., round trip, one way, or other)?	76%: ride = one way trip 35%: ride = round trip
What is the approximate total number of customers you have of each type noted, and what is the approximate number of monthly rides you provide for each customer type noted?	Responses for each agency are listed in Appendix B
Approximately how many new customers (not existing customers) do you add to your service each month?	Responses varied from zero to fifteen. The majority of respondents (15 out of 33) noted that they add between one and five new customers each month.
What is the total number of vehicles operated by your organization, and what is the number of vehicles (for carrying passengers) operated by your organization?	Average number of total vehicles: 8.3  Average number of vehicles that carry passengers: 6.7
Do you have passengers whose rides may be paid for by a variety of programs or sources? If so, please indicate the maximum number of different sources or programs that may pay for one customer's rides.	35%: have clients with at least one funding source 24%: do not have these clients 41%: Question not applicable
Does your organization also pay for rides using vouchers, or pay taxis or other sources (such as family members) to transport an individual? If so, please describe these various methods/modes your organization uses for transportation services.	62%: Do not pay for other rides 12%: Pay for other rides (bus passes or vouchers) 26%: Question not applicable
<i>Reporting Requirements</i>	
What information, if any, pertaining to ridership and fares do you report to any other organization?	23 agencies (68%) report to MDT 2 agencies report to National Transit Database 1 agency report to something "other" 8 noted what they reported
How does your organization collect and report information pertaining to ridership and fares?	The majority of respondents indicated that information from the driver's "tally sheets" are combined (typically in a spreadsheet program) and may be included with financial information before being reported. The majority report the information on a quarterly basis.
Does your organization have any issues and/or challenges with the current system you are using? If so, what are the issues?	76%: No issues (or blank) 24%: Have issues (i.e. human error, system is paper intensive, system provides inaccurate info)
Do you have any suggestions for improving the data collection and/or reporting process?	88%: No suggestions (or blank) 12%: Have suggestions (i.e. smart cards, direct online reporting, electronic collections system)

**Table 3: Continued**

<i>Business Practices</i>	
<b>Question</b>	<b>Response Summary</b>
If your organization collects ridership and/or fare information, how does that data/information move from the vehicles into the office?	87%: Tally Sheets 10%: Driver 1 response: electronic submission
If your organization reports data to other agencies/organizations, how do you do that?	42%: online/e-mail 12%: hard copy/paper 32% use both methods
If your organization invoices another agency/organization for rides, how do you do that?	20 responses: question not applicable 32% (of those listing method): hard copy invoice 2 responses: online/e-mail invoice
<i>Technology Use</i>	
Does your organization have fare boxes in any of the vehicles it uses for passenger transportation? If yes, does your organization use the fare box to track ridership?	24 respondents (70%): no fare boxes 6 respondents (18%): have fare boxes (only one uses it to track ridership)
Does your organization have any other technology on the vehicles it uses for passenger transportation, such as automated passenger counters, automatic vehicle location systems, etc.? If so, please describe the technology or technologies.	Four respondents with other technologies: 1 two-way radio system 2 AVL systems 1 personal GPS receiver
When your organization tracks ridership, does it use spreadsheets or other computerized, electronic methods for tracking ridership? If so, please explain the methods (systems) used.	17 responses (50%): no electronic tracking 16 responses (47%): Excel spreadsheet 1 response (3%): MDT form
Describe any other systems or technologies your organization uses in the process of carrying passengers, including tracking expenses, invoicing, reporting, etc.	4 responses: Quicken/Quickbooks 1 response: Microsoft Excel 1 response: "accounting system" 1 response: "computer"

When analyzing the responses from the questionnaire, it became apparent that a follow-up question was necessary to determine how much time the transit providers were spending on tracking ridership and fares, and creating invoices. Therefore, a follow-up question was sent (via e-mail) to those who had responded to the initial survey. In general, the question asked the amount of time the organization spent, either on a daily, weekly or monthly basis, tracking ridership and fares/payments for transportation (transit) system.

In addition to the original e-mail, a total of three follow-up e-mails were sent. However, only ten responses were obtained from the 34 providers. To standardize the data to an annual basis, 250 service days are estimated, or 52 weeks of service. The responses ranged from 24 hours to 1,250 per year. The average among the ten responses was 313 hours per year, but five of the ten responses were in the range of 80-150 hours. The detailed information on the responses is in Appendix B.

In summary, the responses indicate that the majority of public and specialized transportation (transit) providers in Montana use manual (or paper) methods for tracking ridership and fares. While many agencies use Microsoft Excel or other software (Quick Books) for summarizing

information, the information that feeds into these programs comes from manual collection systems. Our research was able to find only one transit system, Mountain Line in Missoula, which uses electronic fare boxes to track ridership and collect fares. In addition, while the amount of time systems spend tracking ridership and fares varies, the majority of respondents spend between 80 and 150 hours per year (6.7 to 12.5 hour per month) on this task.

One issue that transportation providers face when tracking ridership is compliance with the Americans with Disabilities Act (ADA). The following section describes ADA and how it relates to automated cost recovery systems.

## **AMERICANS WITH DISABILITIES ACT (ADA) ISSUES**

The WTI team reviewed the requirements of the Americans with Disabilities Act (ADA), and considered how the various automated fare recovery technologies may be affected by ADA guidelines. Due to the nature of transit systems and service in Montana, a sizeable percentage of riders/customers are persons with disabilities. It is therefore important to make sure that the automated cost recovery systems would be as compatible as possible for people with various levels of abilities.

The basic intent of the ADA is to ensure that all Americans have access to transportation services. A combination of laws, administrative regulations, legal settlements and generally accepted practices has defined the scope of the ADA program for public transportation. Generally, there are few guidelines regarding the function of fare collection systems, but there are rules and regulations concerning the dimensions and placement of equipment and the fare amount that may be charged for eligible customers. Most transportation providers have established certification processes for disabled customers. These certifications provide a framework for the providers to operate their services and manage their customer interactions.

### **Operational and Customer Considerations**

There are operational, financial and managerial considerations that merit a closer look when considering an automated fare and revenue management system. From an operational standpoint, automated fare collection can enhance system accessibility and system efficiency. It can encourage system use and can also be a tool to guide customers to services that may be more effective for them and for the service provider. Automated fare collection can help providers reduce dwell times, reduce payment delays and provide customers a better way to manage their transportation budgets. Occasionally, disabilities such as visual impairments, cognitive impairments, intellectual disabilities, and disabilities that involve motor function make it difficult for passengers to navigate systems and make fare payments. Automated payment systems hold the promise to ease some of that difficulty and improve customers' abilities to successfully complete their trips. Pre-paid cards or cards that can be managed on-line by the customer or others also provide opportunities to more effectively manage personal travel budgets. Those system benefits are also passed on to non-disabled passengers and customer groups such as seniors, students and children. It is imperative that local interest groups in the disabled community and the medical community are involved from the beginning in discussions and design considerations.

### **Agency Considerations**

From a revenue management standpoint, automated payment systems can improve the management and coordination of the numerous funding programs that subsidize disabled transportation services. The software and management tools that these systems bring in to agencies can also provide reporting and accounting advantages to both the operator and to agencies that interact with them. If agencies are willing to cooperate in the development and implementation of coordinated revenue management systems, service duplication can be decreased and reporting requirements can be more effectively implemented.

## Suggested ADA Minimum Requirements

An operational payment system that respects the spirit and law of the ADA should, at a minimum, have the following capabilities:

- Provide access to fareboxes, validators and readers that meet ADA physical design standards.
- Provide media that are easy to identify and manipulate for all customers.
- Determine proper fare payment.
- Correctly activate and validate fare cards.
- Correctly update customer account information (for example, deduct one trip from 10 trip pass and add applicable transfers).
- Record fares collected by trip and vehicle.
- Record all fares with date, time and location.
- Provide driver the ability to input events to be recorded.
- Provide managers with the tools necessary to effectively operate their systems.
- Provide an acceptable audit trail for transactions from the customer's viewpoint, regulatory review and the agency's needs.

ADA considerations will need to be addressed when any type of system is in its "requirements" phase. The types of fare media used, the placement of any card readers, etc., will all need to be addressed if an automated cost recovery system is to be planned and implemented.

A major factor in determining whether or not to implement an automated cost recovery system is the benefit/cost analysis of the proposed system. The following section describes the benefit/cost analysis of various technologies that would likely be part of an automated cost recovery project.

## **BENEFIT/COST ANALYSIS**

All programs and projects require some level of analysis to determine whether the project should be undertaken. Assessments should extend beyond simple rate-of-return calculations when the impacts of an approach extend beyond financial considerations. Basic analysis can help address the most effective way to achieve a business goal and forms the basis of supportable decisions. Included in each analysis should be a discussion of the “do nothing” choice. That baseline sets the context for comparing options.

This section looks at the benefit/cost analysis from several perspectives, analyzing basic risk factors, discussing benefit/cost analysis from other projects, and then looking at a break-even analysis to describe what level of benefits may be necessary to obtain a positive benefit/cost ratio (a ratio of greater than 1.0)

### **Benefit/Cost Analysis Foundation**

Benefit/cost analysis (B/C) is a tool to directly compare relative costs and expected returns from a project. B/C analysis can be challenging when dealing with technology-based investments and often needs to be supplemented by further complementary analyses. The context of the analysis revolves around basic questions of whether the project should be pursued, what gains are expected, what business goals can be achieved, timing and, fundamentally, can it be done under the constraints of the situation.

Benefits tend to cross a range of values and interest areas. Direct benefits are easiest to measure as the final product or service to new or existing customers. Indirect benefits are those that support the final outcome, but also include efficiency benefits for partner agencies, policy coordination benefits, reduced costs, perceptions of convenience, etc. Benefits are distributed to implementing agencies and their customers in both tangible and intangible forms. Generally, tangible benefits are new customers, new revenues and new services. Intangibles range from convenience, improved information flows, improved public image, and political or business gains. It is often difficult to place a monetary value on intangible benefits. If any assumptions are made about the value of these benefits, they need to be clearly stated in the B/C calculation. All benefits must therefore be gathered and evaluated in a similar fashion.

Costs are estimated by gathering quantifiable direct financial costs, and less apparent indirect costs such as opportunity costs, inefficiency costs, and exiting costs (the costs that may accompany ending the use of an existing system). At times, it is difficult to estimate costs, so it is important both to make reasonable assumptions and to clearly state them. The basic structure of the analysis is to formulate year-to-year direct costs, add operations and maintenance costs over the expected project lifecycle. This analysis of costs leads to the total project costs that will be compared against the projected project benefits.

Once the total benefits and total costs are calculated, the monetary value of the benefits of the project is divided by the monetary value of the costs of the proposed project. If the ratio is 1.0 or greater, the project is expected to pay for itself—that is, the benefits received are greater than the costs involved. It is important to note, however, that a project may be implemented without a B/C ratio of 1.0 or greater. An agency or organization may undertake a project for political or other “intangible” reasons, knowing that a project may not pay for itself. In these instances, however, it is important that everyone involved is aware that, although the B/C ratio is not 1.0 or

greater, the project is being implemented for other reasons. The implementation of the Puget Sound Regional Fare Coordination project is such an example. When asked about the potential B/C ratio of the project, Candace Carlson from King County Metro did not yet have a conclusive answer (Carlson 2006):

**Question:** The overall system cost appears to be approximately \$70 million. Are there any savings from the Smart Card system that have been quantified and projected?

**Answer:** We did some baseline studies of about four of the agencies. We will revisit those. Those were looking at operating functions, primarily those back office functions of handling all of the fare media, the accounting, and also looking at fare box maintenance, that kind of thing. We'll take a look at those. They all project some kind of break-even or slight savings. We'll see how that holds.

Depending upon the length and complexity of a project or projects, a net present value (NPV) calculation may be utilized. The NPV calculation allows the analysis of benefit and cost values in relationship to the long-term monetary costs of a project. The general cautions about B/C techniques include appropriate classification of benefits and on-going costs and the use of NPV calculations. Additionally, notes about funding constraints, policy issues and risk are commonly attached to the discussion of the analysis.

### **Risk Assessment and Sensitivity Analysis**

It is important to remember that few technology investment projects have flawless implementations. There are a wide range of factors that have an impact on the success of a project. It is not necessary to test unlimited possibilities, but notice should be made of risk areas and their probabilities. Risk areas include technology, vendor performance, policy conflict, institutional issues, and financial risk for partners. Evaluators and decision makers must ultimately decide what level of risk to accept and how to manage it. There are many good strategies to manage risk, including segmenting large projects into smaller steps, low-cost testing of new technologies, transferring some risk through contracts, and increasing levels of design before purchasing decisions are made. The agencies involved should make the determination based on their experience, the evaluation data and their level of risk acceptance.

Table 4 provides a high-level assessment of the risks associated with the Auto Cost Recovery (ACR) project. The rankings were done using a High-Medium-Low scale and are based on information gathered from existing projects, industry publications and evaluation assessments prepared by project sponsors around the country.

**Table 4: Auto Cost Recovery Project High-Level Risk Assessment**

Payment Approach	Implementation Cost	Implementation Level of Effort (Agency Risk)	Technology Risk	Gain from Incomplete Implementation (Partial Benefits?)	Benefit Level in Relation to Project Goals
Traditional “Cash and Pass”	Low-Med	Low	Low	Low	Low
Magnetic Stripe Card	High	Med	Low	Med	Med
Transit Smart Card	High	High	Med-High	High	High
Other type cards	High	Med	High	Med	Med-High
Micro-Payment System	Low	Low	Med	High	High

Before the benefit/cost analysis of potential automated cost recovery projects in Montana is discussed, it is important to review the B/C analysis (or lack thereof), of some projects noted in previous sections.

In the Puget Sound area, a total of seven organizations are planning to spend \$70.5 million over the next ten years to implement a smart card solution to allow a single fare source. \$41.8 million is for capital costs, while \$28.7 million is expected to be spent on operational costs over the ten years. As indicated by the exchange noted above, the organizations spending this money hope to break-even (benefits equal costs) or see slight savings (benefits are slightly higher than costs). As with many projects, the true B/C ratio will not be known until after the project has been implemented, and perhaps not known for a number of years.

The CRRRAFT project was discussed in a previous section, and an evaluation of that project was noted in Table 1. Unfortunately, a definitive B/C analysis was not conducted. As noted in the report, “As archived cost data were unavailable, the emphasis is on the opinions of the transit providers and funding agencies on whether the CRRRAFT benefits outweigh its costs.” Without analyzing the specific costs of creating and implementing the CRRRAFT system, it is impossible to determine if it has a positive B/C ratio. Another technology project in a rural setting, the CARTS project, does not have a B/C ratio. This is due in part to the fact that many parts of the system did not “go live” until late fall in 2007. It would certainly be helpful to any future Montana transit technology projects if a B/C ratio is eventually calculated for the CARTS project.

The technologies being implemented as part of the CARTS project have cost about \$400,000 to date. When the initial budget was set at \$256,000, it was estimated that the project would have a five-year payoff. It is unknown at this time how much the project will ultimately cost or how long it will take to pay for itself.

The final project noted before looking at the analysis for Montana projects is the South Carolina Virtual Transit Enterprise (VTE). This project was started in 1996. In 1999, the original plan was finalized as shown in Table 5 (Schwenk 2005).



**Table 5: Four-Point VTE Approach, September 1999**

<b>Point</b>	<b>Definition</b>	<b>Goal</b>
<b>Point 1:</b>	<b>Information Sharing with External Entities</b>	Develop a structured method for selected public provider functions to interface with external entities electronically, to benefit all 18 public providers.
<b>Point 2:</b>	<b>Integrated Automated Fare Collection (AFC)</b>	Integrate AFC technology at one <i>Working Proveout</i> site and integrate a shared passenger accounting system to benefit all 18 public providers and to provide SCDOT with more timely ridership data.
<b>Point 3:</b>	<b>Improve Grants/Contracts Making, Administration, Reporting and Invoicing Processes</b>	Develop a mechanism to improve the Grant Making, Grants Administration, Reporting, and Invoicing process conducted between SCDOT/DMT and the 18 public providers that receive funding through SCDOT/DMT.
<b>Point 4:</b>	<b>Scheduling and Dispatching (S&amp;D) Integration with AVL</b>	Integrate Scheduling & Dispatching (S&D) with an ITS-compliant AVL system. Target one of the public providers as a <i>Working Proveout</i> site, and establish standard procurement specifications, which other public providers can use to build their S&D and AVL systems.

While this approach has been modified, and the project is not yet considered concluded, a total of \$2,510,473 had been spent as of November 2004. The evaluation of South Carolina's Virtual Transit Enterprise did not provide a B/C analysis. As we look at the B/C ratio for potential automated cost recovery projects in Montana, it is important to note that many projects that have been, or are being implemented, have not included specific information on B/C ratios. The Billings MET Transit project included herein as Appendix D, however, is one of the few evaluations specifically addressing the B/C analysis.

### **Benefit/Cost Analysis for Potential Montana ACR Projects**

As noted in the previous section, there have been automated cost recovery and other technology projects that have been implemented either on a statewide basis (e.g., South Carolina, New Mexico), or on a local/regional level (Puget Sound, CARTS). One of the issues in identifying the benefit/cost ratio for any project will be the size and scope of the project, and whether the technologies will be implemented on a statewide or local/regional basis. No matter how the projects may be implemented, there are some fundamental issues that should be considered for any potential automated cost recovery projects (Table 6).

**Table 6: Automated Cost Recovery Project Matrix**

Task	Value/Purpose to Agency	Process	Metric	Goal
<b>Fare verification at point of purchase</b>				
Cash payment verification	Reduced fraud, underpayment and misuse	Survey and correlation with fare box receipts	Average percentage of non-payment or underpayment	Opportunity for revenue improvement
Pass verification	Reduced fraud and misuse	Ride along survey or observations	Average percentage of pass misuse or fraud.	Improved media security and revenue
Transfer, Token, employee and dependent verification	Reduce fraud, misuse and allow tracking of “other fare category” use rates	Ride along survey either with pass study or cash study – correlate transfers received for validity	Average percentage of transfer misuse or fraud	Improved security and revenue
<b>Event Recording</b>				
Block/Route level revenue reporting	Enhancement of route level analysis – improved decision making	Integrate passenger boarding and revenue data	Increases in route/trip level analysis	Improved decision making using cost per rider metric. More productive service delivery
Census Passenger Boardings		Estimate costs of manual or automated process using labor, APCs or other technology	Cost comparison - Opportunity cost or alternative cost comparison	Policy level reporting
NTD Data Collection		Opportunity cost comparison	Relative cost comparison	Transfer of data collection costs to automated system

**Table 6: Continued**

Task	Value/Purpose to Agency	Process	Metric	Goal
<b>Fare Collection Process Management</b>				
Flexibility in fare policy	Management tool		Allows development of effectiveness measures	Improved management of revenue policy
Flexibility in fare media	Marketing tool	Collect annual printing costs for monthly media	Cost comparison	Better customer responsiveness, improved customer interactions, partnerships
Reduced Operator - Passenger fare conflicts	Customer service, driver job satisfaction	Survey for perceived levels of fraud, suggested improvements in physical devices and procedures	Rankings and comparison	Buy in. Operators are a primary customer in this system
Improved reporting management and tools		Estimate of alternatives	Cost substitute for manual collection	Better revenue management and decision making

In general, Table 6 notes that automated cost recovery projects should help track ridership, fare collection, and data management (reporting, invoicing, etc.). An automated cost recovery project should only be implemented if it addresses these issues and has a benefit/cost ratio of 1.0 or greater. If the proposed project does not have a benefit/cost ratio of 1.0 or greater, those involved in the project should recognize that issue and explicitly state why they would implement the project anyway.

### Project Options

As noted earlier in this document, the majority of public and specialized transportation providers in Montana operate on a demand-response basis. Therefore, few systems would receive significant benefits from implementing a farecard system, whether the card was a magnetic stripe or smart card. Another important consideration is that the three largest public transportation providers in Montana—Billings, Great Falls and Missoula—operate independently of the Montana Department of Transportation. These three systems operate under the Federal Transit Administration's (FTA) program known as Section 5307, which means that these systems deal directly with the FTA, and not MDT. Therefore, if MDT wanted to implement any system on a statewide basis, these three systems would do so on a voluntary basis.

The benefit portion of the analysis for each option includes any possible reduction in staff time for the transit providers and other agencies, and the recovery of additional fares. Intangible

benefits that are harder to measure include more real-time information for agencies such as MDT and DPHHS, as well as the potential for reduced time between submitting an invoice and the payment of the invoice (such as with electronic invoicing). Further, an electronic system may allow for daily or weekly invoicing, whereas now that invoicing may take place on a monthly or quarterly basis.

The cost portion of the analysis includes any upfront expenses such as hardware and software purchases and maintenance costs. Any communications costs will also be included in the cost portion of the benefit/cost analysis.

The benefit/cost analysis herein is based on averages—the average benefits a transit system may receive, and the average costs for the various technologies. It is important to remember this, as one system may receive more benefits from a particular technology. Also, depending upon the specific technology and vendor selected, the actual costs may be more or less than what is indicated in this report.

It is also important to note with the analysis that many transit systems are able to utilize federal funds to help purchase software and other technologies. Federal funds may provide from 80 to 86 percent of the technology costs. For example, if a system were to cost \$100,000, only \$14,000 to \$20,000 in local funds may be needed. The transit system would only truly need to recoup the local share for the system to be beneficial. The analysis of the various options noted below show the entire amount of benefits and costs. In addition, the analysis will show the difference between treating costs as “total costs”, or showing the analysis based on “local costs,” the funds that the local transit agency would have to pay.

#### Customer/Rider Management Software (Basic)

As noted previously, many of the public and specialized transit systems in Montana are demand-response systems, which means the customer must call to schedule a ride. The transit system therefore would know who is taking rides and the payment source for those rides. Valley County Transit is now providing same-day demand response rides, and those rides are more demanding to schedule than a traditional demand response ride. In the case of a same-day demand response ride, the ride is more of a fixed route ride, than a demand response ride. Provided that the demand response system has information on their rider, they would likely benefit from customer (rider) management software than from providing farecards to their riders. As noted in the survey results, of those transit systems responding to the survey that reported using software, most reported using Microsoft Excel and a few used QuickBooks. Therefore, a basic software system that tracked ridership and payments could be beneficial to many of the transit providers.

There are various software programs for transit agencies, ranging from basic programs such as Shah Software and Mobilitat, to advanced software such as RouteMatch, Strategen and Trapeze. The more advanced software will be discussed later. Here we will focus on basic customer management software.

For a basic software system, the costs will be the software, annual maintenance costs and, if necessary, a computer. If the software system were based on the agency’s own computer, it is anticipated that there would be no increase in communications costs, or any other costs associated with the software. If the software were installed on an off-site server, and accessed through the Internet, some transportation providers may face increase communication costs as they may be required to upgrade their Internet access.

Benefits accrued from employing the software would be a reduction in time tracking ridership, fares, and invoicing the funding sources. To determine the potential benefits to transit systems, a follow-up question was asked of representatives from the 34 systems that completed the original automated cost survey. They were asked how much time their organization spends tracking ridership and fares/payments (Appendix B). Based on the range of responses, and variation in how much staff may be paid, a range of variables are included in this analysis so that different sized systems can determine whether or not an automated cost recovery system may be beneficial to them.

#### Costs (five-year timeframe)

Software = \$19,500 (estimate, initial purchase)

Maintenance Fee = \$12,000 (\$3,000 per year for years 2 through 5)

Computer = \$0 (assume agency has a computer)

Total costs for five years = \$31,500

#### Benefits (five-year timeframe)

Reduction in time to track ridership, fares and invoicing (time savings as noted, estimated to be 75% of current/existing time), and hourly employee rates include taxes and benefits.

Intangibles: near real-time information, better customer service

Information on the benefit/cost ratios for transit systems, based on the hours they spend on tracking ridership, fares, etc. is provided in Table 7.

**Table 7: Benefit/Cost Analysis-Basic Software**

Annual Time Savings	Employee Rate (hourly basis)	5-year Savings	Benefit/Cost Ratio
90	\$10	\$4,500	0.143
90	\$15	\$6,750	0.214
90	\$20	\$9,000	0.286
225	\$10	\$11,250	0.357
225	\$15	\$16,875	0.536
225	\$20	\$22,500	0.714

Savings of \$6,300 per year (\$31,500 for five years) would be necessary to achieve a benefit/cost ratio of 1.0 or higher.

Note: Software costs may be reduced if a group purchase were made.

#### Computer-Aided Scheduling and Dispatching Software (No in-vehicle technology)

This analysis is very similar to the analysis conducted for MET Transit (Appendix D). The use of computer-aided scheduling and dispatching software not only helps with customer/rider data, it also helps develop the routing of the vehicles in a demand-response system. This is particularly helpful in systems that operate more than five or six vehicles on a daily basis. It is hard for a human being to optimize the schedule for more than that number of vehicles, considering the time and location variables among the rides requested. Transit systems using these technologies have seen dramatic increases in efficiency and, as shown in the MET report, a decrease in service hours or mileage of three percent is all that is needed for the software to pay for itself. As noted earlier, the three large transit systems in Billings, Great Falls, and Missoula deal directly with the

Federal Transit Administration and not MDT, and therefore may not be part of a statewide project. Also, since many of the transit systems in Montana only operate a few vehicles (fewer than six) in demand-responsive service, this software would provide less benefit to them than it would to a larger system.

#### Costs (five-year timeframe)

Software = \$80,000 (estimate, initial purchase)

Maintenance Fee = \$44,000 (\$11,000 per year for years 2 through 5)

Computer = \$3,000 (assume agency needs two powerful computers)

Total costs for five years = \$127,000

#### Benefits (five-year timeframe)

Reduction in time to track ridership, fares and invoicing (time savings as noted, estimated to be 75% of current/existing time), and hourly employee rates include taxes and benefits.

Intangibles: near real-time information; better customer service; potential for reducing time and mileage of transit system (although less likely for small systems).

Table 8 shows a range of benefit/cost ratios for CASD software.

**Table 8: Benefit/Cost Analysis-CASD Software**

<b>Annual Time Savings</b>	<b>Employee Rate (hourly basis)</b>	<b>5-year Savings</b>	<b>Benefit/Cost Ratio</b>
90	\$10	\$4,500	0.035
90	\$15	\$6,750	0.053
90	\$20	\$9,000	0.071
225	\$10	\$11,250	0.089
225	\$15	\$16,875	0.133
225	\$20	\$22,500	0.177

In addition to the savings from ridership, fare and invoicing, a transit system would need to save anywhere from \$20,900 to \$24,500 per year in other operational costs to achieve a benefit/cost ratio of 1.0 or higher.

#### Notes

As previously noted, computer-aided scheduling and dispatching software has greater benefits for larger systems (five or more vehicles). Furthermore, the software cost may be reduced if a group purchase were made or if the system were implemented on a statewide basis. However, trying to implement a system on a statewide basis is not inexpensive. For example, South Carolina spent just over \$2.5 million from February 1996 to November 2004 on its Virtual Transit Enterprise.

#### **Computer-Aided Scheduling and Dispatching Software (with in-vehicle technology)**

This option would take the computer-aided scheduling and dispatching software noted in the previous option and link it to mobile data computers (Appendix C) that would be placed in the demand-responsive (and potentially even the fixed-route) vehicles. Billings MET Transit is exploring adding mobile data computers to its vehicles. The benefit of the mobile data computer is that it “talks” to the software, so that a dispatcher can see if a vehicle is falling behind in its schedule. If so, the driver can shift rides to vehicles that are on-time or ahead of schedule.

Mobile data computers also reduce the amount of time drivers need to communicate on the radio, and can be used to capture data electronically (such as when passengers are picked up and dropped off) for reporting and management purposes.

#### Costs (five-year timeframe)

Software = \$80,000 (estimate, initial purchase)

Maintenance Fee = \$44,000 (\$11,000 per year for years 2-5)

Computer = \$3,000 (assume agency needs two powerful computers)

Mobile Data Computers = (\$3,065 per vehicle, 10 vehicles)

Additional Hardware/Software = \$12,065 (tied to mobile data computers)

Total costs for five years = \$169,715

#### Benefits (five-year timeframe)

Reduction in time to track ridership, fares and invoicing (time savings as noted, estimated to be 75% of current/existing time), and hourly employee rates include taxes and benefits.

Intangibles: near real-time information; better customer service; potential for reducing time and mileage of transit system (although less likely for small systems).

Information on the range of benefit/cost ratios is provided in Table 9.

**Table 9: Benefit/Cost Analysis-CASD Software & In-vehicle Technology**

Annual Time Savings	Employee Rate (hourly basis)	5-year Savings	Benefit/Cost Ratio
90	\$10	\$4,500	0.027
90	\$15	\$6,750	0.040
90	\$20	\$9,000	0.053
225	\$10	\$11,250	0.066
225	\$15	\$16,875	0.099
225	\$20	\$22,500	0.133

In addition to the savings from ridership, fare and invoicing, a transit system would need to save anywhere from \$29,443 to \$33,043 per year in other operational costs to achieve a benefit/cost ratio of 1.0 or higher.

#### Notes

As with the computer-aided scheduling and dispatching software option, this option with in-vehicle technology would be most appropriate for systems with six or more vehicles. A system similar to Billings MET Special Transit would require only a 5 percent decrease in service miles or hours to benefit from a computer-aided scheduling and dispatching software system with in-vehicle technology.

#### **Total versus Local Dollars**

In addition to looking at the total value of the benefits and costs, it is also possible to look at the benefit/cost analysis based on “local dollars.” Due to the funding of transit systems (FTA Section 5311 and 5307 systems), capital projects receive a high amount of Federal match, and operational match is typically 50-60 percent of costs (depending on certain factors). Therefore, a

transit system may pay 14-20 percent of the cost of obtaining ACR technologies, but would accrue benefits at 50-60 percent of the annual savings. Viewing the benefit/cost ratio in terms of “local dollars” would alter the ratios. The previous sections analysis (Table 7, Table 8, and Table 9), are revised herein, based on the local share to purchase the technologies of 20 percent, and benefits gained at 50 percent (which would be considered a “worst case” from a local funding perspective).

As shown in Table 10, if the five year cost of the software is \$9,900 in local dollars (\$3,900 to purchase and \$6,000 of maintenance fees), the cost benefit ratios improve to where there would be a benefit/cost ratio of greater than 1.0 for a transit system that spends approximately 25 hours per month on ridership, fare tracking and invoicing at an employee cost of \$20 per hour.

**Table 10: Benefit/Cost Analysis-Basic Software-Local Dollars**

Annual Time Savings	Employee Rate (hourly basis)	5-year Savings	Benefit/Cost Ratio
90	\$10	\$2,250	0.227
90	\$15	\$3,375	0.341
90	\$20	\$4,500	0.455
225	\$10	\$5,625	0.568
225	\$15	\$8,438	0.852
225	\$20	\$11,250	1.136

Table 11 shows that even when analyzing the benefit/cost ratio of computer-aided scheduling and dispatching (CASD) software, a transit provider would need to save additional operational dollars to achieve a benefit/cost ratio of 1.0 or higher.

**Table 11: Benefit/Cost Analysis-CASD Software-Local Dollars**

Annual Time Savings	Employee Rate (hourly basis)	5-year Savings	Benefit/Cost Ratio
90	\$10	\$2,250	0.058
90	\$15	\$3,375	0.087
90	\$20	\$4,500	0.117
225	\$10	\$5,625	0.146
225	\$15	\$8,438	0.219
225	\$20	\$11,250	0.291

With the CASD software, the five-year total cost would be \$38,600 (\$16,600 for the software and computers, and \$22,000 for the annual maintenance fees). As discussed herein, and highlighted in Appendix D, transit systems that use CASD software typically do reduce operational costs based on annual vehicle hours or vehicle miles.

The benefit/cost analysis for CASD software and in-vehicle technologies in “local dollars” is shown in Table 12.



**Table 12: Benefit/Cost Analysis-CASD Software & In-vehicle Technology-Local Dollars**

Annual Time Savings	Employee Rate (hourly basis)	5-year Savings	Benefit/Cost Ratio
90	\$10	\$2,250	0.048
90	\$15	\$3,375	0.072
90	\$20	\$4,500	0.095
225	\$10	\$5,625	0.119
225	\$15	\$8,438	0.179
225	\$20	\$11,250	0.239

The five-year local cost for the analysis in Table 12 is \$47,143 (\$16,000 for software, \$600 for computers, \$6,130 for the mobile data computers, \$2,413 for the additional hardware and software, and \$22,000 for the maintenance fee). As with the CASD-only analysis, a transit provider would have to obtain additional savings in costs to have a benefit/cost ratio of 1.0 or higher if using a combination of CASD software and in-vehicle technologies. As has been shown in national literature and in the Billings MET Report (Appendix D), additional savings are possible based on the operating characteristics of each provider.

### Benefit/Cost Summary

As noted in this section, the benefit/cost analyses herein use averages of the expected costs, and a range of benefits to determine the ratios. A transit system that spends at least 45 hours per month, paying someone at least \$15 per hour, would be very near a benefit/cost ratio of 1.0 (using total benefit cost dollars). Analyzing “local dollars”, a system spending 25 hours per month at a rate of \$20 per hour, would have a benefit/cost ratio of 1.0

The benefit/cost analysis could be modified based on specific (detailed) pricing of software that may be lower than indicated herein, based on the specifications of the software, and whether or not the price would be lower for a statewide purchase. Further, there may be some additional communications costs, if the software was Internet based, and transportation providers needed an Internet service that may require a cable or satellite based connection.

The authors realize that many small transit systems struggle to find enough local match to provide the appropriate level of service in their community. The purpose of the benefit/cost analysis is to show the potential benefits received, either on a total or local basis, rather than to discuss how local match monies may be obtained.

Based on the information from the analysis, the majority of transportation providers in Montana would likely benefit from a basic rider/customer software system. This system may be enhanced with services/technologies identified in the One Stop Shop project. No matter which technologies may ultimately be selected if the Montana Department of Transportation moves forward with a related project, there will need to be a plan in place that will minimize the risks involved with implementing the technologies, and maximize the benefits to the transit providers and other agencies. The following section discusses the issues surrounding the implementation of automated cost recovery and related technologies.

## IMPLEMENTATION PLAN

A technology with a promising benefit/cost ratio may not deliver what it promises if it is not implemented correctly, or as scheduled. At the time this document was written, there was a possibility that the primary vendor in the Puget Sound technology program discussed in previous sections will declare bankruptcy and cease to exist. In another example, South Carolina's Virtual Transit Enterprise suffered from the lack of a project manager for nearly one year after the project began in February 1996.

The implementation plan must be part of an overall business strategy. Clearly defined project and performance goals are the first step. The plan depends on quality evaluations, manageable funding strategies and effective procurement. Once those are agreed on, the project becomes dependent on project management, training and implementation.

### Implementation Plan Steps

1. Identify potential partnerships and interest areas in the state or region.
2. Develop an informal network of interested parties.
3. Develop business goals, requirements, success measures and outcomes.
4. Identify areas of mutual gain and clearly spell them out for funding partners.
5. Clearly identify management and staff requirements and responsibilities.
6. Define system requirements based on user needs.
7. Define general and specific scope of program.
8. Identify test case project.
9. Develop base requirements for demonstration.
10. Solicit industry feedback.
11. Issue cooperative RFP.
12. Install, test and evaluate.
13. Feed experience and lessons learned into final procurement decisions.

A vision and goal for the implementation of any automated cost recovery project must be developed, whether the project will be implemented on a local, regional, or statewide basis. As it has been famously said, "If you don't know where you are going, how will you know when you get there?" In addition to the automated cost recovery project, there is a research project investigating the feasibility of a one-stop shop in Montana. The one-stop shop would likely provide public and specialized transportation clients a "single point of access" for information about transportation services. As indicated by the CARTS project in Texas, many of the technologies implemented work together to not only provide information to the transit system, but can be used to provide one-stop shop capabilities to the customers/riders. Therefore, it is recommended that MDT integrate the information from both this and the One Stop Shop report and investigate how the reviewed technologies may work together in one comprehensive system.

The first step in planning for implementation of automated cost recovery technologies would be to hold a meeting, or series of meetings, between MDT and transit agencies to determine the interest in implementing automated cost recovery and related technologies. Partner agencies, such as DPHHS, should be included in the discussions, as they fund transportation services, and are likely to benefit from the data obtained by ACR and related technologies, especially if implemented on a regional or statewide basis.

The meetings would help define the information required in Steps 1 through 4 noted above. These steps would help all agencies/organizations involved define the benefits and costs they may realize as the technologies are implemented, and help define what is going to be required of each agency. As noted in the benefit/cost analysis section, the benefit/cost ratio changes depending upon whether the total costs or local costs are being examined. Further, agencies such as MDT and DPHHS may examine the value of near real-time information, and may provide funding for implementing technologies.

Once a vision and partnerships are discussed, then it is important to detail the responsibilities of each agency/organization and person (Step 5). This may be as simple as transit agencies sending staff to training sessions to learn about new software, or it may be more complicated, as agencies may have staff members create a Request for Proposals for the technologies, and participate in the selection process. During this step, an overall project manager, or “champion,” will be identified who will keep the project moving forward and on track.

After the roles and responsibilities have been defined, the more detailed work of determining the system requirements (Step 6) and scope of the program (Step 7) begin. Which technologies may be implemented, and the process for implementation, will be determined at this time. The technologies to be implemented should follow the applicable architecture for intelligent transportation systems (ITS) systems that is in place with MDT. ITS architecture provides the framework for how systems are deployed, addressing issues such as how the various technologies communicate with each other, how older or “legacy” systems may be integrated, etc.

It may be determined that one or several sites may be selected for implementation (Step 8), or that it is necessary to implement the system on a statewide basis. Also, the order in which technologies may be implemented will be determined at this time. For example, new software may be implemented, with automatic vehicle location technologies added six months after the software is operational.

The base requirements for a demonstration (Step 9) will define what is expected of the agencies/organizations that will take part in implementing the new technologies. For example, it may be necessary that the transit systems guarantee they will utilize the technologies (sometimes computers sit in the corner of an office gathering dust), that they will update information and/or send reports on a weekly or monthly basis, etc. This will also require that the participating agencies/organizations keep track of how their business model changes after the implementation of the technologies. If, for example, it is anticipated that the new software will reduce ridership tracking and reporting times by 75 percent, participating agencies will need to track the amount of time employees spend on those tasks.

Base requirements may also include whether the training was completed on-time, and issues with the installation and maintenance of the technologies. The evaluation plan must be developed before the technologies are implemented, so any “before” data can be collected.

After it is determined who would participate in the initial trial or test program, it is a good idea to talk to some people in the industry (such as vendors) to solicit their feedback on the plan (Step 10). During this time, it is important to talk in general terms, and the vendors need to be assured that their participation in the general discussions will not preclude them from bidding on the project. It is also important during this time to make sure that the specifications of the project are not modified to give one vendor an advantage over another, although in some instances a sole-source bid may be appropriate. This step can be viewed as a “sanity check” to make sure that there are not parts of the implementation plan that cannot be met by the industry.

Once there is general agreement with the plan, the next step (Step 11) is to issue the Request for Proposals (RFP). Depending upon the specifics of the project, the RFP may be issued by a state agency (such as MDT, DPHHS, etc.) or the RFP may be issued by a specific transit agency. No matter who issues the RFP, it must follow all applicable rules for selecting a vendor. It is also important that the RFP follows the specifications that were developed earlier in the process. In addition, if more than one technology is going to be implemented, it is very important that one vendor be designated as the “systems integrator.”

Unfortunately, when multiple technologies are being implemented, it can become easy for vendors to point fingers at the other vendors over why a certain system is not working. It is important, then, to have one vendor responsible for making the system work so the agency/organization implementing the technologies is not put in the middle of an argument over whose system is or isn't working.

Implementation will begin after a vendor has been selected through the RFP process (Step 12). The proposals from the vendors should include a timeline for installing the technologies and providing the necessary training. It is important to track how well the vendors perform during the installation process, as this will be one factor in determining whether or not the technologies should be implemented on a wider basis. During this step, a part of the implementation process will be to test the technologies to find out whether, for instance, the mobile devices can talk to the software, or does the software function as advertised (i.e., does the database track the necessary information and does it produce the necessary reports, etc.). Once the technologies have been implemented and tested, the evaluation phase begins.

The evaluation phase requires consideration of numerous factors, including how the RFP process worked, if the implementation and training phase went according to plan, and, ultimately, did the technologies deliver based on the anticipated benefits. To determine the value of the benefits, the evaluation should be conducted at least six months after the implementation of the technologies. This time should allow employees to become familiar with the new technologies, and be able to use them to their maximum extent.

It is important to include employees, and others who will ultimately use the technologies, in all phases of the process as their buy-in is critical. Technology programs can fail when employees decide that the old ways work better, and decide not to use the new technologies, or not use them to their full capabilities. The input from the people using the technologies will be critical in determining the value of the technologies, and capturing the lessons learned from the process (Step 13).

After the implementation phase, and once the evaluation has been conducted, a brief write-up should be done detailing what has been learned and what may be done differently as the technologies are expanded to a regional or statewide basis. As Montana can learn from

technology projects conducted elsewhere in the United States, and even elsewhere in the world, it is important to capture the lessons learned to provide updated information to other states, or to improve the processes within Montana.

As part of this project, the WTI team has been able to review lessons learned from evaluations of other projects that should help the Montana Department of Transportation and/or partner agencies as they determine whether or not to move forward with implementing automated cost recovery and/or related technologies.

Many lessons were learned from South Carolina's experience with the development and implementation of the VTE. They should serve as guidance not only for other states and organizations starting a similar system in their own areas, but also for SCDOT as it continues with the remaining development tasks. These lessons (Schwenk 2005) are:

- Strong, committed and consistent project management and leadership are perhaps the most important elements in a project like VTE that involves a large and diverse group of participants, complex interactions among many technical components, and a prolonged development period. This kind of leadership throughout the duration of the VTE project might have prevented:
  - The decision to terminate the original contractor, SCRA, without a backup plan, stopping the momentum of the project cold in its early stages,
  - Lack of progress in other areas of the VTE project during the time when there was a protest over the award of the scheduling and dispatching software (a protest by a vendor that wasn't awarded the contract),
  - Absence of a project manager for over one year,
  - The need to extend the project duration to more than twice the time originally planned, and
  - Participant attrition, some forgetting about the project altogether and not realizing which components it included.
- The importance of conducting thorough requirements analyses and following what is learned cannot be stressed enough. Problems with requirements definitions surfaced periodically throughout the VTE project:
  - The four-point approach agreed to in Phase I, based on thorough analysis of the technology needs of public providers and SCDOT, did not include vehicle maintenance software, yet it was the first application SCDOT gave to the public providers in Phase II. Only two of the public providers ever used it.
  - RouteMatch conducted detailed requirements analysis of each public provider prior to the Go-Live week. Nevertheless the need for the particular data required for Department of Health and Human Services (DHHS) billing was not realized until the public providers began actually using the system. RouteMatch had to develop several new reports for the public providers and it took at least one public provider over a year to work out all the reporting problems.

- A VTE web site could have been an effective way to instill the sense of belonging to a “VTE community” in the public providers and gone a long way to developing the “virtual enterprise” identity. SCRA hosted a VTE web site during Phase I, but discontinued it after the end of its contract. As one of the more straightforward elements of the VTE project to develop and with the required infrastructure in place (computers with Internet access), the VTE web site should have been one of the first things SCDOT implemented. Public providers could have used it as a focal point for information on VTE and communication with other participants.
- It would have been better first to approach the public providers with the more straightforward elements of VTE to build their enthusiasm and confidence in their capabilities and the VTE Project, and then introduce the more complicated applications to them, conditional on the success of the earlier ones.
- Presenting a thoroughly tested and debugged system to users creates a favorable first impression and positive attitude toward the product. SCDOT tested its electronic invoicing system on a few public providers before rolling it out to the rest, with few resulting glitches. On the other hand, the RouteMatch system, a much more complex system, was rolled out to all public providers at once. Problems encountered, even though some were relatively minor in nature, took a long time to resolve, with the result that many public providers developed a negative attitude toward the system, and decided not to use it.
- During the training sessions, RouteMatch discovered that the training is more successful when the classes are as homogeneous as possible regarding trainee experience with technology, and agency size and S&D needs. Group training that combined several agencies at a time did not address the specific needs of the attendees to the degree needed, and RouteMatch had to spend significant time on training during the Go-Live weeks at each site to insure the users could operate the software properly.
- The lack of digitized road networks that include customer addresses in some rural areas presented an obstacle to using the RouteMatch system in those areas. These networks are necessary for the route planner feature of RouteMatch to determine where the customers live and how to route vehicles for pick-ups. This discouraged some public providers from using the RouteMatch system.

While there will still be lessons to learn from the South Carolina project, there are also lessons being learned by CARTS in Texas. As noted earlier, those lessons (Hosen 2007) include:

- Walk, Don't Run—Implement one technology at a time, master it, then take the next step. Take your time!
- A Solution In Search Of A Problem—Have a vision and goals. What do you want to accomplish with this technology? What are your technology goals?
- Purchase For The Future, Not The Present—Think five to ten years into the future and ensure that your software will work with any new technologies that may be available.

- Demonstrations Do Not Really Count–Demos are nice, but you must see the technology working in the real world before you purchase.
- Seek Out The Best Communications Option–In CARTS case a local power authority was bringing a state-of-the-art system on line.
- It’s Still The Staff–Success depends on staff willingness and ITS capabilities. The best technology requires willing and able staff to maximize performance.

It is important that Montana review these lessons learned as it decides whether or not to move forward with implementing any automated cost recovery or related technologies. The steps herein are general, but this is based on the fact that one (or more) specific technologies have not been identified for implementation, even though basic rider/customer management software appears promising.

The next logical step in possible implementation would be to take the information from this report, and combine it with the information from the One Stop Shop report, and involve stakeholders (transportation providers and agencies such as DPHHS) and develop a vision for transit technologies in Montana. The following section highlights these recommendations, based on the lessons learned and other information obtained through the research conducted as part of this project.

## RECOMMENDATIONS

The purpose of this report was to study the feasibility of implementing automated cost recovery technologies in transportation (transit) systems in Montana. Based on the information gathered through this project, this report recommends the following steps be taken:

- Develop a program plan (vision and goals) that describes the desired outcome of implementing transit technologies in Montana.
- Identify the steps required to accomplish the goals.
- Procure a high-value rider/customer data management system (based on benefit/cost analysis).
- Develop a pilot program for additional technologies (such as in-vehicle technologies) that would provide additional benefits to transit operators.
- Develop a one-stop center that would leverage technologies implemented to support transportation (transit) providers, and would provide a “one-call, one-website” portal for customers and clients.

The first recommendation is to develop a vision (goals) for what technologies could or should be implemented within transit systems in Montana. This first step would require that the Montana Department of Transportation hold a meeting or series of meetings with transit providers and “partner agencies” such as DPHHS, to determine the needs of the transit community, from both an operations/management standpoint, and from a customer standpoint. Once the vision and general goals are agreed to, the next step would be to develop a timeline (or roadmap) for accomplishing the goals. This step would require combining the information in this report along with information from the One Stop Shop project.

This second step would identify which technologies should be implemented and in what order. Each technology implemented should be on the basis of the larger system/goal. For example, it would not make sense to use a proprietary automatic vehicle location (AVL) system that would not be able to communicate with a website that would be used to let customers/riders see the locations of the various transit vehicles. It is also important to try and procure systems that can be upgraded, based on newer technologies and/or communications systems.

It appears that the majority of transit systems in Montana would benefit from a basic rider/customer data management system. This system should be able to support the basic functions of a small demand-responsive system, yet be able to expand to meet the needs of a larger system. The software should probably be capable of computer-aided scheduling and dispatching functions for the largest transit providers in the state, and be able to interface with in-vehicle technologies such as mobile data computers. If there is not one software available to meet all these needs, then two software systems that could communicate with each other would be the next best option.

During the process, MDT will need to decide whether it wants to initially implement technologies with one or more test sites, and then expand the technologies, or if it wants to bring all providers on-line at the same time. Pilot program sites may also be selected for additional or enhanced technologies in order to study the benefits they provide to the transit providers, customers/riders, and state agencies. During the implementation of any technologies, it is



important to make note of how the various processes worked, from the RFP process, to the implementation and training of the technologies, so that if the systems are expanded, the lessons learned can be used to improve the process.

It is recommended that the technology systems put in place be implemented with the overall goal of creating a one-stop shop for transit services in Montana. This does not need to be a complicated process, but while the various components/technologies are being planned and/or implemented, it is important to keep focused on the interoperability of the components, with the goal of eventually implementing a one-stop shop. This recommendation is made with the understanding that there is a separate research project being conducted in Montana related to the one-stop shop concept.

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## **APPENDIX A: SURVEY**

The following survey was sent to 73 public and specialized transportation providers in Montana. A total of 34 responses were received.

**Automated Cost Recovery – A Feasibility Study  
Organizational Survey**

This survey is being conducted by the Western Transportation Institute (MSU-Bozeman) to determine if it is feasible to implement electronic methods to gather ridership and fare/funding information from individuals using public and specialized transportation services within Montana. The information you provide about your organization will help with this effort.

Agency:
Address:
City, Zip:
Contact Person (Name):
Phone Number:
Fax Number:
E-mail:

Please answer the following questions about your organization.

**Organizational Characteristics**

1. Does your organization collect fares (payment) from any individual who rides your vehicles?

Yes       No

If yes, please describe how your organization collect fares (i.e, the driver collects a cash payment, riders have passes or punch cards, etc.).

2. Does your organization collect ridership data?  Yes  No

If yes, who has responsibility (driver, dispatcher or other) for counting ridership, and how do they do it (memory, count sheets, etc.)?

3. How does your organization define a “ride” (i.e., round trip, one-way trip, or other)?

4. What is the approximate total number of customers you have of each type noted below, and what is the approximate number of monthly rides you provide for each customer type noted?

Customer Type	Total Number	Monthly Ridership
Active (currently riding)		
General Public		
Senior Citizens		
Persons with Disabilities		

5. Approximately how many new customers (not existing customers) do you add to your service each month? \_\_\_\_\_
6. What is the total number of vehicles operated by your organization? \_\_\_\_\_  
What is the number of vehicles (for carrying passengers) operated by your organization? \_\_\_\_\_
7. Do you have passengers whose rides may be paid for by a variety of programs or sources? If so, please indicate the maximum number of different sources or programs that may pay for one customer's rides.
8. In addition to paying for rides on public or specialized transportation services, does your organization also pay for rides using vouchers, or paying for transportation provided by taxis or other sources (such as paying for family members to transport an individual)? If so, please describe these various methods/modes your organization uses for transportation services.

### Reporting Requirements

9. What information, if any, pertaining to ridership and fares do you report to any other organization?
10. How does your organization collect and report information pertaining to ridership and fares?
11. Does your organization have any Issues and/or challenges with the current system you are using? If so, what are the issues?
12. Do you have any suggestions for improving the data collection and/or reporting process?

**Organizational Business Practices**

13. If your organization collects ridership and/or fare information, how does that data/information move from the vehicles into the office (i.e., tally sheets, electronic data transfer, etc.)?
14. If your organization reports data to other agencies/organizations, how do you do that (i.e., send a hard copy of the report, e-mail the data, fill in an on-line form, etc.)?
15. If your organization invoices another agency/organization for rides, how do you do that (i.e., send a hard copy of the invoice, e-mail the invoice, fill in an on-line form, etc.)?

**Organizational Use Of Technology**

16. Does your organization have fare boxes in any of its vehicles it uses for passenger transportation? If yes, does your organization use the fare box to track ridership?
17. Does your organization have any other technology on the vehicles it uses for passenger transportation such as automated passenger counters, automatic vehicle location systems, etc.? If so, please describe the technology or technologies.
18. When your organization tracks ridership, does it use spreadsheets or other computerized, electronic methods for tracking ridership? If so, please explain the methods (systems) used.
19. Describe any other systems or technologies your organization uses in the process of carrying passengers, including tracking expenses, invoicing, reporting, etc.

## APPENDIX B: SURVEY RESULTS

The specific answers to each question of the survey are highlighted in this Appendix. The number shown for each answer corresponds to the organization that completed the survey, for tracking and verification purposes. Cumulative totals are provided for applicable questions for the purposes of basic analysis.

### Question 1.

**Does your organization collect fares (payment) from any individual who rides your vehicles? \_\_\_yes \_\_\_no**

**If yes, please describe how your organization collect fares (i.e., the driver collects a cash payment, riders have passes or punch cards, etc.).**

**Yes = 22 (65%); No = 12 (35%)**

1. Yes, Driver collects fares in fare box, fare boxes also accept period passes, stored ride passes, and designated pass program passes.
2. Yes, Fare box, passes and punch cards.
3. Yes, cash payments in fare box; sell punch cards and monthly passes.
4. Yes, driver collects punch cards.
5. Yes, driver collects, riders have passes.
6. Yes, driver collects punch cards.
7. Yes, driver collects cash; riders purchase passes and punch cards.
8. No.
9. No.
10. Yes, driver collects cash; riders purchase passes and punch cards.
11. No.
12. Yes, driver collects cash or a check; riders purchase passes and punch cards.
13. Yes, we provide transportation to folks with D.D.-they do not have to pay just one-two days a week they pay cash or use a voucher.
14. Yes, driver collects, riders have passes.
15. Yes, the driver collects.
16. Yes, the drive collects a cash payment, suggested fare donations.
17. No.
18. Yes, driver collects cash; riders purchase passes and punch cards.
19. no,
20. Yes, driver collects a cash payment; riders purchase passes and punch cards.
21. No.
22. No.
23. No.
24. No.
25. Yes, the driver collects a cash donation.
26. No.
27. Yes, the driver collects contributions.
28. No.
29. no. donation only



30. yes, driver; collects a cash fare
31. yes, driver collects or rider purchase ticket
32. yes & no, on a volunteer basis- we have a suggested donation only- no one is required to pay for a ride
33. yes, we collect fares only if we provide rides for the community health center people who live outside the city limits or under 55yrs old. Otherwise it's a free service.
34. yes, a suggested donation of \$1.00 per ride

### Question 2.

**Does your organization collect ridership data? \_\_\_yes \_\_\_no**

**If yes, who has the responsibility (driver, dispatcher or other) for counting rider ship, and how do they do it (memory, count sheets, etc.)?**

**Yes = 33 (97%); No = 1 (3%)**

1. Yes, Drivers record ridership through fare box.
2. Yes, the driver collects there names and does it everyday the bus runs.
3. Yes, the driver keeps a daily count sheet with date, time, and where they are going.
4. Yes, driver, count sheets.
5. Yes, driver monthly logs.
6. Yes, driver, fill out log sheets daily.
7. Yes, driver; count sheets.
8. Yes, drivers utilize passenger logs to count ridership.
9. Yes, driver; log sheets.
10. yes,
11. Yes, driver; datasheet.
12. yes,
13. No.
14. Yes, driver; datasheets.
15. Yes, count sheets.
16. Yes, driver; daily rider records; compiled by head driver monthly.
17. Yes, driver; count sheets
18. Yes, at the end of the month, the transit, manager counts up the # of rides and the records the information along w/ monthly fare amounts on a computer spread sheet.
19. Yes
20. Yes, Driver; count sheets.
21. Yes, transportation sheets are put in the bus every morning.
22. Yes, Dispatcher computer count sheets.
23. Yes, Driver; count sheets.
24. Yes, Riders sign a sheet and check.
25. Yes, Transportation manager/Driver; count sheets.
26. Yes, excel spread sheets kept updated by coordinator.
27. Yes, Driver and dispatcher; collect data and use count sheets.
28. Yes, count sheets.
29. Yes, Driver writes out info and dispatcher count up info.
30. yes, dispatcher/ computer

31. Yes, Driver; collects data and records it on a daily trip sheet.
32. Yes, Driver; count sheets.
33. Yes, Driver; count sheets. Monthly computer spreadsheet
34. Yes, Driver; mechanical counter units.

### Question 3.

**How does your organization define a “ride” (i.e. round trip, one-way trip, or other)?**

**One way trip = 26 (76%); Round trip = 8 (24%)**

1. one way trip
2. one way trip
3. one way trip
4. Round trip one way is an option.
5. Anytime a person re-enters the bus to go to another destination.
6. one way trip
7. Ride = each time passenger boards the bus.
8. one-way trip
9. one way trip
10. round trip
11. one way trip
12. one way trip
13. one way trip
14. one way trip
15. one way trip
16. one way trip
17. one way trip
18. round trip
19. one way trip
20. round trip
21. round trip
22. one way trip
23. one way trip
24. one way trip
25. round trip
26. one way trip
27. round trip
28. one way trip
29. one way trip
30. one way trip
31. each disembarking is considered a ride
32. one way trip
33. one way trip
34. round trip

**Question 4.**

What is the approximate total number of customers you have of each type noted below, and what is the approximate number of monthly rides you provide for each customer type noted?

Survey	Active (currently riding)		General Public		Senior Citizens		Persons with Disabilities	
	Total Number	Monthly Ridership	Total Number	Monthly Ridership	Total Number	Monthly Ridership	Total Number	Monthly Ridership
1	Unknown	Unknown	Unknown	50,035	Unknown	11,005	Unknown	Combined w/Seniors
2	Unknown	Unknown	176,000	Unknown	176,000	Unknown	90,700	Unknown
3		65,536		43,933		4,114		17,489
4	8	5	3	2	5	3	0	0
5								
6	616				562	1,128	54	732
7	45	3,500	21	1,610	14	1,085	10	805
8							6,079	2,026
9	45	900			45	900	2	10
10								
11							3,600	300
12	35	60	0	0	35	60	2	
13			10	?			2,000	38
14	176		56		49		68	
15					4	72	1	4
16				30		131		90
17						734		Combined w/seniors
18			50	100	200	600	60	1,500
19							70	3,150
20				402		1647		721
21	25		4		25		2	
22	3	2			18	5	9	5
23	315	4,000	100		315			
24							2,952	2,952
25	8	8	3	3	8	8	5	5
26						Varies		Varies
27		3,500		30		1,400		2,026
28							38	
29	Varies	Varies	Varies	Varies	Varies	Varies	Varies	Varies
30	4	48			4	48	2	24
31			5	10	40	200	30	250
32	30	15			28	15	2	15
33		4		0		237		18
34					Varies	141		

**Question 5.**

**Approximately how many new customers (not existing customers) do you add to your service each month?**

**Not Available = 9 (27%); Varies = 2 (6%); 0 = 4 (12%); 1 = 4 (14%); 1-2 = 3 (9%);  
3 to 5 = 8 (24%); 6 or more = 3 (9%)**

1. not available
2. not available
3. varies
4. 1
5. 5
6. 10
7. 3
8. not available
9. not available
10. 3
11. 15
12. 2-5
13. not available
14. not available
15. varies
16. 5
17. not available
18. 5
19. 1
20. 5-10
21. 0
22. 0
23. 4
24. 1
25. 1
26. not available
27. 2-3
28. 0
29. not available
30. 0
31. under5
32. 1-2
33. 1-2
34. 2

**Question 6.****What is the total # of vehicles operated by your organization?****What is the # of vehicles (for carrying passengers) operated by your organization?****Total Vehicles = 268 (Avg. 8 per agency); Passenger Vehicles = 228 (Avg. 7 per agency)**

1. 31,26
2. 34, 20 fixed route and 9 Para transit
3. 45,40
4. 1,1
5. 5,4
6. 9,9
7. 7,7
8. 10,10
9. 3,3
10. 2, 3 on daily basis
11. 2,2
12. 1,1
13. 8,6
14. 4,4
15. 1,1
16. 2,2
17. 12,2
18. 9,7
19. 16,15
20. 9,9
21. 1,1
22. 4,4
23. 24,4
24. 16,15
25. 1,1
26. 3,2
27. 6,6
28. 7,6
29. 1,1
30. 1,1
31. 2,2
32. 1,1
33. 1,1
34. 2,2

**Question 7.**

**Do you have passengers whose rides may be paid for by a variety of programs or sources?**

**If so, please indicate the maximum number of different sources or programs that may pay for one customer's rides.**

**Yes = 12 (35%); No = 8 (24%); Not Applicable = 14 (41%)**

1. Yes, unknown
2. unknown
3. fixed route-None Para transit works with 4 agencies and continues to look at and coordinate with other agencies.
4. n/a
5. n/a
6. yes-3
7. n/a
8. n/a
9. yes churches and hospital
10. yes-3
11. n/a
12. n/a
13. transportation advisory council SAFTEA-LU, & DDP
14. no
15. Medicaid waiver
16. county, state, and federal funds
17. five
18. no
19. no
20. Medicaid & nursing home possibilities include VFW
21. n/a
22. n/a
23. n/a
24. n/a
25. no cash donation
26. n/a
27. n/a
28. an individuals cost plan is determined through the development disabilities program
29. no
30. 3 from grant
31. limited Medicaid transportation
32. n/a
33. no
34. no

**Question 8.**

**In addition to paying for rides on public or specialized transportation services, does your organization also pay for rides using vouchers, or paying for transportation provided by taxis or other sources (such as family members to transport an individual uses for transportation services)?**

**Yes = 4 (12%); No = 21 (62%); Not Applicable (or blank) = 9 (26%)**

1. No
2. N/A
3. No
4. no
5. no
6. no
7. N/A
8. NO
9. no
10. family members can purchase a punch card
11. bus pass
12. no
13. vouchers
14. no
15. no
16. N/A
17. bus vouchers
18. No
19. no
20. N/A
21. no
- 22.
23. no
- 24.
25. no
26. none
27. no
28. no
29. no
30. N/A
31. no
32. N/A
33. N/A
34. no

**Question 9.**

**What information, if any, pertaining to ridership and fares do you report to any other organization?**

**MDT = 23 (68%); NTD = 2 (6%); Other = 1 (3%); What reported = 8 (23%)**

1. ridership by category, by route, rides to/from specific locations(paratransit)
2. National transit database (NTD)
3. We provide info to the NTD and Montana Department of Transportation (MDT)
4. MDT
5. # of rides, # of fares
6. # of passengers, types of riders, miles traveled, rider donations
7. MDT
8. # of rides, # of fares, average # of hours, #rides/day; # of rides/mile
9. # of riders and amount of fares
10. MDT quarterly
11. MDT cost of rider program
12. reasons for trip and customer type
13. total # of rides to DDP and TAC
14. State of Montana, Blackfeet Tribe
15. Area II agency on aging and state
16. MDT quarterly
17. report to HATS
18. Riders names, monthly fare collections, and total # of rides to Sheridan County each month. We also report the above info along w/mileage, and expenses to MDT quarterly
19. rides, miles
20. MDT
21. MDT and Madison County
22. # of riders, miles, hours used, \$ in gas all reported to MDT
23. State of Montana
24. # of rides, performance data, financial data to MDT
25. We report all ridership and fare info to action for Eastern Montana monthly and to MDT quarterly.
26. ridership reported to MDT
27. MDT
28. # of riders, miles, and financial info is reported to MDT quarterly. We also indicate as part of our monthly invoice for DDP whether transportation was provided.
29. MDT
30. # of riders, and miles driven, quarterly expenses
31. MDT
32. Rides provided and contributions received, ect. MDT quarterly.
33. send monthly report to Area V Agency on Aging and quarterly report to MDT due to getting monies from Area V Agency on Aging and the bus being a grant bus through the MDT
34. Mileage and riders reported to MDT quarterly



**Question 10.****How does your organization collect and report information pertaining to ridership and fares?**

1. Fare boxes, fixed route, scheduling software-paratransit
2. Drivers collect # of riders. Finance collects fare info, excel spreadsheets
3. Data is collected from daily count sheet kept by the drivers, which is then entered into a computer database. We do not track fares that relate to rider groups.
4. Data is collected from daily count sheet kept by the drivers, which is then entered into a computer database. The info is reported to MDT quarterly.
5. daily trip sheet for the # of rides
6. computer print outs
7. manually collected and reported
8. logs
9. count sheets
10. daily input from coordinator
11. Data is collected from daily count sheet kept by the drivers.
12. Once/month to Area V Agency Aging, quarterly to MDT.
13. manually on count sheets
14. Daily collection of fares per ridership. If they are not handicapped or elderly fares are deposited to Blackfeet tribe for transit.
15. Yes
16. monthly worksheet
17. drivers collect
18. riders name, # of rides, fares paid are collected each day in log books, which is then entered into a computer database and these reports are sent to Sheridan County and MDT.
19. transportation record from drivers
20. Drivers, dispatch, adm. Assist.
21. rider costs, trip
22. data info sheets
23. #'s only
24. Log in vehicle record all trips (one-way) taken; vehicle logs entered into a monthly log. Quarterly report sent to MDT
25. Transportation manager tallies rides from drivers reporting sheet and counts all fare. This is done monthly.
26. online
27. We keep a log of ridership and fares collected.
28. Collected utilizing passenger logs. Reported to MDT quarterly via their website, reported to DDP monthly via invoice
29. via e-mail reported to MDT
30. Log sheets filled out by drivers
31. Driver collects ridership info/fares. Admin assembles info into usable form.
32. tally sheets
33. Through daily sheets, expenditure, and revenue report from the city clerk.
34. We track the mileage daily and report quarterly.

**Question 11.**

**Does your organization have any issues and/ or challenges with the current system you are using? If so, what are the issues?**

**None/No/or blank = 26 (76%); Comments = 8 (24%)**

1. Difficult getting information in more detail- i.e. ridership, specific route at a time of day.
2. human error
3. no
4. not so far
- 5.
- 6.
7. Charging customers, driver paperwork being accurate, fares not matching reported amounts.
8. no
9. no
10. no
- 11.
- 12.
13. ok
14. Blackfeet transit needs more vehicles for transportation also needs more drivers. Funds are limited.
15. no
16. no
17. no
18. no
19. no
20. Accurate dispatch that allows enough time, vehicles and drivers top/u when needed.
21. no
22. no
23. We have to purchase our own vehicles we like to run 12-15 vehicles, not small buses.
24. too paper oriented
25. no
26. no
27. no
- 28.
29. no
30. no
31. need to be able to track clients/assistance more efficiently
32. no
33. no
34. no

**Question 12.****Do you have any suggestions for improving the data collection and/or reporting process?****No (or blank) = 30 (88%); Comments = 4 (12%)**

- 1.
2. electronic collection system
3. no
4. no
- 5.
6. more direct online reporting
7. smart cards
8. no
9. no
- 10.
- 11.
12. no
- 13.
14. no
15. no
16. no
17. no
18. no
19. no
20. no
21. no
- 22.
23. no
- 24.
25. no
26. no
27. no
- 28.
29. no
30. no
31. more advanced dispatch system
32. no
33. no
34. no

**Question 13.**

**If your organization collects ridership and/or fare information, how does that data/information move from the vehicles into the office (i.e., tally sheets, electronic data transfer, etc.)?**

**Tally Sheets = 26 (87%); Driver = 3 (10%); Electronically = 1 (3%)**

1. electronically transferred through fare collection system
2. tally sheets
3. tally sheets
4. hand delivered by driver
5. tally sheets
- 6.
7. daily rider sheets by vehicle
8. tally sheets
9. tally sheets
10. tally sheets
- 11.
12. tally sheets
13. tally sheets
14. dispatcher, tally sheets
15. tally sheets
16. tally sheets
17. tally sheets
18. tally sheets
19. tally sheets
20. tally sheets
21. NA
22. tally sheets
23. tally sheets
24. tally sheets turn in weekly
25. driver delivers it to the transit managers office
26. tally sheets
27. compiles quarterly
28. tally sheets monthly
29. tally sheets
30. tally sheets monthly
31. tally sheets
32. tally sheets
33. tally sheets
34. tally sheets

**Question 14.**

**If your organization reports data to other agencies/organizations, how do you do that (i.e., send a hard copy of the report, e-mail the data, fill in an on-line form, etc.)?**

**Online or e-mail=16 (47%); Hard copies=4 (12%); Electronic & Hardcopies=11 (32%); N/A or not classified=3 (9%).**

1. all the above
2. internet web site
3. online form
4. hard copy to MDT
5. hard copy report
6. hard copy, online
7. online form mail invoices with info
8. hard copy
9. fill in online form, hard copy
10. MDT quarterly
11. N/A
12. send a copy area V agency on aging MDT gets a computerized quarterly
13. send hard copy
14. email/weekly deposited fare money
15. online report to the state
16. online form to MDT
17. email bus report to Sheridan county, via online to MDT
18. email
19. online form
20. hard copy and online forms
21. hard copy and email
22. hard copy and email
23. email the data
24. online to MDT
25. hard copy thru the mail and online form to MDT
26. email
27. email quarterly to MDT
28. N/A
29. email the data
30. copy of quarterly report sent to MDT
31. online form/ hardcopy when online unviable
32. online form
33. hard copy, online form
34. email quarterly reports

**Question 15.**

**If your organization invoices another agency/organization for rides, how do you do that (i.e., send a hard copy of the report, e-mail data, fill in an on-line form etc.)?**

**Hard copy = 11 (32%); Online or e-mail = 2 (6%); Online & Hardcopy=1 (3%); Not Applicable (or not classified) = 20 (59%)**

1. hard copy and online
2. hard copy
3. hard copy
4. n/a
5. hard copy
6. hard copy
7. hard copy
8. n/a
9. monthly statements
10. monthly billings
11. n/a
12. n/a
13. hard copy
14. n/a
15. send a statement of the online statement
16. n/a
17. n/a
18. hard copy
19. email
20. hard copy
21. n/a
22. n/a
23. n/a
24. n/a
25. n/a
26. n/a
27. hardcopy
28. n/a
29. no invoices donations only
30. n/a
31. hardcopy of invoice
32. n/a
33. hard copy sent
34. n/a

**Question 16.**

**Does your organization have fare boxes in any of its vehicles it uses for passenger transportation? If yes, does your organization use the fare box to track ridership?**

**Yes = 6 (18%); No = 24 (70%); Not Applicable or no answer = 4 (12%)**

**Note: Only one organization uses its fareboxes to track ridership.**

1. Yes, Yes
2. Yes, not fare box use counters
3. yes, don't use fare box to track ridership
4. no
5. yes, don't use fare box to track ridership
6. no
7. N/A
8. no
9. no
10. no
- 11.
12. no
13. no
14. no
15. no
16. yes, don't use fare box to track ridership
17. no
18. no
19. no
20. no
21. no
22. N/A
23. donation only
24. no
25. yes, don't use fare box to track ridership
26. no
27. no
28. no
29. no
30. no
31. no
32. no
33. no
34. no

**Question 17.**

**Does your organization have any other technology on the vehicles it uses for passenger transportation such as automated passenger counters, automatic vehicle location systems, etc.? If so, please describe the technology or technologies.**

**No = 26 (76%); Not Applicable = 4 (12%); Other technologies = 4 (12%)**

1. Auto announces some vehicles are equipped for AVL but that function/equipment not purchased.
2. no
3. AVL systems on all of the Para transit vans to track vehicle location and aid in dispatching.
4. driver carries a personal GPS receiver that he uses to collect data on each trip, download and merge with a maps program and prints out a map of each trip with all the stop-to be used for future route planning.
5. no
6. no
7. N/A
8. no
9. no
10. no
11. no
12. no
13. no
14. 2-way radio from driver to dispatcher
15. no
16. no
17. no
18. no
19. no
20. no
21. N/A
22. n/a
23. n/a
24. no
25. no
26. no
27. no
28. no
29. no
30. no
31. no
32. no
33. no
34. no



**Question 18**

**When your organization tracks ridership, does it use spreadsheets or other computerized, electronic methods for tracking ridership? If so, please explain the methods (system) used.**

**No (or blank) = 17 (50%); Excel Spreadsheets = 16 (47%); MDT Forms = 1 (3%)**

1. spreadsheets to track ridership by day, month, and year. The spread sheet also allows ability to create specific reports.
2. Excel Spread sheets
3. Excel Spread sheets
4. no
5. Excel Spread sheets
6. Excel Spread sheets
7. Excel Spread sheets
8. Excel Spread sheets
9. Excel Spread sheets
- 10.
11. no
- 12.
13. Excel Spread sheets
14. Excel Spread sheets
15. no
16. no
17. Excel Spread sheets
18. Excel Spread sheets
19. Excel Spread sheets
20. no
21. no
22. forms from MDT
23. no
24. Excel Spread sheets
25. Excel Spread sheets, driver tallies ridership
26. no
27. no
28. no
29. no
30. no
31. no
32. no
33. Excel Spread sheets
34. no

**Question 19**

**Describe any other systems or technologies your organization uses in the process of carrying passengers, including tracking expenses, invoicing, reporting, etc.**

**Not Applicable = 25 (73%); Quicken/QuickBooks = 4 (12%); Excel Spreadsheets = 1 (3%)  
Other = 4 (12%)**

1. n/a
2. computer
3. n/a
4. n/a
5. n/a
6. n/a
7. QuickBooks is used to prepare invoices and track expenses and revenue. Excel and lotus to prepare daily trip sheets/manifest.
8. n/a
9. Quicken
10. n/a
11. Excel spreadsheets
12. QuickBooks is used to track expenses.
13. we are physically responsible to DDP, but now report to TAC as well all expenses, ridership totals ect.
14. Automatic chair lifts for the disabled
15. n/a
16. n/a
17. n/a
18. n/a
19. n/a
20. QuickBooks is used to prepare invoices and track expenses and revenue.
21. n/a
22. n/a
23. n/a
24. n/a
25. n/a
26. n/a
27. n/a
28. n/a
29. n/a
30. n/a
31. Accounting system utilized for paying expenses, tracking budget. Reports completed online after manual tracking.
32. n/a
33. n/a
34. n/a

**Follow-up question**

As noted in the document, a follow-up question was sent (via e-mail) to those who had responded to the initial survey. The text of the e-mail is as follows:

First, I would like to thank you for taking the time to complete the Automated Cost Recovery Organizational Survey that was sent to you a few months ago. As we finalize the project, I realized there was one bit of information I forgot to inquire about in the survey. That is the reason for this follow-up e-mail.

I need to know the amount of time your organization spends (either on a daily, weekly or monthly basis) tracking ridership and fares/payments on your transportation (transit) system. You can lump both (ridership and fares/payments) together, or list them separately.

For example, you can respond: "1 hour per day on ridership, and 1 hour per day on fares/payments" or you could respond, "40 hours per month on ridership and fares". For transportation (transit) systems with both fixed route and demand responsive services, I am looking for the hours you spend on both services (fixed route and demand response combined).

Thank you for your response to the previous survey, and thank you for responding to this e-mail.

A total of three follow-up e-mails were sent. However, only the following ten responses were obtained:

1. 35 hours per month fixed route, 9 hours per month demand response. (528 hours/year)
2. 1 hour per day, total. (250 hours/year)
3. Drivers and dispatchers, approximately 5 hours per day. (1,250 hours/year)
4. Drivers and dispatchers, about 2 hours per day. (500 hours/year)
5. 1 hour per week on ridership, 1 hour per week on payments. (104 hours/year)
6. 7 hours per month on ridership and fares. (84 hours/year)
7. 10 hours per month, total. (120 hours/year)
8. 10-15 hours per month. (120-180 hours/year)
9. 2 hours per month, total. (24 hours/year)
10. 10 hours per month, ridership and fares/payments. (120 hours/year)

Note: for purposes of the benefit/cost analysis, it is assumed that there are a total of 250 service days for the transit agencies. The annualized totals (for analysis purposes) are shown after the response.

**APPENDIX C: MOBILE DATA COMPUTER INFORMATION**

The following information was provided by Mentor Engineering (Calgary, Alberta, Canada). It is provided for informational purposes only and should not be considered an endorsement of Mentor Engineering.

# OneSTOP Shopping

MENTOR ENGINEERING'S MOBILE DATA COMPUTER (MDC) is an easily customized vehicle-mounted device that increases the efficiency and productivity of fleet operations. Installed in over 9 countries and 12 industries worldwide, the MDC helps organizations improve response times, decrease operating costs, automate data collection, reduce paperwork and increase overall customer service.



The MDC eliminates the need to purchase multiple devices by incorporating numerous features into a single unit.



## Built to Work

Unlike consumer products such as cell phones and PDAs, the MDC is specifically built to work in the ever-changing fleet environment. Its rugged ABS enclosure and high resistance to temperature and humidity fluctuations make it ideal for vehicle use.



### Safety and Security

The MDC offers an emergency button and optional covert microphone to increase driver and passenger safety. If a problem arises, the driver simply hits the emergency button, and dispatch is notified immediately. With GPS, dispatch can instantly track the vehicle and send help to its precise location.

### Customizable & Flexible

The MDC can be tailored to meet the unique needs of a business. Mentor's engineers will build specific functionality into your system so it works for you. The MDC's multiple inputs and outputs can interface to odometers and other vehicle telemetry (J1708). In addition, it supports numerous peripherals for added functionality.

### Convenience

In-vehicle financial transactions are possible with the MDC's built-in magnetic stripe card reader. Automatic credit card authorization reduces the amount of cash in the vehicle and provides customers a convenient payment option. The MDC's built-in smart card reader allows for quick and easy driver and passenger identification.

### Efficiency

The MDC's automatic data collection feature helps generate a variety of reports to monitor an operation more thoroughly. Previously, drivers filled out manual logs, noting pick-up and drop-off times, mileage, fares and breaks. The MDC does that work and more with the push of a button. The information is then sent in real time to the office, saving manual re-entry time and reducing the possibility of human error.

### Scalability

Mentor offers a complete line of wireless data products in addition to the MDC. That means you can enhance your system by increasing its level of sophistication. Add Mentor Ranger,<sup>®</sup> our rugged, fixed-mount computer, or Stryder,<sup>®</sup> Mentor's rugged, portable tablet computer, to optimize functionality.

### GPS Capability

- **GeoOdometer** automatically calculates vehicle mileage between events like pick-ups and drop-off
- **GeoGuide** points drivers in the right direction and keeps them on course
- **GeoZone** automatically triggers an action (e.g. send odometer and GPS reading) when vehicles enter or leave zones that are pre-defined and programmed into the MDC
- **GeoTarget** automatically triggers an action (e.g. pop up driver message) when a vehicle arrives at, or departs from, a particular geo-coordinate
- **GeoBid** provides drivers the opportunity to bid on fares within their geographic territory

### Supported Peripherals

- Keyboard
- Odometer
- Passenger Counter
- Electronic Fare System
- Smart Card Reader
- Printer
- LED Sign
- Voice Annunciator
- Bar Code Reader
- ...And More

## Technical Specs

- 240 x 64 transfective backlit graphical LCD display with adjustable contrast, scrolling capability and adjustable font size
- Keypad with adjustable backlighting, audible and tactile feedback
- Rugged ABS enclosure
- Optional internal 16-channel GPS receiver for Automatic Vehicle Location (AVL)
- Internal smart card reader/writer and magnetic stripe (e.g. credit or debit) card reader
- Optional PCMCIA slot for increased data storage and reprogramming
- Multiple I/Os: supports a variety of peripherals
- Emergency key and optional covert microphone
- Field programmable: software upgrades can be added to the system without removing the MDC from the vehicle
- Integrated public data or RF modem (optional)
- Optional integrated taximeter
- Size: 8.25" x 3.5" x 2" (210 mm x 89 mm x 50 mm)

Mentor Engineering Inc. reserves the right to modify these specifications and components without notice.



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## Sleeker Faster Stronger

Ranger, Mentor's latest and most technologically advanced mobile computer, sets new standards for enterprise-specific, fixed-mount wireless solutions. Mentor Ranger facilitates fast, reliable, and secure communication between drivers and dispatch. This Windows CE computer is rugged, exceptionally powerful and loaded with unbeatable functionality. Yet, despite its many capabilities, Ranger is small enough to easily fit into any vehicle. Built and tested to withstand harsh vehicle environments, Ranger will perform reliably year after year.

Sleeker, faster, stronger and smaller, Ranger is one of a handful of new-era wireless computers on the market. But, unlike most in its class, Ranger already has in-field experience, serving the EMS, fixed route, demand response, taxi and emergency roadside service industries. With Ranger, clients gain improved response times, operational efficiencies, and driver safety—benefits integral to the sophisticated fleet management processes Ranger supports.

Introducing **Ranger**<sup>®</sup>



64 MB SDRAM  
 Intel® XScale™ 400 MHz Processor  
 Windows CE  
 Internal GPS (optional)  
 Smart Card Reader  
 Internal Wireless Modem  
 6.4" VGA TFT Backlit Color Display & Touchscreen  
 Audio Inputs/Outputs  
 USB Ports (1 host\*, 1 device)  
 Integrated Taximeter (optional)  
 Type 2 Compact Flash Socket (optional)  
 Stereo Speakers  
 64 MB FLASH  
 Odometer and 2 Vehicle I/O's  
 Covert Microphone

\* Presently no support for Isochronous transfers



## End-to-End Wireless Data Solution

Whether your fleet consists of five or 5000 vehicles, Ranger is built to meet your performance requirements. From drivers to dispatch, Ranger helps to ensure your fleet is always connected by allowing access to a wide range of Windows CE applications and providing developers with tools to write software customized to your operation, as well as supporting third-party, industry-specific software.



### In the Vehicle

#### Onboard Navigation

Ranger offers complete onboard navigation tools and supports the latest mapping software. Using either the integrated or external GPS receiver, drivers can easily navigate to their next job with turn-by-turn prompts.

#### Real-time Communication

Paper processes to complete jobs and distribute work schedules, which can result in lost information, confusion and disorganization, become a thing of the past. Ranger replaces this with convenient, real-time electronic communication.

#### Instant Identification

Ranger has a built-in smart card reader and optional magnetic stripe card swipe that offer a simple and secure form of driver and customer identification, and facilitate on-the-spot financial transactions. Both card readers are integrated with Ranger so clutter in the vehicle is kept to a minimum.

#### Easy Viewing

The entire Ranger unit measures little more than 8 x 5 inches, and text is clearly viewed on Ranger's full-color, high-resolution VGA TFT backlit touchscreen display (5.25 x 4 inches). In addition, backlighting ensures screen viewing in a variety of lighting conditions.

### At the Office

#### Computer Aided Dispatch (CAD)

With Ranger, driver schedules, forms, reports and other documents are generated, processed and shared electronically. Dispatchers can generate a driver's daily schedule and instantly send it to the in-vehicle computer.

#### Automatic Vehicle Location (AVL)

With AVL capabilities, Ranger empowers dispatchers with the ability to identify the location and status of each vehicle in their care. When a job comes into the dispatch center, dispatchers can see the whereabouts and status of their drivers and send the appropriate vehicle to a job, dramatically improving response times.

#### Seamless Upgrade

Mentor offers a complete line of mobile data products. If, for example, you are currently operating with Mentor's MDC and wish to upgrade to Ranger, Mentor can provide a convenient upgrade path. In addition, Mentor strives to make all of its products both forward and backward compatible. As your communication needs grow and change, so does your mobile computing solution, easily,

efficiently and economically. Mentor will work to configure its products to work with those technologies that already exist, reducing your costs.

### BBX and XGate

Combine Ranger with Mentor's other mobile products such as BBX for expanded functionality. BBX is a wireless modem/AVL/telematic data collection device with a 16-channel GPS receiver. Or utilize Mentor's XGate middleware—software that connects your Ranger units and host application software by way of virtually any wireless data network for the ultimate in network versatility.

### Technical Specs

- Windows CE operating system
- Intel XScale 400 MHz processor
- Memory: 512Mb of SDRAM (64MB) / 512Mb of FLASH (64MB)
- Size: 8.3" x 5.5" x 1.6" (210mm x 140 mm x 40 mm)
- Multiple I/Os and connection ports
- 6.4" VGA TFT full-color display (640 x 480)
- Internal ISO 7816 smart card reader
- Microphone & stereo speakers
- Type 2 compact flash socket
- Audio inputs/outputs
- Wireless connections: 802.11b capable
- Internal 16-channel GPS receiver (optional)
- Integrated taximeter (optional)



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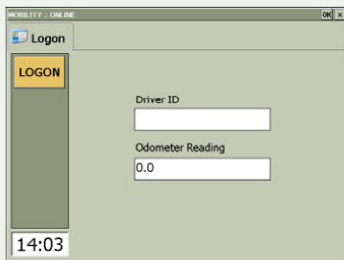


# Mentor's CE Application for Demand Response Transit

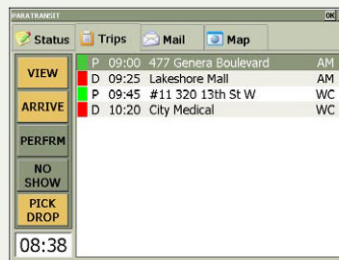


Mentor Engineering has developed a demand response application to run on its Windows CE product line. The application takes advantage of Mentor's years of experience developing mobile software for transit organizations. Features include in-vehicle mapping and navigation, color-coded trip manifests, and pop-up windows for messages requiring prompt attention.

What follows are sample screenshots from this application:



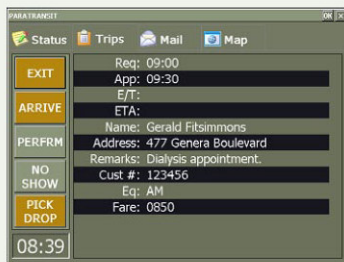
Driver Logon



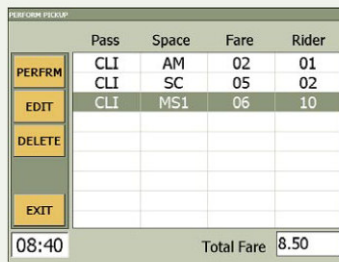
Trip Manifest



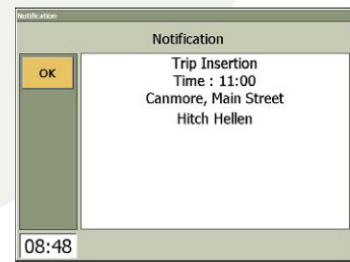
Trip Details



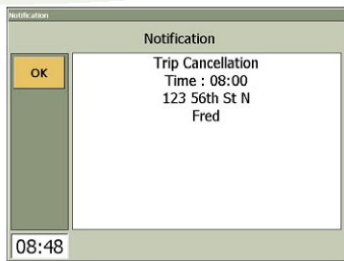
Night Screen



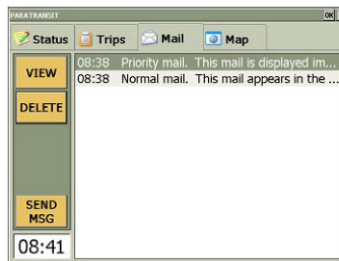
Client Fare Collection



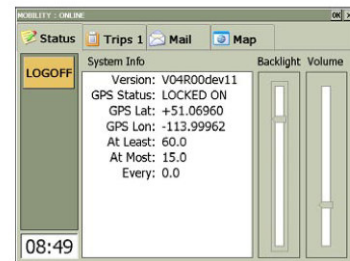
Trip Additions



Trip Cancellations



Mail List



Driver Logoff

## **APPENDIX D: BILLINGS MET ROUTEMATCH REPORT**

Following is a report that was prepared for Billings MET Transit in relation to its implementation of RouteMatch software in its MET Special Transit (demand response) service. The report highlights a cost/benefit analysis of the RouteMatch software. While it doesn't focus specifically on fare collection and reporting, it does discuss the ability of the software to reduce the number of hours (and/or miles) that vehicles travel, thus reducing the cost of providing transportation services.

# **An Evaluation of RouteMatch Software in the Billings MET Special Transit System**

By

David Kack, Research Associate

and

Deepu Philip, Graduate Research Assistant

Of

Western Transportation Institute

College of Engineering

Montana State University - Bozeman

**May 2, 2007**

## EXECUTIVE SUMMARY

In 2003, MET Transit in Billings, Montana was notified that the Mobility Master software it was using for its MET Special Transit (MST) service would no longer be supported, and wanted to research alternative software solutions. MET Transit contracted with the Western Transportation Institute to assist in an analysis of the technology currently used in MST, MET Transit's paratransit operations.

In addition to the software analysis, MST asked WTI to review the benefits of adding automatic vehicle location (AVL) and Mobile Data Communications (MDC). To review the benefits of these additional technologies, the Western Transportation Institute performed a literature review and incorporated those findings into a report for MET Transit [1].

Subsequently, the City of Billings developed a Request for Proposals, and ultimately selected RouteMatch Software. Both MET Transit and RouteMatch Software were interested in evaluating the effect the new software would have on the system. The Western Transportation Institute (WTI) performed an evaluation that looked at both quantitative factors (rides per mile, rides per hour, on-time performance) as well as qualitative factors (surveys of the drivers and dispatchers).

For the evaluation, researchers compared three months (July, August and September) in 2005 with the same three months in 2006, roughly six months after the RouteMatch software was installed. They believed that it was necessary to have comparison data that would show the impact of the software, and decided that after six months of using the new RouteMatch software, the dispatchers should be proficient with the system.

The results indicate that MET Special Transit operations were more efficient after the software was installed. This conclusion is based on data that the rides per mile and rides per hour were higher during the three-month evaluation period for 2006. However, researchers did not have enough data on cost parameters (fuel, insurance costs, etc.) to conduct a definitive analysis of whether or not the RouteMatch software had a positive benefit to cost ratio ("paid for itself").

A break-even analysis, however, did indicate that only a slight gain in efficiency could lead to a positive benefit/cost ratio. The data shows that if the cost of the hardware and software is amortized over a five-year period, and taking into account the annual maintenance fees, MET Special Transit (MST) would only need to decrease mileage and/or hours by approximately three percent for the software to have a positive cost savings for the organization. This is a relatively modest gain in efficiency. As indicated within this report, these appear to be achievable goals.

One item to note about the gains in efficiency is that during the time the RouteMatch software was being used, the MST dispatchers did not use the RouteMatch Scheduling Engine (RSE) function of the software. The RouteMatch Scheduling Engine component is the function that can be utilized to maximize the efficiency of the transportation (transit) service. One hypothesis of why MET Special Transit did not use the RSE is that MST has many contracts with various agencies to provide rides, and was already very efficient at grouping these rides. Therefore, a transportation agency that schedules more individual rides may see a greater benefit from using RouteMatch software, than was experienced by MET Transit.

The analysis of pick up and drop off times indicated that slightly fewer pick ups were made within the 30 minute window established by MET Transit when the RouteMatch software was in

use (84.5 percent in 2006, versus 87.5 percent in 2005). In 2006, slightly more drop offs were made within 15 minutes (plus or minus) of the scheduled time (84.5 percent in 2006 versus 79.8 percent in 2005) with the use of RouteMatch software.

One hypothesis on the differences in the pick up and drop off times is that the RouteMatch software is creating a more “normal” distribution of the times, whereas when the Mobility Master software was being used, and the rides were being scheduled manually, the dispatchers may have provided extra time between origins and destinations, leading to the drop off times being closer to scheduled times.

While a definitive benefit/costs analysis could not be conducted to determine if the RouteMatch Software paid for itself, as indicated by this review, it does appear that only a minor gain in efficiency is necessary for the RouteMatch software to pay for itself (reach the break-even point). The data herein, and previous national studies, indicated that these gains in efficiency are achievable.

## INTRODUCTION

Billings MET Special Transit (MST) is a paratransit service that operates within the Billings, Montana city limits. Service is available between the hours of 6:30 a.m. and 6:00 p.m. during the weekdays, and between 9:00 a.m. and 5:30 p.m. on Saturdays. The service is offered to persons who qualify as ADA Paratransit eligible.

On average, MST provides 250 to 300 rides on a typical day. Approximately half of these rides are subscription rides, meaning the same rides occur at the same time each day. Currently, these rides are all assigned to a specific route. MST has 15 paratransit vehicles at its disposal. Typically, half of these are out at any particular time, and on busy days, as many as 12 vehicles may be in service. The number of vehicles in service is a function of the number of ride requests, the time of day, and the geographic location of origins and destinations.

In order to handle ride requests, MST has two dispatchers available throughout the week between the hours of 7:00 a.m. and 5:00 p.m. and a third person that can dispatch as needed. In order to schedule a ride, an individual must call in a ride request at least 24 hours in advance. The individual cannot schedule a ride more than two weeks in advance. Same day ride requests are scheduled only if time in the current manifests permits.

The process of receiving, scheduling and dispatching rides is a complicated process. For MST it was even more difficult, because the dispatcher was doing the scheduling with no support from the software. MST was using Mobility Master software, which was not working properly, and very little technical support was offered. In fact, MST learned that by the end of 2003, no more support would be provided for the software.

The difficulty with manual dispatching, especially when dealing with more than three or four vehicles, is that the dispatcher/scheduler needs to know where the vehicles are, the current load of the vehicle, and whether the vehicle can handle dropping off the passengers by the required time. This process is typically much more efficient when dispatchers can use Computer Aided Scheduling and Dispatching (CASD) software.

MET Transit contracted with the Western Transportation Institute (WTI) to conduct research to determine the potential benefits of Computer Aided Scheduling and Dispatching software, and other technologies, such as Automated Vehicle Location (AVL) and Mobile Data Communications (MDC). WTI presented its findings to MET Transit [1] and based on the information, Billings MET Transit decided to purchase a new software system for their paratransit service MST.

Subsequently, MET Transit contracted with WTI to assist in writing a Request for Proposals (RFP), which was used to select a software vendor. The RFP was completed and RouteMatch was selected as the software vendor. RouteMatch Software is headquartered in Atlanta, Georgia, with seven additional offices across the U.S. and comprises a team of software engineers, Internet technologists, computer scientists, management information experts, database management professionals, and transportation consultants. RouteMatch provides solutions for demand responsive and fixed route systems, and partners with other vendors to provide additional components (applications) including AVL and MDT/MDC. More information about RouteMatch can be found at [www.routematch.com](http://www.routematch.com).

Both MET Transit and RouteMatch were interested in knowing the impact of the new RouteMatch software on the operations of MET Special Transit. While research has shown benefits of using Computer Aided Scheduling and Dispatching software [2,3,4], and RouteMatch has issued case studies highlighting the benefits of their software, there are relatively few cases where the switch to a new software system has been independently evaluated. With the opportunity presented in Billings, RouteMatch contracted with the Western Transportation Institute to conduct an independent evaluation of the effects of its software on the Billings MET Special Transit (MST) system.

The remainder of this document provides an overview of Computer Aided Scheduling and Dispatching software, and other related technologies; the evaluation of the RouteMatch software in Billings, and conclusions from the evaluation.

## PUBLIC TRANSPORTATION TECHNOLOGIES

MET Transit was interested in exploring three primary technologies: computer-assisted scheduling and dispatching software (CASD), automatic vehicle location (AVL), and mobile data communications (MDC) technologies.

### Technology Overview

Advances in technology along with federal and state transportation initiatives in the United States 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 advanced communication technologies. Computer-assisted scheduling and dispatching (CASD) 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 [2].

While Computer-assisted scheduling and dispatching software on its own has the potential to improve the efficiency of paratransit operations, many transportation providers are also adding AVL and MDC technologies. The now common use of global position satellite (GPS) technology has further increased the use of AVL/MDC technologies [3]. The AVL/MDC technologies interface with CASD to provide a powerful tool to increase the efficiency of a transportation provider.

### Software

Computer-assisted scheduling and dispatching (CASD) software is used to assign demand-responsive transit customers to vehicles. The software makes recommendations, in either real-time or batch processing mode, on which vehicle run to place a requested trip. The software may use Geographic Information Systems to map the source and destination address for making recommendations [3].

Because it is difficult for a human mind to keep track of more than about three vehicles at a time, the CASD software is valuable in providing an initial solution. The dispatcher can then review the manifests (schedule) and make any changes necessary. CASD can be a powerful tool for increasing a transportation provider's efficiency.

In Santa Clara County, California, a paratransit operator, OUTREACH, utilized CASD software and was able to reduce its number of vehicles in service from 200 to 130. Using CASD software, the Winston-Salem Transit Authority was able to reduce its operating cost per vehicle-mile 8.5% and its operating cost per passenger 2.4% [4].

By utilizing new CASD software, it was anticipated that MET Transit should be able to increase its efficiency, allowing more clients to be served for the same operational budget. When tied to other technologies, such as automatic vehicle location (AVL) and mobile data communications (MDC), it was believed that further benefits would be achieved.

## Other Technologies

While computer-assisted scheduling and dispatching software is a powerful tool alone, utilizing it in conjunction with automatic vehicle location and mobile data communications expands the power of the software.

Automatic vehicle location (AVL) technologies measure the real-time location of vehicles using onboard computers and a positioning system (such as a global positioning system) and relay this information to a central location (such as the dispatching office). With an AVL system, the dispatcher, or CASD software, knows the exact position of each paratransit vehicle and can use that information to assign a ride (such as a “will call” or same day request) to the nearest vehicle.

When changes are made to the schedule, or ride requests are processed, agencies typically use a radio to notify drivers of the change. However, many agencies are now using mobile data communications to relay this information between the drivers and the dispatching center. Mobile data communications (MDC) are accomplished by providing a link between the dispatch center and the paratransit vehicle, equipped with a mobile data terminal (MDT).

Mobile data terminals are small computer terminals in the vehicle that allow a driver to receive and send text and numerical data by radio signal. This communication system, when tied into an AVL and CASD software package, allows the dispatcher to make changes to schedules and relay those changes without making a radio call. Further, by monitoring the progress of the schedules, the CASD/AVL/MDC system can alert the dispatcher if any of the paratransit vehicles are falling behind schedule, and can provide recommendations for shifting rides to other vehicles.

While each of the technologies, CASD, AVL and MDC, provide a unique advantage, the technologies are most effective when they are combined. It was recommended that if MET Transit pursues new technologies that it should invest in all three of the above noted systems. As of the writing of this report, MET Special Transit is using the RouteMatch software with Automatic Vehicle Location technology. MET Transit hopes to invest in Mobile Data Communications when it can secure additional funding.



## EVALUATION

The focus of this project was to evaluate the effect, if any, that the introduction of RouteMatch software had on the service provided by MET Special Transit (MST). The analysis procedure is summarized as follows:

- An initial set of data was collected for the months of July, August and September in Year 2005, which is before the purchase and installation of the software.
- An analysis was performed on the data so that performance measures (benchmarks) were established.
- A second set of data was collected for the same three month period in 2006, which is approximately six months after the installation of the software.
- A data analysis was performed on the 2006 set of data.
- The values (two sets of data) were compared to each other to determine the effect of the software.

It should be noted that during the period of this analysis that the dispatchers at MET Special Transit did not use the RouteMatch Scheduling Engine (RSE) that is part of the RouteMatch Software. RSE is typically used to optimize the schedule (manifest) for the demand-responsive service. One reason given for not using RouteMatch Scheduling Engine was that many of the rides provided for by MST are already grouped, and that using RSE would not lead to any significant improvements in the schedule. This is discussed in more detail later in this section.

### Performance Measures

Demand responsive transportation systems such as MST are judged (measured) by different people on different parameters. Administration/management typically looks at parameters (“measures of effectiveness” or “MOEs”) such as the cost per ride, rides per hour and rides per mile. Dispatchers and drivers may use more subjective parameters, such as the ease of creating and/or driving the schedule (based on the manifest). Riders use both subjective and objective measures, such as the timeliness of the pick up and drop off times, as well as how long they are on the vehicle.

In this project, we considered both the objective and subjective measurements. However the only measurement with a passenger’s perspective is the timeliness of the pick up and/or drop off. All other measurements are based on MET Transit’s perspective, including both the administration/management and dispatch/driver perspectives.

The specific measures of effectiveness used in the evaluation include:

- Rides per mile
- Rides per hour
- Cost per ride
- Pick up time performance
- Drop off time performance
- Survey results from the dispatchers
- Survey results from the drivers

In evaluating the RouteMatch software, an attempt has been made to account for all of the extraneous variables, to the maximum extent possible. This allows for a true accounting/analysis of the impact the software has had on MST operations. The following sections provide an explanation of these measures, and the results from the evaluation.

### **Rides per Mile/Rides per Hour**

The rides per mile and rides per hour measures are used to determine how efficiently the service is being operated. An inefficient service would have very few rides per hour or rides per mile. Both of these factors can be influenced by the size of the area a transportation provider services. For example, if a provider typically travels 20-30 miles to get one rider, their rides per mile may be significantly lower than a provider who travels only 5-10 miles to pick up riders.

However, by efficiently scheduling and dispatching rides, a transportation provider can “group” more rides on each vehicle, and be more productive with assets (vehicles and drivers). As previously noted, some transportation systems have been able to decrease the number of vehicles in service by 35 percent by being more efficient in their scheduling, primarily by using computer aided scheduling and dispatching software [4].

Table D-1 shows the rides, hours and mileage for the July-September period in 2005 and 2006 that are used for this report. Table D-2 and Table D-3 show the differences in the rides per hour and rides per mile for MST, before (2005) and after (2006) the use of the RouteMatch software. The full data used for this comparison is shown in Appendix A.

**Table D-1: 2005-2006 Data**

	2005	2006	Difference	Percentage
Rides	17,007	16,097	-910	-5.35%
Hours	4,790	4,241	-549	-11.46%
Mileage	54,742	50,566	-4,176	-7.63%

**Table D-2: MST Rides per Hour**

Month	2005	2006	Difference	Percentage
July	3.56	3.70	0.14	3.93%
August	3.55	3.85	0.30	8.45%
September	3.54	3.83	0.29	8.19%
3-month avg.	3.55	3.80	0.25	7.04%

**Table D-3: MST Rides per Mile**

Month	2005	2006	Difference	Percentage
July	0.31	0.32	0.01	3.23%
August	0.31	0.32	0.01	3.23%
September	0.31	0.32	0.01	3.23%
3-month avg.	0.31	0.32	0.01	3.23%

Table D-1 indicates that while fewer rides were provided during the July-September period in 2006, the hours and mileage decreased at a greater rate during this time period. Table D-2 and Table D-3 highlight an increase in efficiency as the rides provided on a per mile and per hour basis were slightly higher when the RouteMatch software was in use. However, it is important to note that the Route Schedule Engine (RSE) portion of the RouteMatch software was not being utilized during this time. It is unclear, therefore, what caused the changes in these metrics.

### Cost per Ride

The cost per ride is another measure of efficiency and system performance. For example, if it costs a transportation system \$500,000 to provide paratransit service, and a total of 100,000 rides are provided, the cost per ride is five dollars (\$5) or  $\$500,000/100,000=\$5$ .

It is important to note that the cost per ride may increase, without any service changes in a transportation system. For example, if the paratransit system's insurance increased by \$10,000 per year, the total cost for providing the service would increase to \$510,000. Based on this information, the cost per ride would increase to five dollars and ten cents (\$5.10). Therefore, when the cost per ride increases (or decreases), it is always important to analyze why the change occurred. Unfortunately, not enough data was available to account for variables such as fuel and insurance costs. MET Transit acknowledged that their fuel and insurance costs had increased, but they could not specify by how much. Therefore, the data was not available for a cost-per-ride comparison based on the introduction of RouteMatch Software for MET Special Transit.

However, a break-even analysis was conducted to determine how much would have to be saved on an annual basis to make the RouteMatch Software cost effective.

### Break-Even Analysis

MET Transit paid a total of \$83,575 for the RouteMatch Software, including the hardware necessary to operate the software. For the purpose of this analysis, it was calculated that the software and hardware will have a five-year lifespan. Based on this scenario, MET Transit would need to save approximately \$16,715 per year to reach the break-even point. However, there is a software maintenance fee of \$11,835 per year. When this maintenance fee is included with the amortized purchase price, a total of \$28,550 would need to be saved on an annual basis for the software to have a positive benefit/cost ratio.

Based on MET Special Transit's costs of \$55.22 per vehicle revenue hour, and \$4.81 per mile for 2005 (see Appendix A), MST would need to save approximately \$1.83 per hour, or \$0.16 per mile for a positive benefit/cost ratio for the software, with all other costs being equal (see below).

$$\$28,550 / 15,568 \text{ hours} = \$1.83 \text{ per hour (3.31\%)}$$

$$\$28,550 / 178,627 \text{ miles} = \$0.16 \text{ per mile (3.33\%)}$$

A second way to conduct this analysis is to include the \$28,550 annualized software cost into the total annual operating costs, and then determine the number of hours or miles that would need to be reduced to reach the break-even point. MET Transit's costs for its demand responsive service were \$859,612 in 2005. If the \$28,550 annual cost for the RouteMatch Software was added to the 2005 costs, a total of \$888,162 is used as a balance for calculating necessary savings. The following calculations yield the needed savings to achieve a break-even point:

$$\$888,162 / 15,568 \text{ hours} = \$57.05 \text{ per hour}$$

$$\$28,550 / \$57.05 \text{ per hour} = 500 \text{ hours (reduction to reach the break-even point)}$$

$$\$888,162 / 178,627 \text{ miles} = \$4.97 \text{ per mile}$$

$$\$28,550 / \$4.97 \text{ per mile} = 5,744 \text{ miles (reduction to reach the break-even point)}$$

The savings necessary in hours or miles to achieve a break-even point equate to a three percent reduction [500 hours / 15,568 hours = 3.2%; 5,744 miles / 178,627 miles = 3.2%]

As noted earlier in this document, transportation systems implementing computer-aided scheduling and dispatching systems have seen a significant increase in efficiency. While Billings MET Special Transit has been relatively efficient in that it has several contracts that allows the service to group rides, the data in Table 1, Table 2 and Table 3 indicate that MST was more efficient during the period analyzed when the RouteMatch software was being used. Because not enough cost factors such as fuel and insurance were tracked, it was not possible to determine the specific benefit/cost ratio.

As indicated in this analysis, however, only a relatively minor gain in efficiency is necessary to reach a break-even point for the software. A three percent reduction in mileage or revenue hours is all that is required for the software to “pay for itself.”

In addition to the RouteMatch Software, Billings MET Transit also spent approximately \$43,500 to add Automatic Vehicle Location (AVL) technology to its vehicles. This technology is a “stand alone” system, in that it was not required as part of the purchase and installation of the RouteMatch software. If the cost of the AVL system is amortized over a five-year period, and a analysis similar to the software costs is conducted, Billings MET Transit would need to reduce its mileage and/or revenue hours by approximately 0.9 percent (142 hours; 1,626 miles) for the AVL system to reach the break-even point.

Finally, the break-even analysis did not take into account additional benefits that may be achieved by using the RouteMatch software, such as a reduction in the amount of time it takes to compile reports about the transportation systems performance, or invoicing. A time study of the dispatchers/schedulers and paratransit managers would have been necessary to capture this data. Due to the time and budget of this project, the time study was not possible. Anecdotal evidence of an improvement in some of the areas can be captured through the surveys, however, which are noted later in this document.

## **Time Performance**

There are two times that concern a rider, when they are picked up and when they are dropped off. Some riders are more concerned with when they are picked up, while others focus on when they are dropped off. The transit agency tries to make sure that they pick up their clients as close to the scheduled time as possible, and drop the clients off in as timely a manner as possible.

In analyzing the time performance, it is also important to remember that while the dispatcher, utilizing the software, may create an efficient (timely) manifest, the drivers may chose to alter the manifest, or pick up and/or drop off clients in a different order than is indicated by the manifest. Further, weather and traffic conditions may warrant changing the order of the rides on the manifest. Therefore, while a change in scheduling and dispatching software can have a significant impact on the timeliness of a transit system, other factors, such as the drivers’ adherence to the manifest is also important to consider.

For this analysis, the data was reviewed and “outliers” were removed. Outliers are typically a function of how the software and/or the dispatchers/schedulers deal with “will call” rides. Will call rides are rides that do not have a specific time, typically a pick up time, associated with them. For instance, a rider may be dropped off at a doctors’ appointment, and then will call the transit agency when the appointment is done for a pick up. One agency may “guess” that the appointment will last an hour or hour and a half, and schedule the return ride based on that information, another agency may schedule the return ride for a 5:00 pm pick up and then revise that time once the rider calls.

Based on how will call rides are scheduled, the pick up and drop off time performance of a transit system may be skewed. That is why the data was reviewed and “cleaned” before the analysis was conducted. This is also why the number of pick up and drop off times are not exactly related to the total number of rides that are used in this document. In 2005, we analyzed

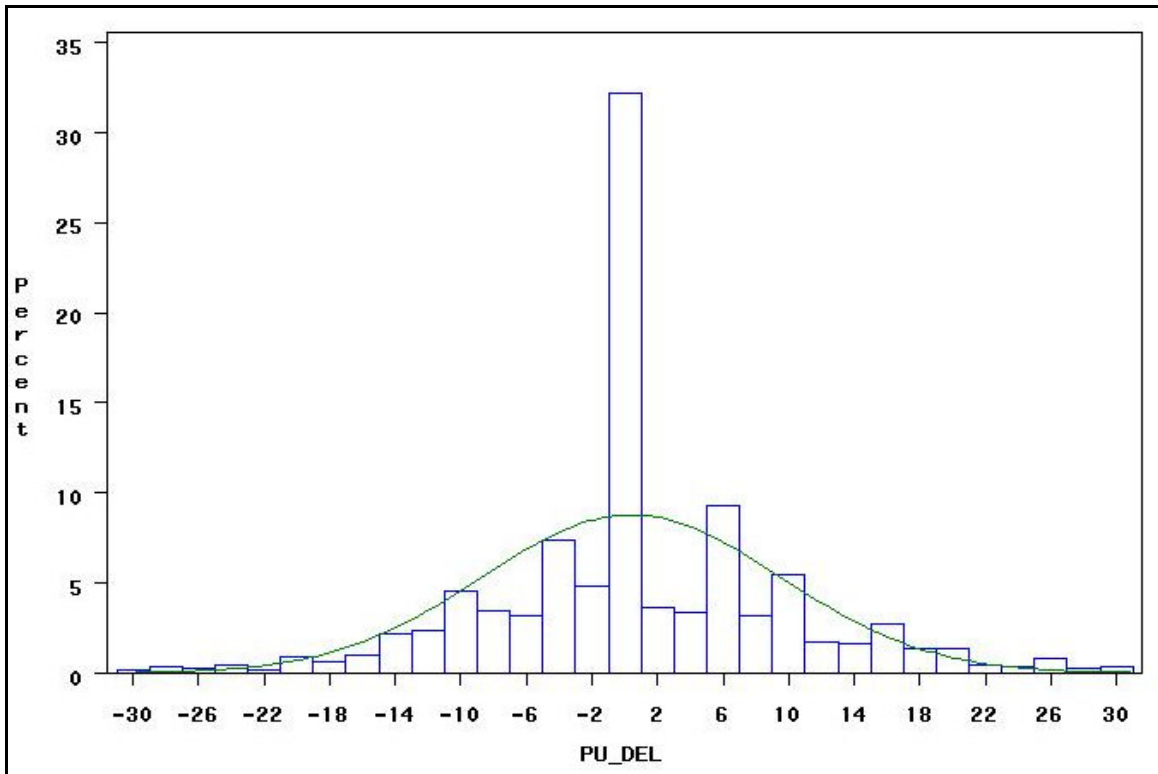
12,036 pick up and 11,842 drop off times, but noted 17,007 rides. In 2006, 13,647 pick up and 13,173 drop off times were analyzed and 16,097 rides noted.

From these figures it can be seen that cleaning the data leads to an unequal number of pick up and drop off times and rides (one pick up and one drop off would equal one ride). The ridership is also higher than the number of pick up and drop off times based on how attendants are scheduled. If a ride is scheduled for a client (one pick up and drop off time), but the client has an attendant, then two rides are provided for one pick up and drop off time. Therefore, the number of rides in this analysis is higher than the pick up and drop off times because of two factors, the “cleaning” of the data and the attendant rides. Additional information on the data can be found in Appendix D.

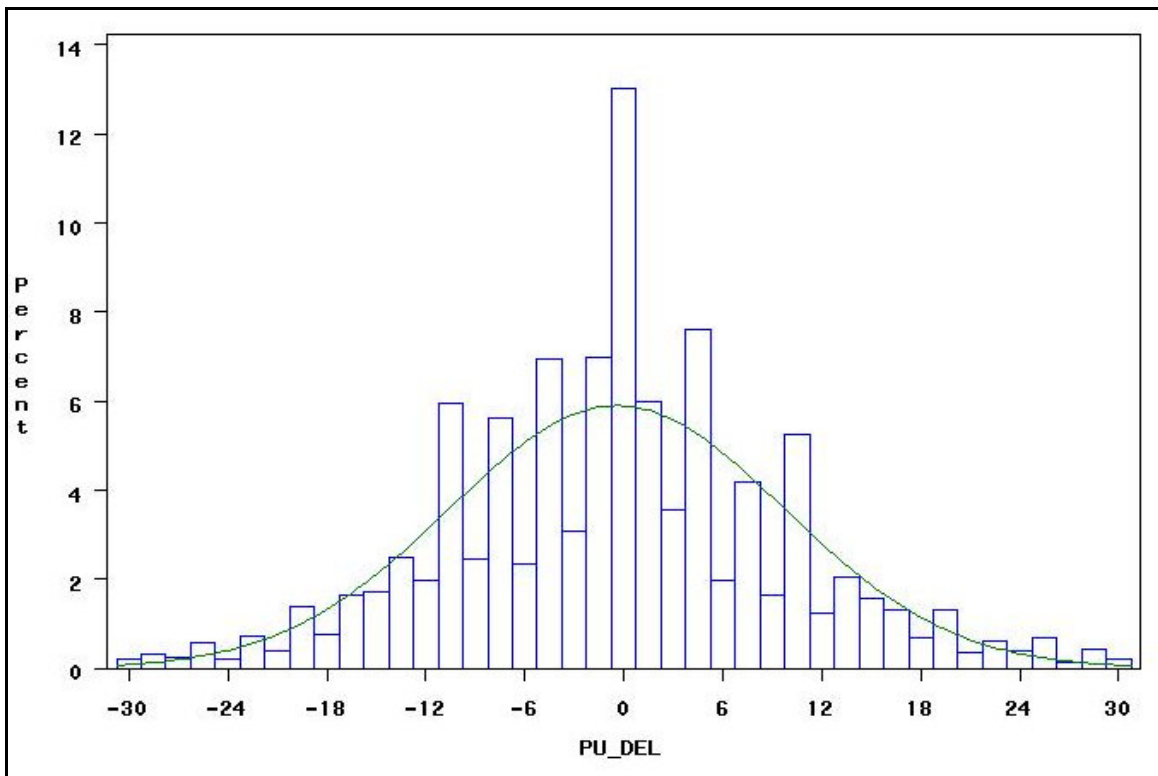
### Pick up Time Performance

While transportation providers make every effort to arrive as close to the scheduled pick up time as possible, the Federal Transit Administration and Americans with Disabilities Act provides for a thirty (30) minute “window” for the pick up time for paratransit passengers. Transit providers can set this window. Billings MET Special Transit (MST) uses a window of ten (10) minutes prior to, and twenty (20) minutes after the scheduled pick up time. For example, if a rider schedules a ride with a pick up time of 9:30 am, the vehicle may arrive (and the passenger needs to be ready) anytime from 9:20 am to 9:50 am. Further, an early pick up is desirable to passengers, as long as the vehicle does not arrive too early [5].

In order to evaluate the effectiveness of the RouteMatch software, the pick up times are evaluated using the “window” established by MST. Figure D-1 and Figure show the distribution of pick up times for the July-September periods for 2005 and 2006 that were analyzed for this report.



**Figure D-1: Distribution of pick up time deviations for 2005**



**Figure D-2: Distribution of pick up time deviation for 2006**

The pick up times were analyzed further, and that data is shown in Table D-4, Table D-5, and Table.

**Table D-4: Comparison of pick up times**

Pick up Time	2005		2006	
	count	percent	count	percent
More than 15 minutes early	700	5.80%	837	6.13%
11-15 minutes early	634	5.26%	874	6.40%
6-10 minutes early	1,163	9.64%	1,565	11.47%
0-5 minutes early	1,841	15.26%	2,342	17.16%
On time	3,685	30.55%	1,775	13.01%
0-5 minutes late	1,668	13.83%	2,321	17.01%
6-10 minutes late	1,237	10.25%	2,018	14.79%
11-15 minutes late	664	5.50%	1,050	7.69%
16-20 minutes late	295	2.45%	512	3.75%
more than 20 minutes late	176	1.46%	353	2.59%
<b>Totals</b>	<b>12,063</b>	<b>100.00%</b>	<b>13,647</b>	<b>100.00%</b>

**Table D-5: Summary statistics for early pick up times**

Statistical Measures	2005 (Min)	2006 (Min)
Number of Observations (N)	8,023	7,393
Sample Mean ( $\bar{x}$ )	4.9811	6.7047
Sample Median ( $\tilde{x}$ )	2.0	5.0
Standard Deviation (s)	6.5662	6.8584
Inter Quartile Range (IQR)	8.0	9.0

**Table D-6: Summary statistics for late pick up times**

Statistical Measures	2005 (Min)	2006 (Min)
Number of Observations (N)	7,725	8,029
Sample Mean ( $\bar{x}$ )	-4.5377	-6.8789
Sample Median ( $\tilde{x}$ )	-1.0	-5.0
Standard Deviation (s)	6.1565	6.59
Inter Quartile Range (IQR)	8.0	9.0

This data shows that in 2005, 87.5 percent of the pick ups were made within the “window” established by MET (10 minutes prior, and up to 20 minutes after the scheduled time). In 2006, 84.9 percent of pick up times were made within the window. Slightly more rides in 2006 were more than 10 minutes early compared to 2005, 12.5 percent versus 11.1 percent, but more pick ups in 2006 were also more than 20 minutes late, 2.6 percent, versus 1.5 percent in 2005.



This is further reflected in Table D-5 and Table, as we see the mean time for an early pick up increasing almost two minutes between 2005 and 2006 (5 minutes versus 6.7 minutes early), with a similar increase in late pick up times (4.5 minutes late versus 6.9 minutes late). The standard deviation for the pick up times also increased between 2005 and 2006, so the software may be causing more of a normal distribution in pick up times than was realized with the Mobility Master software, when rides were manually scheduled.

### Drop off Time Performance

As noted earlier, passengers sometimes focus on the pick up time and/or the drop off time. This section focuses on the drop off time performance of MET Special Transit, before and after the use of RouteMatch software. Unlike pick up times which have a “window” for use, drop off times are more dynamic.

For example, a customer may be picked-up five minutes early, and expect that they would be dropped-off five minutes early. However, they may end up being dropped-off ten minutes late. Also, customers may have an expectation that the transit service will take close to the same amount of time for a trip as would be expected in a car. Those who frequently ride a transit system, be it fixed route or demand-responsive, usually realize that it typically takes longer to cover the same distance (take a trip) on a transit system versus a car. With this being said, however, it is still important to analyze the changes in drop off time performance based on the change in software.

Figure D-3 and Figure D-4 show the distribution of drop off times before (2005) and after (2006) the implementation of the RouteMatch Software. Table D-7, Table 8 and Table D-9 show the drop off data and analysis.

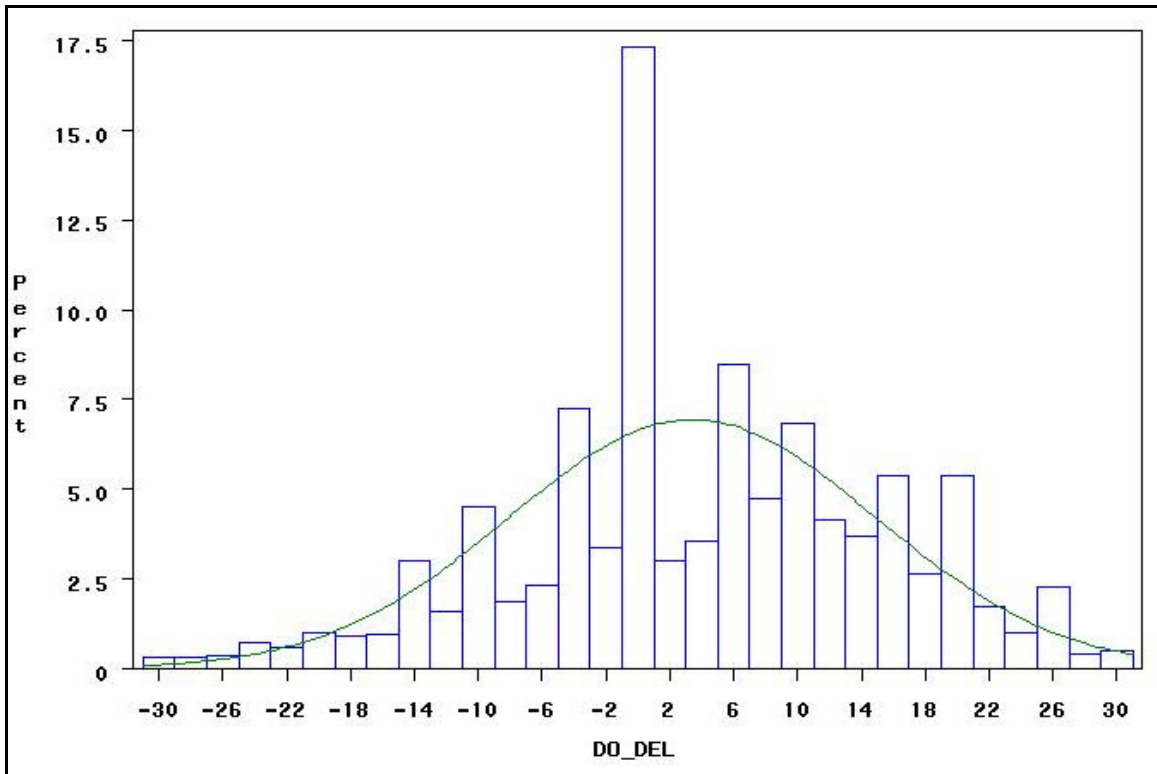


Figure D-3: Distribution of drop off time deviations for 2005

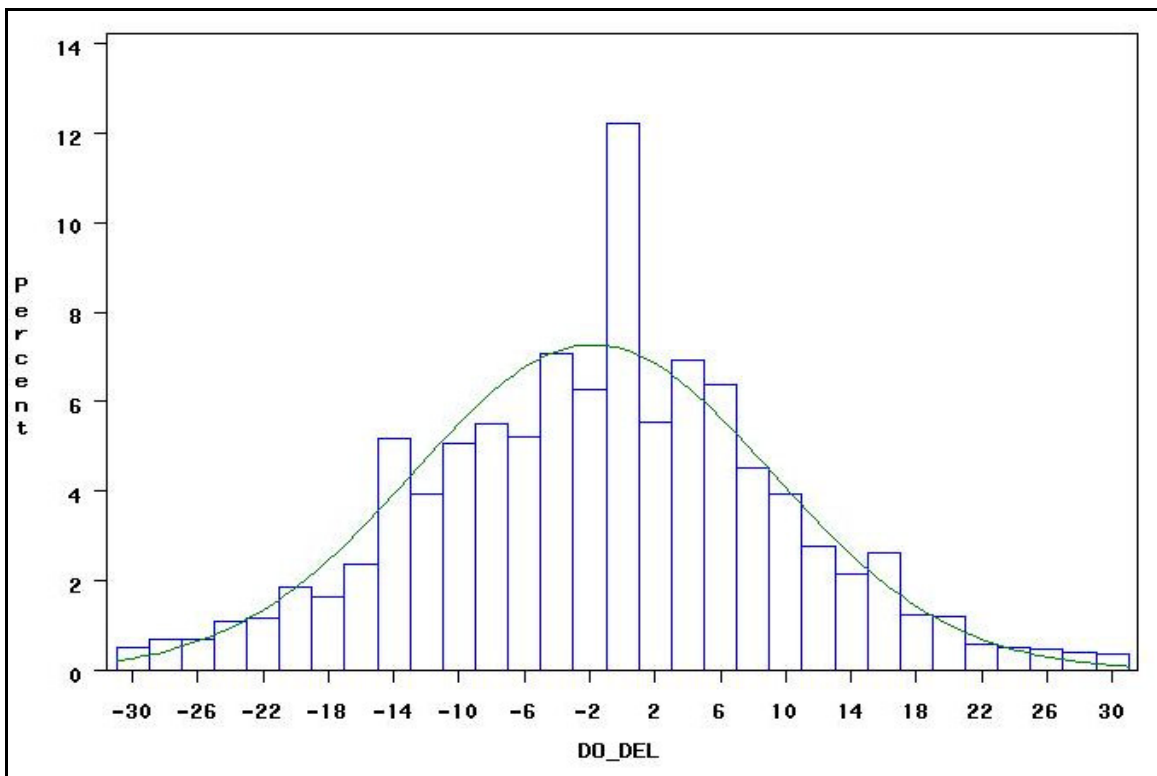


Figure D-4: Distribution of drop off time deviations for 2006

**Table D-7: Comparison of drop off times**

<b>Drop off Time</b>	<b>2005</b>		<b>2006</b>	
	count	percent	count	percent
More than 15 minutes early	1,783	15.06%	727	5.52%
11-15 minutes early	1,422	12.01%	895	6.79%
6-10 minutes early	1,565	13.22%	1,396	10.60%
.1-5 minutes early	1,584	13.38%	2,194	16.66%
On time	1,896	16.01%	1,151	8.74%
.1-5 minutes late	1,409	11.90%	2,220	16.85%
6-10 minutes late	936	7.90%	1,825	13.85%
11-15 minutes late	638	5.39%	1,449	11.00%
more than 15 minutes late	609	5.14%	1,316	9.99%
<b>Totals</b>	<b>11,842</b>	<b>100.00%</b>	<b>13,173</b>	<b>100.00%</b>

**Table D-8: Summary statistics for early drop off data for Billings MET Transit**

<b>Statistical Measures</b>	<b>2005 (Min)</b>	<b>2006 (Min)</b>
Number of Observations (N)	8,250	6,363
Sample Mean ( $\bar{x}$ )	9.1555	7.0773
Sample Median ( $\tilde{x}$ )	8.0	5.000
Standard Deviation (s)	7.8206	6.6799
Inter Quartile Range (IQR)	14.0	9.0

**Table D-9: Summary statistics for late drop off time for MET Transit data**

<b>Statistical Measures</b>	<b>2005 (Min)</b>	<b>2006 (Min)</b>
Number of Observations (N)	5,488	7,961
Sample Mean ( $\bar{x}$ )	-6.4133	-8.6376
Sample Median ( $\tilde{x}$ )	-5.0	-7.0
Standard Deviation (s)	7.1957	7.3709
Inter Quartile Range (IQR)	10.0	12.0

The data indicates that 79.8 percent of the drop offs in 2005 were on-time, or within 15 minutes on either side (early or late) of the scheduled drop off time. In 2006, this figure rose to 84.5 percent of drop off times. However, there was an increase in the percentage of drop offs between 2005 and 2006 that were more than 15 minutes late, 5 percent versus 10 percent.

The variance in early and late drop offs is also reflected in the data shown in Table 8 and Table D-9. The average early drop off time decreased almost two minutes between 2005 and 2006, 9.2 versus 7 minutes), and the standard deviation also decreased, by approximately 1.1 minutes. Late drop offs increased, however, as the time increased 2.2 minutes from 2005 to 2006 (6.4 versus 8.6 minutes), and the standard deviation increased, although very little (7.2 versus 7.4 minutes).

It is important to remember that the drop off time is typically a function of the software. Prior to implementation of RouteMatch, the dispatchers were manually scheduling rides, and may have allowed more time between origins and destinations. Therefore, more drop offs could have been early, or at least not as late, as when the RouteMatch software was scheduling the rides. While analyzing the pick up and drop off times is valuable, it is also valuable to determine the views of the people who are using the software, scheduling and dispatching the rides, and operating the vehicles. The following section reviews the surveys distributed to MST's drivers and dispatchers.

## Dispatcher and Driver Surveys

Two sets of surveys were distributed to both the dispatchers and drivers of MET Special Transit (MST). One set was distributed in December 2005 while the Mobility Master software was in use, and the second set of surveys was distributed while the RouteMatch software was in use (September 2006 for the drivers and April 2007 for the dispatchers). The survey instruments are shown in Appendix B. The questions for the two surveys (based on the software) were similar, so comparisons could be made. The comments of the dispatchers and drivers are summarized in this section, while the full comments can be found in Appendix C.

The survey administered to the dispatchers was used to determine their opinion on how much the software aided them with their duties. The first question of the survey used a seven-point scale (7=strongly agree, 1=strongly disagree) so the dispatchers could indicate how strongly they agreed the software aided them in various tasks they perform. MST has a total of three dispatchers, so therefore the responses of one dispatcher can have a significant influence on the mean score. It is also important to note that when the initial survey for the RouteMatch software was distributed in September 2006, one of the dispatchers was on maternity leave, and no surveys were returned. That is why a second attempt was made in April 2007 to have the dispatchers complete the survey, which they did. It is not known whether or not having the survey conducted at a later time had any influence on the results. The dispatchers' responses to the first question of the survey are shown in Table D-10.

**Table D-10: Dispatchers' Responses to Survey Question 1**

Question/Factor	Mobility Master Mean Score	RouteMatch Mean Score
a) The software helps me schedule individual rides	1.33	5.67
b) The software helps me schedule group rides	1.33	3.00
c) The software helps me schedule subscription (recurring) rides	1.33	4.00
d) The software helps me provide a manifest for the drivers	6.33	7.00
e) The manifest (routing) produced by the software is efficient	2.33	6.33
f) The manifest produced by the software is accurate in the time it takes to get from one stop to another	3.33	2.67
g) The drivers follow the manifest produced by the software	5.67	6.67
h) It is easy to make changes to the manifest	6.00	6.33
i) The software is helpful in generating reports	4.67	6.00
j) Overall the software help me perform my job	5.33	6.00

In general, these results indicate that the dispatchers believe that the RouteMatch software is better at assisting them with their various tasks. This may be based on the fact that Mobility Master software was not performing any scheduling tasks, and the dispatchers had to schedule all of the rides manually. More detailed information about the specifics of the software was obtained from the remaining questions of the dispatcher survey, questions 2-4. These questions were

open-ended questions that were used to try and get more detailed information about the dispatchers' view of the software.

Question 2 asked, "If there was one thing you could change about the (Mobility Master or RouteMatch) software, what would it be?" Question 3 asked the dispatchers to "Please provide any comments you have about how the (Mobility Master or RouteMatch) software may or may not assist you with your dispatching/scheduling duties." Finally, Question 4 asked the dispatchers to "Please provide any other comments you have about technologies, policies or procedures that could assist you with your dispatching/scheduling duties." The complete comments from the dispatcher and driver surveys can be found in Appendix C.

### Driver Surveys

The drivers' surveys (one for each of the software) asked a total of four questions. Question 1 used a seven-point scale (7=strongly agree, 1=strongly disagree), so that the drivers could indicate their response to seven items related to the software. A total of five drivers completed the survey for each software. The drivers' responses are shown in Table D-11.

**Table D-11: Drivers' Responses to Survey Question 1**

Item	Mean Score Mobility Master	Mean Score RouteMatch
a) The manifest I get from the dispatchers is accurate	6.0	4.2
b) The manifest I get from the dispatchers is efficient (provides a good routing)	5.6	4.0
c) The manifest is accurate in the time it takes to get from one stop to another	4.0	3.6
d) I follow the manifest as it is printed	5.2	4.8
e) In order to be more efficient, I don't always follow the pick up/drop off order of the manifest	6.6	6.4
f) I believe that I could create a better manifest (routing) that is provided by the current software	3.2	4.6
g) Overall, the manifest created by the software helps me perform my job	6.2	4.8

In general, the results of the drivers survey tends to indicate that the drivers preferred the manifests received from the Mobility Master software. The only item for which RouteMatch scored better than Mobility Master was the item relating to whether or not the driver believed that they could create a better manifest (item f).

The remaining questions of the survey (Questions 2-4), were open-ended questions that were used to obtain more information from the drivers. Question 2 asked, "If there was one thing you could change about the manifests you receive from the dispatchers/schedulers, what would it be?" Question 3 asked the drivers to "Please provide any comments you have about how the software may or may not assist you with your driving duties." Finally, Question 4 asked the drivers to "Please provide any other comments you have about technologies, policies or procedures that could assist you with your driving duties." The responses to these questions for both the Mobility Master and RouteMatch software are shown in Appendix C.

As previously noted, the dispatchers did not use the RouteMatch Scheduling Engine (RSE) within the RouteMatch software. Therefore, while the manifests that were produced by the dispatchers did look different to the drivers, the dispatchers were still manually scheduling most of the rides with the RouteMatch software, as they had with the Mobility Master software. Possibly, this was due in part to the fact that many of the rides provided by MET Special Transit (MST) are based on contracts, and many of the riders are already grouped by pick up and drop off locations.

It is unclear from this analysis which factors contributed to the changes in the scores in the drivers' survey. One hypothesis could be that the drivers were simply not used to the change in the appearance of the manifests. It is possible that a second driver survey, a year after the RouteMatch software has been in use, may yield different results.

## CONCLUSIONS

Previous studies have shown how the use of computer-aided scheduling and dispatching systems can increase efficiency in demand-response (or paratransit) organizations [2,4]. The purpose of this research was to identify the effects, if any, that implementing RouteMatch software would have on the operations of Billings MET Special Transit (MST). MST had been using Mobility Master software in its operations, but the dispatchers were manually scheduling rides due to issues with the software. MET Special Transit was relatively efficient, mainly due to the fact that it has numerous contracts for services, and is skilled at grouping rides.

The introduction of the RouteMatch software allowed the possibility of the software scheduling the rides, to hopefully increase the efficiency of the demand-responsive transit system. The Western Transportation Institute (WTI) examined two three-month periods, before and after the implementation of the RouteMatch software, to determine the impacts, if any, the software had on MST's operations.

“Before” and “after” data was collected and compared. The data collected for analysis included:

- Rides per hour,
- Rides per mile,
- Dispatcher and driver attitudes,
- Pick up time performance, and
- Drop off time performance.

It was planned that a cost-benefit analysis would occur; however, not enough cost parameters such as fuel and insurance prices were collected so that this analysis could be conducted. A break-even analysis was conducted, however, which provided information as to how much money would need to be saved, in terms of reduced mileage or hours in service, for the RouteMatch software to pay for itself.

The results of the analysis indicate that MST was more efficient when the RouteMatch software was being used. This is evident by the rides per hour increasing between the three-month comparison period (2005 versus 2006) at 7.04 percent, and the rides per mile increasing by 3.23 percent. It is this gain in efficiency that allows for the software to save money and achieve a break-even point, or “pay for itself.”

Due to the fact that not enough information on cost factors such as average fuel prices, insurance costs, etc. were collected for analysis, a direct benefit/cost analysis could not be conducted. The break-even analysis that was conducted, however, indicated that only a relatively minor (three percent) gain in efficiency would be necessary to reach the break-even point. For example, MET Special Transit would only need to provide the same number of rides, while reducing mileage (or hours) by three percent. As indicated herein, and by other research, this is certainly an attainable goal.

In addition to the quantifiable information that was analyzed, qualitative data, in the form of dispatcher and driver surveys was collected. The dispatchers' responses indicated that they believed the RouteMatch software helped them accomplish their various tasks better than the Mobility Master software they were previously using.



The drivers' surveys indicate that the drivers preferred, for the most part, the manifests (routing) provided by the Mobility Master software. In one seemingly contradictory response, however, the drivers indicated that the RouteMatch software was superior in producing the manifest (routing). One hypothesis for the responses is that the survey was conducted only six months after the RouteMatch software was in use, and the drivers may not have adjusted to the new manifests. A follow-up survey a year or so after RouteMatch has been in use may yield different results.

The final quantitative data that was analyzed was the pick up and drop off time performance of MET Special Transit before and after the implementation of the RouteMatch software. The data indicated that fewer pick ups times fell within the 30-minute window established by MST when the RouteMatch software was being used (84.9% versus 87.5%). The data also indicated that in 2006, more pick up times were earlier than the 10-minute window parameter (12.5% versus 11.1%), but pick up times that were more than 20 minutes late, or fell outside the window, also increased when RouteMatch was in use (2.6% versus 1.5%). The drop off time performance analysis indicated slightly different results.

Drop off times do not have a similar window as pick up times, but for this analysis we constructed a "window" that was plus or minus fifteen minutes of the scheduled drop off time. In 2006, when RouteMatch software was in use, more drop off times fell within the 30-minute window (84.5% versus 79.8%). Fewer drop off times in 2006, when RouteMatch software was in use, were earlier than in 2005 (5.52% versus 15.06%); however, more drop off times were late when RouteMatch software was being used (9.99% versus 5.14%). There are several hypotheses for the differences in the timing data.

The first hypothesis is that when RouteMatch was not being used (in 2005), the dispatchers that were creating the manifests allowed extra time between origins and destinations, so that more pick up and drop off times were within the windows, or were early. This is somewhat related to the second hypothesis, which is that when the RouteMatch software was in use, the software tried to create a "normal distribution" within the window, which resulted in the results indicated herein.

In summary, based on the data from other research, as well as the data contained herein, the implementation of computer-aided scheduling and dispatching software can increase the efficiency of demand-responsive (paratransit) organizations. Further, as indicated by the data herein specific to MET Special Transit, a gain in efficiency of only three percent, will lead to the break-even point to where the software will begin to pay for itself. This relatively short-term analysis concluded that MET Special Transit was more efficient with the Route Match software, and that the efficiencies necessary to reach the break-even point are achievable.

## REFERENCES

1. David Kack, “Billings MET Transit Paratransit Technology Review”, Western Transportation Institute, prepared for Billings MET Transit, Billings, MT, September 2003.
2. Metaxatos, P., and Pagano, A. *Computer-Aided Scheduling and Dispatching Systems: Impacts on Operations and Coordination*. Urban Transportation Center, University of Illinois at Chicago. Submitted for Publication to the 9<sup>th</sup> ITS World Congress Proceedings, May 2002.
3. Transportation Research Board. *Transit Cooperative Research Program (TCRP) Synthesis 24: AVL Systems for Bus Transit*. Washington, DC: National Research Council, 1997.
4. Volpe National Transportation Systems Center. *Benefits Assessment of Advanced Public Transportation System Technologies Update 2000*. Washington, DC: Federal Transit Administration Report FTA-MA-26-7007-00-4, November 2000.
5. Tom Brennan and Will Rodman, “Performance Measures and Measuring Results – Best Practices Today and Tomorrow”, Nelson/Nygaard Consulting Associates, PowerPoint Presentation on NYS Public Transit Fall Training Program Albany, NY, November 18, 2005.

## APPENDIX – DATA FOR ANALYSIS

The following is the data that was utilized for comparison purposes. The data was obtained from Billings MET Transit, with further data obtained from the National Transit Database.

Billings MST Data

	Jul 05	Jul 06	Aug 05	Aug 06	Sep 05	Sep 06	7/05-9/05	7/06-9/06
Rides	5,439	4,988	6,034	5,941	5,534	5,168	17,007	16,097
Hours	1,527	1,348	1,701	1,542	1,562	1,351	4,790	4,241
Miles	17,611	15,721	19,370	18,488	17,761	16,357	54,742	50,566
Rides/Hour	3.56	3.70	3.55	3.85	3.54	3.83	3.55	3.80
Rides/Mile	0.31	0.32	0.31	0.32	0.31	0.32	0.31	0.32

Rides = Ambulatory and Wheel Chair Rides

Hours = Revenue Hours (Vehicle Hours)

Miles = Vehicle Miles (Service Miles)

Billings MET Transit (Demand Responsive) Data – 2005 Totals

Operating Expenses: \$859,612

Vehicle Revenue Miles: 178,627

Vehicle Revenue Hours: 15,568

## **APPENDIX – DISPATCHER AND DRIVER SURVEYS**

Surveys were distributed to both the dispatchers and drivers based on both software, Mobility Master and RouteMatch. Only the RouteMatch versions of the surveys are included herein.

### Billings Dispatcher Survey RouteMatch Software

This survey is being conducted by the Western Transportation Institute-Montana State University/Bozeman to help determine the benefits of Scheduling/Dispatching Software.

To what level do you agree or disagree with the following statements about the RouteMatch Software?

	Strongly Agree	6	5	Neutral	3	2	Strongly Disagree
	7			4			1
a) The software helps me schedule individual rides.							
b) The software helps me schedule group rides.							
c) The software helps me schedule subscription (recurring) rides.							
d) The software helps provide a manifest for the drivers.							
e) The manifest (routing) produced by the software is efficient.							
f) The manifest produced by the software is accurate in the time it takes to get from one stop to another.							
g) The drivers follow the manifest produced by the software.							
h) It is easy to make changes to the manifest.							
i) The software is helpful in generating reports.							
j) Overall, the software helps me perform my job.							

If there was one thing you could change about the RouteMatch software, what would it be?

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Over ►

Please provide any comments you have about how the RouteMatch software may or may not assist you with your dispatching/scheduling duties.

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Please provide any other comments you have about technologies, policies or procedures that could assist you with your dispatching/scheduling duties.

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**Thank you for your time!**



## Billings MST Driver Survey RouteMatch Software



This survey is being conducted by the Western Transportation Institute-Montana State University/ Bozeman to help determine the benefits of Scheduling/Dispatching Software.

1. To what level do you agree or disagree with the following statements about the manifests you receive from the dispatchers/schedulers (using RouteMatch Software)?

	Strongly Agree 7	6	5	Neutral 4	3	2	Strongly Disagree 1
a) The manifest I get from the dispatchers is accurate.							
b) The manifest I get from the dispatchers is efficient (provides a good routing).							
c) The manifest is accurate in the time it takes to get from one stop to another.							
d) I follow the manifest as it is printed.							
e) In order to be more efficient, I don't always follow the pick-up/drop-off order of the manifest.							
f) I believe that I could create a better manifest (routing) than is provided by the current software.							
g) Overall, the manifest created by the software helps me perform my job.							

If there was one thing you could change about the manifests you receive from the dispatchers/schedulers, what would it be?

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**Over ▶**

Please provide any comments you have about how the RouteMatch software may or may not assist you with your driving duties.

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Please provide any other comments you have about technologies, policies or procedures that could assist you with your driving duties.

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**Thank you for your time!**



## APPENDIX – SURVEY COMMENTS

### Dispatcher Comments – Mobility Master

Notes: The number next to comment is survey number for tracking purposes. Edits were not made to the comments.

Q2. If there was one thing you could change about the Mobility Master software, what would it be?

- 1) Common locations should be viewed in alphabetical order.
- 2) Speed
- 3) MM is basically a data entry program w/ no ability to assist in scheduling.

Q3. Please provide any comments you have about how the Mobility Master software may or may not assist you with your dispatching/scheduling duties.

- 1) The dispatchers report is on too many sheets of paper. I would like to be able to view more quickly for dispatching purposes. Same for the “TBS” sheet.

Q4. Please provide any other comments you have about technologies, policies or procedures that could assist you with your dispatching/scheduling duties.

- 2) Speed-accuracy.

### Dispatcher Comments – RouteMatch

Q2. If there was one thing you could change about the RouteMatch software, what would it be?

- 1) When I put in times for pick up or drop off in trips the program doesn't leave them there. I have to go into scheduling and change the times. Example: Time to p/u is 9AM, I schedule the trip and it pops up in a different time. It's frustrating.

- 2) That you can uncancel trips. Ability to cancel all trips according to destination. Holiday cancellations by the day. On time reporting. Would like to see better reports on ridership, denials, ridership – I get different figures from billing & NTD Report customized for us

- 3) I would like to be able to copy & paste times in verification.

Q3. Please provide any comments you have about how the RouteMatch software may or may not assist you with your dispatching/scheduling duties.

2) The scheduling engine to schedule group rides need some adjusting – I have this issue reported to the help desk. The recommendation tool to schedule one ride at a time will give us similar trips but not always a feasible schedule

3) Often times the software chooses ridiculous choices when it comes to scheduling. However, overall, the software is better than the software we have used in the past.

Q4. Please provide any other comments you have about technologies, policies or procedures that could assist you with your dispatching/scheduling duties.

1) There are times when going from one screen to another clicques (editor note: could mean “clicks”) occur on the new screen. Does timing have to do with this?

#### **Driver - Mobility Master Survey Comments**

Q2. If there was one thing you could change about the manifests you receive from the dispatchers/schedulers, what would it be?

1) It's OK.

3) It's fine as-is.

5) Listing of more accurate times. E.g. p/u 1:00 d/o xtown 1:05

Q3. Please provide any comments you have about how the Mobility Master software may or may not assist you with your driving duties.

3) The manifest works very well for me, and it is easy to read and follow.

Q4. Please provide any other comments you have about technologies, policies or procedures that could assist you with your driving duties.

(No comments received)

**Driver - RouteMatch Survey Comments**

Q2. If there was one thing you could change about the RouteMatch software, what would it be?

- 2) The time they give you to go from point A to point B. They will give you 5 min. to drive 6 miles and 15 min. to drive 2 miles.
- 4) Sometimes, there is no business name with the addresses or apartment #s, but for the most part, the people are the same, so you remember where to go I guess.
- 5) Times given-inaccurate

Q3. Please provide any comments you have about how the RouteMatch software may or may not assist you with your driving duties.

- 2) The times on the manifest did not change at all when they got the new software-not even close to reality. Sometimes they have wrong addresses on manifests or not enough information at all-telling management about this things doesn't do any good-nothing changes.
- 3) Doesn't always allow proper times between stops.
- 4) Its OK for the most part.
- 5) Keeps me on my toes-confuses me daily.

Q4. Please provide any other comments you have about technologies, policies or procedures that could assist you with your driving duties.

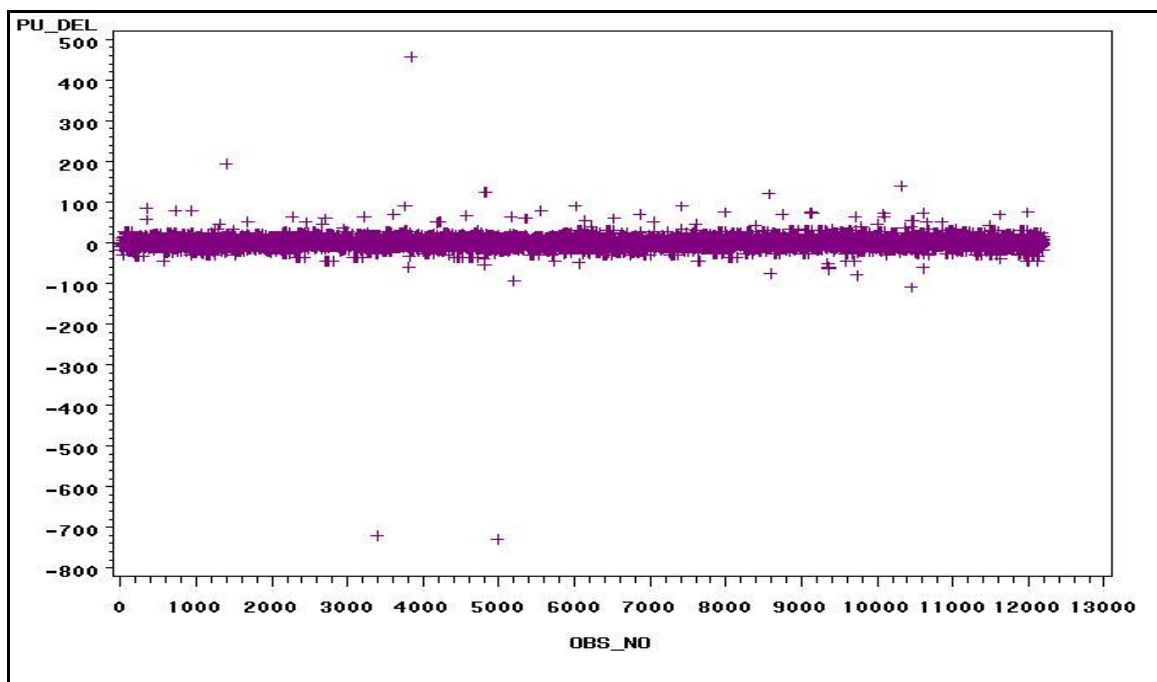
- 2) Some of these parking lots and driveways ware are sent to are next to impossible to get around in and if we do any damage it is our butt on the line-management and dispatchers don't have a clue what we go through, they don't seem to tell everybody (clients) about the 10 min. policy and then people get mad at us for doing our job, manifests are pretty much of a joke; we strap people in, but have no control over people if they loosen or undo their seatbelts, we have to drive in crazy traffic and can't watch clients every minute and if something happens, we get written up for it.
- 3) Take into consideration traffic in certain areas of town.
- 5) There has to be a better way.

## APPENDIX – DETAILED TIME ANALYSIS

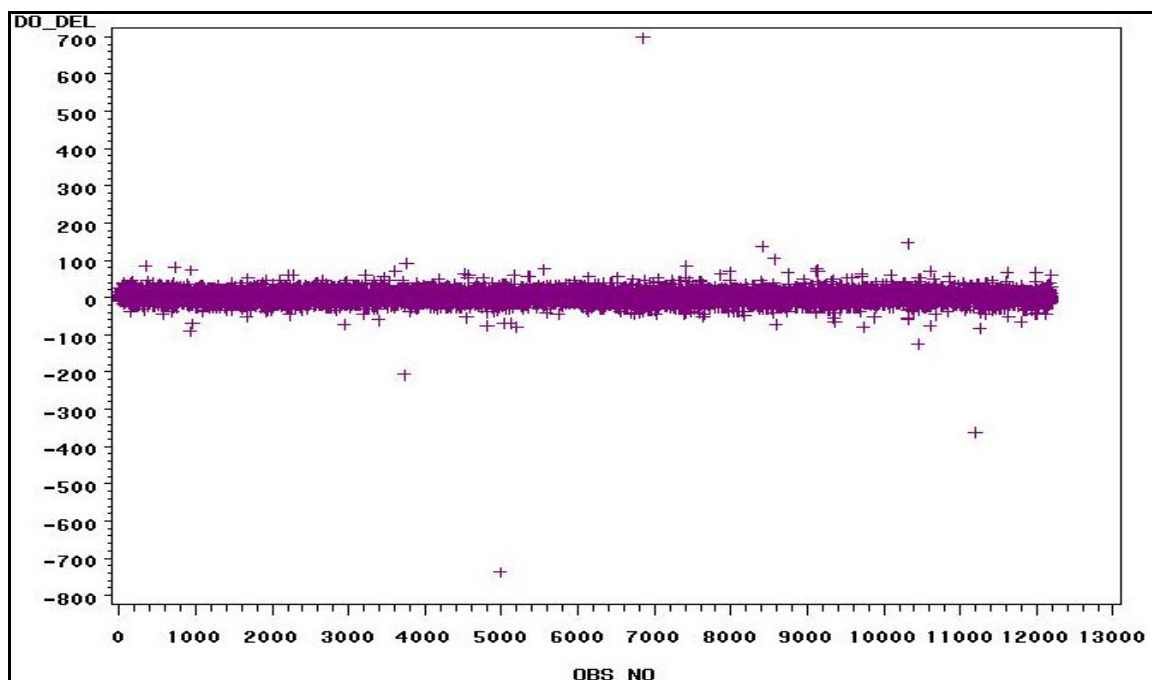
There were two sets of data collected to conduct this analysis. The first set of data contains the information about all the rides provided by Billings MET Special Transit for the months of July, August and September for the year 2005. The data has 12,202 observations, documenting pick up and drop off times of every ride provided during the time period. We initially conducted a dot plot to analyze the integrity of the data. The pick up times and drop off times were plotted separately.

### Unprocessed Data Analysis

Figure D-5 shows the pick up time dot plot. It is evident from the dot plot that there are large outlying values. These values occur due to the way the “Will Call” rides are setup. Will call rides are used by dispatchers for rides such as after a doctor’s appointment, when the rider will call and say they are ready to be picked-up. Thus after examining the dot plots and the frequency table for the data, we decided to reject data values with pick up deviations that are earlier than or later than 30 minutes as outliers.



**Figure D-5: Dot plot showing unprocessed data for pick up time deviations**



**Figure D-6: Dot plot showing unprocessed data for drop off time deviations**

Figure D-6 shows that a similar pattern is noticeable in drop off times as well. The same practice of marking “Will Calls” at the end of the day results in the outliers. After combined examination with the frequency distribution and the dot plots we decided to discard drop off time deviations earlier of later than 45 minutes as outliers.

The initial analyses on the unprocessed data provided us with the information necessary to filter and clean the data. Only the filtered data was used for our analysis. Table D-1 summarizes the raw and clean data.

**Table D-12: Summary information on pick up and drop off data after filtering**

Year	Data Characteristic	Total Obs	Valid Obs	Usable %	Outlier %
2005	Pick up times	12,202	12,063	98.86	1.14
	Drop off times	12,202	11,842	97.05	2.95
2006	Pick up times	13,965	13,647	97.72	2.28
	Drop off times	13,965	13,173	94.33	5.67

The data was then split into four groups, which were:

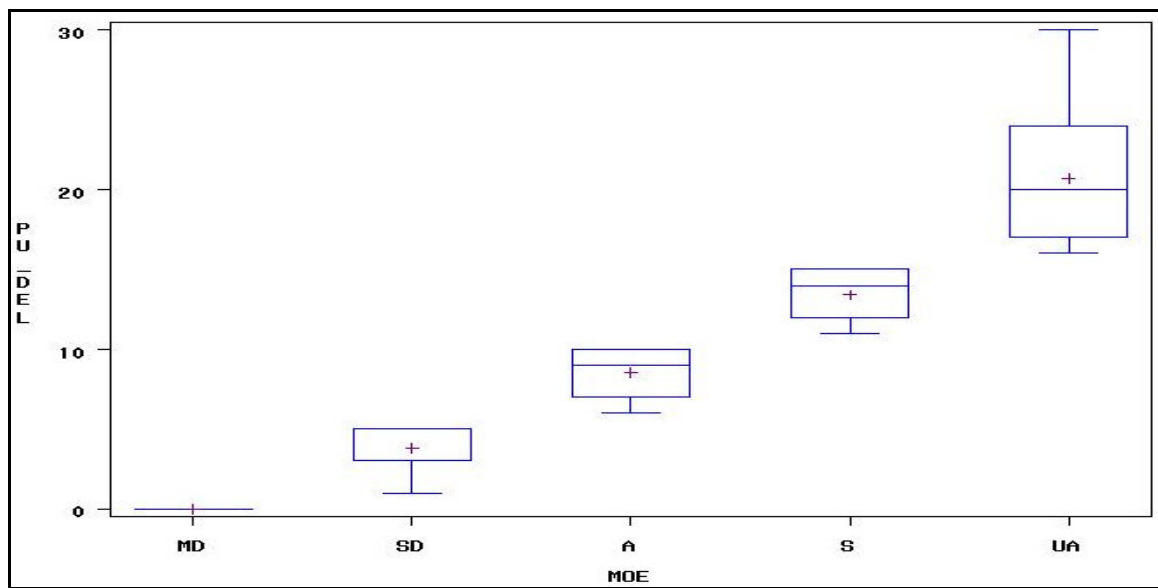
1. Early passenger pick up
2. Late passenger pick up
3. Early passenger drop off
4. Late passenger drop off

## Processed Data Analysis

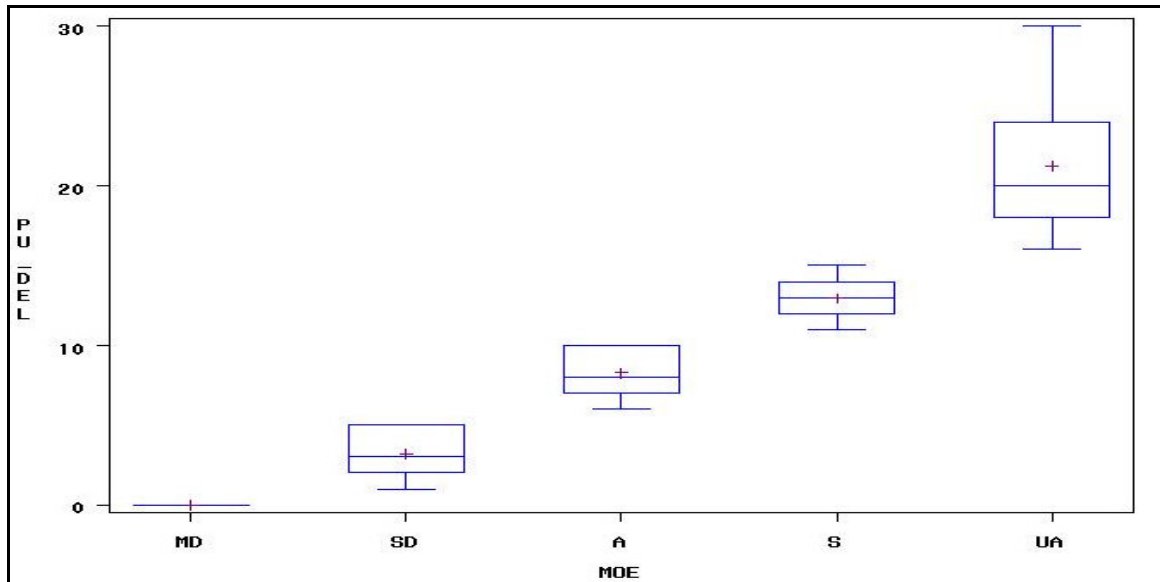
Much of the data was presented in the main section of this document. However, additional analysis is included herein for those interested in further details. To show the spread and characteristics of the data we created a box plot for pick up and drop off times. We utilized the labels shown in Table D-1 for the box plots. Figure D-7 shows the box plot for early pick up times for 2005, while Figure D-8 shows the box plot for year 2006. It can be seen that all the three quartiles with median is visible for all time categories for year 2006, and shows almost uniform variation, supporting the fact that the software has reduced variability in pick up times by grouping rides.

**Table D-13: Time Measures of Effectiveness**

Description	Comments
More than 15 minutes early	Unacceptable (UA)
10.1-15 minutes early	Satisfactory (S)
5.1 – 10 minutes early	Acceptable (A)
.1 – 6 minutes early	Somewhat Desirable (SD)
On time pick up (0 minutes early)	Most Desirable (MD)
.1-5 minutes late	Somewhat Desirable (SD)
5.1-10 minutes late	Acceptable (A)
10.1 – 20 minutes late	Satisfactory (S)
More than 20 minutes late	Unacceptable (UA)

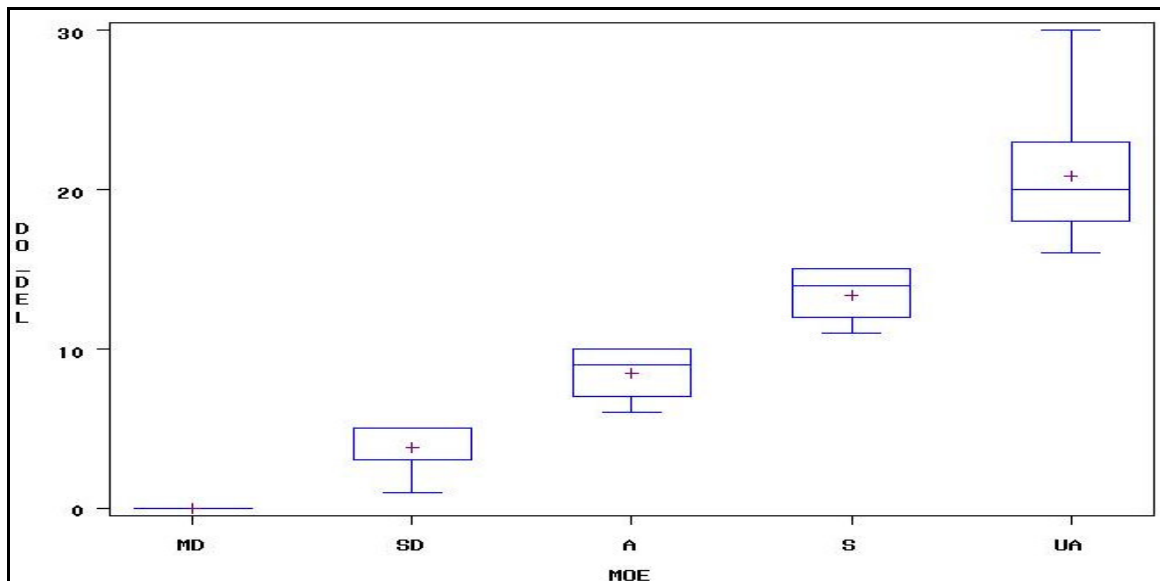


**Figure D-7: Box plot of early pick up times categories for 2005**

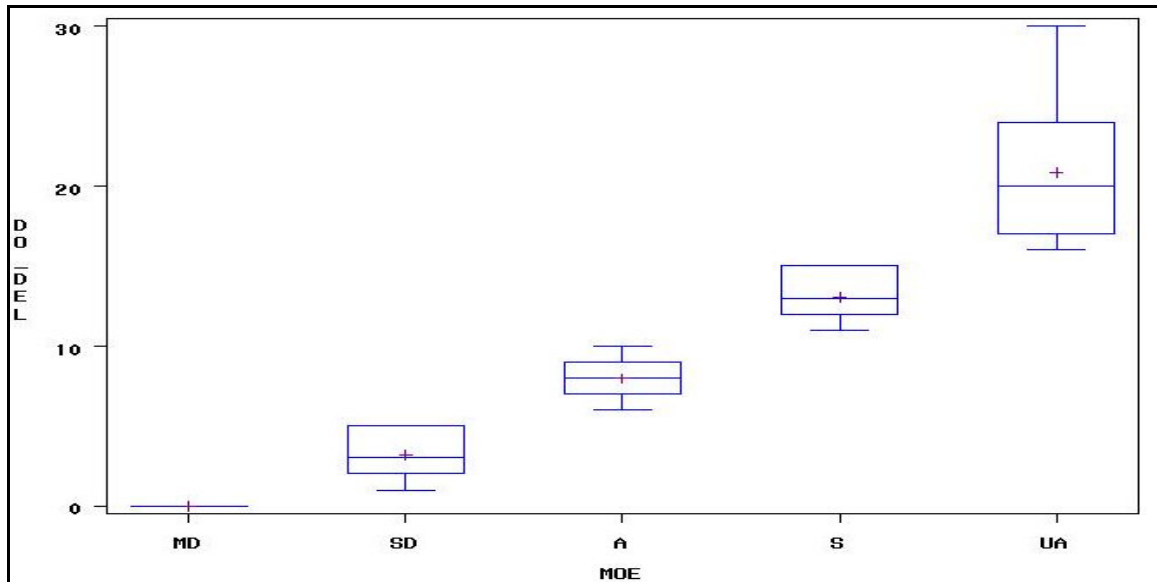


**Figure D-8: Box plot of early pick up time categories for 2006**

Figure D-9 shows the box plot for early drop off times for 2005, while Figure D-10 shows the data for 2006. By comparing both diagrams we can see that in year 2006, the variability within the 10 minute window of the scheduled drop off time is minimal. This may be achieved by grouping rides to similar locations, which might be the work of the scheduling algorithm, which would result in dropping-off passengers closer to their scheduled time, as compared to 2005.

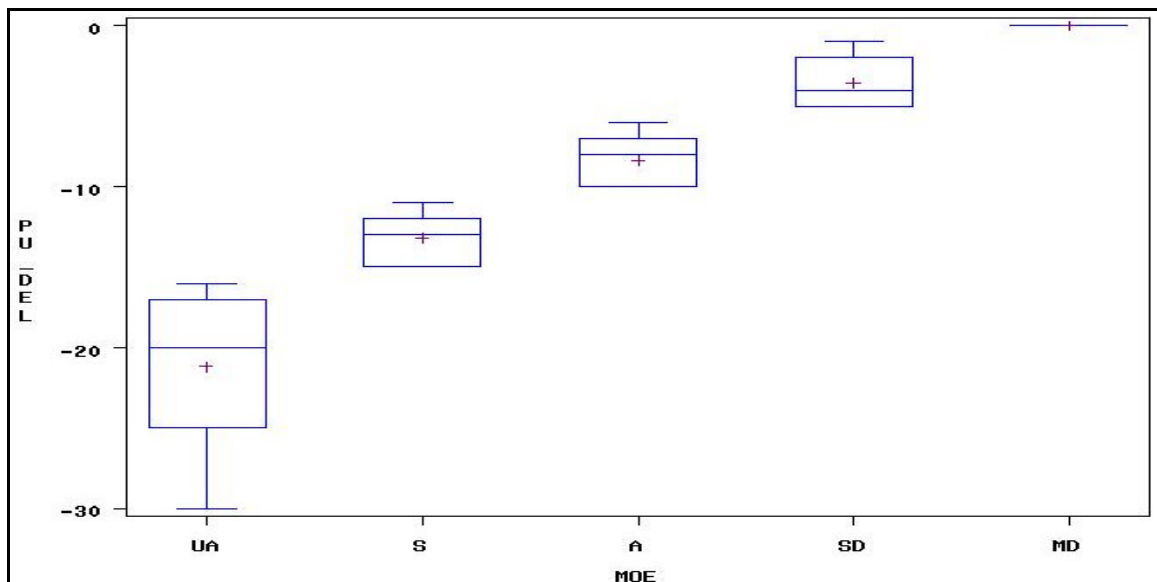


**Figure D-9: Box plot of early drop off time categories for 2005**



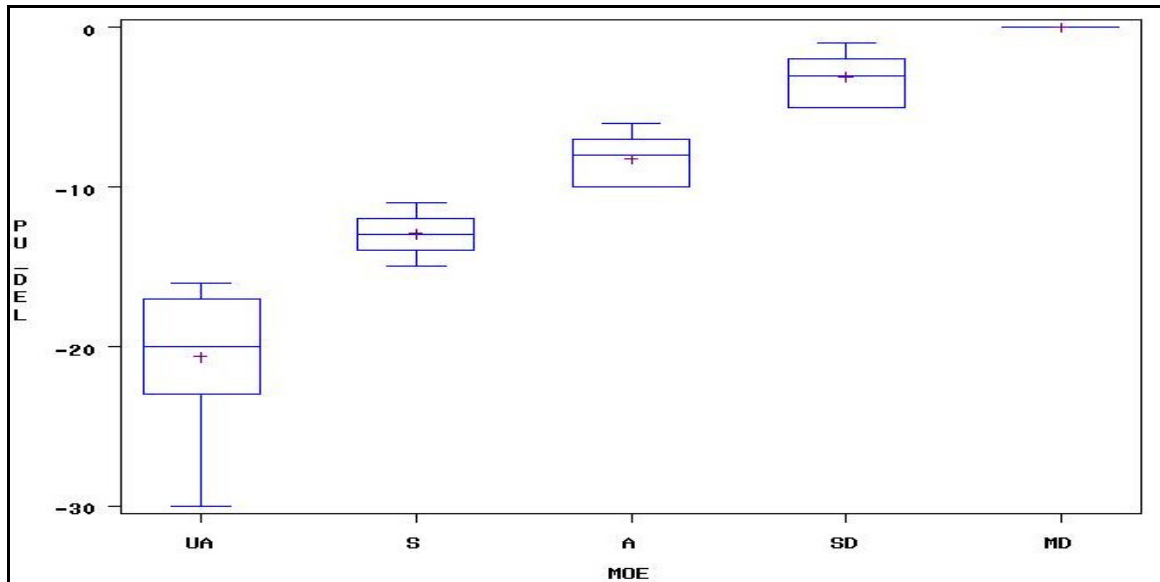
**Figure D-10: Box plot of early drop off time categories for 2006**

Figure D-11 represents the box plot showing the categories for the late pick up data for 2005, while Figure D-12 shows the same data for 2006. Interestingly, we can see that the 6 -10 minute late pick ups and 11 – 15 minutes late pick up displays similar spread and quartiles, suggesting that two subdivisions could be considered together. From Figure D-12 it is worth noticing that the variation in the lateness for year 2006 shows a uniform behavior compared to the non-uniformity shown in year 2005 in Figure D-11.



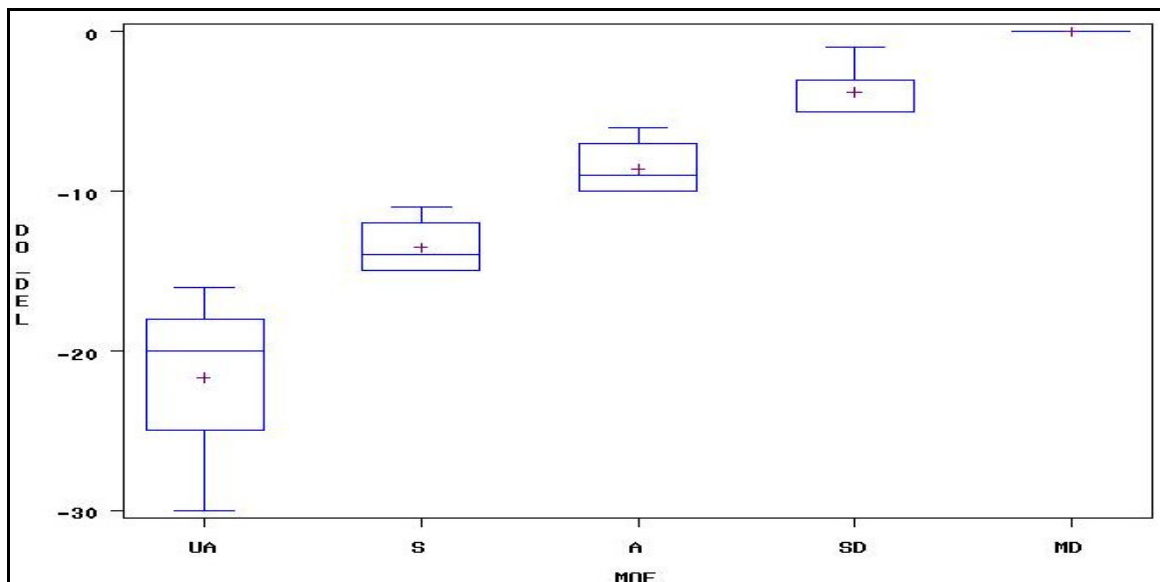
**Figure D-11: Box plot for late pick up categories for 2005**





**Figure D-12: Box plot for late pick up categories for 2006**

Figure D-13 represents the box plot showing the spread of the late drop off data for 2005. It is noticeable that the 10 – 15 minute late and greater than 15 minute late categories exhibit the same pattern in year 2006 (Figure D-14). This point to the situation where rides that are already delayed are further delayed to keep the rides that are on time to be completed within the scheduled time. The scheduling algorithm parameter settings need to be known to make a complete analysis.



**Figure D-13: Box plot for late drop off categories for 2005**

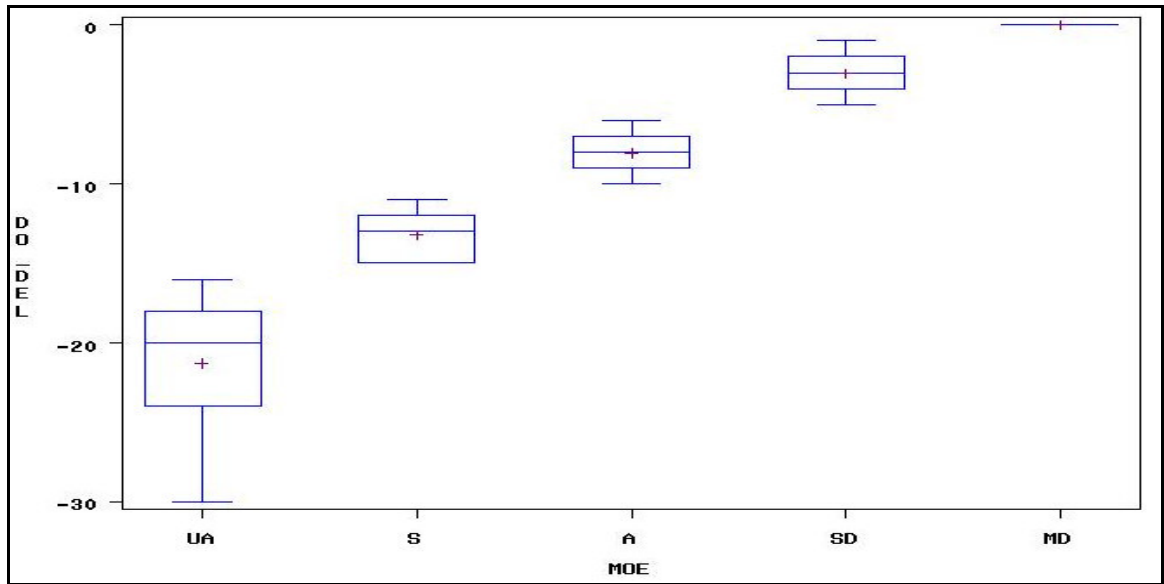


Figure D-14: Box plot for late drop off categories for 2006

## APPENDIX - SAS ANALYSIS PROGRAM FOR TIME-RELATED DATA

\* Program to read the ride data for Billings MET transit system and thus

evaluate the effectiveness of the RouteMatch program;

\* Code written by Deepu Philip;

\* Date: 05/23/2006;

\* Please notice:

All code is copyrighted by Deepu Philip and subject to the GNU General Public License, specifically, the following applies to all files:

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You should have received a copy of the GNU General Public License along with this program in license.txt.

If you haven't received a copy, write to the Free Software Foundation, Inc., 59 Temple Place - Suite 330, Boston, MA 02111-1307, USA, or browse to <http://www.gnu.org/licenses/gpl.html>;

\* this section obtains data from the file based on given file type;

**DATA** RIDE; \* read the accident data from file;

INFILE 'C:\DEEPU\WTI\2006SUMMER\BILLINGSDATAJULYSEPT2005.CSV' DLM =  
' , ';

FIRSTOBS = 2 LRECL = 500;

```
LENGTH SRV_DATE $ 25; * service date;
LENGTH PUTM $ 25; * Pickup time;
LENGTH DOTM $ 25; * Dropoff time;
LENGTH ACT_PUTM $ 25; * actual Pickup time;
LENGTH ACT_DOTM $ 25; * actual Dropoff time;
LENGTH PU_EL $ 6; * Pickup early or late;
LENGTH DO_EL $ 6; *Dropoff early or late;
LENGTH TRIP_SC $ 5; * trip status code;
LENGTH TRIP_SD $ 10; * trip status description;
LENGTH TRIP_TYP $ 3; * trip type;

* input all the fields in the data file for program to read;
INPUT SRV_DATE $ PUTM $ DOTM $ ACT_PUTM $ ACT_DOTM $ PU_DEL PU_EL $
      DO_DEL DO_EL $ TRIP_SC $ TRIP_SD $ TRIP_TYP $;

* any non numeric values are removed;
IF DO_DEL=. THEN DELETE;
IF PU_DEL=. THEN DELETE;

OBS_NO + 1; * adding an observation number with the data set;

DROP SRV_DATE; * drop unused variables;
RUN;

* check whether the input is correct
This is again another debug option and will be turned off during runs;
PROC PRINT DATA = RIDE;
      TITLE 'BILLINGS RIDE DATA YEAR 2005';
      VAR OBS_NO DOTM PU_DEL DO_DEL TRIP_TYP; * variables to print;
RUN;

DATA RIDEMODIF; * modify the ride data;
      SET RIDE; * set old data;

* now parse the scheduled pickup and drop off times;
LENGTH PUDATE $ 10; * scheduled pickup date;
```

```
LENGTH DODATE $ 10;    * scheduled dropoff date;
LENGTH PUTIME $ 6;     * scheduled pickup time;
LENGTH DOTIME $ 6;     * scheduled dropoff time;

PUDATE = SCAN(PUTM,1,' '); * get date information from the string;
PUTIME = SCAN(PUTM,2,' '); * get time information;
PUTIMEHRS = 0 + SCAN(PUTIME,1,':'); * hour of pickup;
PUTIMEMIN = SCAN(PUTIME,2,':'); * minute of pickup;

DODATE = SCAN(DOTM,1,' '); * get date information from the string;
DOTIME = SCAN(DOTM,2,' '); * get time information;
DOTIMEHRS = 0 + SCAN(DOTIME,1,':'); * hour of dropoff;
DOTIMEMIN = SCAN(DOTIME,2,':'); * minute of dropoff;

DROP PUTM DOTM PUTIME DOTIME; * drop parsed variables;

* now convert the pickup early late to binary variable;
IF PU_EL EQ 'early' THEN BNPUEL = 1; * early is denoted by 1;
ELSE IF PU_EL EQ 'late' THEN BNPUEL = 0; * late is denoted by 0;
ELSE BNPUEL = 99; * missing values;

DROP PU_EL; * drop the string;

* now convert the dropoff early late to binary variable;
IF DO_EL EQ 'early' THEN BNDOEL = 1; * early is denoted by 1;
ELSE IF DO_EL EQ 'late' THEN BNDOEL = 0; * late is denoted by 0;
ELSE BNDOEL = 99; * missing values if any;

DROP DO_EL; * drop the string;

* now parse the actual pickup and drop off times;
/* this info is redundant as we can obtain the same from the deltas
LENGTH APUDATE $ 10; * actual pickup date;
LENGTH ADODATE $ 10; * actual dropoff date;
LENGTH APUTIME $ 6; * actual pickup time;
LENGTH ADOTIME $ 6; * actual dropoff time;
```

```
        APUDATE = SCAN(ACT_PUTM,1,' '); * get date information from the
string;
        APUTIME = SCAN(ACT_PUTM,2,' '); * get time information;

        ADODATE = SCAN(ACT_DOTM,1,' '); * get date information from the
string;
        ADOTIME = SCAN(ACT_DOTM,2,' '); * get time information; */

        DROP ACT_PUTM ACT_DOTM; * drop parsed variables;
RUN;

* check whether the data modification is correct
just for debugging and will only be turned on when needed;
PROC PRINT DATA = RIDEMODIF;
        TITLE 'BILLINGS RIDE PARSED DATA';
        VAR PUDATE PUTIMEHRS PUTIMEMIN PU_DEL BNPUEL DOTIME DO_DEL
TRIP_TYP; * variables to print;
RUN;

* now the initial analysis of the data begins.
The analysis is accomplished by a series of sas procedures
generate a frequency distribution for pickup deltas;
PROC FREQ DATA = RIDEMODIF;
        TITLE 'Billings scheduled pickup times - frequency distribution';
        TABLES PU_DEL;
RUN;

* generate a frequency distribution for drop off deltas;
PROC FREQ DATA = RIDEMODIF;
        TITLE 'Billings scheduled drop off times - frequency distribution';
        TABLES DO_DEL;
RUN;

* we now do the dot plots to visualize the spread of the data;
* set the graphics environment for doing the dot plots;
GOPTIONS RESET=all;
SYMBOL COLOR = PURPLE;
* generate dot plot for the pickup times;
```

```
PROC GPLOT DATA = RIDEMODIF;
    PLOT PU_DEL*OBS_NO;
RUN;

* generate dot plot for the dropoff times;
PROC GPLOT DATA = RIDEMODIF;
    PLOT DO_DEL*OBS_NO;
RUN;

* from analysis it is clear that there are extreme observations that
are
creating a skew in the data.
The reasons for the outliers are the current way of putting the
willcalls.
So we are modifying the data after discarding the outliers.
Create data sets for pickup and drop off times;
DATA PICKUP(KEEP = OBS_NO PUDATE PUTIMEHRS PUTIMEMIN PU_DEL)
    DROPOFF(KEEP = OBS_NO DODATE DOTIMEHRS DOTIMEMIN DO_DEL);
    SET RIDEMODIF;    * initially analyzed data set;
RUN;

* print to see whether the data sets are created correctly
this is just a debug tool;
PROC PRINT DATA = PICKUP;
    TITLE 'Billings passenger pickup time data only (2005)';
    VAR OBS_NO PUDATE PUTIMEHRS PU_DEL;    * variables to print;
RUN;

* create early pickup data set from the pickup;
DATA PICKUPE;
    SET PICKUP;
    IF PU_DEL < 0 THEN DELETE;    * keep only the positive pickup times;
    IF PU_DEL > 30 THEN DELETE;    * remove outliers;
RUN;

* create late pickup data set from the pickup;
DATA PICKUPL;
    SET PICKUP;
```

```
* include zero in the late pickup according to the coding in data;
  IF PU_DEL > 0 THEN DELETE; * keep only the negative pickup times;
  IF PU_DEL < -30 THEN DELETE; * remove outliers;
RUN;

* print to see whether the data sets are created correctly
this is just a debug tool;
PROC PRINT DATA = PICKUPL;
  TITLE 'Billings passenger late pickup time data only (2005)';
  VAR OBS_NO PUDATE PUTIMEHRS PU_DEL; * variables to print;
RUN;

* now modify the early pickup data with MOE;
DATA PICKUPE_MOE;
  SET PICKUPE;
  LENGTH MOE $ 2;
  * now analyze generate variables for earliness;
  IF PU_DEL = 0 THEN MOE = 'MD';
  ELSE IF 0 < PU_DEL <= 5 THEN MOE = 'SD';
  ELSE IF 5 < PU_DEL <= 10 THEN MOE = 'A';
  ELSE IF 10 < PU_DEL <= 15 THEN MOE = 'S';
  ELSE IF PU_DEL > 15 THEN MOE = 'UA';
RUN;

* print to see whether the data sets are created correctly
this is just a debug tool;
PROC PRINT DATA = PICKUPE_MOE;
  TITLE 'Billings passenger early pickup modified data (2005)';
  VAR OBS_NO PUDATE PUTIMEHRS PU_DEL MOE; * variables to print;
RUN;

* now obtain the frequency table for the MOE from the early pickup
data;
PROC FREQ DATA = PICKUPE_MOE;
  TITLE 'Frequency Distribution for Early Pickup Data - Billings
(2005)';
  TABLES MOE;
RUN;
```



```
* sort the data to generate a box plot for early pickup times;
PROC SORT DATA = PICKUPE_MOE OUT = PICKUPE_MOEST;
    BY PU_DEL;
RUN;

* now create the box plot;
TITLE 'Boxplot for Early Pickup Times Data - Billings (2005)';
PROC BOXPLOT DATA = PICKUPE_MOEST;
    PLOT PU_DEL * MOE / BOXSTYLE = SCHEMATICID CBOXES = BLUE BOXWIDTH
= 10;
RUN;

* run the procedure for generating summary statistics for early pickup
data;
PROC UNIVARIATE DATA = PICKUPE_MOEST NORMAL PLOT;
    TITLE 'Summary statistics for Early Pickup data - Billings
(2005)';
    VAR PU_DEL;
RUN;

* now modify the late pickup data with MOE;
DATA PICKUPL_MOE;
    SET PICKUPL;
    LENGTH MOE $ 2;
    * now analyze generate variables for lateness;
    IF PU_DEL = 0 THEN MOE = 'MD';
    ELSE IF 0 > PU_DEL >= -5 THEN MOE = 'SD';
    ELSE IF -5 > PU_DEL >= -10 THEN MOE = 'A';
    ELSE IF -10 > PU_DEL >= -15 THEN MOE = 'S';
    ELSE IF PU_DEL < -15 THEN MOE = 'UA';
RUN;

* now obtain the frequency table for the MOE from the late pickup data;
PROC FREQ DATA = PICKUPL_MOE;
    TITLE 'Frequency Distribution for Late Pickup Data - Billings
(2005)';
    TABLES MOE;
```

```
RUN;

* sort the data to generate a box plot for late pickup times;
PROC SORT DATA = PICKUPL_MOE OUT = PICKUPL_MOEST;
    BY PU_DEL;
RUN;

* now create the box plot;
TITLE 'Boxplot for Late Pickup Times Data - Billings (2005)';
PROC BOXPLOT DATA = PICKUPL_MOEST;
    PLOT PU_DEL * MOE / BOXSTYLE = SCHEMATICID CBOXES = BLUE BOXWIDTH
= 10;
RUN;

* run the procedure for generating summary statistics for late pickup
data;
PROC UNIVARIATE DATA = PICKUPL_MOEST NORMAL PLOT;
    TITLE 'Summary statistics for Late Pickup data - Billings
(2005)';
    VAR PU_DEL;
RUN;

* now replicate the analysis for the drop off times
create the early and late drop off time data;
* create early pickup data set from the pickup;
DATA DROPOFFE;
    SET DROPOFF;
    IF DO_DEL < 0 THEN DELETE; * keep only the positive pickup times;
    IF DO_DEL > 30 THEN DELETE; * remove outliers;
RUN;

* create late pickup data set from the pickup;
DATA DROPOFFL;
    SET DROPOFF;
    * include zero in the late pickup according to the coding in data;
    IF DO_DEL > 0 THEN DELETE; * keep only the negative pickup times;
    IF DO_DEL < -30 THEN DELETE; * remove outliers;
RUN;
```

```
* print to see whether the data sets are created correctly
this is just a debug tool;
PROC PRINT DATA = DROPOFFE;
    TITLE 'Billings passenger early drop off time data only (2005)';
    VAR OBS_NO DODATE DOTIMEHRS DO_DEL; * variables to print;
RUN;

* now modify the early drop off data with MOE;
DATA DROPOFFE_MOE;
    SET DROPOFFE;
    LENGTH MOE $ 2;
    * now analyze generate variables for earliness;
    IF DO_DEL = 0 THEN MOE = 'MD';
    ELSE IF 0 < DO_DEL <= 5 THEN MOE = 'SD';
    ELSE IF 5 < DO_DEL <= 10 THEN MOE = 'A';
    ELSE IF 10 < DO_DEL <= 15 THEN MOE = 'S';
    ELSE IF DO_DEL > 15 THEN MOE = 'UA';
RUN;

* print to see whether the data sets are created correctly
this is just a debug tool;
PROC PRINT DATA = DROPOFFE_MOE;
    TITLE 'Billings passenger early drop off modified data with MOE
(2005)';
    VAR OBS_NO DODATE DOTIMEHRS DO_DEL MOE; * variables to print;
RUN;

* now obtain the frequency table for the MOE from the early drop off
data;
PROC FREQ DATA = DROPOFFE_MOE;
    TITLE 'Frequency Distribution for Early Drop off Data - Billings
(2005)';
    TABLES MOE;
RUN;

* sort the data to generate a box plot for early drop off times;
PROC SORT DATA = DROPOFFE_MOE OUT = DROPOFFE_MOEST;
```

```
        BY DO_DEL;
RUN;

* now create the box plot;
TITLE 'Boxplot for Early Drop off Times Data - Billings (2005)';
PROC BOXPLOT DATA = DROPOFFE_MOEST;
        PLOT DO_DEL * MOE / BOXSTYLE = SCHEMATICID CBOXES = BLUE BOXWIDTH
= 10;
RUN;

* run the procedure for generating summary statistics for early drop
off data;
PROC UNIVARIATE DATA = DROPOFFE_MOEST NORMAL PLOT;
        TITLE 'Summary statistics for Early Drop off data - Billings
(2005)';
        VAR DO_DEL;
RUN;

* now modify the late drop off data with MOE;
DATA DROPOFFL_MOE;
        SET DROPOFFL;
        LENGTH MOE $ 2;
        * now analyze generate variables for lateness;
        IF DO_DEL = 0 THEN MOE = 'MD';
        ELSE IF 0 > DO_DEL >= -5 THEN MOE = 'SD';
        ELSE IF -5 > DO_DEL >= -10 THEN MOE = 'A';
        ELSE IF -10 > DO_DEL >= -15 THEN MOE = 'S';
        ELSE IF DO_DEL < -15 THEN MOE = 'UA';
RUN;

* print to see whether the data sets are created correctly
this is just a debug tool;
PROC PRINT DATA = DROPOFFL_MOE;
        TITLE 'Billings passenger late drop off modified data with MOE
(2005)';
        VAR OBS_NO DODATE DOTIMEHRS DO_DEL MOE; * variables to print;
RUN; */
```

```
* now obtain the frequency table for the MOE from the late drop off
data;
PROC FREQ DATA = DROPOFFL_MOE;
    TITLE 'Frequency Distribution for Late Drop off Data - Billings
(2005)';
    TABLES MOE;
RUN;

* sort the data to generate a box plot for late drop off times;
PROC SORT DATA = DROPOFFL_MOE OUT = DROPOFFL_MOEST;
    BY DO_DEL;
RUN;

* now create the box plot;
TITLE 'Boxplot for Late Drop off Times Data - Billings (2005)';
PROC BOXPLOT DATA = DROPOFFL_MOEST;
    PLOT DO_DEL * MOE / BOXSTYLE = SCHEMATICID CBOXES = BLUE BOXWIDTH
= 10;
RUN;

* run the procedure for generating summary statistics for late drop off
data;
PROC UNIVARIATE DATA = DROPOFFL_MOEST NORMAL PLOT;
    TITLE 'Summary statistics for Late Drop off data - Billings
(2005)';
    VAR DO_DEL;
RUN;

DATA PICKUPT;
    SET PICKUP;
    IF PU_DEL < -30 THEN DELETE; * outliers;
    IF PU_DEL > 30 THEN DELETE; * outliers;
RUN;

* now modify the pickup data data with MOE;
DATA PICKUPT_MOE;
    SET PICKUPT;
```

```
LENGTH MOE $ 2;
* now analyze generate variables for lateness;
IF PU_DEL >= -15 THEN MOE = 'A';
ELSE IF -15 > PU_DEL >= -10 THEN MOE = 'B';
ELSE IF -10 > PU_DEL >= -6 THEN MOE = 'C';
ELSE IF PU_DEL = -5 THEN MOE = 'D';
ELSE IF PU_DEL = -4 THEN MOE = 'E';
ELSE IF PU_DEL = -3 THEN MOE = 'F';
ELSE IF PU_DEL = -2 THEN MOE = 'G';
ELSE IF PU_DEL = -1 THEN MOE = 'H';
ELSE IF PU_DEL = 0 THEN MOE = 'I';
ELSE IF PU_DEL = 1 THEN MOE = 'J';
ELSE IF PU_DEL = 2 THEN MOE = 'K';
ELSE IF PU_DEL = 3 THEN MOE = 'L';
ELSE IF PU_DEL = 4 THEN MOE = 'M';
ELSE IF PU_DEL = 5 THEN MOE = 'N';
ELSE IF 5 < PU_DEL <= 10 THEN MOE = 'O';
ELSE IF 10 < PU_DEL <= 15 THEN MOE = 'P';
ELSE IF PU_DEL > 15 THEN MOE = 'Q';

RUN;

* now sort the pickup times with MOE for normal plot;
PROC SORT DATA=PICKUPT_MOE;
  BY MOE;
RUN;

* create the normal plot on the whole pickup times;
* the normal plot procedure code is modified as a macro;
TITLE 'NORMAL PLOT FOR WHOLE PICKUP TIMES - Billings (2005)';
PROC UNIVARIATE DATA=PICKUPT_MOE;
  HISTOGRAM PU_DEL/ CBARLINE = BLUE NORMAL;
RUN;

* drop off analysis begin here - the procedure remains the same;
* different data sets are used;
* now do the same analysis for drop off times;
DATA DROPOFFT;
  SET DROPOFF;
```

```
        IF DO_DEL < -30 THEN DELETE; * outliers;
        IF DO_DEL > 30 THEN DELETE; * outliers;
RUN;
* now modify the pickup data data with MOE;
DATA DROPOFFT_MOE;
    SET DROPOFFT;
    LENGTH MOE $ 2;
    * now analyze generate variables for lateness;
    IF DO_DEL >= -15 THEN MOE = 'A';
    ELSE IF -15 > DO_DEL >= -10 THEN MOE = 'B';
    ELSE IF -10 > DO_DEL >= -6 THEN MOE = 'C';
    ELSE IF DO_DEL = -5 THEN MOE = 'D';
    ELSE IF DO_DEL = -4 THEN MOE = 'E';
    ELSE IF DO_DEL = -3 THEN MOE = 'F';
    ELSE IF DO_DEL = -2 THEN MOE = 'G';
    ELSE IF DO_DEL = -1 THEN MOE = 'H';
    ELSE IF DO_DEL = 0 THEN MOE = 'I';
    ELSE IF DO_DEL = 1 THEN MOE = 'J';
    ELSE IF DO_DEL = 2 THEN MOE = 'K';
    ELSE IF DO_DEL = 3 THEN MOE = 'L';
    ELSE IF DO_DEL = 4 THEN MOE = 'M';
    ELSE IF DO_DEL = 5 THEN MOE = 'N';
    ELSE IF 5 < DO_DEL <= 10 THEN MOE = 'O';
    ELSE IF 10 < DO_DEL <= 15 THEN MOE = 'P';
    ELSE IF DO_DEL > 15 THEN MOE = 'Q';
RUN;

* sort the drop off times for normal plot;
PROC SORT DATA=DROPOFFT_MOE;
    BY MOE;
RUN;
* now display the normal plot for the drop off times;
* the modified procedure is used as a macro;
TITLE 'NORMAL PLOT FOR WHOLE DROPOFF TIMES - Billings (2005)';
PROC UNIVARIATE DATA=DROPOFFT_MOE;
    HISTOGRAM DO_DEL/ CBARLINE = BLUE NORMAL;
RUN;
QUIT;
```

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format at no cost.