# An Evaluation of RouteMatch Software in the Billings, MT, Special Transit System

**by David Kack and Deepu Philip**

*This research evaluates the impact of RouteMatch Software on the MET Special Transit service in Billings, MT, and analyzes the gains in service efficiency compared to those achieved with the MET's previous software solution, Mobility Master Software. In this review, before and after quantitative and qualitative data are analyzed, including rides per hour, rides per mile, dispatcher and driver attitudes, and pick up and drop off time performances. The results indicate that MET Special Transit operations were slightly more efficient after the software was installed, and that with a slight gain in efficiency, the RouteMatch Software could have a positive cost to benefit ratio.*

## INTRODUCTION

Billings MET Special Transit (MST) is a paratransit service operating within the Billings, MT, city limits 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 7 a.m. and 5 p m. and a third person that can dispatch as needed. To schedule a ride, an individual must call 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 CASD software, and other technologies, such as automated vehicle location (AVL), and mobile data communications (MDC). WTI presented its findings to MET Transit and based on the information, Billings MET Transit decided to purchase a new software system for its paratransit service, MST (Kack 2003).

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. More information about RouteMatch can be found at 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 CASD software (Metaxatos 2002), and RouteMatch has issued case studies highlighting the benefits of its 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 system.

The remainder of this document provides an overview of CASD 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 aided 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. 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 (Metaxatos 2002).

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 (Transportation Research Board 1997). 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 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 (Transportation Research Board 1997).

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% (Volpe 2000).

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 and mobile data communications, 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 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 GPS) 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, 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. The analysis procedure is summarized as follows.

- An initial set of data was collected for July, August, and September 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 was not possible to account for all variables that could have an impact on MET Special Transit's performance. For example, the amount of road construction and other factors which could add to the time and/or miles it would take to provide a ride, were not analyzed. However, it was believed that by using the same months of the year for the two time periods in which the data was collected would account for these variables as much as possible.

Further, it should be noted that during the period of this analysis, 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 issue 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 from 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, its 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 (Volpe 2000).

Table 1 shows the rides, hours, and mileage for the July-September period in 2005 and 2006 that are used for this report. Table 2 and Table 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.

**Table 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 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 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 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 2 and Table 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 $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 $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 its fuel and insurance costs had increased, but it 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, if the fuel and insurance costs were considered to be constant, the RouteMatch software would have a positive impact if the vehicle hours and/or vehicle mileage was reduced. In the absence of the cost variable, 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, 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 hours = $1.83 per hour (3.31%)

$28,550 / 178,627 miles = $0.16 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 hours = $57.05 per hour

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

$888,162 / 178,627 miles = $4.97 per mile

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

The savings necessary in hours or miles to achieve a break-even point equate to a 3 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 allow 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 3% 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 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% (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 it picks up its 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 doctor's 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, while another agency may schedule the return ride for a 5 p m. 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 bee 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.

**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 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 10 minutes prior to, and 20 minutes after the scheduled pick up time. For example, if a rider schedules a ride with a pick up time of 9:30 a m., the vehicle may arrive (and the passenger needs to be ready) anytime from 9:20 a.m. to 9:50 a m. Further, an early pick up is desirable to passengers, as long as the vehicle does not arrive too early (Brennan 2005).

In order to evaluate the effectiveness of the RouteMatch software, the pick up times are evaluated using the "window" established by MST. Figure 1 and Figure 2 show the distribution of pick up times for the July-September periods for 2005 and 2006 that were analyzed for this report.

**Figure 1: Distribution of Pick Up Time Deviations for 2005**

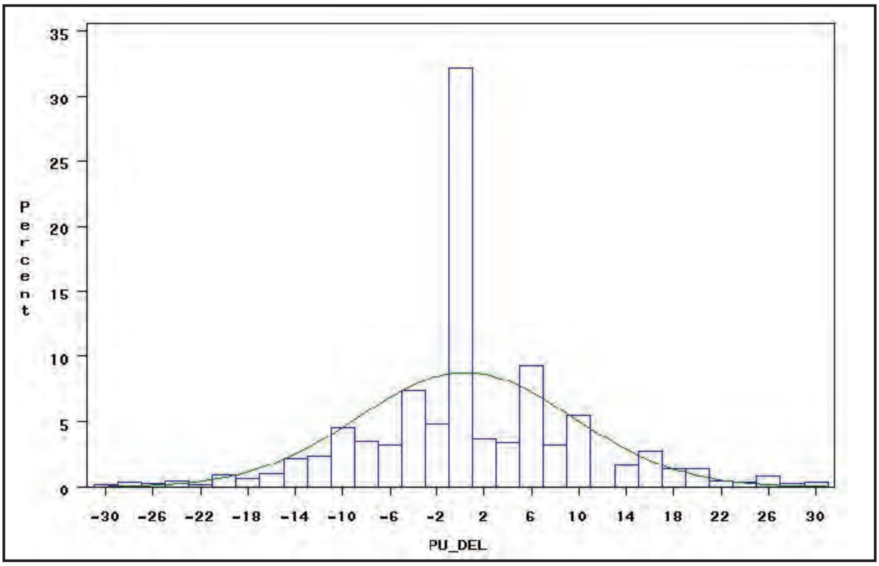
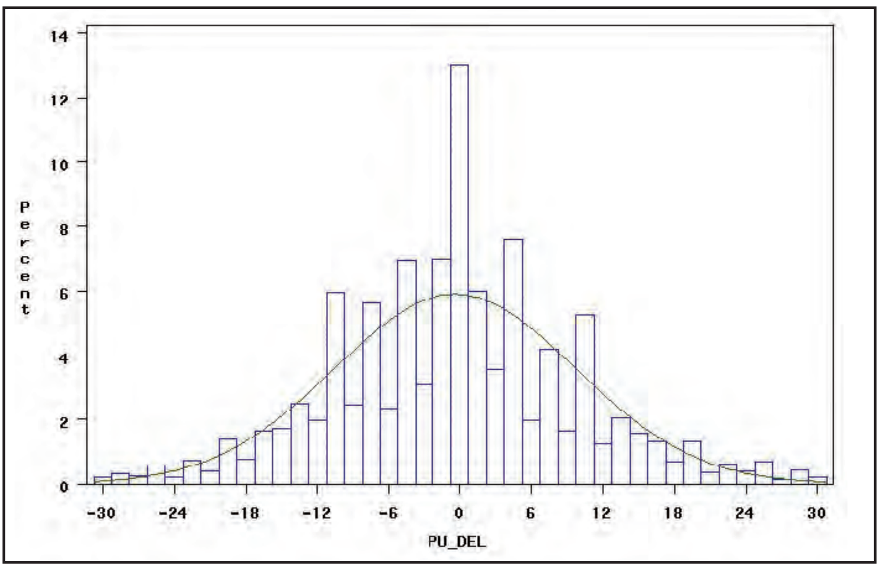



**Figure 2: Distribution of Pick Up Time Deviation for 2006**



The pick up times were analyzed further, and that data is shown in Table 4, Table 5, and Table 6.

**Table 4: Comparison of Pick Up Times**

| | 2005 | | 2006 | |
|---|---|---|---|---|
| **Pick up Time** | 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% |
| **Totals** | **12,063** | **100.00%** | **13,647** | **100.00%** |

**Table 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 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% 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% 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% versus 11.1%, but more pick ups in 2006 were also more than 20 minutes late, 2.6%, versus 1.5% in 2005.

This is further reflected in Table 5 and Table 6, 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 he would be dropped off five minutes early. However, he may end up being dropped off 10 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 3 and Figure 4 show the distribution of drop off times before (2005) and after (2006) the implementation of the RouteMatch software. Table 7, Table 8, and Table 9 show the drop off data and analysis.

**Figure 3: Distribution of Drop Off Time Deviations for 2005**

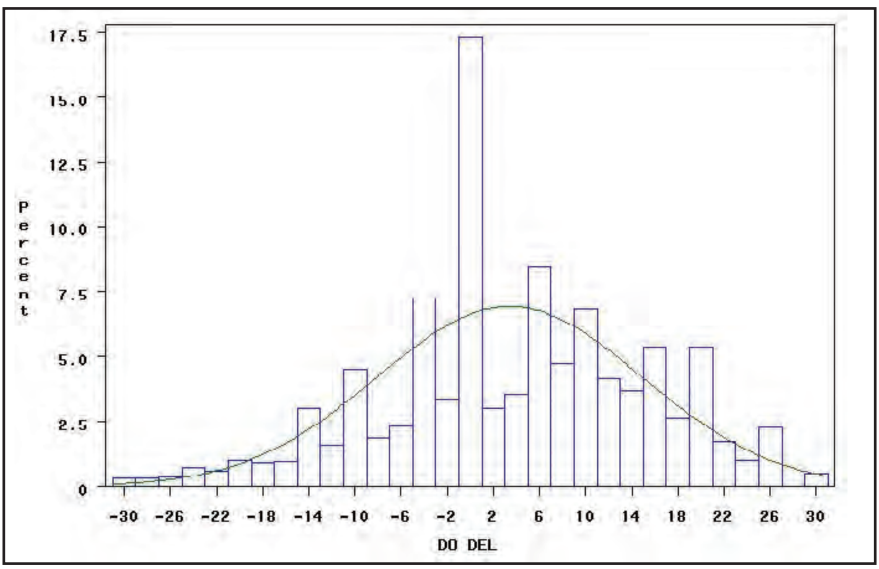


**Figure 4: Distribution of Drop Off Time Deviations for 2006**

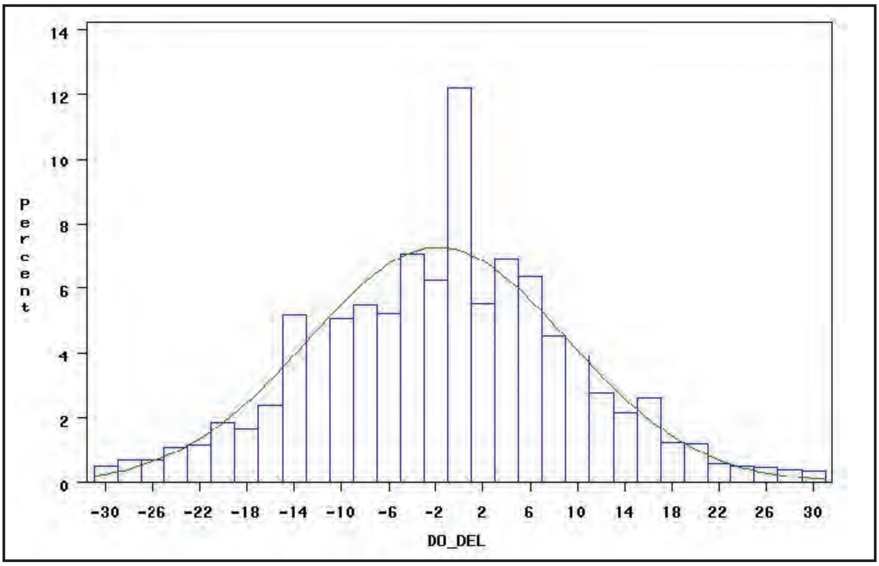



**Table 7: Comparison of Drop Off Times**

| | 2005 | | 2006 | |
|---|---|---|---|---|
| **Drop Off Time** | 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% |
| **Totals** | **11,842** | **100.00%** | **13,173** | **100.00%** |

**Table 8: Summary Statistics for Early Drop Off Data for Billings MET Transit**

| Statistical Measures | 2005 (Min) | 2006 (Min) |
|---|---|---|
| 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 9: Summary Statistics for Late Drop off Time for MET Transit Data**

| Statistical Measures | 2005 (Min) | 2006 (Min) |
|---|---|---|
| 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% 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% 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% versus 10%.

The variance in early and late drop offs is also reflected in the data shown in Table 8 and Table 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 questions for the two surveys (based on the software) were similar, so comparisons could be made. With the implementation of the RouteMatch software, the dispatchers received two on-site training courses. The first training occurred approximately one month before implementation, and the other training session occurred as the RouteMatch system was implemented. The drivers were given a short training session by MST personnel, on the new software, and how it may affect the way the manifests looked.

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 10.

**Table 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."

**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 11.

**Table 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."

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 (Mwtaxotas 2002). 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
- 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%, and the rides per mile increasing by 3.23%. 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 (3%) 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 3%. 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 15 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 3% 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.

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***David Kack*** *is the program manager for the Mobility and Public Transportation research area at the Western Transportation Institute (WTI)-Montana State University. David holds a master's degree in business administration and specializes in transportation coordination, management, and planning. At WTI, he has worked on several projects to develop and improve rural passenger transportation systems. He served on the team that developed the Montana Coordinated Transportation Handbook, and served as the principal investigator for the Real Choices Systems Change Grant project, which focused on improving public and specialized transportation in two communities in Montana.*

*He is currently the chairman of the GALAVAN/Streamline Advisory Board which provides general public and paratransit transportation services in the greater Bozeman area. David is also the coordinator for the Skyline public transportation system in Big Sky, which includes both local and intercity service between Big Sky and Bozeman (a distance of approximately 55 miles). David is a member of the TRB Rural Public and Intercity Bus Committee, and has extensive experience working with the public and cultivating multi-agency institutional relationships for the purpose of transportation development.*