Evaluation of User Impacts of Transit Automatic Vehicle Location Systems in Medium and Small Size Transit Systems

Zhong-Ren Peng, Yi Zhu and Edward Beimborn

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16. Abstract

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The surveys indicate that transit system with AVL had improved schedule adherence and on-time performance. Surveys of perceptions of the transit service and the importance of AVL characteristics showed little change comparing with before the AVL was implemented. Features like improving on time performance, knowing when the bus will arrive, knowing that another bus will be dispatched in case of breakdown are still valued as important to transit users and their decisions to ride more often. The surveys also indicate that more passenger trips may be realized if better information was offered to users.

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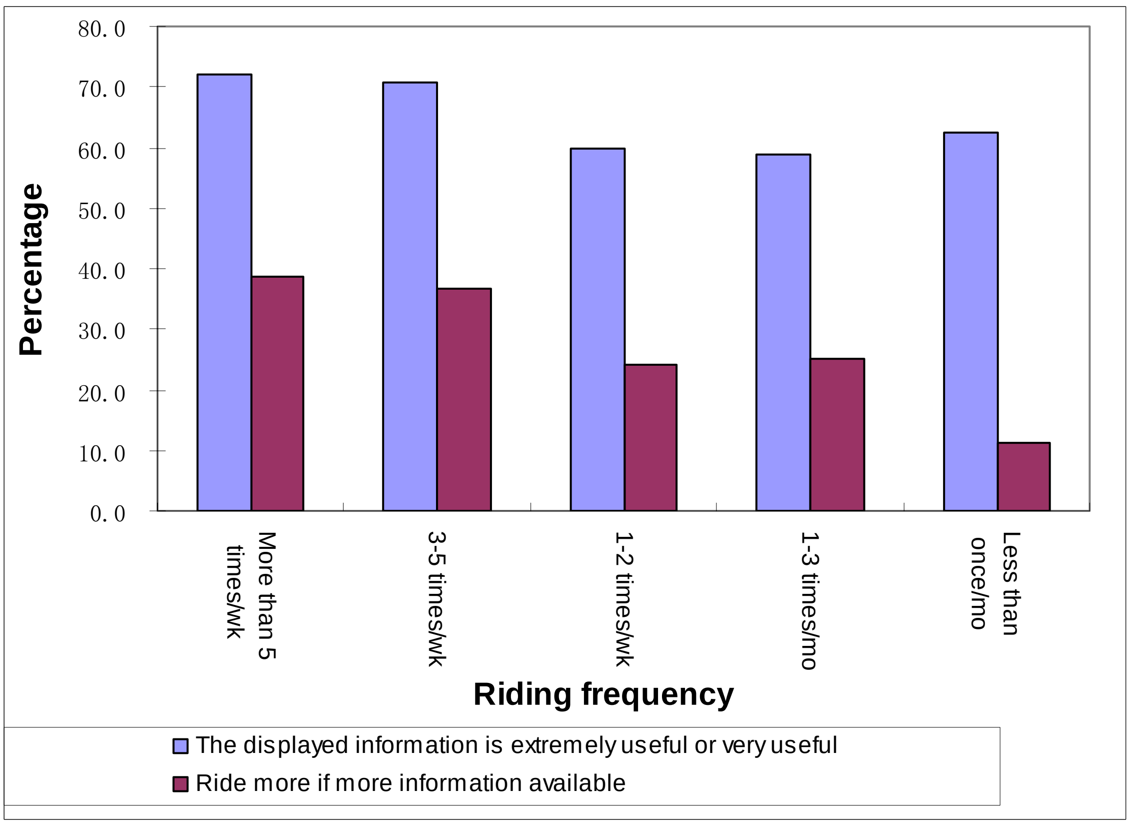

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Final Report to the Wisconsin Department of Transportation:

Evaluation of the User Impacts of Automatic Vehicle Location Systems in Medium and Small Transit Systems

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ABSTRACT

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The surveys indicate that transit system with AVL had improved schedule adherence and on-time performance. Surveys of perceptions of the transit service and the importance of AVL characteristics showed little change comparing with before the AVL was implemented. Features like improving on time performance, knowing when the bus will arrive, knowing that another bus will be dispatched in case of breakdown are still valued as important to transit users and their decisions to ride more often. The surveys also indicate that more passenger trips may be realized if better information was offered to users.

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INTRODUCTION

The need for a more efficient transit system has led transit agencies toward the use of Automatic Vehicle Location (AVL) Systems. By year 2000, 88 transit agencies in the United States had equipped with operational AVL systems, and 142 were planning such systems, including many medium and small transit agencies (Schweiger, 2003). The benefits of AVL technology have been addressed in a number of sources (Jonathan et al, 2000; Schweiger et al, 2003，etc) and can be summarized as follows (Jonathan et al 2000):

- Improve bus on-time performance and service efficiency
- Reduce passenger wait time
- Provide customers with real-time service information.
- Improve safety on buses.
- Improve response times to incidents and emergencies.
- Improved communications between supervisors, dispatchers, and operators.

But the question remains, does the AVL systems deliver the benefits that been expected? The number of studies that provided quantitative evidence for the effects of AVL technology on the transit systems and riders is very limited. These studies focused on benefits of AVL system to transit agencies, e.g., possible efficiency gains, productivity improvement, cost reductions and service performance (Gillen et al, 2001; Lee et al, 2001; Strathman, 2000; Strathman, 2002; Furth, 2003). However, little has been done to measure the perceived benefits of AVL systems to the transit users. A critical question is whether the adoption of AVL systems impacts transit users and can attract more ridership. To do this requires data about riders' activity and perceptions through user surveys.

Most prior studies were of large transit agencies. Few sources deal with AVL systems among the median and small sized traffic systems, (Peng et al, 2002). Medium and small transit agencies tend to have less severe congestion and fewer instances when vehicles are off schedule. Thus, the question remains unanswered as to how AVL systems benefit small and medium size transit agencies.

This study specifically addresses AVL implementation in two medium sized transit agencies, the Belle Urban System in the city of Racine, Wisconsin and the Waukesha Metro Transit System in the city of Waukesha, Wisconsin from the users' perspective. Before and after surveys were conducted of transit users' perceptions and bus on time performance. Quantitative data were collected to assess the impacts of AVL on schedule adherence, passenger wait time and passenger perception. In addition, similar surveys were conducted in Manitowoc, Wisconsin where AVL was not implemented.

Procurement Process:

The procurement of AVL systems took place after the first round of surveys during the years 2001-2005. This process proved to be more difficult than originally anticipated for a variety of reasons. Among them were changes in vendor organizations, local funding requirements and procurement procedures. In addition the lead time for product delivery, installation and testing proved to be greater than anticipated. As a result, the AVL systems became operational about two years later than anticipated. During this time other changes occurred in the transit agencies and elsewhere that may have some impact on the findings of the study. These changes include reductions in the level of service in the transit agencies studies and external factors such as changing prices of energy and different economic conditions in the before and after study time periods.

PREVIOUS STUDY OF THE BENEFITS OF AUTOMATIC VEHICLE LOCATION SYSTEMS

A previous project at UWM (see Appendix A) conducted a comprehensive analysis of AVL benefits. Two surveys were conducted in this study, one with transit service providers and the other with transit users. The purpose of transit agency survey was to obtain information about the experiences of agencies using AVL systems, while the purpose of transit user survey was to identify the importance that transit users place on the attributes of transit service that AVL may affect. Based on the survey results from the transit agencies and riders, major benefits of AVL systems to transit agencies and riders were identified. These benefits are developed into a “benefit tree” as shown in Fig. 1.

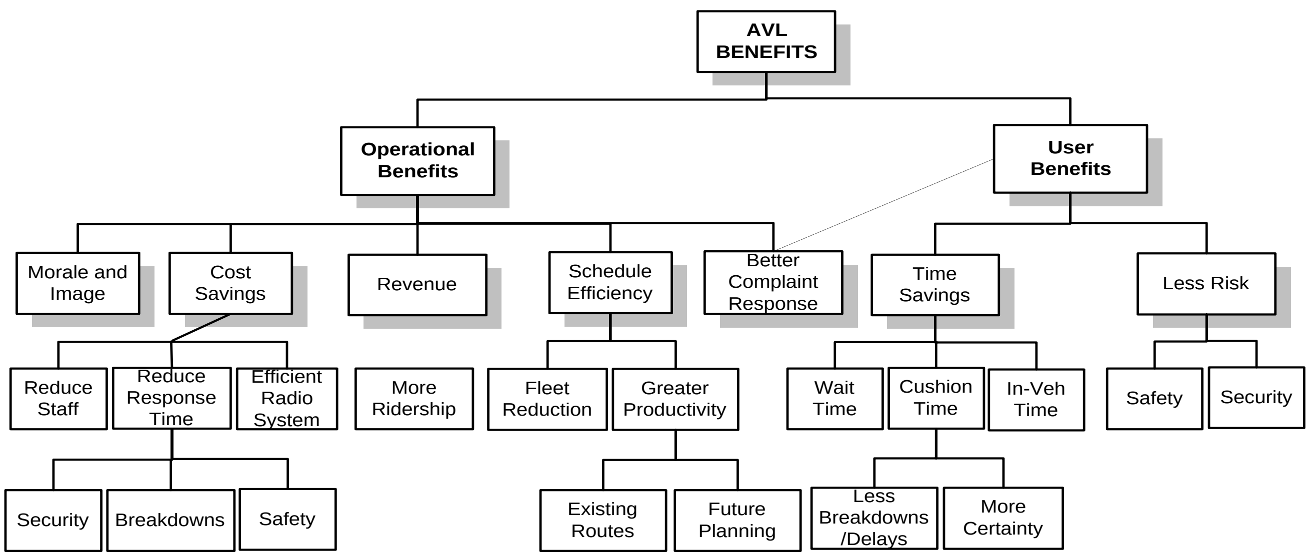


Figure 1: AVL Benefit Tree

Agency Benefits

The major benefits of AVL cited by the managers are related to service factors. Customer benefits occur through improved services, as the AVL technology is in nearly all cases a hidden system. The major benefits of AVL systems cited by agencies were:

- Improved efficiency of the system management and on-time performance. The monitoring capability of the AVL system allows the agency to make better decision about scheduling and routing, and to improve on-time performance. AVL permits automated dispatch and scheduling (Nelson 1995; Khattak et al 1998; Tellechea and Stone 1998).

- Improved customer communication. Disputes about non-arrival of vehicles and similar customer complaints can be handled better because documented evidence of the real-time location of vehicles is available from the AVL system.
- Better flex routing services. The AVL technology allows the flexibility of incorporating some demand-responsive services such as route deviation into the regular fixed-route service. This is particularly important for small agencies and para-transit services that operate in a low-density environment.
- Decreased reservation time. Paratransit services usually required 24 to 48 hour advance reservations prior to the AVL system. With the AVL the reservation time has been brought down to one hour or less in many cases. Occasionally real-time scheduling can also be done, which is a great time saving to passengers.
- Efficient use of resources. Most small and medium sized agencies felt that an AVL system would help utilize the resources more efficiently with the introduction of demand responsive services in regular fixed routes (COLTS, 1997).

The advantage of AVL to the operation and management of a transit agency is centered on its ability to reduce costs while providing a more efficient service. The measurable benefits from an AVL system include cost reduction by the elimination of staff and reducing response time to incidents, as well as increased efficiency of existing routes and greater productivity without increasing staff and/or vehicles. Both of these areas would lead to greater revenue generation through cost savings and the increase of potential ridership. The un-measurable benefits of AVL to an agency have to do with the ability to use AVL for public relations to increase awareness and pride in the existing service.

User Benefits

Major benefits to transit riders include the reduction of wait time and the improvement of security. AVL can improve on-time performance and help reduce wait time at bus stops. The reduction of wait time at a bus stop also helps the perception of security. Moreover, the assurance that the vehicle is equipped with emergency response system and could alarm the emergency response team further improve the perception of security on-board the bus.

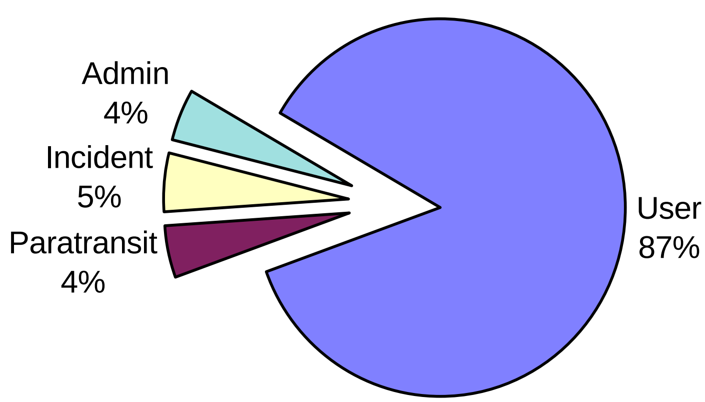
To find out how the transit riders value features of AVL, an on-board user survey was conducted to help assess the value of implementing an AVL system in small sized transit agencies. The City of Manitowoc, Wisconsin was selected as the site of an on-board user survey because it is a representative of a small sized agency. The system operates five full-time dedicated buses and one van with flexible scheduling. The overall response rate was around 80 percent. The following are the highlights of the on-board survey results.

The questionnaire asked passengers to rank the relative importance of the major factors that affect their decisions to ride a bus. The most important ranking is scored 1 and the least important ranking is scored 5. The on-time performance of the bus service emerged as the most important factor for the transit riders. In fact the occasional riders tended to mark it as very important in their decision to ride a bus. Overall 61 percent of the respondents considered the on-time performance as very important. Availability of real-time information on the bus service ranked second on the list. Over half (51 percent) of the respondents felt this was very important.

Benefit Cost Analysis:

As part of the study a benefit cost analysis was conducted to determine conditions that would warrant implementation of an AVL system in a small or medium size transit agency. The overall benefit cost situation showed that most of the benefits would be user benefits as shown in Figure 2. This figure was based on typical cost information and traveler values available at the time of the study.

Figure 2: Distribution of AVL Benefits



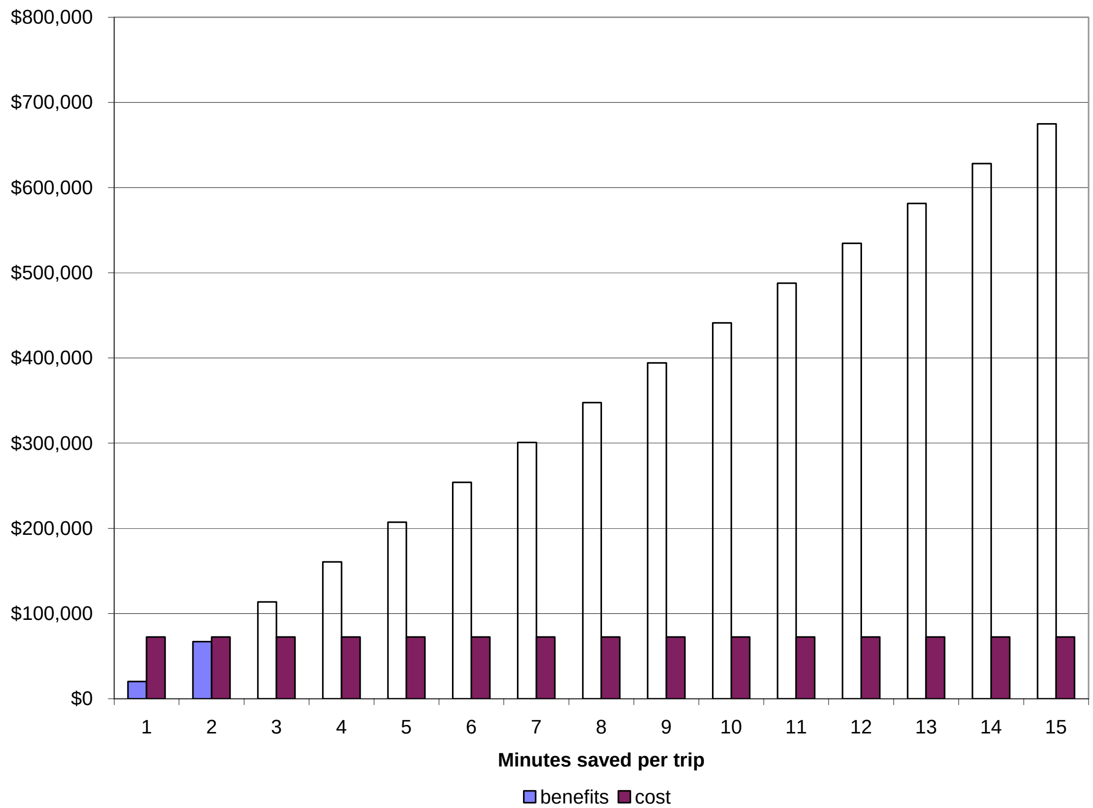
A breakeven analysis was conducted to identify the breakeven point in terms of the passenger wait time saving required to cover annualized system costs. Based on the range of cost estimates, the breakeven point is set to be equal to the low and high estimate of the costs. Several scenarios were analyzed as discussed below.

If we exclude administrative savings and only consider user timesaving from the AVL technology, we can calculate user benefits breakeven points. To be conservative, we first assume that transit ridership would be kept constant. We further assume that there would be no saving from administrative expense and incident saving. The only benefit to be considered is the saving from the wait time reduction of the transit users.

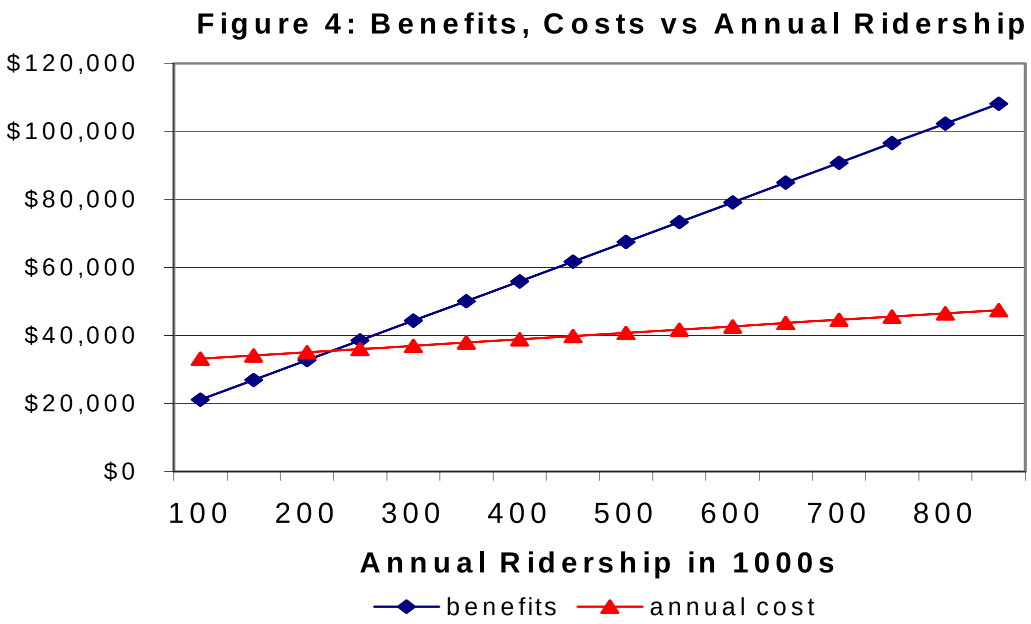
Total user benefits depend on transit ridership, the value of time and the amount of wait-time saving. Ridership can be broken down into different trip purposes such as home-based work, school, others and non-home based trips. The value of time and the wait time for every trip purpose can be derived from a mode split model such as that developed by metropolitan planning organizations for transportation planning purpose. The critical question is how much wait time can be saved by using the AVL technology. For the breakeven analysis, the required minimal timesaving can be estimated. Using data from Racine, and parameters derived from the Southeastern Wisconsin Regional Planning Commission (SEWRPC)'s transportation mode split model (SEWRPC 1995), the breakeven time savings could be calculated. Results are shown in Figure 3 and indicate that the breakeven point is very sensitive to average user time savings per trip.

As shown in Figure 3, Benefit vs. User Time Saved/Trip, user benefits are very sensitive to the wait-time savings. As the wait-time savings increase, the user benefits increase dramatically. In the example used, the break-even point is when the wait-time saving is about 0.45 minute or 27 seconds per trip. Given that this is a very small number, it indicates that the potential for AVL wait time savings to exceed its cost is high. It is not difficult to imagine an AVL system to increase the on-time performance to reduce the wait time by less than a half minute.

Figure 3: Benefits vs. user time saved/trip



Further analysis examined the effects of annual ridership levels on the breakeven point. Figure 4 shows that the increases of transit ridership will increase both benefits and costs, but the increase of benefits occurs faster than the increase in costs. These calculations were made assuming that user benefits, incident benefits and fleet size will vary directly with annual trips. With the assumptions made in the example, the break-even point is at about 220,000 trips per year, or 4200 trips per week. Smaller transit systems should take careful consideration of potential thresholds of usage when considering adoption of AVL technology.



Conclusions and Recommendations of Earlier study

The study concluded that Automatic Vehicle Locator technology has matured to the point where it can be implemented in a wide variety of agencies. There have been sufficient field applications of the technology to resolve technical features of AVL and make it a viable option for smaller transit agencies.

Transit users place a high degree of importance on features that minimize waiting uncertainty and increase their feeling of security. Features that AVL may provide such as: vehicles operating on schedule, knowing when a bus will arrive if late, knowing another bus can be dispatched if there is a breakdown and knowing there is an emergency communications system were rated highly by transit users based on the survey done as part of this study.

The implementation of AVL technology involves significant human factors and management issues that should not be underestimated. AVL provides more control of vehicles and may change the way in which transit systems acquire and use information. Transit agencies considering the use of AVL need to examine their entire operating procedure to assure that the maximum potential of AVL is utilized. It is important to select an AVL vendor with a significant track record in AVL for transit and likelihood for continuance in the AVL business. Vendor service and assistance at startup is extremely important to the success of an AVL system.

AVL systems potentially can have large benefits, which easily exceed the costs of the systems. These benefits largely occur to transit users if their vehicle waiting time can be reduced by even a small amount. Other effects such as increased sense of security and reduced response time for incidents cannot be easily quantified but would add to the benefits of an AVL system. In addition, AVL systems have the potential for better management information, which can lead to more productive service, and better planning for future needs.

The benefits of AVL systems are chiefly a direct function of annual system ridership while costs tend to vary only slightly with ridership. Benefits are also most likely to occur on systems that have problems maintaining schedules and service reliability. AVL systems should be implemented in a way to maximize their impact on passenger waiting times. This is an area of high potential benefits. Mechanisms to increase awareness of vehicle arrival times should be actively explored to provide the best use of an AVL system

Based on the analysis of the nature of AVL systems and their potential benefits, the following was recommended :

- A demonstration project or projects of AVL should occur in Wisconsin. These projects ideally should include a demonstration of the potential for shared AVL systems with other government agencies such as public works departments, law enforcement agencies and other transit agencies.
- Criteria for selection of a demonstration site should include: existence of a GIS system for the municipality, agreements between departments to share services, the existence of a coordination committee to assure compliance with national architecture standards, willingness to do a "before and after" study of the effectiveness of the system, potential for paratransit/regular transit AVL coordination, needs to replace existing communications system, and availability of radio channels for an AVL system.
- Demonstration projects should be accompanied with a rigorous evaluation that includes a before and after analysis of effects. Data should be collected on user wait times, on-time performance, incidents, management practices and system usage to assist in the evaluation of the demonstration.
- Transit systems equipped with AVL should make an effort to let passengers know about the system. These agencies should actively pursue systems that provide real time bus location and arrival information to users. Such services can lead to fuller realization of AVL benefits.
- AVL system design and components must be consistent with the national and regional ITS architecture and established ITS standard to ensure the compatibility with other ITS systems and expandability to include other components in the future.

SURVEY METHODS

Two sets of surveys were conducted before and after the installation of AVL systems. The first surveys were collected in the cities of Racine and Manitowoc, Wisconsin in 2001 and the city of Waukesha in 2002 before AVL systems were installed. A detailed report of the findings of the studies conducted before implementation of the AVL systems is given in Appendix B of this report.

The follow-up surveys were carried out in 2005. Both the Belle Urban System in Racine and the Waukesha metro transit system in Waukesha have installed and operated the AVL system in its bus vehicles several months before the survey was conducted. The Maritime Metro Transit System in the city of Manitowoc, Wisconsin, had originally planned to install AVL as well, but canceled the project. This enabled the survey data collected from Manitowoc to be a used as a control group to be compared with the data in Racine and Waukesha. The Belle Urban System in Racine has 11 fixed routes and a daily ridership of around 4,000. The Waukesha Metro Transit System has 12 fixed routes and a daily ridership of around 4,600. The Maritime Metro Transit System in the city of Manitowoc has 5 fixed routes and a daily ridership of 550 to 600. All three systems are small and medium-sized transit systems in the definition of FTA (Casey et al, 1996).

The surveys in 2001, 2002 and 2005 generally consisted of three components: an onboard transit rider survey, an on-time performance survey, and a passenger wait-time survey. The onboard rider survey is designed to collect the information on how transit riders value the benefits of AVL and how they consider the performance of bus systems. The on-time performance survey was intended to estimate the effects of AVL systems on schedule adherence. The passenger wait time survey was used to find actual wait time of the riders in major bus stops. In all six sets of data were collected (before and after) for the three different systems.

The process for collecting the data was similar in all the studies. For example, five people conducted the surveys in the city of Racine on April 7th (Thursday) and 8th (Friday), 2005 beginning 8:30 am and ending at around 3:30 pm. One double-side page questionnaire with 18 questions (see appendix) was distributed to the passengers of three routes (Route 3, Route 4 and Route 5). The survey return rate was over 80%. Meanwhile, on board surveyors also recorded the actual arriving time of buses at each time point and others were at selected stops and recorded the passengers’ actual wait time. A total of 310 valid survey forms and 97 passenger wait time cases were collected in the city of Racine.

On May 5th and May 6th, 2005, a similar survey was carried out in the city of Manitowoc on 4 bus routes (Route 2, Route 3 and Route 4, Route 5). The return rate of the onboard survey is about 80%. The two day onboard survey collected 120 survey forms and the 52 observations on passenger wait time.

The follow-up survey in Waukesha was conducted by five trained surveyors on Sep. 16th, 19th and 23rd, beginning at 8:00 am and ending at around 4:00 pm. The questionnaire was distributed to the passengers of seven routes (Route 1, Route 2 and Route 3, Route 4, Route 7, Route 8 and Route 9). The survey return rate was over 80%. Meanwhile, on board surveyors also recorded the actual arriving time of buses at each time point and others were at selected stops and recorded the passengers' actual wait time. A total of 303 valid survey forms and 105 passenger wait time samples were collected in the city of Waukesha.

Copies of the surveys conducted before the AVL installation are given in Appendix C.

MAJOR FINDINGS

The following is the major findings from the surveys. The analysis will focus on the data from the surveys in Racine and Waukesha. But some comparisons will also be carried out among these cities with Manitowoc. Also, before and after comparisons are conducted between the 2001/2002 surveys and the 2005 surveys.

On-time Performance improvement

In Racine, buses were generally on time for both 2001 and 2005, but the 2005 data reveals the installation of AVL enhanced on-time performance significantly. As shown in table 1, the average time difference between the scheduled arrive time and actual arrive time deceased from 155.95 seconds in 2001 to 99.7 seconds in 2005, which is about an 36% improvement at the route level. Meanwhile, the standard deviation also deceased from 136.05 seconds to 112.46 seconds which means that the bus service was more reliable than before. A t test shows that buses with AVL in 2005 are significantly better than those in 2001 in terms of on-time performance. In contrast, there is not much difference in Manitowoc for the same time period. That indicates the improvements of the on-time performance of bus service in Racine could be largely ascribed to the AVL system.

TABLE 1 Statistics of On Time Performance of the Transit Services

Time of the bus being late or early	Waukesha		Racine		Manitowoc	
	2005	2002	2005	2001	2005	2001
N (Valid)	360	271	302	731	280	349
More -10 min	0	0	0	0	0	0.30%
-10 ~ -5 min	0	0	0.70%	5.20%	0	0.60%
-5~ -3 min	1.10%	1.50%	3.90%	11.10%	1.10%	0.20%
-3 ~ -1min	2.20%	8.80%	6.70%	23.90%	8.50%	5.20%
-1~0 min	9.80%	10.00%	9.60%	14.10%	13.60%	8.00%
0 ~ 1min	65.00%	41.40%	35.40%	23.90%	46.80%	50.50%
1~ 3min	10.80%	28.40%	17.50%	11.00%	20.00%	26.30%
3~ 5min	3.90%	5.40%	9.60%	4.60%	8.20%	7.80%
5~ 10min	5.50%	3.90%	3.00%	5.40%	1.80%	1.10%
More than 10 min	0.60%	0.70%	0	0.80%	0	0
Mean (seconds)	53.44	65.45	99.735	155.95	85.928	86.415
Median (seconds)	30	60	60	120	60	60
Std. Deviation (seconds)	129.5	133.68	112.465	136.054	92.332	98.061
Maximum (seconds)	822	780	600	960	420	1035

More specifically, a detailed comparison in Table 1 shows that 58.6% of the delays in Racine for 2005 are within one minute, which compares favorably with that in 2001. Based on the industry standard of "on-time" (i.e., 0 minutes early to 5 minutes late), 62.5% of buses are "on time" in 2005, comparing with 39.5% in 2001, a 23% improvement. Furthermore, the proportion of the bus trips that are late or early by more than 5 minutes decreased from 11.4% in 2001 to 3.7% in 2005. This suggests that buses in Racine were running more on time after the usage of the AVL system. In terms of bus riders' perceptions, around 30.2% of the riders in Racine thought the buses run on time almost always, 46.6% of the riders thought the buses run on time most of the time. The data is quite close to the survey of 2001, which is 28.8% and 48.3% respectively. By contrast, as table 1 shows that the bus on-time performance in Manitowoc (without the AVL system) does not change much between 2001 and 2005. The share of the riders who considered the buses run on time almost always is almost the same for both year 2001 and 2005 (57%). But the percentage of the riders who thought the buses run on time most of the time increased from 34% in 2001 to 41.7% in 2005.

Similarly, in Waukesha, the survey in 2005 also revealed that the buses were more on time than those in 2002. As shown in table 1, the average time difference between the scheduled arrival time and actual arrival time is 53 seconds, which is a 18.5% improvement of that in 2002. The standard deviation in 2005 is 129.5 seconds compared with 133.68 seconds in 2002. However, a t-test shows that there is no statistical difference in overall on-time performance between 2002 and 2005. At each time point, about 80% of buses arrive within 0 - 5 minutes later than the scheduled time in 2005. The counterpart figure in 2002 is 75.2%. In 2005, about 5.7% of buses were more than 5 minutes late, but most of the delays were caused by waiting for the passing trains or waiting for other buses for connections in the bus transit center. However, in 2002, fewer of the buses arrived more than 5 minutes later (4.6%) but more arrived one or more minutes earlier (10.3%). The survey in 2005 also showed around 39.2% of the riders considered the buses run on time almost always, 46.5% of the riders thought the buses run on time most of the time. In the survey of 2002, the percentages were 36.5% and 51.3% respectively. The proportion of the riders who thought the buses are rarely on time was 3.7% in 2005 and 3.3% in 2002.

On-time Performance at the Route and Time-point Level

Data were analyzed at both the route level and time point level, as well. As reported in our prior study in 2001, the bus service in Racine were generally on time at the system level, but there was significant difference among the routes and time points (Peng et al, 2002).

An ANOVA analysis was performed to test the hypothesis that there is a difference in on-time performance among different routes in Racine in 2005. The f score is 2.377, which is significant at the 0.095 level (Table 2). So, we cannot reject the null hypothesis that there is no significant difference in on-time performances among different routes. This means that there is no significant difference in terms of on-time performance from route to route, which indicates that the service is generally on time at all routes for both time periods. This is different from the result of the 2001 data (Peng et al, 2002). This is another indication that AVL may play an important role in improving transit on-time performance.

By contrast with the 2001 data, the average delay time in Racine in 2005 was reduced 70 seconds on Route 3, by 38 seconds for Route 4 and 52 seconds for Route 7 (Table 3). As shown in figure 5, the curves for the Routes in 2005 are smoother in comparison with those for 2001. That means the bus on-time performances at different time points in 2005 did not fluctuate as much as in 2001. It indicates that the on-time performance in 2005 is not only improved at the route level but also improved at the individual time point level as well.

TABLE 2 ANOVA Analysis among Different Routes of the survey in Racine in 2005

	Sum of Squares	degree of freedom	Mean Square	F	Sig.
Between Groups	97590.609	2	48795.304	2.377	.095
Within Groups	6136655.749	299	20523.932		
Total	6234246.358	301			

TABLE 3 Statistics of On-time Performance of three Routes in Racine

Item		Route 3		Route 4		Route 7	
		Racine 2005	Racine 2001	Racine 2005	Racine 2001	Racine 2005	Racine 2001
N	Valid	119	126	129	97	54	118
Mean (seconds)		80.1681	150.00	112.0930	150.3093	113.3333	165.7627
Std. deviation (seconds)		104.00443	110.18	113.34181	131.65971	123.71605	171.45136
Median (seconds)		60.0000	120.00	60.0000	120.0000	90.0000	120.0000
Maximum (seconds)		360.00	600.00	600.00	480.00	600.00	960.00

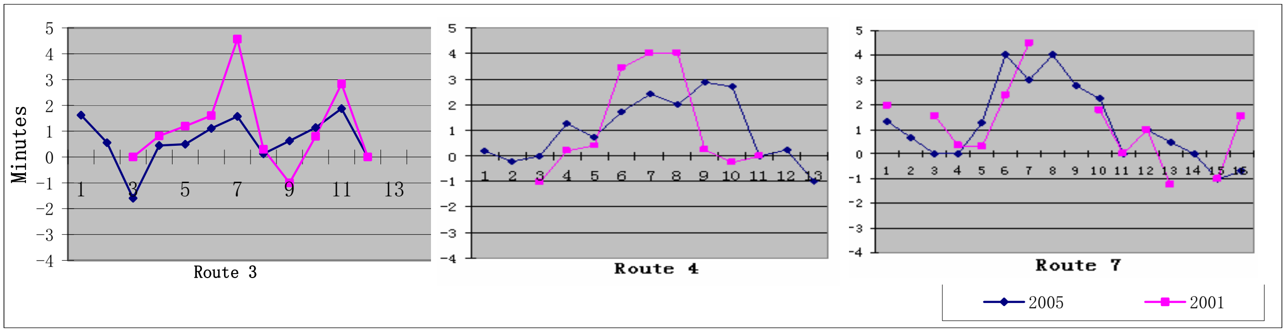


FIGURE 5 Bus on time performance of Racine Route3, 4 and 7 at the time points.

The ANOVA analysis was also performed to test the hypothesis that there is a difference in on-time performance among different routes in Waukesha in 2005. The f score is 3.306, which is significant at the 0.099 level. As a result, we can reject the null hypothesis that there is no significant difference in on-time performances among different routes. This means that there is significant difference in terms of on-time performance from route to route. The difference may be caused by the difference of the trip length. For example, Route 1 has to spend one and a half hour to finish the whole trip, while route 4 & 8 can cover the whole trip within half an hour. That means, theoretically, route 1 is more likely to be less on time than route 4 and 8. However, the ANOVA test on 2002 data doesn't show significant difference in on-time performances among different routes.

Passenger Wait Time

Passenger wait time is generally used as an indicator to measure the quality of service of a transit system. Because the AVL system can improve bus on-time performance, the wait time of passengers is expected to decline if all other factors remain unchanged. The passenger wait time (table 4) in this study can be divided into two types: the observed wait time and the reported wait time in the on-board surveys. For Racine in 2005, the average observed actual passenger waiting time (10.196 min) was very similar to the reported average waiting time (10.639 min). But, the median for observed wait time was 8 minutes while the reported wait time was 5 minutes. For Waukesha in 2005, the average observed actual passenger waiting time (8.0 min) is very similar to the user-reported average waiting time (8.7 min). The median for both observed wait time and reported wait time is the same, about 5 minutes.

The ANOVA tests was performed, which showed there is no statistical difference between the observed wait time and reported wait time in both transit systems. However, in Racine, there is a difference between an observed and reported wait time when the wait time is very short or very long. According to the observed results, 36.2% of the passengers' waits were within 5 minutes, comparing with 50% of the passengers reported their wait times were less than 5 minutes. While 32% of passengers were observed waiting more than 10 minutes and 26% of them thought their wait time were more than

10 minutes. The longest observed waiting time was 40 min, whereas the longest reported waiting time is 60 min.

In Waukesha, the observed data showed very similar wait time distribution as the reported data. According to the observation results, 54.9% of the passengers waited within 5 minutes and 30.4% of passengers waited more than 10 minutes. Among them 2% of the passengers waited more than 30 minutes. In terms of reported data, more than 50% of the passengers said their wait times were less than 5 minutes and 24.1% of them thought their wait time were more than 10 minutes. The longest observed waiting time is 33 min, whereas the longest reported waiting time is 60 min.

TABLE 4 Difference of the Passenger Wait Time in 2001/2002 and 2005 in Racine and Waukesha

City	Racine				Waukesha			
Passenger wait time	Observed		Reported		Observed		Reported	
	2005	2001	2005	2001	2005	2002	2005	2002
[0-2] minutes	18.60%	28.30%	18.10%	16.10%	20.60 %	32.80%	19.30%	28.90%
[2-5] minutes	17.60%	22.10%	35.60%	42.30%	34.30 %	17.90%	35.60%	40.80%
[5-10] minutes	32.10%	18.20%	20.60%	19.40%	14.70 %	20.30%	21.00%	17.10%
[10-15] minutes	13.40%	10.10%	8.70%	8.20%	11.80 %	11.20%	11.60%	6.20%
[15-30] minutes	13.40%	19.60%	11.50%	12.10%	16.60 %	14.90%	10.50%	5.40%
More than 30 minutes	5.20%	1.70%	5.90%	1.90%	2.00%	2.90%	2.00%	1.60%
Total	100%	100%	100%	100%	100%	100%	100%	100%
Mean (min)	10.196	8.032	10.639	8.801	8.157	8.321	8.735	7.147
Median (min)	8	5	5	5	5	5	5	5
Standard deviation (min)	9.411	8.744	12.375	8.806	7.349	9.203	8.705	8.121
Maximum (min)	40	65	60	60	33	60	60	62

As shown in the table 4, Racine transit users had a longer wait time in 2005 (10.196 minutes) than in 2001 (8.036 minutes). In 2005, 36.2% of the passengers waited within 5 minutes and 5.2% of passengers were observed to wait more than 30 minutes. By contrast, 50.4% of the passengers waited within 5 minutes in 2001 and only 1.7% of the passengers waited more than 30 minutes. The comparison of the reported wait time also reveals an average increase of 1.8 minutes in average wait time and a much higher percentage of passengers who waited more than 30 minutes. Two ANOVA were performed toward two sets of wait time and the results suggest there is statistically significant difference between the wait time in 2001 and that in 2005.

In Waukesha, in comparison with the result of 2005, the reported passenger wait time in 2002 was shorter, while the observed wait time was longer. The waiting time data for Racine surveys and Waukesha survey in 2002 indicated that the passengers tend to under-report their wait time when the wait time is relatively short, whereas they tend to over-report their wait time when the wait time is long (longer than 30 minutes) This is inconsistent with the early survey, which suggests that passengers were more likely to underestimate their wait time when they waited for bus for more than 10 minutes. This difference may also a result of rounding errors in the on-board survey. It may be that because the LCDs in the transit center can display the time, that help the riders estimate their wait time more accurately.

According to the result of on-board survey, in Racine, the percentage of passengers that thought the wait time is unreasonable has increased from 17% in 2001 to 20% in 2005. In Waukesha, that percentage has increased from 7.5% in 2002 to 12% in 2005. Over the same period, the counterpart in Manitowoc dropped from 5% to 2.6%. That indicates the service quality of the transit systems in Racine and Waukesha decreased from 2001/2002 in terms of passenger wait time. This conclusion is inconsistent with the previous assumption that the installation of AVL could reduce wait time. Since we have demonstrated that the improvement of schedule adherence in Racine, we can infer that other factors like service changes that decreased the frequency of the bus trips may result in the increase of passenger wait time.

The number of the vehicle bus trips in Racine and Waukesha declined between 2001/2002 and 2005 because of cuts in service. In Racine, the annual vehicle revenue miles for buses decreased from 1,341,700 miles in 2001 to 1,190,000 miles in 2004 and annual vehicle revenue hours decreased from 100,070 hours to 90,700 (Sources: National Transit Database). During this time, one fixed route was cut and headways were increased for other routes. For example, in 2001, there were 27 trips for Route 1 between 5:30 am to 6:30 pm while in 2005, there were 23. In Waukesha, the annual vehicle revenue hours are 66,394 in 2002 and 62,658 in 2003 and it is keep declining. Thus, the growth of passenger wait time may be the result of the adjustment of the routes and level of service.

Passenger Perceived Service Quality

Passengers' perceptions of the quality of transit services in terms of on-time performance and wait time were also collected. Table 5 shows an improvement in the perceived service quality of the bus systems in Racine and Waukesha in 2005 in comparison to 2001. In Racine, about half (50.2%) of the respondents agreed the bus now seems to be on time more often, and 35.4% of the passengers agreed that the bus now seems to run more frequently. About two thirds, (36.1%), of the passengers thought they waited less time for buses and 56.6% of the passengers thought the bus now runs closer to their homes or work locations. Except for bus frequency, more riders provided positive comments on schedule reliability, wait time and bus route location.

In Waukesha, more than half of the respondents (54.8%) thought the buses are performing more on time this year than last year, while only 11.1% of the respondents object it. In terms of the bus frequency, less than one third of the respondents (31.2%) the buses are running more often this year than last year. In addition, 40.1% of the respondents believed they are waiting less time this year but 38.1% of the respondents thought they waited more time. With regard to the accessibility of the bus routes, exactly half of the respondents thought the buses running closer to their houses and offices.

In the Manitowoc survey the perceptions of the quality of service factors are all higher than in the other two cities with less than 5% of passengers having negative opinions on these factors.

TABLE 5 Passengers' Perceptions of the Transit Services Comparing With Last Year

Compared with last year:	Racine (2005)			Waukesha (2005)			Manitowoc (2005)		
	Agree	Disagree	Same	Agree	Disagree	Same	Agree	Disagree	Same
The bus now is on time more often	50.20%	21.80%	28%	54.80%	11.10%	34%	63.70%	2.70%	33.60%
The bus now runs more frequently	35.40%	37.80%	26.80%	31.20%	31.60%	37.20%	69.00%	3.50%	27.40%
I now wait less time for buses	36.10%	31.60%	32.30%	40.10%	21.80%	38.10%	58.70%	3.70%	37.60%
Bus runs more closely to my home	56.60%	17.60%	25.80%	45.80%	15.40%	38.80%	50.50%	3.70%	40.80%

With regard to the ride frequency, in Racine in 2005, 35.6% of the respondents believed that they ride bus more often than in the previous year. About one eight (12.4%) of the respondents begin to use the bus transit in the current year. However, 17.8% of the respondents replied that they ride the same compare with the last year. In Waukesha, the survey results show that nearly one half (44.1%) of the respondents in 2005 replied that they ride bus more often than last year. Another 15.6% of the riders began to ride the buses this year and only 11.1% of the respondents replied that they ride less often than last year, which is largely because of riding with other people (28.1%), owing a car now (25.0%), having moved (18.85) and less frequency of the bus services (18.8%). From figure 6, we can see in both Racine and Waukesha, the frequent riders tend to ride more this year compared with last year.

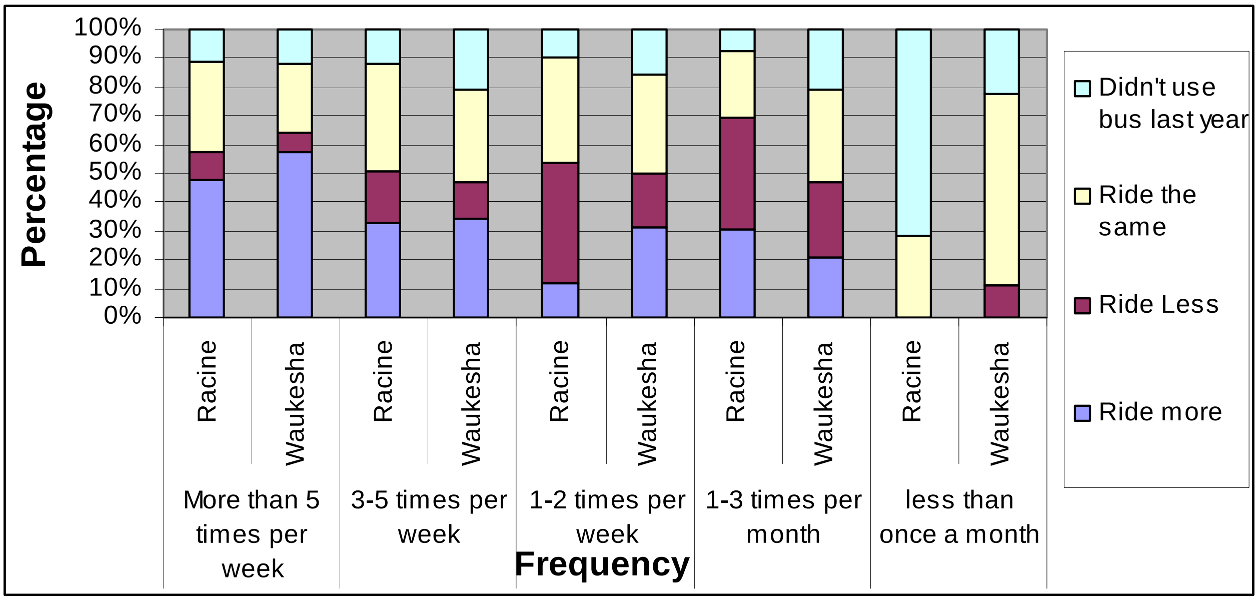


FIGURE 6: Riding frequency of the riders compared with the last year in Racine and Waukesha in 2005

Rider Preferences about AVL

Te implementation of AVL user information technologies was different in the two cities. In of Racine, real-time bus information display at bus stops and the Internet, voice enunciator were not implemented while Waukesha provides real time display at some of their stops. AVL features such as real-time bus dispatch and in-vehicle safety features cannot be observed by transit users and were not included in the surveys. To gain knowledge about how riders value these AVL-related features, the on-board survey also asked passengers to rank the importance of AVL-related features such as real-time information and timely transit dispatch, and other factors that will affect their decisions to ride buses, such as seats availability and transit fare.

Respondents ranked factors from “very important” (scored 5) to “very unimportant” (scored 1). Then, these scores were weighted in terms of the frequency of response. Table 6 shows the importance of 10 factors included in the surveys and the percentage of respondents considering the corresponding factors as “very important” while Figures 7 and 8 show the weighted averages for the factors for Racine and Waukesha.

TABLE 6 Ranking of Factors that Affect Decisions to Ride Bus

Factor	Rank in Racine		Rank in Waukesha		Rank in Manitowoc	
	2005	2001	2005	2001	2005	2001
Knowing when the bus will actually arrive at the bus stop	1 (85.6%)	1 (79.4%)	1 (86.9%)	1 (83.8%)	1 (78%)	1
Bus arrived at the scheduled time	2 (78.9%)	2 (72.7%)	2 (77.7%)	2 (80.2%)	2 (70.7%)	3
Knowing that another bus can be immediately dispatched if there is a breakdown	3 (77.2%)	4 (73.9%)	3 (74.6%)	4 (71.1%)	4 (65.5%)	4
Low bus fares	4 (76.2%)	3 (70.1%)	4 (73.5%)	3 (73.0%)	3 (71.6%)	2
Knowing how late the bus is in case of a delay	5 (69.4%)	5 (60.0%)	5 (66.5%)	5 (60.7%)	5 (54.4%)	5
Knowing the bus is equipped with a 911 emergency system	6 (68.8%)	6 (63.9%)	7 (62.0%)	6 (62.5%)	6 (60.7%)	6
Knowing the transit system uses the latest vehicle location technology	7 (57.4%)	8 (52%)	6 (57.3%)	8 (48.8%)	8 (45.5%)	7
Having a seat available at all times	8 (56.4%)	7 (51.3%)	8 (58.0%)	7 (48.8%)	7 (50.4%)	8
Displaying the name of the next stop inside the bus	9 (47.3%)	9 (27.3%)	9 (40.7%)	9 (35%)	9 (32.1%)	9
Having the drivers call on the stops	10 (29.7%)	10 (24%)	10 (34.7%)	10 (28.4%)	10 (27.7%)	10

Note: the percentages in the table represent the percentage of respondents scoring the corresponding factors as "very important" in affecting their decision. The percentages for the survey in Manitowoc in 2001 are unavailable.

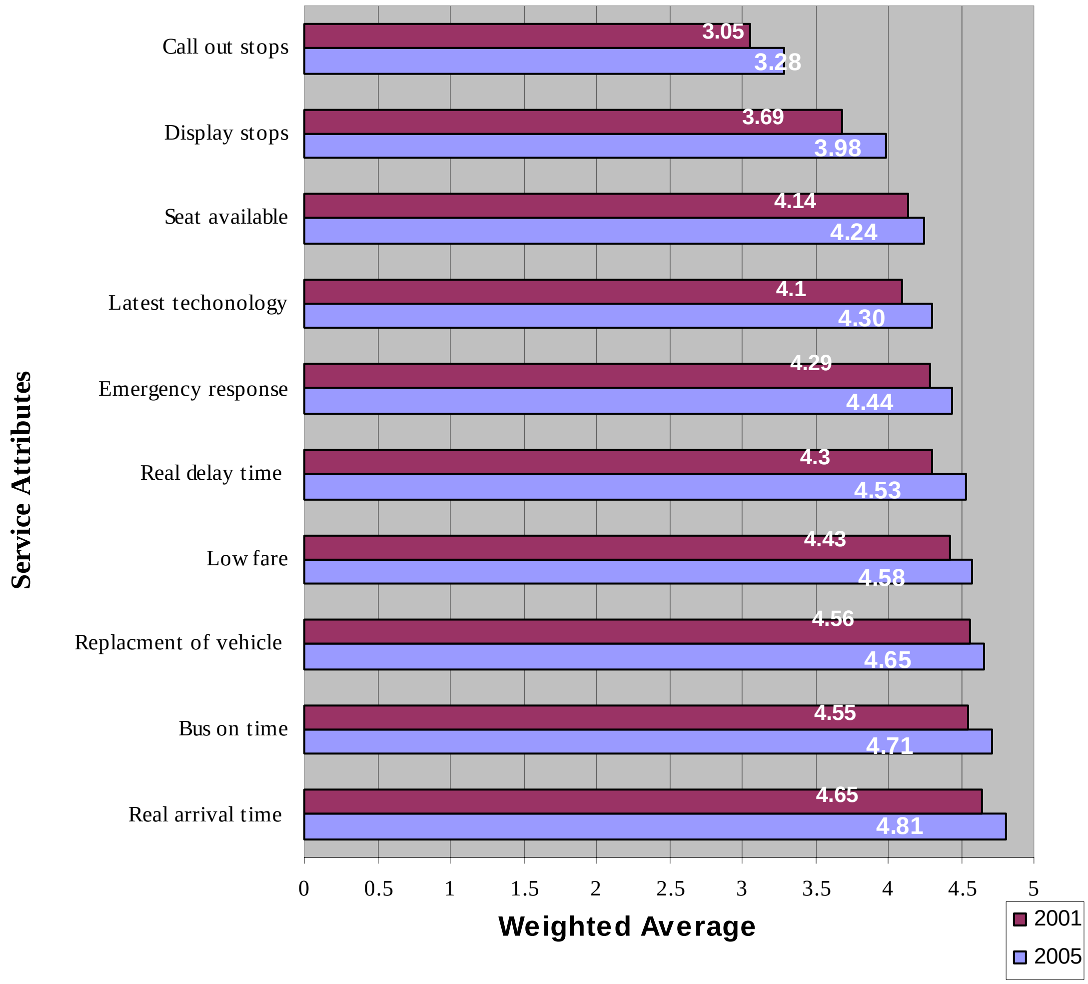


FIGURE 7: Weighted averages of 10 factors in the Racine surveys.

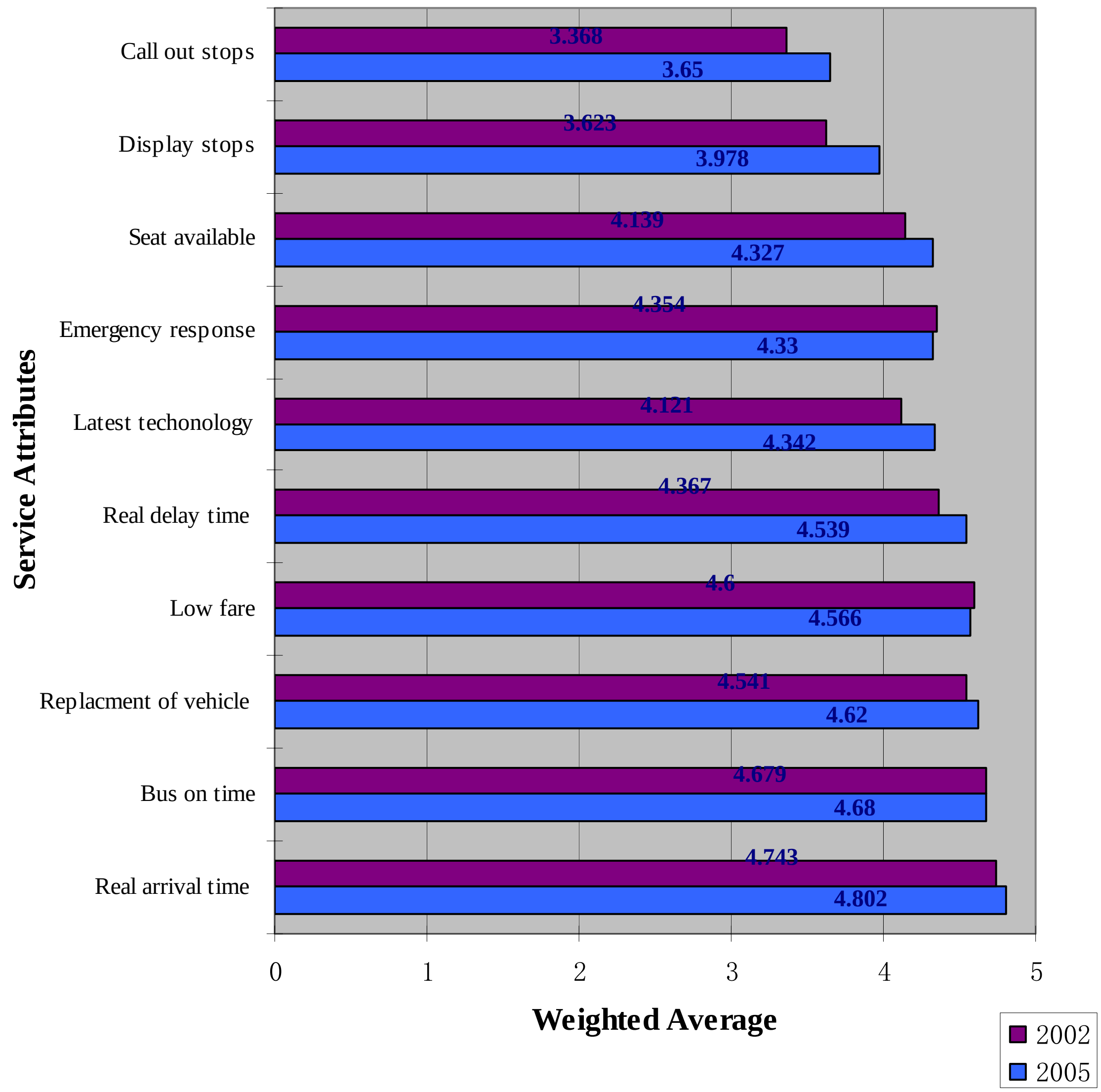


FIGURE 8: Weighted averages of 10 factors in the Waukesha surveys

As shown in Table 6 and Figure 7, the results in Racine in 2005 were very similar to those in 2001. Among all these factors, "knowing when the bus will actually arrive at the bus stop" was consistently valued by passengers as the most important factor with 85.6% of the passengers rating this factor as very important. "Bus arrived at the scheduled time" is ranked second in the surveys. "Knowing that another bus can be immediately dispatched if there is a breakdown" changed from the 4th in the three surveys to 3rd and "low bus fares" falls to the 4th. The rank of the top three factors indicates the bus riders in Racine are still very sensitive to the schedule reliability, "Knowing how late the bus is in case of a delay" and "knowing the bus is equipped with a 911 emergency system" are also valued high in the surveys. These are benefits which can result from AVL technology. The Racine survey in 2005 has a higher rank for the factor "knowing the transit system uses the latest vehicle location technology" compared to 2001. The percentage of the respondents scoring it as "very important" also increased from 52% in 2001 to 57.4% in 2005. By contrast, "displaying the name of the next stop inside the bus" and "having the drivers call on the stops" are still the least important factors in transit users' minds. Around 29.8% of the respondents in 2005 knew AVL installed in the bus system and 62.1% of these respondents scored it as very important. By comparison, 55.4% of the respondents who don't know AVL ranked this factor as very important.

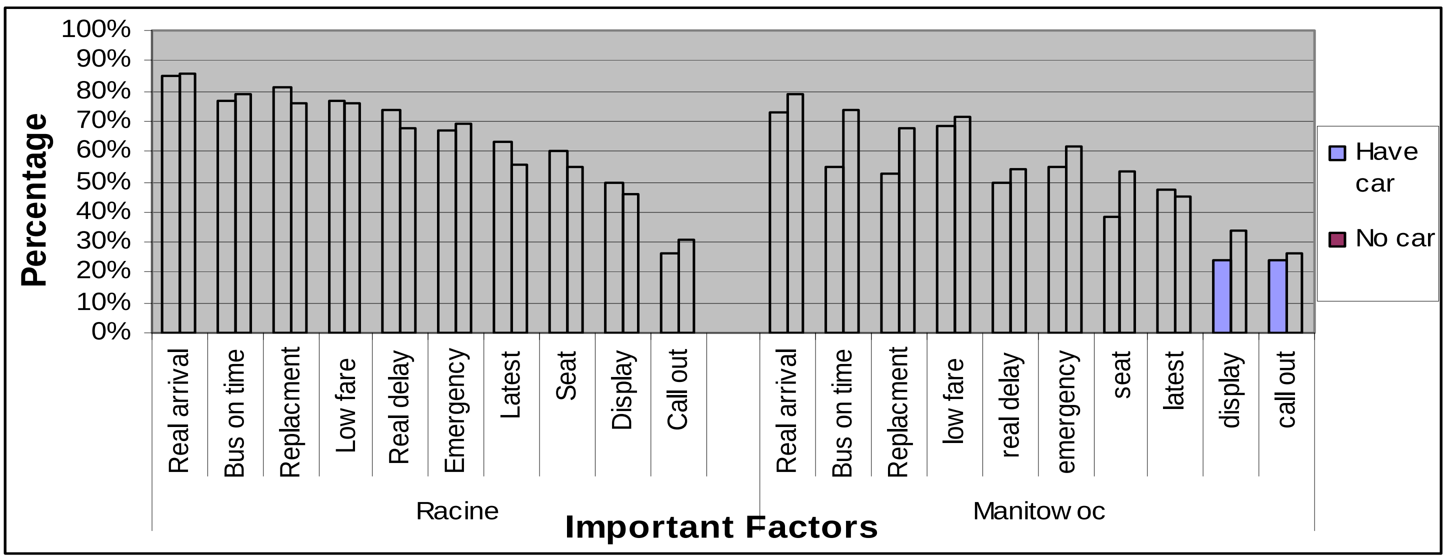
Similarly, in Waukesha, respondents also ranked knowing when the bus will arrive and that the bus arrives at scheduled time as the first and second most important factors. Attributes "having the next stop displayed" or the "driver call out the stops" were also ranked as the least important among riders. The largest difference between the ranking of the factors that affect decisions to ride bus in 2002 and 2005 is the rank of latest vehicle location technology. It was ranked the 8th in the survey of 2002. But, after the AVL system was implemented in 2005, its rank was increased to the 6^{th}. In 2005, around 46.3% of the respondents knew AVL through various sources. Among them, 26.5% knew AVL through electronic signs at the Transit Center, 9.2% knew from the city media and 18.2% knew from bus drivers and 5% from other sources. 66.2% of the respondents who knew the AVL system scored it as very important. By comparison, only less than one half of the respondents (49.7%) who don't know AVL ranked this factor as very important.

Overall, the 2005 survey shows that transit users still valued factors related to the benefits of AVL system. In comparison with the survey in 2001/2002, higher proportions of the respondents ranked AVL related benefits as "most important". However, the rank of AVL was lowered partially because riders don't know it or its functions.

Choice riders' perceptions of the Different AVL Benefits

Captive riders are those who don't have an alternative way to travel besides the bus (Peng et, al, 2001) while choice riders have alternative way to travel such as the car. (Choice riders were defined as those who answered "yes" to the question "Did you own or have access to a car that you could have used for the trip you are making today?") Because choice riders are much flexible on choosing the travel means than captive riders, they are potential customers that transit systems may want to attract. Their perceptions are important for the transit systems to improve service and hence attract more ridership. The survey in Racine in 2005 indicated that 78.2% of all respondents did not have a car as an alternative mode to travel in comparison with 78.1% in 2001. As shown in figure 8, car availability showed little difference on the ranking of the importance of the factors. Respondents with a car place more importance on bus replacement for breakdowns, real delay time information and AVL technology than passengers who don't own car. These improvements can all be realized through the implementation of AVL system. Thus the installation of AVL in the bus service system could attract more ridership from those with a car available.

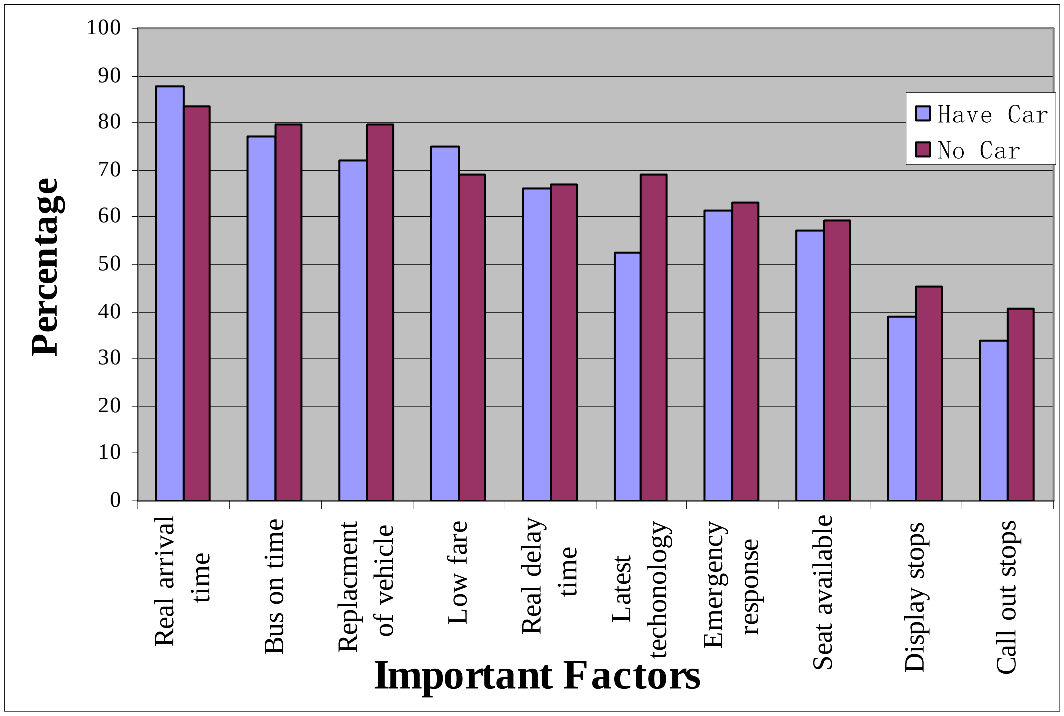
By contrast, in Waukesha, 73.2% of all respondents did not have a car available as an alternative mode to travel, while that figure in the survey of 2002 is 86.1%. Thus, more choice riders began to use public transit after the installation of AVL systems. However it should also be noted that other factors such as changes in fuel prices or changes in the economy also occurred which probably also affected the choice to use transit In the 2002 survey, car availability showed some difference on the ranking of the importance of the factors, especially for the factor "latest location technology" and "seat availability". By comparison, in 2005, the gap between the perceptions "latest location technology" was larger between those with a car available and those without. Except "low fare", other factors were valued more important by no car respondents rather than riders having alternative travel mode, partially because these captive riders have to rely on transit as their sole transportation mode.



Note: the percentages in the table represent the percentage of respondents scoring the corresponding factors as "very important" in affecting their decision.

FIGURE 9 Effects of Car Availability in Ranking of Decision Factors in Racine and Manitowoc in 2005

In Manitowoc, 18.5% of the respondents have access to a car. From figure 9, it appears that people who own cars are less sensitive to the all factors except for AVL technology. So, it would be difficult to attract choice riders in Manitowoc even if better information services are offered.



Note: the percentages in the table represent the percentage of respondents scoring the corresponding factors as "very important" in affecting their decision.

FIGURE 10 Effects of Car Availability in Ranking of Decision Factors in Waukesha in 2005

Information Accessibility

With asked what means people would use to receive the real time information, 23.3% of the passengers in Racine choose internet, 38.7% would use cell phone and 58% would choose standard telephone. By contrast, in 2001, 20% of the respondents would use internet, 24% would use cell phone and 56% would use standard telephone. These data reflect the increase in of cell phone usage during the time between the surveys and indicate that transit agencies should consider using cell phones to make real time transit information available, as well as by internet, and the standard phone.

In Waukesha, riders access to the bus schedule information through more various channels. In 2002, most respondents received information by hard copies of the schedule (78.2%). However, many also received info by calling the office (20.7%), from other people (21.2%), or stop information (25.8%). Some also listed other as their response, mostly indicating they get information from drivers. In 2005, most of the respondents still use hard copy bus schedules (74.4%) to know when the buses would leave the stops.

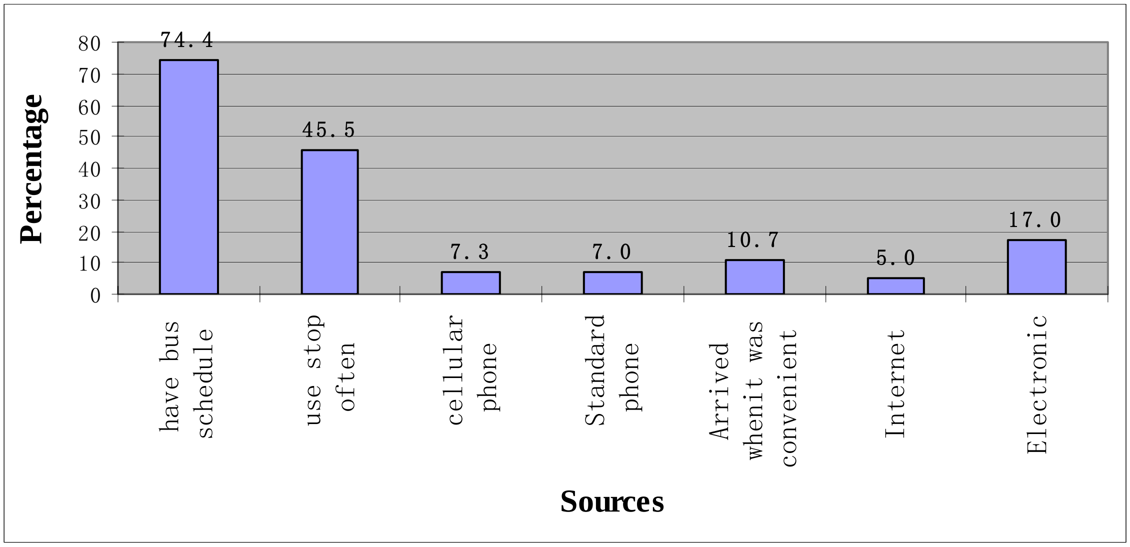


FIGURE 11: How did riders know when the bus will leave the bus stop they used (Waukesha 2005)

Electronic bus arrival information was the installed in the transit center shortly before the surveys, and (17%) of the respondents indicated they got information from the displays. Waukesha metro transit system also began to display the arrival information of the buses as well as at the bus transit centers. These have been well received: 40.6% of the respondents thought the electronic information is extremely useful and 29.0% of the respondents thought that information is very useful. Only 1.4% of the respondents thought the arrival information is not useful. All together 87.4% of the respondents believed the electronic information is either very accurate or accurate most of the times. Some of the riders thought the arrival information was somewhat accurate because the information is not displayed all the time. Figure 12 exhibits the percentage of the respondents who think the electronic information is extremely or very useful across the different group of riders categorized by the riding frequency. Apparently, people who ride more often value the electronic information as more useful.

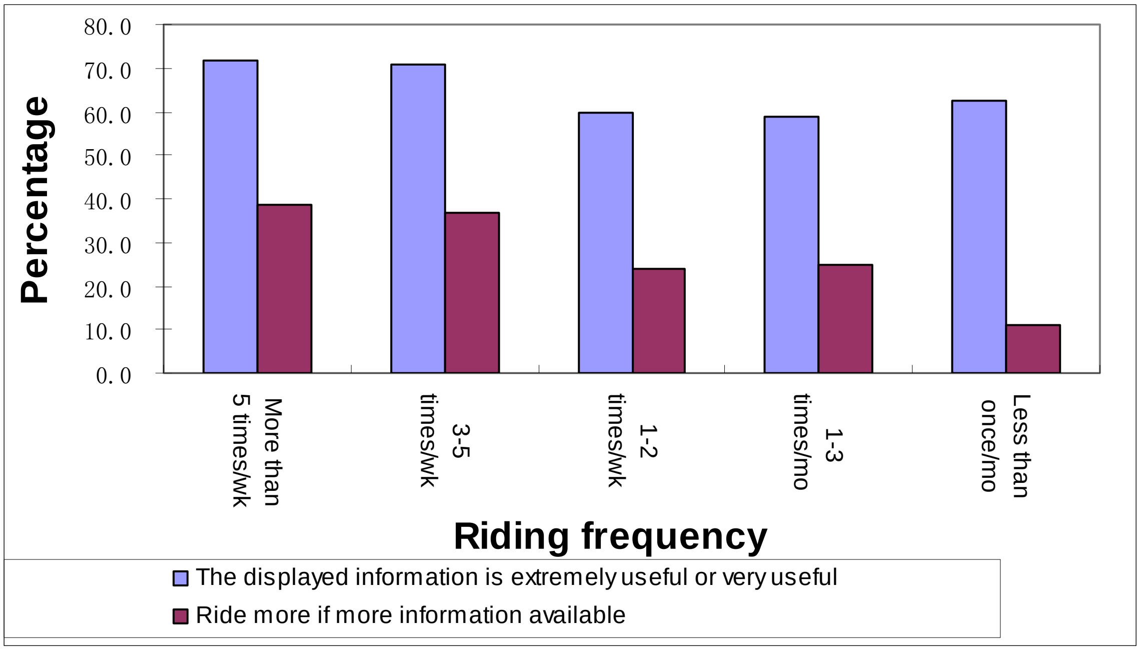


FIGURE 12 Rider's perceptions on the transit information provided (Waukesha, 2005)

More Potential Riders?

Besides an increase on-time performance and improvements in the quality of transit services, AVL technology is also expected to attract more transit users or at least keep the current level of transit ridership. Although the AVL systems in Racine and Waukesha have been in operation too short a time period to draw any conclusions, we did ask the existing passengers about this question.

The survey results in Racine show that more than one third (36.1%) of the respondents in 2005 replied that if better information were available, they would ride bus more often, which is lower than that in 2001 (40.6%), but close to 34.8% in the survey in Waukesha in 2005 and higher than 23.9% in the survey in Manitowoc in 2005. A majority of the passengers will, however, ride the same.

Among these respondents, high frequency riders indicated they would ride more at a higher rate if better information were available (figure 13 and 14). That is different from the result of 2001 survey, which showed low frequent riders would possibly ride more (Peng et al, 2002).

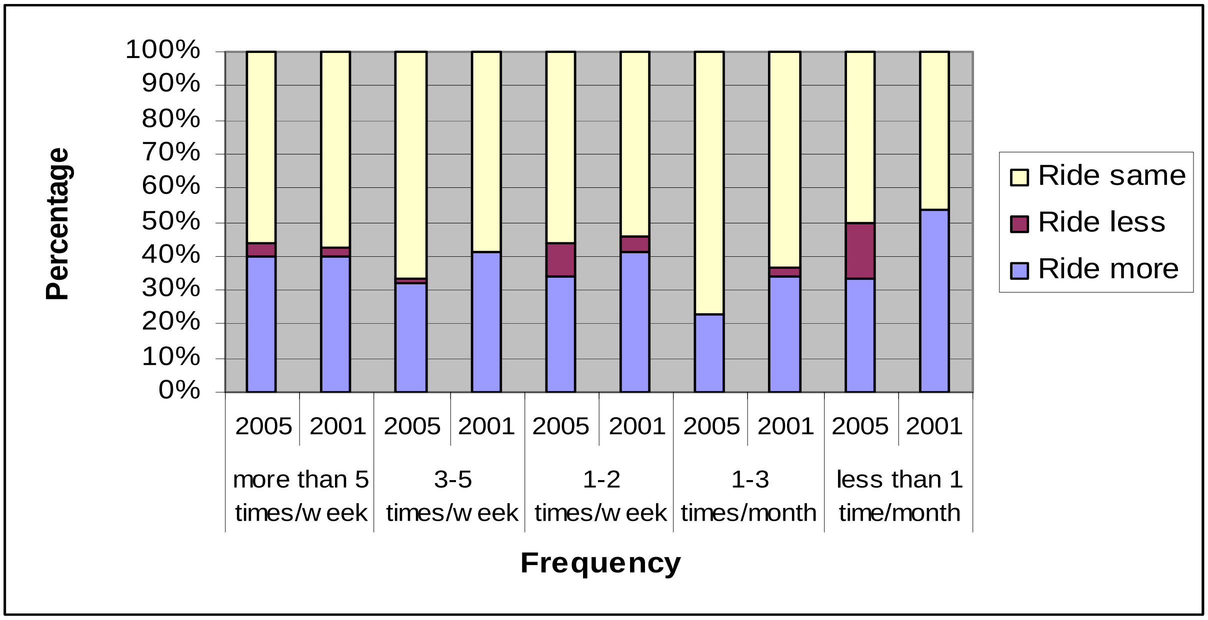


FIGURE 13: Effect of better information in influencing riding choice in Racine.

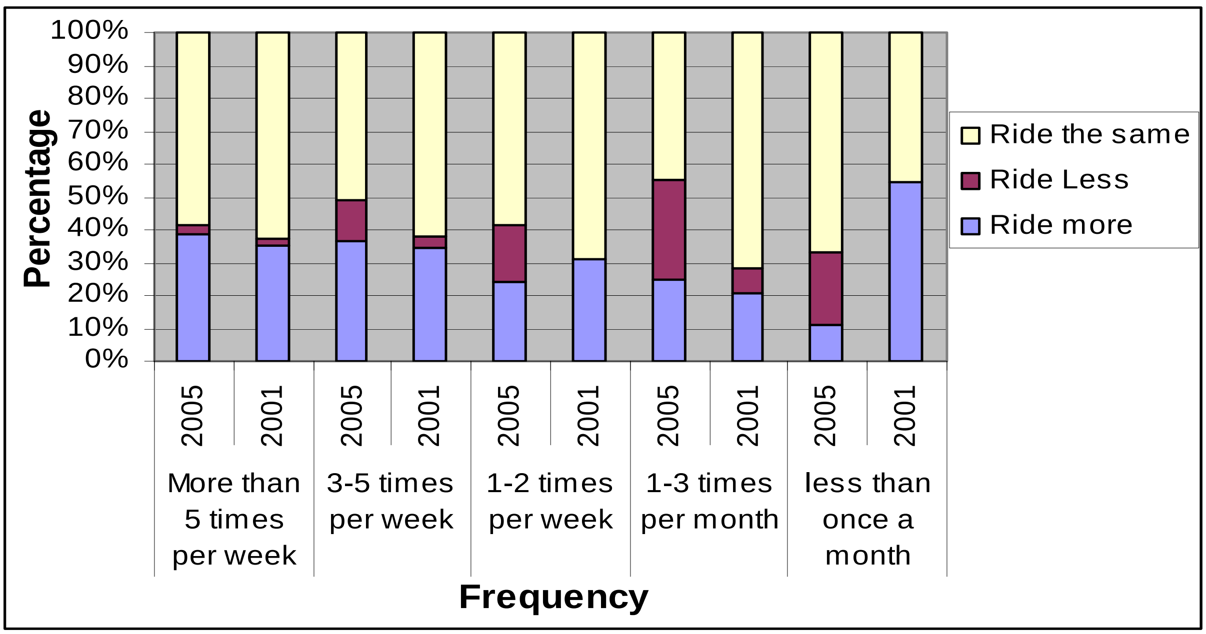


FIGURE 14: Effect of better information in influencing riding choice in Waukesha

A logit analysis was performed toward the 2005 Racine data to identify the characteristics of the population that will use more transit service if better information was available (Table 7). Several observations could be derived from this logit analysis results:

1. People who are not satisfied with the current transit service are more willing to ride more if better information were provided. For example, passengers who think

the bus does not run on time would use more transit if better information were available. Also, people who currently wait bus for more than 15 minutes are more likely to ride more if better information is available.

2. People who have easy access to transit services are more willing to ride more if better information were provided. For example, if passengers walk to bus stops and those who think the bus now run more close to their home are willing to ride more if better information were available.
3. Young and middle aged people (aged 18-65) are willing to ride more if better information was available. Unlike the survey in 2001, the availability of a car does not seem to have any influence on people's willingness of riding more bus if better information were available.

TABLE 7 Logit Analysis Result

Independent Variables		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1(a)	LessOntime	1.502	.356	17.843	1	.000	4.489
	WaitLong	.780	.353	4.891	1	.027	2.182
	Walk	1.037	.296	12.275	1	.000	2.821
	Close	.766	.302	6.448	1	.011	2.152
	Young	1.474	.451	10.710	1	.001	4.368
	Midage	.976	.418	5.444	1	.020	2.654
	OwnCar	-.034	.365	.009	1	.926	.966
	Constant	-3.013	.511	34.762	1	.000	.049

Note: Dependent Variable: RideMore: 1=ride more often if better information were provided, 0=otherwise
-2 Log likelihood (B) = 287.689
WaitLong: 1=waiting time is more than 15 minutes, 0=otherwise
Lessontime: 1=compare with last year, the bus runs less on time this year, 0=otherwise
Walk: 1=get to bus stop by walking, 0=otherwise
Close: 1= compare with last year, the bus now runs more close to my home (work), 0=otherwise
Young: 1= with age 18 to 25, 0=otherwise
Midage: 1=with age 26-65, 0=otherwise
OwnCar: 1=car available, 0=not available

Although we have no observed data to confirm, but based on the survey results do indicate that better and timelier information through the AVL system could lead to more transit ridership.

CONCLUSIONS

This study focused on the assessment of the effects of AVL systems on the medium and small sized transit agencies. A before and after comparison of the transit on time performance showed that the schedule adherence of the transit system in Racine has been significantly improved, most likely as the result of the AVL systems. The survey results also exhibit that the AVL system improved the schedule adherence not only at the system level, but also at the route level and time point level. In addition, the transit service is more reliable after the installation of AVL system. However, although AVL systems improved the on-time performance, the average wait time of passengers in Racine was longer than that in 2001. This may be a reduction in bus service frequency and an adjustment of bus routes that occurred over the same period of time.

In addition, AVL seems to be able offer customers' features that they desired the most. Better on-time performance and schedule reliability are regarded as the most important by transit riders consistently in both cities and over time. Other factors related to the benefits of AVL systems, including "Knowing when the bus will actually arrive at the bus stop", "timely dispatch in case of emergency" and "knowing how long the delay is in case of delay" are also considered as very important for transit riders. These findings are important for transit agencies in their decision-making and planning process. For example, "Knowing when the bus will actually arrive at the bus stop" is consistently ranked as the number one important factor for transit passengers which points out a need to publicize the real-time bus information on bus stops, the Internet, and by cell phone.

From these surveys, we were unable to answer the question with certainty that "Will AVL systems help to attract more transit riders?" On the one hand, about 36% of survey respondents stated that they would ride more with better and timelier transit information, but a larger groups state they will ride the same amount. On the other hand, many passengers seem to be willing to ride more if better information and better services are available, particularly for those who are not quite satisfied with the current transit services. However, the AVL system was relatively new in our study, and only around 30% of riders knew the buses have the AVL system. Besides, some benefits of AVL like real time information and timely transit dispatch were not available yet. Therefore, the issue that whether AVL systems can attract more ridership remains unclear at this time and deserves further studies.

RECOMMENDATIONS:

This study raises the critical question of should AVL systems be included in all future transit vehicle purchases in the state of Wisconsin. The answer is not straight forward. Clearly AVL systems can improve on-time performance for transit systems and users highly value the characteristics that AVL systems provide. Our surveys consistently indicated a user demand for better information and better on-time performance. However if a transit system has very good on-time performance without AVL, then there is little opportunity to improve that which is already very good. Thus AVL is probably not needed when there is good on-time performance but should be provided wherever current on-time performance is poor. AVL when provided should include passenger information systems that convey bus arrival times to users such as provided in Waukesha. Installation of AVL on existing vehicles should be done wherever on-time performance is a problem.

It is likely that the costs of AVL will decrease in the future and that it will be evolve to being standard equipment on new vehicles. In addition, other technologies such as cellular location systems will also become widespread. Thus for new vehicle purchases, transit agencies should be aggressive in acquiring the AVL technology and making it available to their users. Streamlining of procurement systems and use of standardized specifications is essential to avoid the delays encountered in the case study cities.

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Appendix A:

Evaluation of the Benefits of Automated Vehicle Location Systems for Small and Medium Sized Transit Agencies

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Benefit Analysis of Automated Vehicle Location Systems for Small Transit Agencies

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ABSTRACT

This paper presents an analysis of the potential benefits and applications of Automatic Vehicle Location Systems (AVL) in small and medium sized transit agencies. These were identified through a transit agency/transit user assessment. The user's assessment included a survey of small to medium transit agencies that have implemented AVL to determine their experience with the technology and the benefits it has provided. In addition, a survey was conducted of transit users in a Wisconsin community to assess the level of importance that transit users place on features of transit service that AVL can affect. This information was used to identify the costs and benefits of AVL to the transit riders and service providers.

The study reached the following conclusions: Transit users place a high degree of importance on features that minimize waiting uncertainty and increase their feeling of security. AVL systems potentially can have large benefits, which easily exceed the costs of the systems. These benefits largely occur to transit users through reductions in vehicle waiting time even if only by a small amount. Other effects such as increased sense of security and reduced response time for incidents cannot be easily quantified but would add to the benefits of an AVL system. Such benefits, as user benefits, may not necessarily accrue directly to the transit agency nor be directly recoverable as revenue. In addition, AVL systems have the potential for better management information that can lead to more productive service and better planning for future needs.

INTRODUCTION

There is dilemma in assessing the costs and benefits of new technology in transportation. On the one hand, transportation analysts are under increasing political pressure to provide cost-benefit analysis before deploying a new technology such as intelligent transportation systems. Policy makers and legislatures are often reluctant to authorize new projects without a cost-benefit number or other proper justification. On the other hand, it is difficult to assess the costs and benefits of a system without observed data from a deployment.

The Wisconsin Department of Transportation (WisDOT) in the USA considered adopting Automated Vehicle Location (AVL) systems in small and medium sized transit agencies in the State of Wisconsin. WisDOT was interested in knowing whether the implementation of AVL in those small and medium sized transit systems is cost effective. Although a few agencies have

AVL deployment, there was no before and after performance data available for cost-benefit analysis. There is a great need for a method to help transportation professionals to conduct a sketchy cost-benefit analysis before a deployment.

This study specifically addresses the cost-benefit issues of AVL applications in small and medium sized transit agencies, i.e., transit agencies with fleet size less than 50 vehicles (according to the Federal Transit Administration's definition, Casey et al, 1996). Small to medium transit agencies were contacted to determine their perception of their experience with AVL and the benefits it has provided. In addition a survey was conducted of transit users in a Wisconsin community to assess the level of importance that they place on features of transit service that AVL can affect. A cost-benefit and sensitivity analysis is conducted to determine the break-even point, and the analysis sensitivities to different factor variations. The study concludes with suggestions for transit agencies that are thinking of adopting AVL systems.

SURVEY OF TRANSIT SERVICE PROVIDERS AND USERS

Two surveys were conducted in this study, one with transit service providers and the other with transit users. The purpose of transit agency survey was to obtain information about the experiences of agencies using AVL systems, while the purpose of transit user survey was to identify the importance that transit users place on the attributes of transit service that AVL may affect.

The major benefits of AVL cited by the managers are related to service factors. Customer benefits occur through improved services, as the AVL technology is in nearly all cases a hidden system. The major benefits of AVL systems cited by agencies were:

- Improved efficiency of the system management and on-time performance. The monitoring capability of the AVL system allows the agency to make better decision about scheduling and routing, and to improve on-time performance. AVL permits automated dispatch and scheduling (Nelson 1995; Khattak et al 1998; Tellechea and Stone 1998).
- Improved customer communication. Disputes about non-arrival of vehicles and similar customer complaints can be handled better because documented evidence of the real-time location of vehicles is available from the AVL system.
- Better flex routing services. The AVL technology allows the flexibility of incorporating some demand-responsive services such as route deviation into the regular fixed-route service. This is particularly important for small agencies and para-transit services that operate in a low-density environment.
- Decreased reservation time. Paratransit services usually required 24 to 48 hour advance reservations prior to the AVL system. With the AVL the reservation time has been brought down to one hour or less in many cases. Occasionally real-time scheduling can also be done, which is a great time saving to passengers.
- Efficient use of resources. Most small and medium sized agencies felt that an AVL system would help utilize the resources more efficiently with the introduction of demand responsive services in regular fixed routes (COLTS, 1997).

RIDERS' PERCEPTIONS OF THE IMPORTANCE OF TRANSIT SERVICE ATTRIBUTES

Notwithstanding the transit mangers' perceived benefits of the AVL system, the ultimate goal of AVL and transit is to serve the passenger. It is important to find out how the transit riders value those features that AVL can provide. An on-board user survey was conducted to help assess the value of implementing an AVL system in small sized transit agencies from the users' perspective as well as to get feedback about riders' concerns and perceptions about transit service characteristics. The City of Manitowoc, Wisconsin was selected as the site of an on-board user survey because it is a representative of a small sized agency. The system operates five full-time dedicated buses and one van with flexible scheduling. The overall response rate was around 80 percent. The following are the highlights of the on-board survey results.

The questionnaire asked passengers to rank the relative importance of the major factors that affect their decisions to ride a bus. The most important ranking is scored 1 and the least important ranking is scored 5. The on-time performance of the bus service emerged as the most important factor for the transit riders. In fact the occasional riders tended to mark it as very important in their decision to ride a bus. Overall 61 percent of the respondents considered the on-time performance as very important. Availability of real-time information on the bus service ranked second on the list. Over half (51 percent) of the respondents felt this was very important (Table 1).

Table 1: Rider Rating of Transit Attributes

Variable	Weighted Importance Score
Bus is on-time	1.48
Real-time Information	1.55
Low Fares	1.62
Replacement on breakdown	1.66
Emergency Response	1.68
Exact Delay Time	1.78
Availability of Seat	1.91
Latest technology	2.01
Display Next Stop	2.39
Calling out Stop	2.82

A FRAMEWORK OF BENEFIT COST ANALYSIS OF AVL SYSTEMS

A parametric benefit-cost analysis was conducted to determine the relative magnitude of AVL benefits and costs. This process allows some estimates of the relative magnitudes of benefits and costs and the relative contribution of different factors to benefits and costs. The purpose of this exercise is not to come up with an absolute value of benefit/cost ratio; but to determine which factors are most important in the analysis. It presents break-even points under different cost scenarios. The intention of the analysis is to serve as a rough guidance for policy makers to make decisions on whether AVL should be deployed in the small and medium sized transit agencies and what conditions are required for the benefits of the AVL system to break even with costs.

Identification of Potential AVL Benefits

Based on the survey results from the transit agencies and riders, major benefits of AVL systems to transit agencies and riders are identified. These benefits are developed into a “benefit tree” as shown in Fig. 1.

Agency Benefits

The advantage of AVL to the operation and management of a transit agency is centered on its ability to reduce costs while providing a more efficient service. The measurable benefits from an AVL system include cost reduction by the elimination of staff and reducing response time to incidents, as well as increased efficiency of existing routes and greater productivity without increasing staff and/or vehicles. Both of these areas would lead to greater revenue generation through cost savings and the increase of potential ridership. The un-measurable benefits of AVL to an agency have to do with the ability to use AVL for public relations to increase awareness and pride in the existing service.

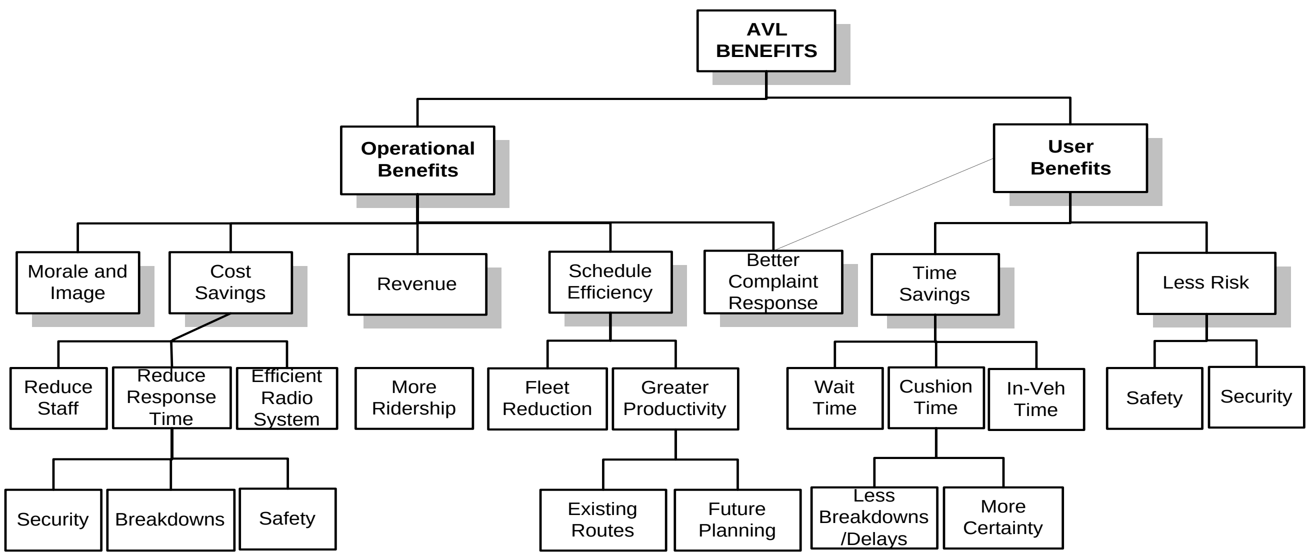

Figure 1: AVL Benefit Tree

User Benefits

Major benefits to transit riders include the reduction of wait time and the improvement of security. AVL can improve on-time performance and help reduce wait time at bus stops. The reduction of wait time at a bus stop also helps the perception of security. Moreover, the assurance that the vehicle is equipped with emergency response system and could alarm the emergency response team further improve the perception of security on-board the bus.

BENEFIT AND COST ANALYSIS OF AVL

The cost of AVL is difficult to fully quantify, because many systems adopted AVL in conjunction with the upgrade or replacement of their radio system. Some transit agencies considered the implementation of AVL as an add-on to the upgrade or replacement of the current radio system. Therefore, it is inaccurate to contribute all costs to the AVL system. Furthermore, it is also difficult to separate the costs of radio upgrade and AVL addition since they are bundled together. In general, the costs of AVL include capital costs and ongoing maintenance costs. The cost of the system varies greatly depending on the capabilities of the system. Table 2 shows some examples of the system costs that include the costs of GPS units, hardware and software costs in the control center and ongoing maintenance costs.

Table 2 AVL System Costs and Related Fleet Size

City/ System	Cost of the System	Fleet Size	Costs per Bus
San Jose, CA – Outreach	$750,000	15 buses, 55 vans	$10,714
Palatka, FL - Arc Transit	$50,000	14 buses	$ 3,571
Winston-Salem, NC – WSTA	$235,000	17 buses	$13,824
Scranton, PA – COLTS	$357,935	32 buses	$11,185
Woodbridge, VA – PRTC	$245,000	20 buses	$12,250
Average	$327,587	30.6 buses	$10,705

A case study for Racine, Wisconsin, USA was conducted. Racine is a city of about 100,000 people, located between Milwaukee and Chicago. It operates a thirty vehicle fixed route transit system and provides paratransit service with eight vehicles.

It was initially assumed that the project will last for 5 years and that the discount rate is eight percent. Therefore, the annual system cost range is from $45,556 to $95,137 (Table 3). The cost distribution chart (Figure 2) shows that the capital cost is about two-thirds (67 percent) of the total cost and the maintenance cost is about one-third (33 percent) at the low estimate, whereas about 80 percent capital cost and 20 percent maintenance cost at the high bound estimate. It should be noted that the costs of AVL technology are constantly changing and become cheaper because of more mature technology and more competition. The cost numbers reported here reflect the cost structure as of September 1998.

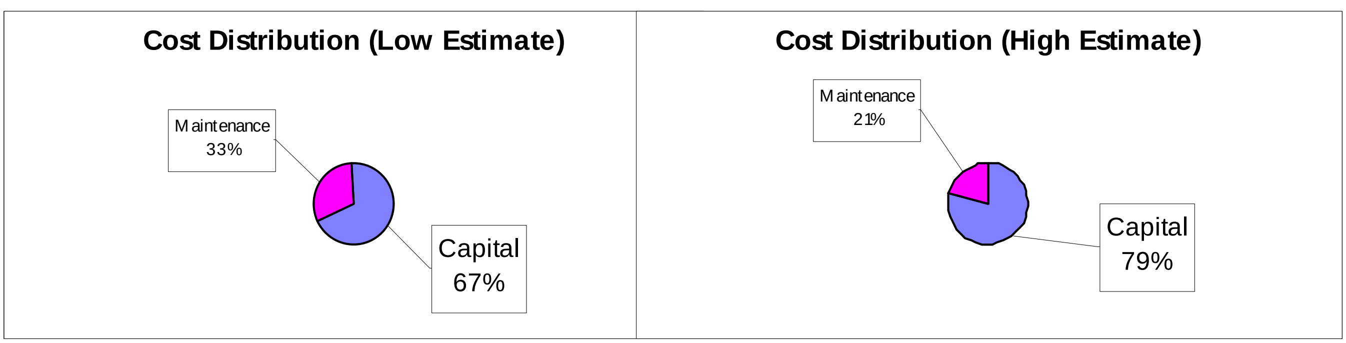

Figure 2 AVL System Cost Distribution

Table 3. AVL System Cost Estimation

AVL system costs					
Capital costs	Units	Unit cost (low bound)	Costs_low	Unit cost (high bound)	Costs_high
Cost /vehicle	46 vehicles	$2,000	$92,000	$5,000	$230,000
Control Center	1	$10,000	$10,000	$50,000	$50,000
Other	1	$20,000	$20,000	$20,000	$20,000
Capital subtotal			$122,000		$300,000
Annualized Capital Costs (8% discount rate)			$30,556		$75,137
Annual AVL Administration			$20,000		$30,000
Annual Maintenance			$15,000		$20,000
Annualized Total Costs			$65,556		$125,137

Breakeven Analysis

The purpose of the breakeven analysis is to identify the breakeven point in terms of the wait time saving required to cover annualized system costs. Based on the range of cost estimates, the breakeven point is set to be equal to the low and high estimate of the costs. Several scenarios are analyzed as discussed below.

Breakeven Analysis for User Time Saving

If we exclude administrative savings and only consider user timesaving from the AVL technology, we can calculate user benefits breakeven points. To be conservative, we first assume that transit ridership would be kept constant. We further assume that there would be no saving from administrative expense and incident saving. The only benefit to be considered is the saving from the wait time reduction of the transit users.

Total user benefits depend on transit ridership, the value of time and the amount of wait-time saving. Ridership can be broken down into different trip purposes such as home-based work, school, others and non-home based trips. The value of time and the wait time for every trip purpose can be derived from a mode split model such as that developed by metropolitan planning organizations for transportation planning purpose. The critical question is how much wait time can be saved by using the AVL technology. For the breakeven analysis, the required minimal timesaving can be estimated.

An example of user benefits estimation is given in Table 4. The annual fixed-route ridership in Racine is 1,771,000 trips and paratransit ridership is about 19,500. Among those, 29 percent are home-based work trips, 40 percent are school trips, 26 percent are shopping or other trips, and 4 percent are non-home-based trips. Parameters to convert timesaving into dollar benefits were derived from the Southeastern Wisconsin Regional Planning Commission (SEWRPC)'s transportation mode split model (SEWRPC 1995). This model was calibrated based on survey data, to simulate how travelers make tradeoffs between travel time, travel cost, waiting time and other factors. The derived value of travel time for work trips of $2.09 per hour, and $0.41, $0.42

and $2.05 per hour for school, shop/other and non-home based trips respectively. A wait time multiplier is used to adjust for the perceived longer wait time. The SEWRPC model implies that people perceive wait time about 2.62 times longer than the actual wait time for work trips. Multipliers for other trip purposes are 1.00 for school trips, 7.36 for shopping trips and 7.00 for non-home based trips.

The user benefits can be estimated by the following formulas:

> Benefits for trip purpose $_i$ = Ridership by trip purpose $_i$ * value of time of trip purpose $_i$ * wait multiplier for trip purpose $_i$ * wait time saved

For example, the benefits of the work trips are 29% * 1770993 * 2.09 * 2.62 * t/60, where t is the time saved in minutes. A similar calculation can be done for other trip purposes and the total user benefit is the sum of all trip purposes for fixed route service.

System Information	Fixed	Paratransit	Total			
Annual ridership	1,770,993	17,731	1,788,724			
Fleet size	38	8	46			
Trip Purposes	Pct	Trips	Time Value	Wait weight	wait min/trip	benefits
Work trips	29%	518,901	2.09	2.62	t	47357t
School Trips	40%	715,481	0.41	1.00	t	4889t
Shop/other	26%	464,000	0.42	7.36	t	23905t
Non-Home based	4%	72,611	2.05	7.00	t	17366t
Fixed Route Subtotal	100%	1,770,993				
Paratransit Users		17,731	0.97	3.39	t	973t
Total		1,788,724				94490t

Table 4:User Benefits of AVL

For the paratransit users, there is no data on its breakdown of trip purposes, so the same proportion of trip purposes as the fixed route is assumed. Similarly, the weighted time value (using the proportion of trip purposes as the weight) is assumed for the paratransit trips. The total benefit of paratransit users can be calculated in a like manner.

Since we are interested in the breakeven point, the minimal total benefits should equal to the annual costs (both low estimate and high estimate of AVL system costs). The breakeven point is a saving of between 0.7 (= 65556/94490) and 1.3 (= 125137/94490) minutes of wait time based on the current ridership. Given that these are very small numbers, it indicates that the potential for AVL wait-time savings to exceed the cost of implementing AVL is high, even when the possible efficiency gains of administration and management are omitted.

Breakeven Analysis of Transit Ridership Changes

The above analysis assume the transit ridership remain unchanged. What if the ridership changes? How would ridership changes affect the breakeven analysis results? We estimate the breakeven points of wait time saving are estimated under different ridership scenarios. To estimate the breakeven points of the time saving under different ridership scenarios, the benefits are set equal to the low and high estimates of the costs. Since the major benefit of the AVL technology is the user benefits, this analysis excludes the potential benefits to transit providers. The breakeven points of time saving are shown in Table 5 and Figure 3.

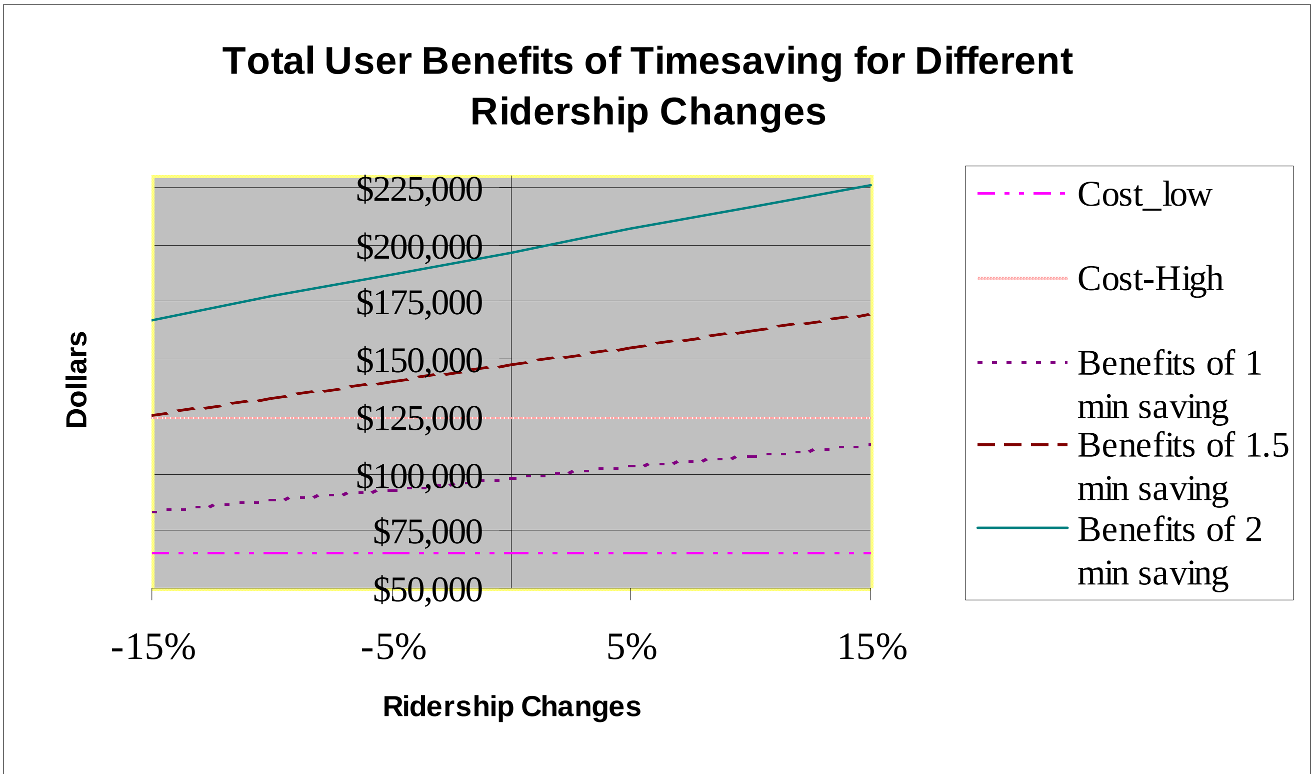

Figure 3. Total user benefits of time savings by ridership changes.

It can be seen that when transit ridership goes up, the required average time saving for individual riders goes down. For example, when the ridership reduces by 15 percent from the current level, the minimal timesaving required to breakeven ranges from 0.78 minute to 1.5 minutes; while when the ridership increases by 15 percent from the current level, the time saving needed to break even ranges from 0.58 minutes to 1.11 minutes.

Table 5: Breakeven points of time saving with regards to ridership changes

Ridership changes	Annual trips	Trips/week	Cost_low	Cost-High	Breakeven timesaving (low estimates)	Breakeven timesaving (high estimates)
-15%	1,520,415	29,239	$65,556	$125,137	0.78	1.50
-10%	1,609,852	30,959	$65,556	$125,137	0.74	1.41
-5%	1,699,288	32,679	$65,556	$125,137	0.70	1.34
0%	1,788,724	34,399	$65,556	$125,137	0.67	1.27
5%	1,878,160	36,118	$65,556	$125,137	0.63	1.21
10%	1,967,596	37,838	$65,556	$125,137	0.61	1.16
15%	2,057,033	39,558	$65,556	$125,137	0.58	1.11

To estimate the magnitude of costs and benefits of AVL under different ridership scenarios, user benefits for 1, 1.5 and 2 minutes of wait time saved are estimated as shown in Table 6. These results show that the user benefits of one-minute time saving can exceed the low estimate of costs of AVL but would be short of the high estimate of the AVL costs. The benefits of an average of 1.5 and 2 minute timesaving for individual rides would exceed the high estimate of the AVL costs.

Table 6. User benefits of timesaving for different ridership changes

Ridership changes	Annual trips	Trips/week	Cost_low	Cost-High	Benefits of 1 min saving	Benefits of 1.5 min saving	Benefits of 2 min saving
-15%	1,520,415	29,239	$65,556	$125,137	$83,625	$125,437	$167,249
-10%	1,609,852	30,959	$65,556	$125,137	$88,544	$132,816	$177,088
-5%	1,699,288	32,679	$65,556	$125,137	$93,463	$140,194	$186,926
0%	1,788,724	34,399	$65,556	$125,137	$98,382	$147,573	$196,764
5%	1,878,160	36,118	$65,556	$125,137	$103,301	$154,952	$206,602
10%	1,967,596	37,838	$65,556	$125,137	$108,220	$162,330	$216,440
15%	2,057,033	39,558	$65,556	$125,137	$113,139	$169,709	$226,279

DISCUSSION AND CONCLUSIONS

The breakeven analysis shows that it is difficult for small and median-sized transit agencies to reduce the administrative expense so much to recover the costs of deploying the AVL technology. The main benefits of AVL lie in wait timesaving of passengers. The results are consistent with the benefit cost analysis used for highway investment studies. In those studies, timesaving from a highway improvement tends to be the most significant element of highway benefits. Wait time savings can occur in several ways. With AVL, transit dispatcher has more accurate information and better communication with bus drivers, which should result in better adherence to schedules and on-time performance. Better dispatch service and emergency response would result in an overall decrease in delays.

It should also be noted that only a small number of quantifiable benefits have been identified in the analysis. Many other potential benefits have not been taken into account because of the lack of data or because of the difficulty of quantification. For example, the installation of a silent alarm system can improve the perception of security for both passengers and drivers. This psychological effect is difficult to put a dollar value on. The introduction of AVL may provide a basis for other new technologies, which may subsequently help transit agencies realize further operation efficiencies. Other non-quantifiable benefits include better information for performance evaluation, scheduling and planning, improved agency image, better handling of customer complaints and potential reduction in the number of complaints.

The costs of implementing the AVL technology in small and median-sized transit agencies can be reduced by sharing the AVL system with other municipal agencies such as police, public works department, or with other transit agencies within a region. For example, Outreach, California, USA has successfully implemented a Broker Model to serve fifteen cities within the valley region using a shared AVL system (Chira-Chavala, 1997). Agencies can gain enormously from the economy of scale by sharing the costs.

AVL systems should be implemented in a way to maximize their impact on passenger waiting times. This is an area of high potential benefits. Mechanisms to increase awareness of vehicle arrival times and to disseminate real-time information should be actively explored to provide the best use of an AVL system (Peng and Jan, 1999).

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Appendix B:

(Report of surveys before AVL Implementation)

Transit User Perceptions of Automatic Vehicle Location System Benefits

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Transportation Research Board, Record 1791, pp127-133

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Transit User's Perceptions of AVL Benefits

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Transit User's Perceptions of AVL Benefits

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Abstract

This paper reports on an attitudinal survey on transit rider's perception of the importance transit users place on features of an Automatic Vehicle Location (AVL) system. On board surveys and on-time field checks were conducted in the cities of Manitowoc and Racine, Wisconsin to determine how users in those cities perceive their transit system and how well it performs. The surveys indicate that transit riders put a great value on increased on-time performance and improved schedule reliability. Passengers value features that AVL technology could bring, such as improving on-time performance, knowing when the next bus will arrive, knowing how long the delay is in case of delay, knowing another bus could be dispatched in case of breakdown. The surveys indicate that AVL technology could improve transit services and add value to passengers. The survey also found the expected ridership increase resulting from the AVL technology is moderate.

On-time performance surveys conducted in each city indicate that transit services in these communities generally operate on time at the route level. Although there are bigger variations at the time-point level, transit services tend to be on time most of the time. The implementation of AVL could further improve on-time performance, but maybe only marginally.

Key Words: Public Transportation, Automatic Vehicle Location System (AVL), Transit Services, On-Time Performance, Intelligent Transportation Systems (ITS).

INTRODUCTION

Automatic Vehicle Location (AVL) systems for public transit systems may have many benefits to transit agencies and riders, including improving on-time performance, raising productivity, enhancing security, and increasing ridership (Casey, et al. 1996, 1998; Gomez, Zhao and Shen, 1998; Casey, 1999; Peng et al. 2000; Gillen et al. 2001). AVL can provide transit dispatchers, planners, and transit riders real-time information about bus locations, running speed, and other information such as incidents. Transit dispatchers can use this real-time information to adjust for bus schedules to avoid bus bunching, and conducting real-time dispatch and controls such as sending another bus in the case of a bus breakdown. The transit planner could use this information to more efficiently plan transit routes and stops, and adjust for schedules. Transit users could benefit from increased on-time performance and schedule reliability, as well as up-to-the-minute real-time information to reduce waiting anxiety and cushion time. Because transit riders are extremely sensitive to schedule reliability (Wachs 1981; Abkowitz and Tozzi 1987; Cervero 1990), the increased arrival-time reliability could potentially increase transit ridership and improve service satisfaction.

There are a few studies in the literature that measured the impacts of AVL technology on on-time performance, service reliability and operation productivity (Gomez, Zhao and Shen, 1998; Housell and McLeod 1998; Khattaak and Hickman 1998; Casey, 1999; Strathman et al. 1999, 2000; Peng et al. 2000, Ding and Chien 2001; Gillen et al. 2001; Lee et al. 2001). However, there is no study that examines the impact of AVL technology on transit riders, as well as the rider's perceptions of the benefits of the AVL technology.

This paper reports the results of several attitudinal surveys of transit riders about the importance of what AVL could bring. Specifically, this paper tries to answer the following questions:

- How important is real-time bus location and arrival information to transit users?
- What aspect of AVL technology does the transit riders value the most?
- Will the use of AVL technology increase transit ridership?
- What is the current status of on-time performance of small and medium sized transit systems, and how much room is left for the AVL system to improve on-time performance?

SURVEY METHODS

Two types of surveys were conducted; an on-board transit rider survey and an on-time performance survey. The purpose of the on-board rider survey was to find out how transit riders perceive the importance of features brought by the AVL technology. The purpose of the on-time performance survey was to establish a baseline of current status of on-time performance of some small and medium sized transit systems.

The on-board rider survey was designed to focus on how transit riders value the potential benefits of AVL technology, e.g., real time information, on-time performance, improved safety, timely transit dispatch. In addition, some other questions are also proposed to provide background and control information, such as the value of lower fares and seat availability. The survey form was limited to one double-side page in length and included 15 questions (Appendix 1).

Two cities in the state of Wisconsin, Manitowoc and Racine, were chosen for the survey. These two cities have been chosen as sites to implement the AVL technology on their transit systems by the Wisconsin Department of Transportation. The transit system in the City of Manitowoc operates five full-time dedicated buses and one van with flexible scheduling, with a daily ridership of 800-900; and the City of Racine has 26 buses and 12 fixed routes, with a daily ridership of 6500-7500. Based on the definition by the Federal Transit Administration, both of them are in the category of small and medium sized transit systems, i.e., transit agencies with fleet size less than 50 vehicles (Casey et al, 1996).

The survey was conducted in the City of Manitowoc at March 21 and 22, 2001 by three people. A similar survey was conducted in the City of Racine at May 23rd (Wednesday) and 24th (Thursday), 2001 by eight people. The surveyors started to ride the bus at 7:00 am and ended the survey at 6:00 pm each day. Survey forms were distributed to every rider and collected before the riders got off the bus. Surveyors were available to help the riders to answer any question if necessary. The majority of the riders were very cooperative with a survey return rate of over 90% in the Manitowoc and over 80% in Racine for the time period and routes covered.

Besides delivering the survey forms to riders, surveyors also collected bus on-time performance data. Each surveyor had a bus schedule and knew the scheduled arrival time at each time point. When the bus got to each time point, the surveyor recorded the actual arrival time. To increase the sample size of the on-time performance data, two additional days were used in Racine for time checks . In addition to the on-board observation by the on-board surveyors, two additional surveyors drove around different time points to check bus arrival time randomly.

To be statistically significant, the sample size of the on-time performance was determined by the following formula:

$$n \quad \left(\frac{t * s}{E}\right)^2$$

Where, n is the desired sample size, t is the t score with the desired confidence limits, s is the estimated standard deviation, and E is the amount of error that can be tolerated. For example, if we want the significant level at 5%, 30 seconds are the tolerated error, and the standard deviation of the difference of actual arrival time and scheduled arrival time from the first day’s observation is 120 seconds. The required minimal sample size for this route is:

$$n \quad \left(\frac{t * s}{E}\right)^2 \quad \left(\frac{1.96 * 120}{30}\right)^2 \quad 62$$

That is, we have to have at least 62 observations from different time points on the same route. If the tolerated error of observed arrival time and schedule time is thirty seconds, and the significant level is at 5%, all routes in both cities satisfy the minimal sample size requirements.

The methods used in this study can be easily adapted to other transit agencies to determine customer satisfaction with the quality of transit service. The method used is a customer satisfaction survey as described in chapter 5 of the TCRP Web document 6, the Transit Capacity and Quality of Service Manual. In particular, we focused on perceptions of service reliability as measured by the survey. Such methods can be used to determine customer satisfaction and can supplement other performance measures to measure quality of service.

MAJOR FINDINGS FROM THE ON-BOARD RIDER SURVEY

There were 608 survey forms returned for Racine and 194 for Manitowoc. The following are the major findings from the on-board rider survey at the two cities. The data for two cities have been analyzed separately, but the results are very similar. The differences between the two cities were not statistically significant. Therefore, the results from two cities are reported here together.

1. Overall Rankings of the Importance of Different Elements of the AVL Benefits.

The questionnaire asked passengers to rank the relative importance of the major factors that affect their decisions to ride a bus. The most important ranking is scored 5 and the least important ranking is scored 1. These scores were then weighted using the frequency of respondents who selected the factors. The importance of the factors is then ranked based on the weighted index as shown in Table 1.

As shown in Table 1, both “knowing when the bus will actually arrive at the bus stop” and “Bus arrives at the scheduled time” are consistently valued by the passengers to be the most important factors. Transit riders also place high value on “knowing how late the bus is in case of delay.” These results are consistent with those from a survey conducted in Manitowoc three years ago, which indicated that real-time information and bus operating on time were valued to be the most important by transit riders. This is also consistent with prior studies that transit riders are very sensitive to schedule reliability than almost any other service features (Sterman and Schofer 1976; Wachs 1981; Cervero 1990).

Table 1 Ranking of all factors in affecting passengers' decision of riding bus

Factor	Rank in Racine (2001)	Rank in Manitowoc (2001)	Rank in Manitowoc (1998)
Knowing when the bus will actually arrive at the bus stop	1	1	2
Bus arrives at the scheduled time	2	3	1
Knowing that another bus can be immediately dispatched if there is a breakdown	3	4	4
Low bus fares	4	2	3
Knowing how late the bus is in case of a delay	5	5	6
Knowing the bus is equipped with a 911 emergency system	6	6	5
Having a seat available at all times	7	8	7
Knowing the transit system uses the latest vehicle location technology	8	7	8
Displaying the name of the next stop inside the bus	9	9	9
Having the driver call out the stops	10	10	10

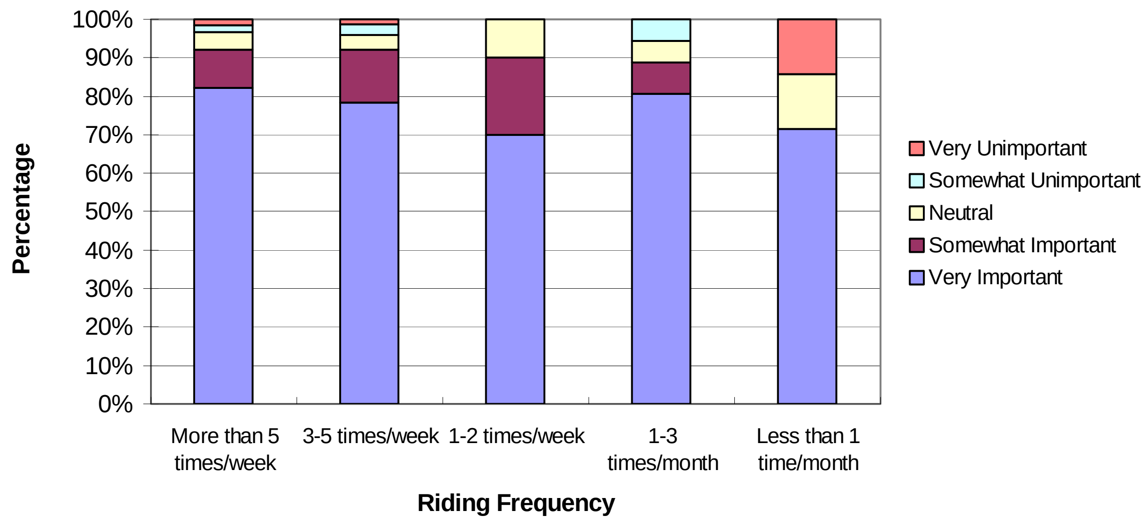
In addition, passengers also place a high degree of importance on "Knowing that another bus can be immediately dispatched if there is a breakdown" and "Knowing the bus is equipped with a 911 emergency system." These are benefits that can result from deploying the AVL technologies.

Furthermore, "lowering bus fares" is also ranked as important by transit riders. On the other hand, since the bus users, especially those who use the bus service very often, knew the route they are riding very well, having the driver call out stops or having the name of the next stop displayed inside the bus are ranked as the two most unimportant factors in the surveys. Simply having a latest technology is not valued highly by the transit riders.

2. Real-Time Information

As shown in table 1, real-time information about the bus service actually will arrive is the most important factor in influencing bus riders' perception of bus performance. Overall, 79.4% of the respondents considered this factor as most important. When cross-tabulating with the frequency of using the transit service, it is found that generally the ones who ride more often tend to value this factor as the most important one in their decision to ride a bus (Figure 1).

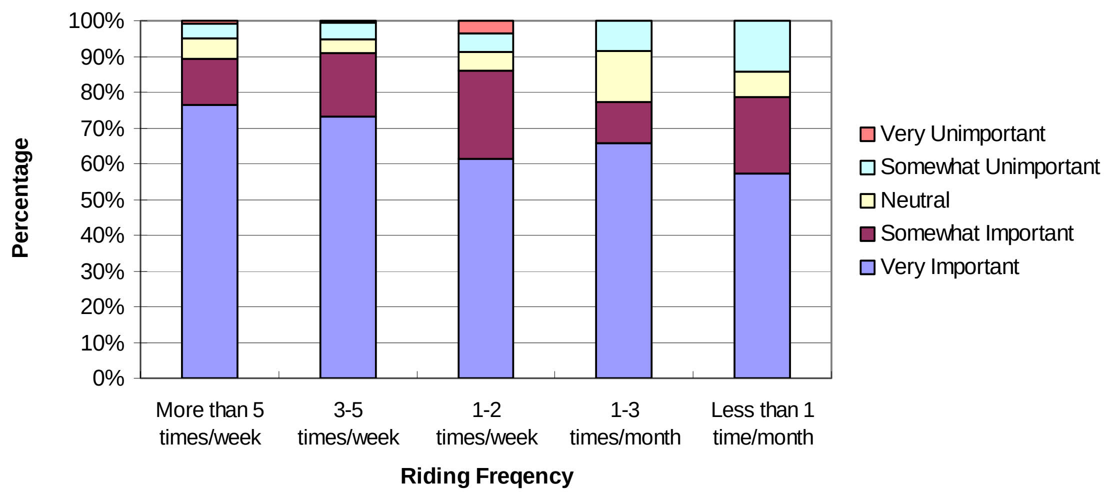
Figure 1 The Importance of Real-time information



3. On-time performance

The second most important factor that influences the rider's satisfaction with the bus service is the bus on-time performance. 72.7% of all the respondents give this factor the most important rank.

Figure 2 On-time performance



In addition, from the percentage distribution (Figure 2), we found that those who ride more often tend to give higher score to this factor.

4. Passenger Waiting Time

To further understand the bus on-time performance in influencing passenger's decision of riding a bus, we made an observation on actual passenger waiting-time about two months later in the City of Racine. Three researchers stayed in selected major bus stops and recorded the passengers' actual arrival time and the time getting into the bus. This two-day observation recorded in total of 974 cases, among them, 964 records are usable.

The recorded real waiting time was compared with the reported waiting time we obtained from the on-board survey. The average observed actual passenger waiting time (8.03 minutes) is very similar to the reported average waiting time (8.82 minutes). However, the longest recorded actual waiting time was more than an hour (3900 seconds), which may obscured the average.

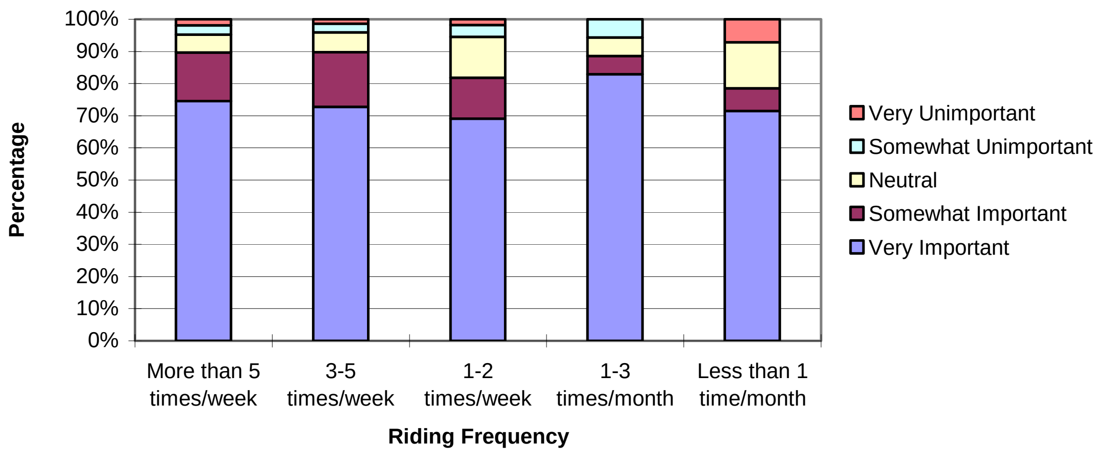
Based on the observation, 1.4% of all the passengers waited on the stop more than 30 minutes, which is about the same as the average headway. This is similar to the result obtained from the on-board survey (1.9%). Nearly one third of the passengers (30.5%) waited the bus for more than 10 minutes, while the corresponding percentage of passengers who reported waiting for 10 to 15 minutes during the on-board survey was only 22.1%. This may indicate that when passengers waited for the bus more than 10 minutes, they tended to underestimate their waiting time. Similarly, but to a less extend, 20.1% of observed passengers waited for more than 15 minutes while 14.0% of passengers reported that they waited more than 15 minutes.

During the field observation, we observed that at least 80% of longer waiting times (more than 10 minutes) were due to bad bus on-time performance. In addition, we also recorded 94 passengers who left instead of boarding the bus. The average waiting time for those passengers who eventually left is nearly 10 minutes (597 seconds), but it varies greatly; the standard deviation is more than 8 minutes (493 seconds). This happened because some observed passengers waited at the stop for several minutes (some times less than 2 minutes) and then left. Since the field observer can't directly contact the passengers and ask them why they left, it is unclear what their reasons were.. But it is not unreasonable to assume that many of them left because they thought they were waiting too long. In fact, the longest observed waiting time (3900 seconds) was recorded on one passenger who eventually left while being angry. It is possible that this person might not ride the bus again if there is a chance of using an alternative travel mode. This is another indication that increasing on-time performance could reduce waiting time and increase ridership.

5. Replacement of Vehicle

Having a replacement of vehicle available for unexpected breakdowns emerged as the third most important factor in influencing passengers' decision of riding bus. This reflects the value of time as well as the sense of security, 73.9% of survey respondents ranked this factor as "very important,"* especially those who ride less than 3 times a month (figure 3).

Figure 3 Replacement of Another Bus When Breakdowns

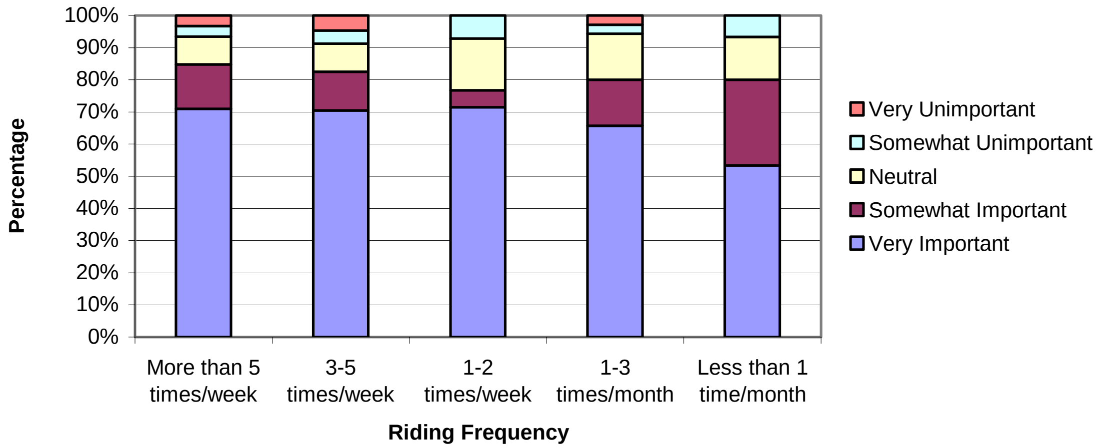


6. Low Fare

Low fare has ranked the fourth important factor by the respondents. More than 70% of all the respondents (70.1%) give this factor a "very important" score. Interestingly, those who ride more frequently tends to favor lower fare than those who ride less frequently (Figure 4). This indicates that the lower fare may not be a critical factor in attracting those who use transit occasionally. This is consistent with prior research that transit service is not very price elastic (Cervero, 1990).

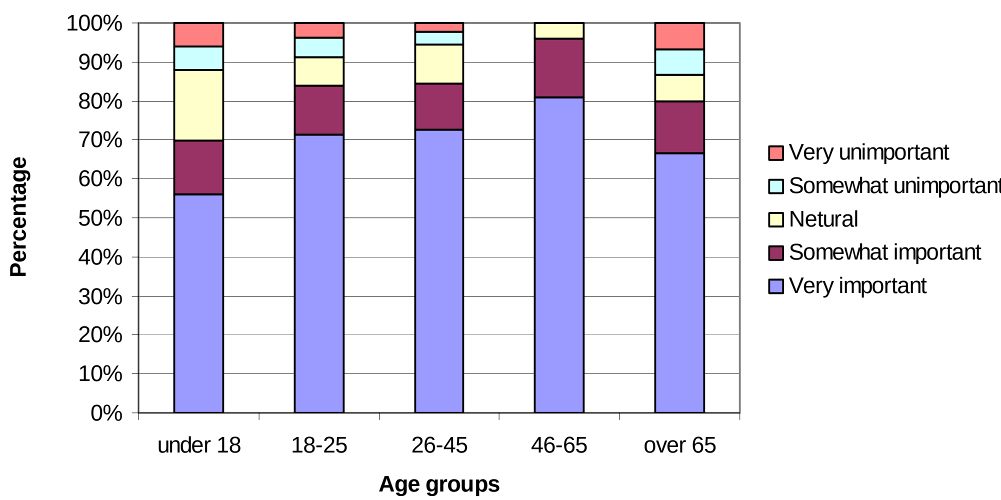
* Because the numbers of respondents to different questions varied among questions, and the ranking of a factor's importance was calculated from all groups (not only the group who responded it as "most important") of respondents, the percentage of respondents who answer the factor as "most important" is not the absolute indicator in determining the factor's ranking. So, it is possible that though some factor had a higher percentage of respondents ranked it as "most important", its rank will still be lower overall.

Figure 4 Importance of Low Fare



The percentage of those passengers who rank this factor as the most important factor increases with passengers age, until age 65 when it declined somewhat. (Figure 5).

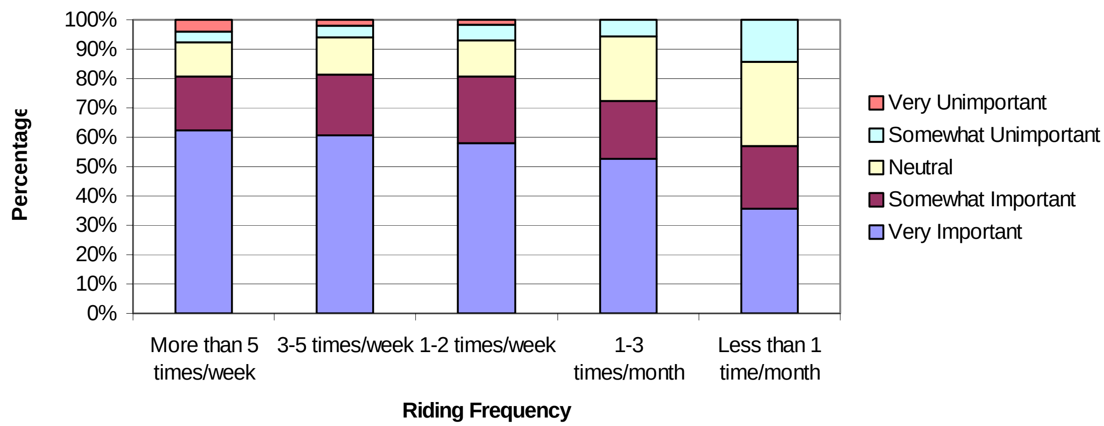
Figure 5 Distribution of low fare among different age groups



7. Knowing the exact delay time

Knowing the exact bus delay time ranked fifth in importance. Overall, the percentage of passengers who ranked this factor as the most important is 60.0% of the total. The noticeable difference is the group who ride less than one time a month (Figure 6).

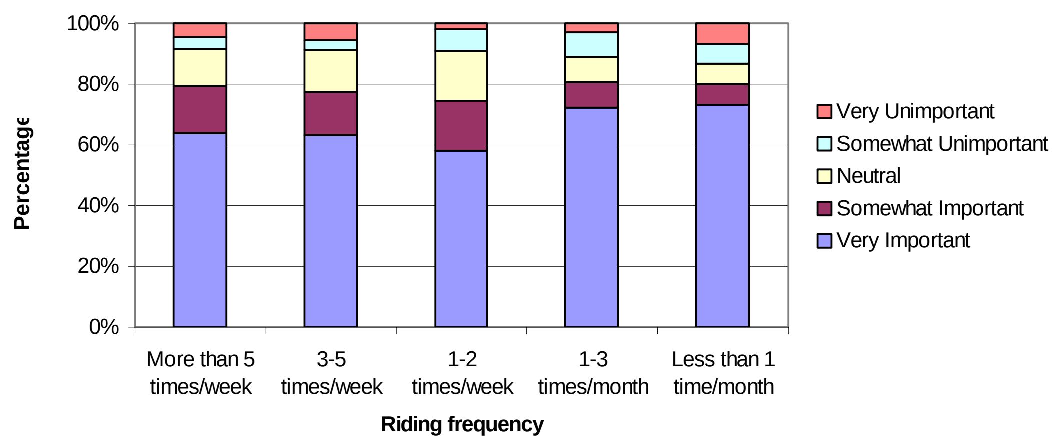
Figure 6. Importance of displaying delay time



8. Emergency Response

About two thirds of the respondents (63.9%) of all survey respondents rank this factor as very important. A noticeable difference is that passengers who ride less often tend to consider more of this factor as "most important" than those who ride more (figure 7). This may indicate the negative perceptions associated with the use of transit, especially for those non-riders and less frequent riders.

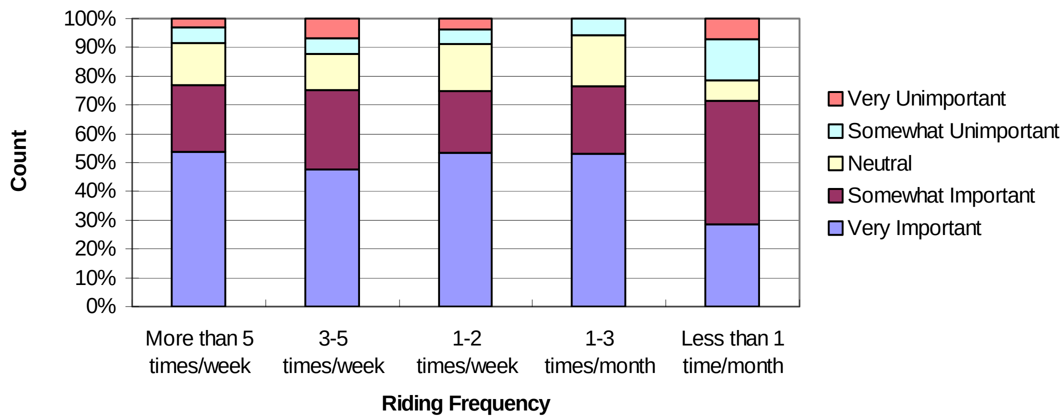
Figure 7 Importance of emergency response



9. Availability of seat

According to the observation of on-board surveyors, almost all bus riders could find a seat on the bus. So it is not surprising that this factor was not ranked as very important. Indeed, only 51.3% of all the respondents thought this factor as the most important one in affecting their decision of riding a bus or not. This observation holds true regardless of riding frequency (Figure 8).

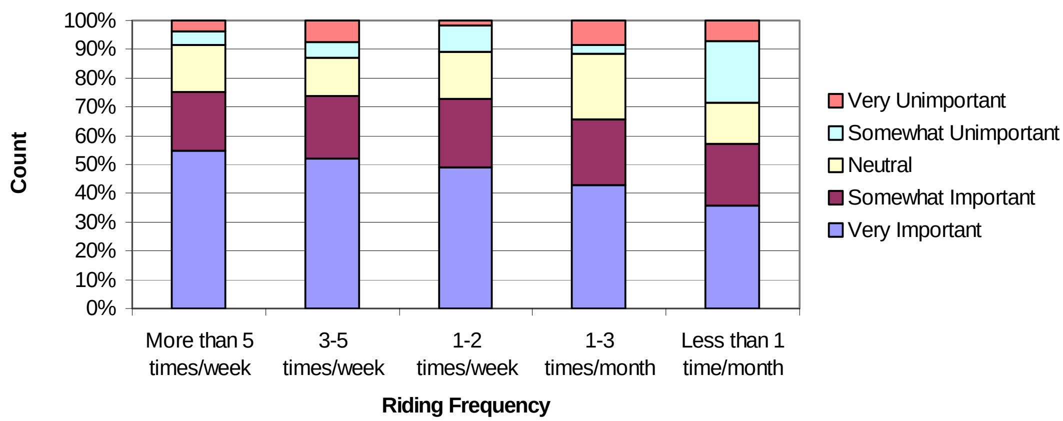
Figure 8 Importance of seat availability



10. Latest technology

From the survey, knowing that the bus was equipped with the latest technology seems to be less important than other factors. Overall there is 52% of the total respondents rank this factor as a "very important" factor in riding a bus. This holds true for riders with different use frequencies (figure 9).

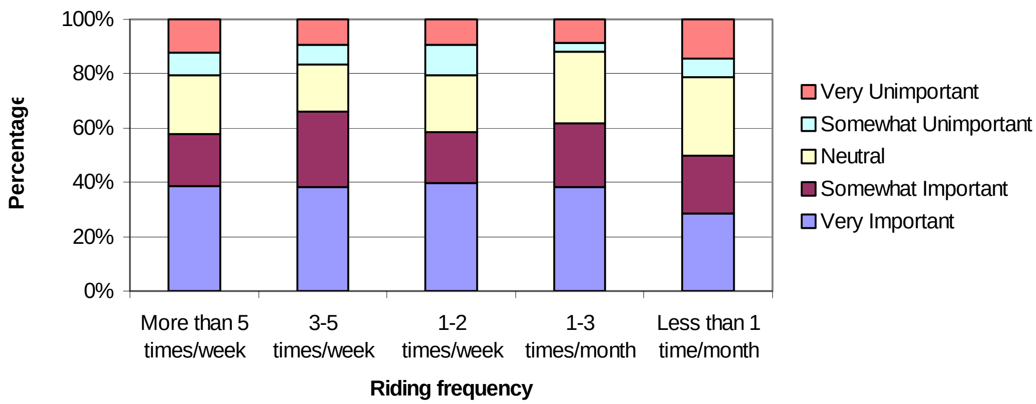
Figure 9 Importance of latest technology



11. Stop display and Calling Out Stops

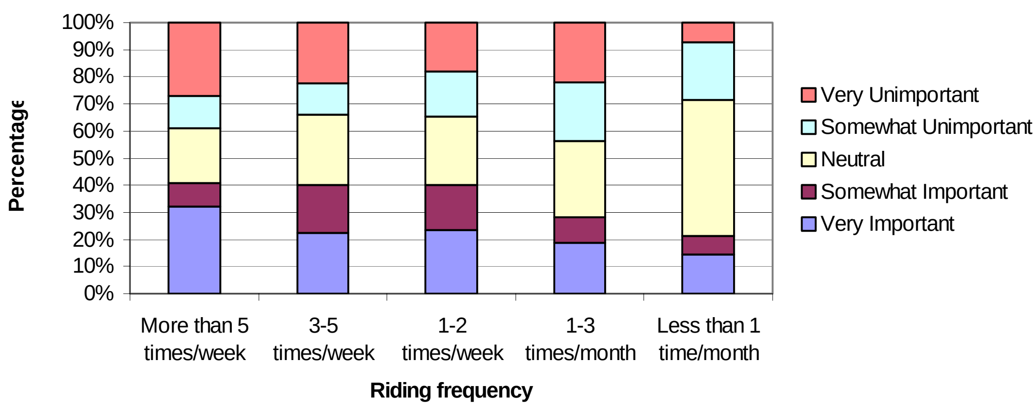
Since most respondents ride the bus quite often, they are very familiar with the stops they want to get of. Therefore, having the stops displayed inside the bus or having the driver calling out the stop names looks not that important to these passengers. Even people who didn't ride the bus very often tended to ignore this factor (figure 10).

Figure 10 Importance of displaying stops



Similarly, having the bus driver called out the stops was the least important factor influencing the decision to ride the bus. Overall there are only 27.3% of all respondents ranked this factor as "very important", while almost the same percentage of all respondents ranked this factor as "very unimportant" (24%). From the figure 11, it can be seen that people who ride the bus more often had less need to have the driver call out the stops.

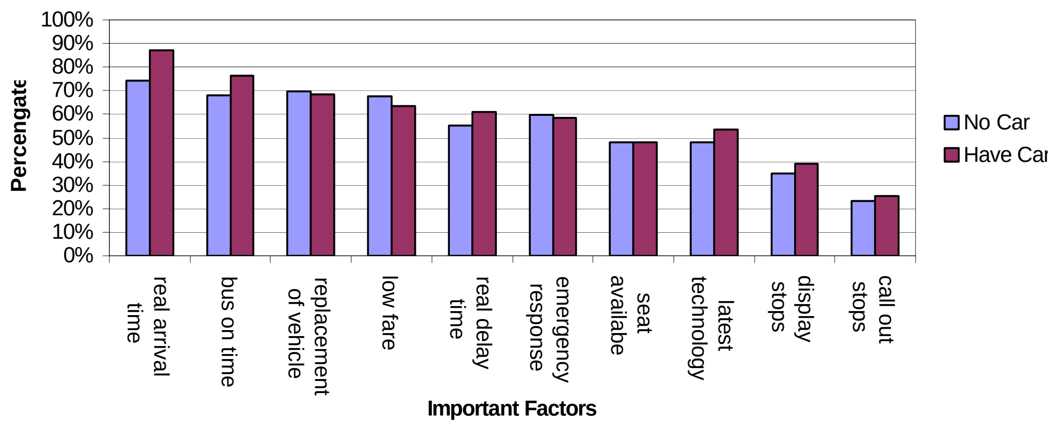
Figure 11 Importance of calling out stops



12. Captive Riders

Captive riders are those who didn't have an alternative way to travel besides the bus. The survey indicated that 78.1% of all respondents didn't have a car as an alternative mode to travel. Nonetheless, we found that the car availability doesn't have much effect on the ranking of the importance of factors, with the exception of the first two factors. (Figure 12).

Figure 12 Car availability in affecting people's ranking of decision factors

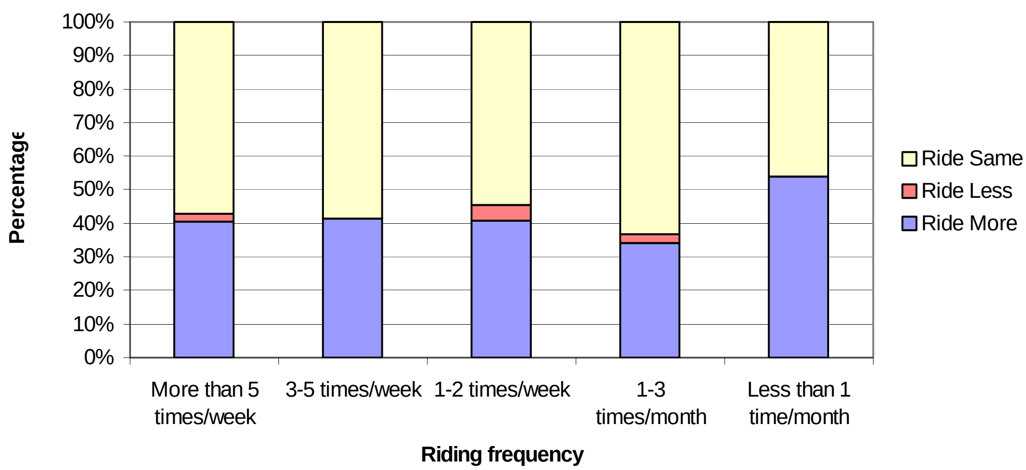


From the figure 12, it appears that people who own a car tend to be more sensitive to time saving issues. Those who own a car place more importance on "Knowing the exact arrival time", "Buses arrive as schedule" and "Knowing the exact delay time" as the "very important" factor, than those who don't have a car available. This indicates that efforts to improve on-time performance and real-time information may be important factors for choice riders.

13. More Potential Riders?

One hope is that AVL technology might lead to more ridership. The results, however are somewhat mixed. A majority of respondents indicted it would not have any effect on their decision to use transit. However 40.6% of all respondents answered that if better information were available, they would ride more often. Less frequent riders may have a higher tendency to ride more buses if better information were available (figure 13).

Figure 13 Better Information in influencing riding choice



We have performed a Logit analysis on the probability of using more transit services if better information is available. The logit analysis result is shown in Table 2.

Table 2. Logit analysis result

Dependent Variable: Ride More: 1=ride more often, 0=ride the same amount

	B	S.E.	Wald	df
WaitTooLong	0.791	0.256	9.536	1
OwnCar	0.382	0.206	3.447	1
RarelyOnTime	0.608	0.39	2.432	1
SomeOnTime	0.221	0.252	0.769	1
City	0.797	0.225	12.502	1
Constant	-1.503	0.209	51.739	1

-2 Log likelihood (0) =

-2 Log likelihood (B) = 807.207

WaitTooLong: 1=the waiting time is not reasonable, 0=reasonable

OwnCar: 1=car available, 0=not available

RarelyOnTime: 1=bus rarely on time, 0=otherwise

SomeOnTime: 1=bus bus on time sometimes, 0=otherwise

City: Racine=1, Manitowoc=0

This logit analysis shows that

(1) When the passenger perceives the waiting time is too long, they would be more likely to use more transit than those who think the current waiting time is reasonable.
(2) When the passenger has a car available, they would be more likely to use more transit than those who do not have a car available if better and more timely information is available.
(3) When the passenger thinks the current transit services rarely or only sometimes on time, they would be more likely to ride more often than those who think the current transit services is mostly running on time, if better and more timely information is available.
(4) Based on the coefficients, those who think the current transit services is rarely on time are more likely to ride than those who think the current transit services running are sometimes on time, if more timely information is available.
(5) People residing at the City of Racine is more likely to ride more buses than those who live in the City of Manitowoc, if better and more timely information is available.

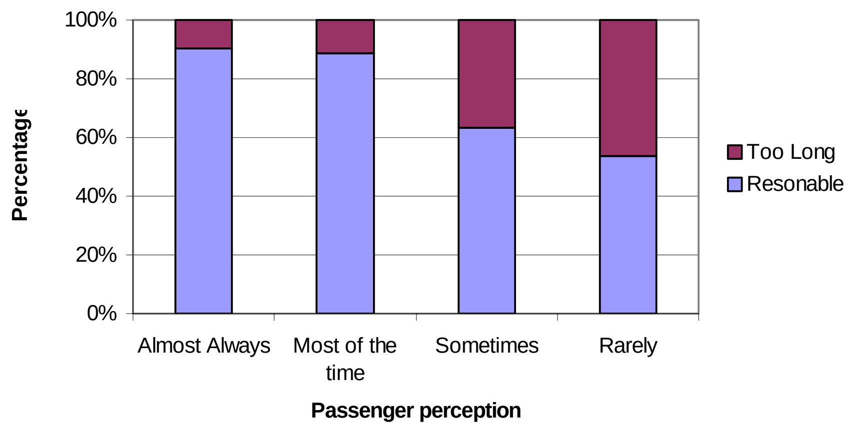
This Logit analysis shows better and more timely information could help improve customer services, raise the image of transit providers, and attract more riders, especially those who *think* the current services are not that great. Better information can help to convert occasional transit users to more frequent users. Since we surveyed transit users only, our data does not tell us how non-riders would react to better information. This is an obvious topic for further research.

14. Passenger's perception of bus on-time performance

Riders' perception to bus on-time performance is mostly positive; 29% of survey respondents reporting the bus was almost always on time, 49% reported bus on time most of times, only 5% reported the bus rarely on time. Most of riders (83%) considered the amount of waiting time as reasonable.

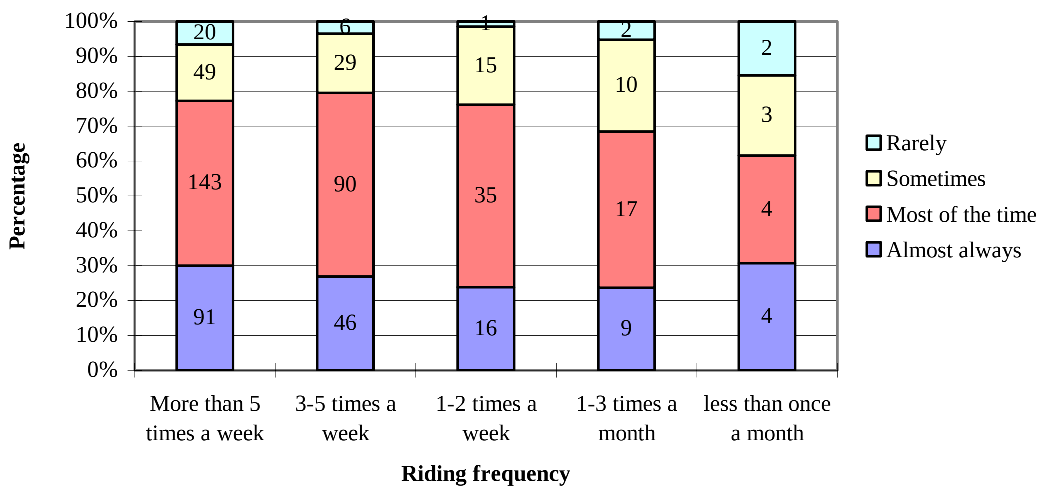
Those who regarded their waiting time as "reasonable" felt that the bus arrived on time "almost always" (figure 14).

Figure 14 Passenger perception of bus on-time performance



Furthermore, the passenger's perception of bus on-time performance is also related to ridership frequency. The more often the passenger rides the bus, the more likely they consider the bus runs on time (Figure 15). It implies that a few bad experiences may leave a bad impression on the rider and less frequent ridership.

Figure 15. Riding frequency and its relation with passengers' waiting time perception



15. Information Access

Most riders got the bus schedule information from printed schedules. When asked how would they access to real-time information, most of them indicated they would use a standard telephone, some would access the information from the Internet. About 30 percent of respondents have Internet access and 26% have a cellular phone. This indicates that transit agencies should consider using the Internet and cellular phones to make real-time information available.

16. Other factors in affecting people's decision of riding a bus

Through comments on open questions, we found some other factors that transit riders consider to be important in affecting their decisions of riding a bus.

Bus driver's attitude was cited by some passengers who complained about some bus drivers having attitudinal problems towards passengers such as smoking on the bus, etc.

A second factor cites was the need to extend the bus service's hours. Bus service in Racine City does provides limited Saturday and Sunday services. Some respondents regarded these kinds of Saturday and Sunday services inadequate.

MAJOR FINDINGS FROM THE ON-TIME PERFORMANCE SURVEY

The on-time performance of each transit system was measured using the time difference between observed actual bus arrival time and the scheduled time on specific time-points. The difference of on-time performance among different routes has been analyzed via ANOVA (ANalysis Of VAriance).

1. The actual on-time performance

According to our on-time performance check, on average, all the routes were running relatively on time during the time of the surveys (Table 3). At the route level, the average variation from the schedule was about one minute. However, the standard deviation was large (over 100 seconds), indicating the on-time performance at the time-point level is not as good as the route level. The longest delay at a time point happened in this survey was 1285 seconds (21 minutes).

Table 3. The average on-time performance in Racine City's bus routes

Routes	Average time difference between scheduled and actual (seconds)	Standard Deviation
Route 1	-58.49*	251.67
Route 2	-55.78	204.19
Route 3	41.06	261.52
Route 4	-18.97	195.60
Route 5	-67.96	143.09
Route 68	34.96	106.76
Route 7	46.11	191.92
Route 86	31.69	191.17
Route 20	-19.71	39.19

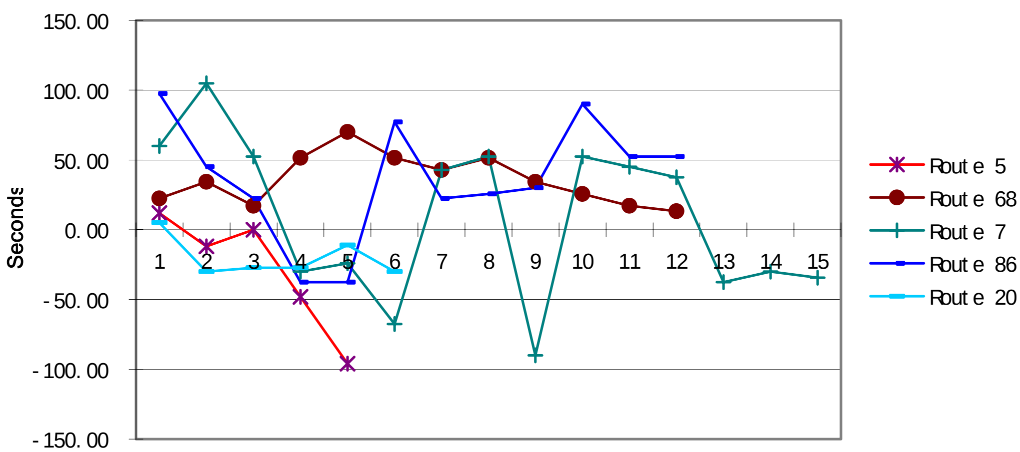
*: Positive numbers indicate that the bus arrived late, and negative numbers indicate the bus arrived early in average.

According to our observation, the busier routes have a larger, the standard deviation. Route 3 in Racine City is the busiest route, which has the highest standard deviation,while Route 20, the least busy route, had the smallest standard deviation.

2. On-time performance variations between different time-points

As indicated above, there are differences in on-time performance at different time points in the same route. On-time performance records were available for 5 routes (route 5, 7, 20, 68 and 86) at each time point.

Figure 17 On-time performance varies among different time points



The pattern in Figure 17 is apparent. Route 7 and 86 are the two busiest routes among the five routes, and their variances among different time-points are the highest. The least busy one, route 20, shows a relatively smooth on-time performance pattern among different time points; it is also the shortest route.

3. Different on-time performance among different routes

According to Table 3, we can assume that there is a difference in on-time performance among different routes. To further prove the assumption, we conducted the ANOVA analysis among the nine routes. Table 4 shows the result.

Table 4. ANOVA analyses among different routes in Racine City

	Sum of Squares	Degree of freedom	Mean Square	F	Sig.
Between Groups	2546136.58	8	318267.072	8.342	0.000
Within Groups	48108307.34	1261	38150.918		
Total	50654443.92	1269			

The F statistics is 8.342 and statistical significance is above 99% level. According to this result, the null hypothesis that there is no on-time difference for different routes could be safely rejected at least at the 1% significant level. There is a significant difference between the on-time performance of the routes.

Table 5. Correlation between bus's busy degree and its different on-time performance

		Standard Deviation	Busy Degree
Standard Deviation	Pearson Correlation	1	0.627
	Sig. (2-tailed)		0.071
Busy Degree	Pearson Correlation	0.627	1
	Sig. (2-tailed)	0.071	

To verify our assumption that on-time performance is related to the ridership of different routes, a correlation and regression analysis was conducted between the standard deviation of on-time performance and the number of returned survey forms. Table 5 and Table 6 show the result:

Table 6 Regression between bus' busy degree and its different on-time performance

Coefficients						
		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	115.111	34.651		3.322	0.013
	Busy Degree	0.903	0.424	0.627	2.128	0.071
Dependent Variable: Standard Deviation						

The results show that the standard deviation of each route's on-time performance is highly associated with the ridership on the route.

CONCLUSIONS

This study shows that transit riders put a high value on increasing on-time performance and improving schedule reliability. Passengers value many of the features that an AVL system could have, such as improving on-time performance, knowing when the next bus will arrive, knowing how long the delay is in case of delay, knowing another bus could be dispatched in case of breakdown. This is consistent across cities and over time. In short, AVL technology can improve transit services that the passenger values highly.

The survey indicates that ridership impact of AVL technology is moderate with most existing users will ride transit about the same amount even if real-time information is available. About 40% of survey respondents stated that they would ride more with better information.. Better and more timely bus arrival information may help attract more uses of those who *think* the currently transit services is less than satisfactory. Overall, a Logit analysis shows that better and more timely information could help improve customer services, raise the image of transit providers, and have a moderate effect on attracting more riders.. Since we surveyed current transit users, we do not have information on how non-transit users would respond to better information.

The on-time performance survey indicates that most transit services operate on time at the route level. Although there are bigger variations at the time-point level, transit services at the small and medium sized transit services tend to be on time most of the time. The implementation of AVL could further improve on-time performance, but since performance is already very good, the change would be small.

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Maritime Metro Transit Survey

Dear Maritime Metro Customer: In order to help us better serve you, won't you please take a few moments to fill out this short survey? All responses are strictly confidential, and you will not be identified in any way.

1. How did you know when this bus would leave the bus stop that you used?
   - ❑ I have a bus schedule
   - ❑ I use this stop often and have come to know the schedule
   - ❑ I called the transit system help line to get the time
   - ❑ I arrived when it was convenient for me with the hope that the bus would arrive soon

2. How long did you have to wait at the stop before the bus arrived? ____minutes

3. Do you consider the amount of time that you had to wait for the bus to be:
   ❑ Reasonable ❑ Too long
   Comments:____

4. In your opinion, how often do the buses on this route run on time?
   ❑ Almost always ❑ Most of the time ❑ Sometimes ❑ Rarely

5. How did you get to the bus stop today?
   - ❑ I walked, and it took me ___ minutes
   - ❑ I drove, and it took me ___ minutes
   - ❑ I was dropped off, and it took me ___ minutes
   - ❑ I transferred from another route

6. How often, on average, do you ride the bus?
   - ❑ More than 5 times a week
   - ❑ 3-5 times a week
   - ❑ 1-2 times a week
   - ❑ 1-3 times a month
   - ❑ Less than once a month

7. What is the primary purpose of your trip today? (Please check only one)
   ❑ Work ❑ Shopping ❑ School ❑ Medical ❑ Other_________

8. How do you get information about the bus service? (Please check all that apply)
   - ❑ I have a copy of the bus schedule
   - ❑ I call the bus company
   - ❑ From other people
   - ❑ From information displayed at the bus stop
   - ❑ Other_________________________________

9. If you knew exactly when the bus would arrive at a stop, how would it affect your use of the bus?
   - ❑ I would ride more often
   - ❑ I would ride less often
   - ❑ I would ride the same amount

10. Please rate how important the following are in your decision to ride the bus:

	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Very Unimportant
Knowing when the bus will actually arrive at the bus stop------------------------------>	❑	❑	❑	❑	❑
Bus arrives at the scheduled time-->	❑	❑	❑	❑	❑
Knowing how late the bus is in case of a delay -->	❑	❑	❑	❑	❑
Displaying the name of the next stop inside the bus ------------------------------------->	❑	❑	❑	❑	❑
Having the driver call out the stops --->	❑	❑	❑	❑	❑
Knowing the bus is equipped with a 911 emergency system --------------------------->	❑	❑	❑	❑	❑
Knowing that another bus can be immediately dispatched if there is a breakdown-->	❑	❑	❑	❑	❑
Knowing the transit system uses the latest vehicle location technology -------------->	❑	❑	❑	❑	❑
Having a seat available at all times--->	❑	❑	❑	❑	❑
Low bus fares-->	❑	❑	❑	❑	❑

11. Which of the following do you currently own or have access to? (Please check all that apply)
❑ Internet ❑ Cellular telephone

12. If up-to-date bus information was available, how would you use it? (Please check all that apply)
❑ I would use the Internet to get the information
❑ I would use a cellular telephone to get the information
❑ I would use a standard telephone to get the information
❑ I would not use up-to-date bus information

13. Did you have a car available that you could have used for the trip you are making today?
❑ Yes ❑ No

14. Are you a:
❑ Male ❑ Female

15. What is your age group?
❑ Under 18 ❑ 18-25 ❑ 26-45 ❑ 46-65 ❑ Over 65

Please list any other comments that you may have about this service below:

List of tables and figures

Appendix C:

Copies of Survey Forms

Racine 2001, 2005
Manitowoc 2001, 2005
Waukesha 2002, 2005

Racine Transit Survey (2001)

Dear Belle Transit Customer: In order to help us better serve you, won't you please take a few moments to fill out this short survey? All responses are strictly confidential, and you will not be identified in any way.

1. How did you know when this bus would leave the bus stop that you used?
   ❑ I have a bus schedule
   ❑ I use this stop often and have come to know the schedule
   ❑ I called the transit system help line to get the time
   ❑ I arrived when it was convenient for me with the hope that the bus would arrive soon

2. How long did you have to wait at the stop before the bus arrived? ____minutes

3. Do you consider the amount of time that you had to wait for the bus to be:
   ❑ Reasonable ❑ Too long
   Comments:____

4. In your opinion, how often do the buses on this route run on time?
   ❑ Almost always ❑ Most of the time ❑ Sometimes ❑ Rarely

5. How did you get to the bus stop today?
   ❑ I walked, and it took me ___ minutes
   ❑ I drove, and it took me ___ minutes
   ❑ I was dropped off, and it took me ___ minutes
   ❑ I transferred from another route

6. How often, on average, do you ride the bus?
   ❑ More than 5 times a week
   ❑ 3-5 times a week
   ❑ 1-2 times a week
   ❑ 1-3 times a month
   ❑ Less than once a month

7. What is the primary purpose of your trip today? (Please check only one)
   ❑ Work ❑ Shopping ❑ School ❑ Medical ❑ Other_________

8. How do you get information about the bus service? (Please check all that apply)
   ❑ I have a copy of the bus schedule
   ❑ I call the bus company
   ❑ From other people
   ❑ From information displayed at the bus stop
   ❑ Other_________________________________

9. If you knew exactly when the bus would arrive at a stop, how would it affect your use of the bus?
   ❑ I would ride more often
   ❑ I would ride less often
   ❑ I would ride the same amount

[MORE QUESTIONS ON THE BACK==>]

10. Please rate how important the following are in your decision to ride the bus:

	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Very Unimportant
Knowing when the bus will actually arrive at the bus stop----------------------------->	❑	❑	❑	❑	❑
Bus arrives at the scheduled time-->	❑	❑	❑	❑	❑
Knowing how late the bus is in case of a delay --->	❑	❑	❑	❑	❑
Displaying the name of the next stop inside the bus ------------------------------------>	❑	❑	❑	❑	❑
Having the driver call out the stops --->	❑	❑	❑	❑	❑
Knowing the bus is equipped with a 911 emergency system -------------------------->	❑	❑	❑	❑	❑
Knowing that another bus can be immediately dispatched if there is a breakdown-->	❑	❑	❑	❑	❑
Knowing the transit system uses the latest vehicle location technology -------------->	❑	❑	❑	❑	❑
Having a seat available at all times-->	❑	❑	❑	❑	❑
Low bus fares-->	❑	❑	❑	❑	❑

11. Which of the following do you currently own or have access to? (Please check all that apply)
    ❑Internet ❑Cellular telephone

12. If up-to-date bus information was available, how would you use it? (Please check all that apply)
    ❑I would use the Internet to get the information
    ❑I would use a cellular telephone to get the information
    ❑I would use a standard telephone to get the information
    ❑I would not use up-to-date bus information

13. Did you have a car available that you could have used for the trip you are making today?
    ❑Yes ❑No

14. Are you a:
    ❑Male ❑Female

15. What is your age group?
    ❑Under 18 ❑18-25 ❑26-45 ❑46-65 ❑Over 65

Please list any other comments that you may have about this service below:

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY!

Racine Transit Survey (2005)

Dear Belle Transit Customer: In order to help us better serve you, could you please take a few moments to fill out this short survey? All responses are strictly confidential, and you will not be identified in any way.

1. How did you know when this bus would leave the bus stop that you used?
   - ❑ I have a bus schedule
   - ❑ I use this stop often and have come to know the schedule
   - ❑ I called the transit system help line to get the time
   - ❑ I arrived when it was convenient for me with the hope that the bus would arrive soon
   - ❑ I checked the transit website on the internet

2. How long did you wait at the stop before the bus arrived? ______minutes today?

3. Do you consider the amount of time that you had to wait for the bus to be:
   ❑ Reasonable ❑ Too long
   Comments:____

4. In your opinion, how often do the buses on this route run on time?
   ❑ Almost always ❑ Most of the time ❑ Sometimes ❑ Rarely

5. Do you know if the buses have an automatic vehicle location system (a system that knows the position of your buses in real time)
   ❑ Yes ❑ No

6. How did you get to the bus stop today?
   - ❑ I walked, and it took me _____ minutes
   - ❑ I drove, and it took me _____ minutes
   - ❑ I was dropped off, and it took me _____ minutes
   - ❑ I transferred from another route - Route Number _____

7. How often, on average, do you ride the bus?
   - ❑ More than 5 times a week
   - ❑ 3-5 times a week
   - ❑ 1-2 times a week
   - ❑ 1-3 times a month
   - ❑ Less than once a month

8. Compare with last year, do you now

- ❑ ride more often , ❑ Ride less often ❑ Ride the same amount. ❑ Didn't use the bus last year

9. Compared to last year, do you agree of disagree with the following:
   The bus now seems to be on time more often ❑ Agree ❑ Disagree ❑ No Difference
   The bus now runs more frequently ❑ Agree❑ Disagree ❑ No Difference
   I now wait less time for buses . ❑ Agree ❑ Disagree ❑ No Difference
   The bus now runs more closely to my home and/or work. ❑ Agree ❑ Disagree ❑ No Difference

10. What is the primary purpose of your trip today? (Please check only one)
    ❑ Work ❑ Shopping ❑ School ❑ Medical ❑ Other________

[MORE QUESTIONS ON THE BACK===>]

11. How do you get information about the bus service? (Please check all that apply)
   - ❑ I have a copy of the bus schedule
   - ❑ I call the bus company
   - ❑ From other people
   - ❑ From information displayed at the bus stop
   - ❑ From the City of Waukesha website
   - ❑ Other________________________________

12. If you knew exactly when the bus would arrive at a stop, how would it change your use of the bus?
   ❑ I would ride more often ❑ I would ride less often ❑ I would ride the same amount

13. Please rate how important the following are in your decision to ride the bus:

	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Very Unimportant
Knowing the actual bus arrival time at your stop--->	❑	❑	❑	❑	❑
Bus arrives at the scheduled time-->	❑	❑	❑	❑	❑
Knowing how late the bus is in case of a delay --->	❑	❑	❑	❑	❑
Displaying the name of the next stop inside the bus ------------------------------------>	❑	❑	❑	❑	❑
Having the driver call out the stops -->	❑	❑	❑	❑	❑
Knowing the bus is equipped with a 911 emergency system --------------------------->	❑	❑	❑	❑	❑
Knowing that another bus will be immediately dispatched if there is a breakdown-->	❑	❑	❑	❑	❑
Knowing the transit system uses the latest vehicle location technology -------------->	❑	❑	❑	❑	❑
Having a seat available at all times--->	❑	❑	❑	❑	❑
Low bus fares-->	❑	❑	❑	❑	❑

14. Which of the following do you currently own or have access to? (Please check all that apply)
   ❑ Internet ❑ Cellular telephone

15. How would you access up-to-date bus information? (Please check all that apply)
   - ❑ I would use the Internet to get the information
   - ❑ I would use a cellular telephone to get the information
   - ❑ I would use a standard telephone to get the information
   - ❑ I would not use up-to-date bus information

16. Did you own or have access to a car that you could have used for the trip you are making today?
   ❑ Yes ❑ No

17. Are you a:
   ❑ Male ❑ Female

18. What is your age group?
   ❑ Under 18 ❑ 18-25 ❑ 26-45 ❑ 46-65 ❑ Over 65

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY!

Maritime Metro Transit Survey (May, 2001)

Dear Maritime Metro Customer: In order to help us better serve you, won't you please take a few moments to fill out this short survey? All responses are strictly confidential, and you will not be identified in any way.

1. How did you know when this bus would leave the bus stop that you used?

❑ I have a bus schedule
❑ I use this stop often and have come to know the schedule
❑ I called the transit system help line to get the time
❑ I arrived when it was convenient for me with the hope that the bus would arrive soon

2. How long did you have to wait at the stop before the bus arrived? ____minutes

3. Do you consider the amount of time that you had to wait for the bus to be:

❑ Reasonable ❑ Too long
Comments:____

4. In your opinion, how often do the buses on this route run on time?

❑ Almost always ❑ Most of the time ❑ Sometimes ❑ Rarely

5. How did you get to the bus stop today?

❑ I walked, and it took me ___ minutes
❑ I drove, and it took me ___ minutes
❑ I was dropped off, and it took me ___ minutes
❑ I transferred from another route

6. How often, on average, do you ride the bus?

❑ More than 5 times a week
❑ 3-5 times a week
❑ 1-2 times a week
❑ 1-3 times a month
❑ Less than once a month

7. What is the primary purpose of your trip today? (Please check only one)

❑ Work ❑ Shopping ❑ School ❑ Medical ❑ Other_________

8. How do you get information about the bus service? (Please check all that apply)

❑ I have a copy of the bus schedule
❑ I call the bus company
❑ From other people
❑ From information displayed at the bus stop
❑ Other_________________________________

9. If you knew exactly when the bus would arrive at a stop, how would it affect your use of the bus?

❑ I would ride more often
❑ I would ride less often
❑ I would ride the same amount

10. Please rate how important the following are in your decision to ride the bus:

	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Very Unimportant
Knowing when the bus will actually arrive at the bus stop------------------------------>	❑	❑	❑	❑	❑
Bus arrives at the scheduled time-->	❑	❑	❑	❑	❑
Knowing how late the bus is in case of a delay -->	❑	❑	❑	❑	❑
Displaying the name of the next stop inside the bus ------------------------------------->	❑	❑	❑	❑	❑
Having the driver call out the stops --->	❑	❑	❑	❑	❑
Knowing the bus is equipped with a 911 emergency system ---------------------------->	❑	❑	❑	❑	❑
Knowing that another bus can be immediately dispatched if there is a breakdown-->	❑	❑	❑	❑	❑
Knowing the transit system uses the latest vehicle location technology -------------->	❑	❑	❑	❑	❑
Having a seat available at all times-->	❑	❑	❑	❑	❑
Low bus fares-->	❑	❑	❑	❑	❑

11. Which of the following do you currently own or have access to? (Please check all that apply)

❑ Internet ❑ Cellular telephone

12. If up-to-date bus information was available, how would you use it? (Please check all that apply)

❑ I would use the Internet to get the information

❑ I would use a cellular telephone to get the information

❑ I would use a standard telephone to get the information

❑ I would not use up-to-date bus information

13. Did you have a car available that you could have used for the trip you are making today?

❑ Yes ❑ No

14. Are you a:

❑ Male ❑ Female

15. What is your age group?

❑ Under 18 ❑ 18-25 ❑ 26-45 ❑ 46-65 ❑ Over 65

Please list any other comments that you may have about this service below:

Waukesha Metro Transit Survey (2002)

Dear Waukesha Metro Customer: In order to help us better serve you, won't you please take a few moments to fill out this short survey? All responses are strictly confidential, and you will not be identified in any way.

1. How did you know when this bus would leave the bus stop that you used?
   - ❑ I have a bus schedule
   - ❑ I use this stop often and have come to know the schedule
   - ❑ I called the transit system help line to get the time
   - ❑ I arrived when it was convenient for me with the hope that the bus would arrive soon
   - ❑ I checked out from the Internet

2. How long did you have to wait at the stop before the bus arrived? ____minutes

3. Do you consider the amount of time that you had to wait for the bus to be:
❑ Reasonable ❑ Too long
Comments:____

4. In your opinion, how often do the buses on this route run on time?
❑ Almost always ❑ Most of the time ❑ Sometimes ❑ Rarely

5. How did you get to the bus stop today?
   - ❑ I walked, and it took me ___ minutes
   - ❑ I drove, and it took me ___ minutes
   - ❑ I was dropped off, and it took me ___ minutes
   - ❑ I transferred from another route

6. How often, on average, do you ride the bus?
   - ❑ More than 5 times a week
   - ❑ 3-5 times a week
   - ❑ 1-2 times a week
   - ❑ 1-3 times a month
   - ❑ Less than once a month

7. What is the primary purpose of your trip today? (Please check only one)
❑ Work ❑ Shopping ❑ School ❑ Medical ❑ Other________

8. How do you get information about the bus service? (Please check all that apply)
   - ❑ I have a copy of the bus schedule
   - ❑ I call the bus company
   - ❑ From other people
   - ❑ From information displayed at the bus stop
   - ❑ From the City of Waukesha website
   - ❑ Other_________________________________

9. If you knew exactly when the bus would arrive at a stop, how would it affect your use of the bus?
   - ❑ I would ride more often
   - ❑ I would ride less often
   - ❑ I would ride the same amount

[MORE QUESTIONS ON THE BACK==>]

10. Please rate how important the following are in your decision to ride the bus:

	Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Very Unimportant
Knowing when the bus will actually arrive at the bus stop----------------------------->	❑	❑	❑	❑	❑
Bus arrives at the scheduled time--->	❑	❑	❑	❑	❑
Knowing how late the bus is in case of a delay -->	❑	❑	❑	❑	❑
Displaying the name of the next stop inside the bus ------------------------------------->	❑	❑	❑	❑	❑
Having the driver call out the stops --->	❑	❑	❑	❑	❑
Knowing the bus is equipped with a 911 emergency system --------------------------->	❑	❑	❑	❑	❑
Knowing that another bus can be immediately dispatched if there is a breakdown-->	❑	❑	❑	❑	❑
Knowing the transit system uses the latest vehicle location technology -------------->	❑	❑	❑	❑	❑
Having a seat available at all times--->	❑	❑	❑	❑	❑
Low bus fares-->	❑	❑	❑	❑	❑

11. Which of the following do you currently own or have access to? (Please check all that apply)

❑ Internet ❑ Cellular telephone

12. If up-to-date bus information was available, how would you use it? (Please check all that apply)

- ❑ I would use the Internet to get the information
- ❑ I would use a cellular telephone to get the information
- ❑ I would use a standard telephone to get the information
- ❑ I would not use up-to-date bus information

13. Did you have a car available that you could have used for the trip you are making today?

❑ Yes ❑ No

14. Are you a:

❑ Male ❑ Female

15. What is your age group?

❑ Under 18 ❑ 18-25 ❑ 26-45 ❑ 46-65 ❑ Over 65

Please list any other comments that you may have about this service below:

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY!

Waukesha Metro Transit Survey (2005)

Dear Waukesha Metro Customer: In order to help us better serve you, would you please take a few moments to fill out this short survey? All responses are strictly confidential, and you will not be identified in any way.

1. How did you know when this bus would leave the bus stop that you used?
   - ❑ 1I have a bus schedule
   - ❑ 2I use this stop often and have come to know the schedule
   - ❑ 3I called the transit system help line to get the time
   - ❑ 4I arrived when it was convenient for me with the hope that the bus would arrive soon
   - ❑ 5I checked the transit website on the internet
   - ❑ 6I checked the electronic bus arrival information displayed at the bus stop

2. How long did you wait at the stop before the bus arrived? ______minutes today?

3. Do you consider the amount of time that you had to wait for the bus to be:

❑ 1Reasonable ❑ 2Too long Comments:_________________________________

4. In your opinion, how often do the buses on this route run on time?

❑ 1Almost always ❑ 2Most of the time ❑ 3Sometimes ❑ 4Rarely

5. Do you know if the buses have an automatic vehicle location system (a system that knows the where the buses are at all times) ❑ 1Yes ❑ 2No

6. How do you know the buses have the automatic vehicle location systems?

❑ 1Electronic display at bus stops ❑ 2City or media report ❑ 3bus drivers
❑ 4others (Please specify)____

7. How do you like the electronic bus arrival information displayed at the bus stop?

❑ 1Extremely useful ❑ 2very useful ❑ 3useful ❑ 4somewhat useful ❑ 5not useful
Comments ____

8. Is the bus arrival information displayed at the stop

❑ 1Very accurate ❑ 2Accurate most of the times ❑ 3accurate sometimes ❑ 4not accurate at all

9. Does the electronic bus information display at the bus stops change your use of the bus?

   ❑ 1I ride more often ❑ 2I ride less often ❑ 3I ride the same amount

10. How did you get to the bus stop today?
    - ❑ 1I walked, and it took me _____ minutes
    - ❑ 2I drove, and it took me _____ minutes
    - ❑ 3I was dropped off, and it took me _____ minutes
    - ❑ 4I transferred from another route - Route Number _____

11. How often, on average, do you ride the bus?

1More than 5 times a week ❑ 23-5 times a week
31-2 times a week ❑ 41-3 times a month ❑5Less than once a month

12. Compare with last year, do you now

❑ 1Ride more often ❑ 2Ride less often ❑ 3Ride the same amount. ❑ 4Didn't use the bus last year

13. If you ride less often than last year, why
❑ $_1$Have a car now ❑ $_2$ Bus is less frequent ❑ $_3$ Ride with other people ❑ $_4$Moved
❑ $_5$Other Reasons__________

14. Compared to last year, do you agree or disagree with the following:
The bus now seems to be on time more often ❑ $_1$Agree ❑ $_2$Disagree ❑ $_3$No Difference
The bus now runs more frequently ❑$_1$Agree ❑ $_2$Disagree ❑ $_3$No Difference
I now wait less time for buses. ❑ $_1$Agree ❑ $_2$Disagree ❑ $_3$No Difference
The bus now runs more closely to my home and/or work. ❑ $_1$Agree ❑ $_2$Disagree ❑ $_3$No Difference

15. What is the primary purpose of your trip today? (Please check only one)
❑ $_1$Work ❑ $_2$Shopping ❑ $_3$School ❑ $_4$Medical ❑ $_5$Other_________

16. Please rate how important the following are in your decision to ride the bus:

	Very Important$_1$	Somewhat Important$_2$	Neutral$_3$	Somewhat Unimportant	Very Unimportant$_5$
Knowing the actual bus arrival time at your stop-->	❑	❑	❑	❑	❑
Bus arrives at the scheduled time--->	❑	❑	❑	❑	❑
Knowing how late the bus is in case of a delay -->	❑	❑	❑	❑	❑
Displaying the name of the next stop inside the bus -------------------------------------->	❑	❑	❑	❑	❑
Having the driver call out the stops -->	❑	❑	❑	❑	❑
Knowing the bus is equipped with a 911 emergency system ---------------------------->	❑	❑	❑	❑	❑
Knowing that another bus will be immediately dispatched if there is a breakdown-->	❑	❑	❑	❑	❑
Knowing the transit system uses the latest vehicle location technology --------------->	❑	❑	❑	❑	❑
Having a seat available at all times-->	❑	❑	❑	❑	❑
Low bus fares--->	❑	❑	❑	❑	❑

17. How do you access bus information? (Please check all that apply)
- ❑ $_1$I use the Internet to get the information
- ❑ $_2$I use a cellular telephone to get the information
- ❑ $_3$I use a standard telephone to get the information
- ❑ $_4$I rely on the electronic bus arrival information displayed at the bus stops
- ❑ I don't use anything besides maps and schedules

18. Did you own or have access to a car that you could have used for the trip you are making today?
❑ $_1$Yes ❑ $_2$No

19. Are you a: ❑ $_1$Male ❑ $_2$Female

20. What is your age group?

❑ $_1$Under 18 ❑ $_2$18-25 ❑ $_3$26-45 ❑ $_4$46-65 ❑ $_5$Over 65

Please list any other comments that you may have about this service below:

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