FINAL DRAFT

Phoenix Metropolitan Model Deployment Initiative

Evaluation
Report

U.S. Department
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**Federal Highway
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Intelligent Transportation Systems

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1. Report No. FHWA-JPO-00-015	2. Government Accession No.	3. Recipient's Catalog No.		
4. Title and Subtitle Phoenix Metropolitan Model Deployment Initiative Evaluation Report (Draft)		5. Report Date April, 2000		
		6. Performing Organization Code		
7. Authors C. Zimmerman (Battelle), J. Marks (Multisystems), J. Jenq (Battelle); with contributions by C. Cluett (Battelle), A. DeBlasio (VNTSC), J. Lappin (EG&G), H. Rakha (Virginia Tech), K. Wunderlich (JPL)		8. Performing Organization Report No.		
9. Performing Organization Name and Address Battelle 901 D Street, SW Suite 900 Washington, DC 20024		10. Work Unit No. (TRAIS)		
		11. Contract or Grant No. DTFH61-96-C-00077		
12. Sponsoring Agency Name and Address United States Department of Transportation ITS Joint Program Office, HOIT-1 400 7th Street SW Washington, DC 20590		13. Type of Report and Period Covered		
		14. Sponsoring Agency Code HOIT-1		
15. Supplementary Notes Dr. Joseph I. Peters				

16. Abstract
This report presents the evaluation results of the Phoenix, Arizona Metropolitan Model Deployment Initiative (MMDI). The MMDI was a three-year program of the Intelligent Transportation Systems (ITS) Joint Program Office of the U.S. Department of Transportation. It focused on aggressive deployment of ITS at four sites across the United States, including the metropolitan areas of San Antonio, Seattle, NY/NJ/Connecticut as well as Phoenix. The focus of the deployments was on integration of existing ITS and deployment and integration of new ITS components. Nineteen public sector agencies and thirteen private firms participated in AZTech, the name given to the Phoenix MMDI.

The evaluation encompassed fifteen AZTech projects. Eight projects provided advanced traveler information services; four projects were concerned with traffic management systems; and three deployed transit management systems. Traveler information services used public traffic and transit data from the central AZTech server along with data from the private sector. To address diverse market segments a wide range of dissemination technologies was used, including a personalized messaging system, Trailmaster Web site, commercialized Web page, *Traffic Check* Cable TV, in-vehicle navigation devices, Fastline personal communication device, transit status information, and travel information kiosks. AZTech's traffic management systems included eight "Smart Corridor" projects, three of which were included in the evaluation. Traffic management systems were deployed to provide interjurisdictional traffic signal coordination along major arterial roads in the region and to implement a computer-aided incident management system to facilitate efficiency and accuracy of incident investigations. Three transit management systems were deployed, all with automatic vehicle location technology to aid in dispatch and to provide status information to travelers. Integration among these various projects was a key feature of the AZTech program.

The evaluation focused on six key study areas: network efficiency, safety, energy and emissions, customer satisfaction, costs of deployment, benefit/cost analysis, and institutional lessons. The intent was to evaluate changes in each of these areas brought about by deployment of new projects, as well as integration of both new and existing projects. This report presents the observed impacts of each of the fifteen MMDI projects and their integration and provides conclusions and recommendations based on the results.

Key Words Intelligent Transportation Systems (ITS), Metropolitan Model Deployment Initiative (MMDI), Evaluation		18. Distribution Statement No restrictions. This document is available to the public from: The National Technical Information Service, Springfield, VA 22161.		
19. Security Classif. (of this report) unclassified	20. Security Classif. (of this page) unclassified		21.No of Pages	22. Price N/A

Form DOT F 1700.7   **(8-72)**   Reproduction of completed page authorized

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

List of Tables

Table of Contents (Continued)

List of Tables (Continued)

List of Figures

Table of Contents (Continued)

List of Figures (Continued)

1.   Executive Summary

This document presents the results of the evaluation of AZTech, the Metropolitan Model Deployment Initiative (MMDI) for the Phoenix metropolitan area. The AZTech project was chosen by the U.S. DOT as one of four sites to receive funding under the national Intelligent Transportation System (ITS) MMDI. Other MMDI locations are the metropolitan areas of San Antonio, Texas; New York/New Jersey/Connecticut; and Seattle, Washington. These four sites provided the opportunity to evaluate the benefits to be achieved from the integration of several ITS components simultaneously within a single metropolitan area.

1.1   BACKGROUND ON THE PHOENIX MMDI PROJECT

The goals of the AZTech project center on providing improved safety and regional mobility through enhanced traffic management and regional, multimodal traveler information. To accomplish this, the AZTech partners are building on the existing infrastructure and organizational relationships. AZTech is integrating systems of traffic management, incident management, and transit agencies, which previously were isolated systems.

The AZTech project is a seven-year project to develop and integrate intelligent transportation systems for the Phoenix metropolitan area. With a pre-MMDI investment of about $250 million in intelligent transportation infrastructure, the AZTech MMDI received approximately $7.5 million from the U.S. DOT and leveraged an additional $30 million from the public and private sectors (Figure 1.1). With most system components now partially or completely deployed after the two-year implementation period, the project has begun its five-year operational phase.
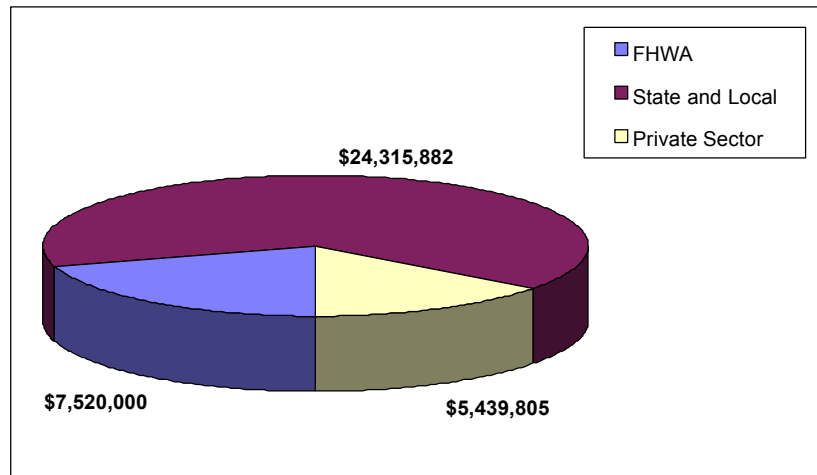
Figure 1.1: Share of AZTech Funding

AZTech was formed by 19 public sector partners and 13 private sector partners by building on existing relationships and recruiting organizations and interest groups not traditionally involved in transportation activities. On behalf of the partnership, Arizona DOT performs project administration and Maricopa County performs project management. Individual projects are administered through collaborative arrangements among AZTech partners. Collaboration occurs between multiple public agencies or between agencies and private sector partners depending upon the needs of the project.

1.2   RESULTS OF THE EVALUATION

The evaluation of AZTech took place between 1997 and 1999. Plans for the evaluation were developed jointly by the U.S. DOT's National Evaluation Team and the local AZTech Project Team and involved coordinating national and local objectives for evaluation. Priorities were developed for the types of benefits data that were sought and these were matched with the deployment schedule and timeframe of the evaluation period along with the resources available for implementing the

evaluation. During the evaluation period a variety of evaluation activities were planned and implemented, and several planned evaluations were not completed due to budget constraints or limitations in the project deployments. Nevertheless, the successful completion of many of the evaluation efforts provides a valuable picture of the benefits that an integrated ITS program has brought to the Phoenix metropolitan region. The lessons learned will provide a foundation for further ITS deployments in the Phoenix region, and other metropolitan areas can learn from their example. In addition, the results from AZTech contribute to the base of knowledge about ITS benefits, which is the objective of the National ITS Evaluation Program.

The AZTech MMDI evaluation encompassed 15 projects, all of which were evaluated in some capacity, and a number of projects received extensive evaluations. Not all the results could be presented in this report, and references are made in the body of the report to other evaluation documents that can be consulted for further information.

1.2.1   Integration—A Principal Focus of Evaluation

The MMDI evaluations had as a primary objective an assessment of the benefits of integration, posing the question "was the whole greater than sum of the parts?" For the Phoenix MMDI, the answer to the question is a qualified yes.

One of the strongest outcomes of integration was the strengthening of institutional ties among public agencies in the region. The AZTech MMDI had as an advantage at the outset a pre-existing history of agency collaboration. The MMDI built on that foundation and strengthened the existing relationships so that the region now has a better potential for improving the functioning of the transportation system in Phoenix not only for its operators (i.e., the road and highway, transit and emergency response agencies), but also for their customers—the traveling public—as well. Travelers now have better and more accessible information on travel conditions and alternatives. Moreover, the potential for improved operations should help travel conditions as ITS continues to be deployed. A good example of this type of integration is the signal timing coordination between the cities of Tempe and Scottsdale, which was part of AZTech's "Smart Corridor" program. While the coordination efforts have had a modest beginning, they set the stage for similar coordination in other "smart corridors."

Another demonstration of the benefits of integration is the sharing of costs among projects and agencies. As presented throughout the report, many projects were able to take advantage of investments, such as the central computerized database known as the AZTech Server. The sharing of that investment among multiple projects allowed for economies of scale, thereby making individual projects more affordable for participating agencies.

Integration of ITS projects into an overall program under the AZTech umbrella provided a critical mass of multiple agencies. When coupled with the spotlight of MMDI funding and external attention from the ITS community, U.S. DOT, and the media, this critical mass served to heighten awareness about ITS among local officials. An individual ITS project would have been unlikely to rise to that level in the consciousness of politicians and decision-makers in the Phoenix region.

Integration has had additional direct benefits in other ways. Integration of systems may require new policies and procedures to be developed and adopted as exemplified by sharing of video images. Video images of traffic conditions are an asset to the ADOT Trailmaster Web page and to private sector services such as Etak's *Traffic Check* Cable TV. Integration provided the technical ability to share images across systems and between public and private partners, but new rules on how video images would be used were needed in order for the integration to be truly effective.

Despite some demonstrated support for the value of ITS integration, it has not been upheld uniformly in AZTech. Integration of multiple ITS projects has turned out to be more complicated and time consuming than expected. Consequently, some projects, such as the Smart Corridors, are still in the process of completion. Thus, the benefits of those projects were not available to be evaluated within the necessary timeframe of this study.

Also challenging the integration hypothesis is that public/private integration has had only limited success, because of the reliance upon commercialization of services, principally traveler information services. The public sector had hoped that integration of publicly provided data sources with private sector fusion and dissemination capabilities would lead to successfully commercialized traveler information services within the Phoenix region. As has been demonstrated from the lack of commercial success to date with the Fastline service and Etak's personal messaging services, marketplace conditions and the ability of private partners to make a business in that market are as important as public sector participation. That is not to say, however, that the public sector should not help foster success, especially in areas that can make a difference, such as marketing traveler information to travelers.

1.2.2   Institutional Lessons Learned

The institutional assessment of the MMDIs revealed that successful actions taken at a particular MMDI site were often taken at other sites, too. Based on in-depth interviews at each MMDI site, the institutional study identified eight actions that were especially important in Phoenix. These included:

- Building on existing relationships
- Reaching the general public
- Reaching elected and appointed officials
- Defining intra-agency management and staffing requirements
- Developing the management structure for the MMDI
- Assigning intellectual property rights
- Selecting the appropriate procurement mechanisms
- Developing policies that govern operations.

Among these, AZTech's ability to work from pre-established relationships among public agencies in the region proved particularly beneficial. In years preceding the award of the MMDI to the Phoenix metropolitan region, a number of actions had been taken that helped build coalitions to address various transportation needs. Starting in 1993 with the Metropolitan Area Governments Information Center (MAGIC) study and followed two years later by the receipt of an ITS Early Deployment Planning grant, these efforts and others brought agencies together to pursue common interests. The relationships established in these earlier initiatives proved critical by the time of the MMDI program started in 1996. It would have been much more difficult and time consuming to implement such an ambitious program as AZTech without this collaborative history and network of interpersonal relationships in place.

Similarly noteworthy are the practical steps to the day-to-day challenges that arise in managing a complex program such as AZTech. Creative solutions were found to vexing problems dealing with procurement instruments and contract language relating to intellectual property rights. For example, AZTech MMDI participants were able to draw on three innovative procurement instruments for timely procurement: sole-source contracting, on-call contracting, and joint, inter-jurisdictional procurements. Simply saving time and making progress in deployment is essential for maintaining momentum and showing progress to stakeholders and AZTech effectively demonstrated ways for removing barriers that impede and do not contribute to the program.

1.2.3   Traveler Information Systems

The public and private partners of AZTech clearly wanted to offer travelers a wide range of dissemination technologies for obtaining traveler information. Recognizing the diversity of travelers and opportunities they have for accessing traveler information, AZTech partners' plans encompassed pre-trip and en route services, publicly subsidized and commercial customized services, and high-tech and low-tech approaches that would appeal to all segments of the traveling public. They developed eight traveler information projects, including three public sector ATIS dissemination technologies (Trailmaster Website, transit status information, and kiosks). AZTech's private sector partners deployed four services (Etak's personalized messaging service; Etak's commercial web page; Etak's *Traffic Check* cable TV system; and Fastline's personalized communication device). A private sector in-vehicle system was planned, but canceled. A toll-free telephone service for traffic information was implemented by ADOT prior to AZTech, but was not part of the evaluation program.

The eight traveler information projects were evaluated, with two of them investigated in detail from the standpoint of customer satisfaction. For all eight projects the cost of deployment was assessed and all the projects figured in the overall institutional assessment of AZTech.

The experience in Phoenix serves to highlight the tremendous promise and the potential pitfalls of deployment of advanced traveler information systems (ATIS). The results of the customer satisfaction studies demonstrate that some of those technologies have been met with public interest and user acceptance, as will be discussed below. Unfortunately, the commercial services have not been very successful to date. Many evaluations for the commercial services were shelved due to delayed and canceled deployments or limited usage preventing meaningful evaluation.

It is important to note the context in which AZTech traveler information services are deployed. Based on measures of traffic congestion and travel mobility, Phoenix does not suffer the most severe problems when compared to other metropolitan areas. Moreover, the network of highways and arterials offers Phoenix travelers many options when they do encounter congestion. These factors may help explain the modest response to traveler information services observed in the MMDI evaluation in Phoenix.

Customer Satisfaction with AZTech ATIS

One of the most productive aspects of the ATIS evaluations in Phoenix is what has been learned about customer satisfaction. The public sector Web site, Trailmaster, was subject to extensive evaluation based on focus groups and web log analysis. *Traffic Check* Cable TV service developed by Etak and carried on Tempe government's public access channel was similarly investigated using telephone surveys. The research in Phoenix and the other MMDI sites indicates that travelers' use of information is conditioned by four types of factors: 1) the regional or situational context, such as the availability of alternative routes, amount of traffic congestion, or adverse weather conditions; 2) the quality of the ATIS service, such as ease of access and availability and accuracy of real-time information; 3) the characteristics of the trip, including the length of the commute and degree of congestion experienced on the commute; and 4) the characteristics of the traveler, such as education and household income or comfort with high technology. In the Phoenix region, results from the customer satisfaction studies have been usually consistent with these expectations. Some of the key findings include the following:

- As illustrated in Figure 1.2, usage of the Trailmaster Web site has grown steadily (50% over the 10-month evaluation period) and can be expected to continue to grow as the quality and coverage of travel conditions increases as instrumentation of roadways expands. Users are particularly

interested in arterial or non-freeway conditions, and availability of such information could substantially boost regular usage.
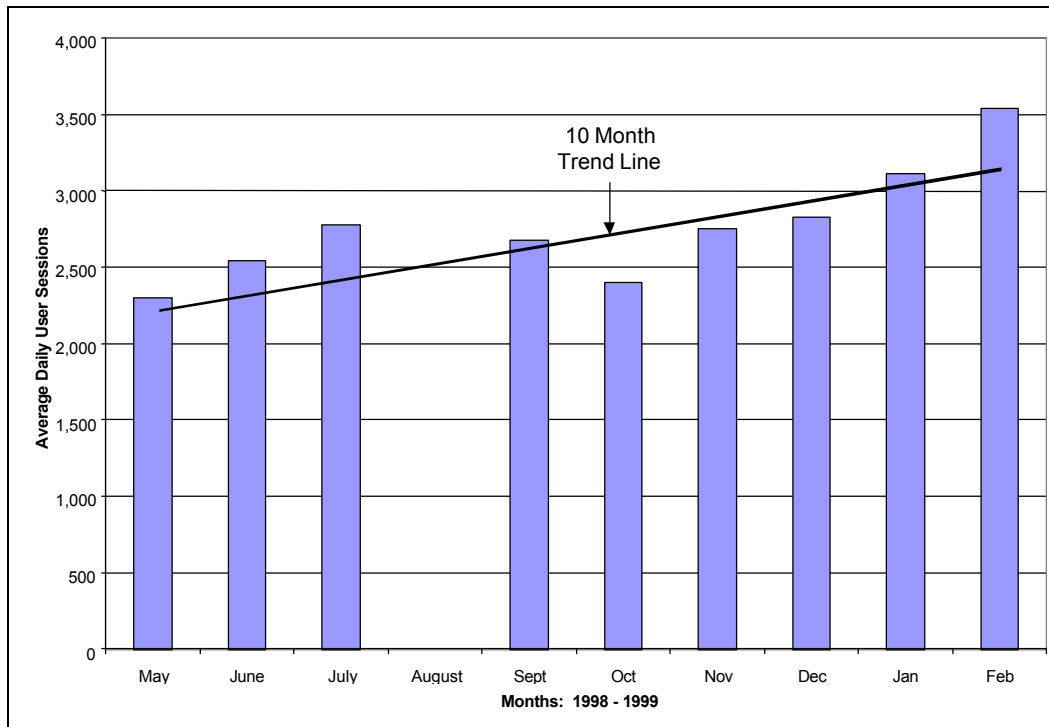
Figure 1.2: Average Number of Daily Trailmaster User Sessions Per Month, 10-Month Trend Line

- Users also indicated a preference for dynamic over static information, as exemplified by camera images, which are one of the most popular features on the Trailmaster Web site. Six of the top 10 most visited pages pertain to traffic monitoring cameras.
- Patterns of ATIS usage in the Phoenix region by day of week and time of day are generally consistent with those observed in other locations, although the pattern tends to be smoother with fewer spikes of usage observed elsewhere. The absence of dramatic weather conditions during the evaluation period, along with generally lower levels of congestion, may explain this phenomenon in Phoenix ATIS usage.
- With regular usage of Web-based ATIS, frequent users appear to become more efficient and selective in the information they access. Evidence for this is that the number of pages viewed per session has dropped (3.5 to 2.1) while the average duration of a session has increased (7.8 to 8.5 minutes).
- Information on travel conditions available on the *Traffic Check* cable TV program caused viewers to change travel behaviors. 74% of commuters who learned of traffic problems from the program made two or more trip changes within the last year, with change of route the most common change made.
- Although demographic characteristics weren't related to the frequency of use of *Traffic Check* cable TV, commuters who reported congested traffic at least twice a week or who had attitudinal characteristics such as a desire for accurate traffic information or worrying about being late were likely to be frequent users of the program.

- Despite the utility of traveler information services to those who have tried them, willingness to pay is low. As shown in Figure 1.3, only 26% of frequent viewers and 19% of all *Traffic Check* viewers reported they would be willing to pay $1.00 a month to continue receiving the service.
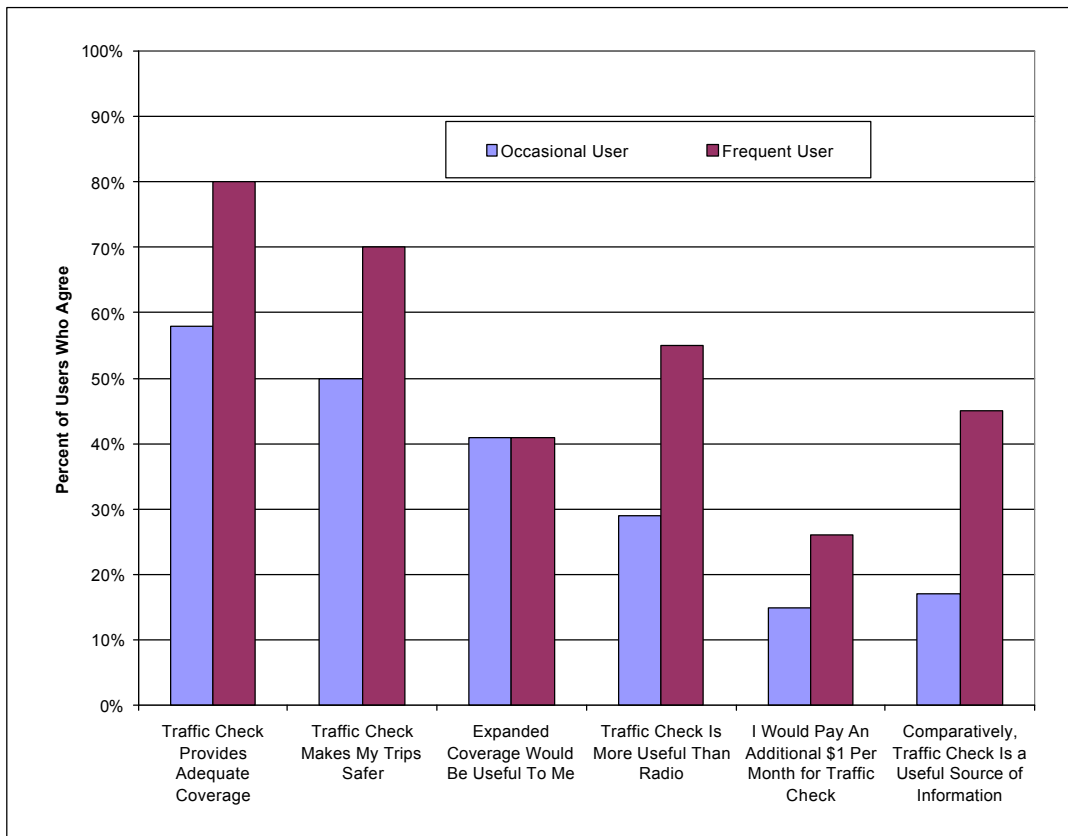
Figure 1.3: Comparisons Between Occasional and Frequent Users on Satisfaction with *Traffic Check*

In comparing Phoenix with the Seattle MMDI results on customer satisfaction, a stronger user response is apparent in Seattle. One likely explanation for this discrepancy is that traffic conditions are far less problematic for the typical commuter, in Phoenix, where commuters did not report significant congestion, knew of alternative routes, and were far less troubled by the potential for travel delays. Thus, there appears to be less of a motivation for seeking out and using information to address commuting problems.

The Challenges of Commercializing ATIS

Although five commercial ATIS projects were planned and four ultimately deployed, none have been a commercial success to date. The lack of commercial success so far for ATIS in Phoenix may be attributed to several factors. These include inability to attract additional private sector investment, especially companies that control the dissemination technology, such as the cable TV or paging networks, without which the services cannot be deployed. Another factor limiting the success of the commercial services is the need for promotion. Creating awareness of a service and stimulating services requires resources that some private sector partners may not be able to muster by

themselves. A third factor affecting the potential for commercial ATIS in Phoenix may be the limited appeal of the services given the traffic conditions in the region. Appeal of certain services, fax and e-mail for example, may be limited because users may not be willing to pay the cost that commercialization requires. For a commercial ATIS to succeed, the business case must identify sufficient demand among the target customer segment, and that demand may not have reached a large enough threshold in the Phoenix region to support commercial ATIS enterprises.

1.2.4   Traffic Management Systems

AZTech focused its traffic management efforts on improving traffic movement in eight "Smart Corridors" throughout the region. AZTech also dealt with the incident side of traffic management with the Computer-Aided Incident Investigation project aimed at improved handling of incidents so that traffic delays would be reduced. All of these projects focused on interjurisdictional coordination built around common technological approaches.

Evaluation of the Smart Corridors program was highly focused on the impacts of cross-jurisdictional traffic signal coordination. Although three corridors were planned for evaluation, extensive evaluation was done on a single corridor, the arterial known as Scottsdale Road and Rural Road, at different points along its path. Two jurisdictions, the Cities of Scottsdale and Tempe decided to coordinate the signals at three intersections in an attempt to improve traffic progression at the jurisdictional boundary. These three signals controlled a three-mile section of the arterial. Using GPS-equipped vehicles, multiple "floating-car" runs were conducted on the Scottsdale/Rural Road corridor to collect field data for assessing the impact of the signal retiming. Tables 1.1 - 1.3 indicate either a small improvement or no change in several of the measures of effectiveness that were tested (speed, number of stops, delay, fuel consumption, emissions and crashes). Further analysis of the data confirmed that the impacts of the re-timing of the three traffic signals are localized and correlated with the intersections where the change was made. However, when corridor-wide impacts were assessed using a traffic simulation model, the impact could not be reliably detected. The benefits of signal retiming dissipated when spread over the larger area. Apparently, the small extent of change (three traffic signals out of twenty-one on the mainline) limited the area-wide impact on the measures of effectiveness.

Table 1.1: Throughput and Efficiency Results from GPS Data Analysis

		Average
Before	Speed (km/h)	41.9
	Stops	7.2
After (% change)	Speed (km/h)	44.5 (+6.2%)
	Stops	6.9 (-4.2%)

Table 1.2: Fuel Consumption and Emission Results From GPS Data Analysis

		Average
Before	Fuel (liters)	1.20
	HC (grams)	1.22
	CO (grams)	15.4
	NO_x (grams)	3.18
After (% change)	Fuel (liters)	1.18 (0.2%)
	HC (grams)	1.22 (0.0%)
	CO (grams)	15.6 (0.0%)
	NO_x (grams)	3.17 (0.0%)

Table 1.3: Crash Risk Analysis Results
Based on GPS Data Analysis

		Average
Before	Crashesx10^{-6}	27.4
After (% change)	Crashesx10^{-6}	25.6 (-6.7%)

On the other hand, results of a simulation of three hypothetical implementations of aggressively optimized signal re-timing along the same corridor proved much more promising. As shown in Table 1.4, significant improvements were demonstrated in each of the three optimized timing plans (labeled 110/102, ALL-110, and ALL-102 in the table) compared to the "before" condition. (The "after" condition in the table refers to the actual implementation of re-timing at three intersections.) While promising, these results warrant further consideration and investigation with respect to their implications for operations within the corridor.

Table 1.4: Corridor Impacts of AM Peak Optimization, Simulation Study

Plan	Delay (sec/trip)	Stops (stops/trip)	Fuel (liters/trip)	HC (g/trip)	CO (g/trip)	NOx (g/trip)	Crashes (per 10^6 VMT)
BEFORE	107.7	2.58	0.327	5.79	37.471	0.898	7.099
AFTER	101.0 (-6%)*	2.55 (-1%)*	0.322 (-2%)*	5.72 (-1%)	37.069 (-1%)	0.891 (-1%)	6.858 (-3%)*
110/102	90.0 (-16%)	2.38 (-8%)	0.312 (-5%)	5.648 (-2%)	36.621 (-2%)	0.864 (-4%)	6.473 (-9%)
ALL-110	90.9 (-16%)	2.39 (-8%)	0.313 (-4%)	5.665 (-2%)	36.680 (-2%)	0.864 (-4%)	6.507 (-8%)
ALL-102	85.4 (-21%)	2.31 (-10%)	0.307 (-6%)	5.597 (-3%)	36.306 (-3%)	0.851 (-5%)	6.316 (-10%)

*Not statistically significant at 95% confidence level

Thus, the evaluation of AZTech's efforts at improving traffic management through the Smart Corridor program was not able to validate those benefits during the evaluation period. Although there is cause for optimism, the deployment was too limited for significant impacts to be measured. However, it is important to point out that the technology deployed in the Smart Corridor project permits the development of more extensive and sophisticated traffic control strategies beyond the re-timing of three intersections available during the evaluation period. More benefits can be expected as AZTech expands its traffic management operations in the future.

As part of the long-term incident management strategies, AZTech implemented the Computer-Aided Incident Investigation system. This project is another demonstration of AZTech partners' interest in fostering interjurisdictional cooperation to achieve improved incident management. In this case, under the AZTech program, non-transportation agencies are adopting the "Total Station" system designed to reduce incident investigation time and improve the accuracy of accident investigations. Although no evaluation data were available to validate the benefits, the favorable response that agency personnel have had to this technology has resulted in additional installations and improved coordination between

law enforcement and transportation agencies. A positive experience such as this will help build support for ITS technologies not only among the traditional constituency such as traffic departments, but in public safety departments as well.

1.2.5 Transit Management Systems

The transit management projects within AZTech focused on integration among the transit services and integration with the traveler information component of AZTech to provide bus status information to travelers. Three separate transit management projects were undertaken: Transit Vehicle Dispatch, Service Vehicle Dispatch, and Paratransit Vehicle Dispatch. While these projects may have operational benefits to the transit providers and their customers, the National Evaluation Team and AZTech Project Team decided to focus evaluation resources elsewhere within the AZTech program where the potential evaluation data had higher priority. Consequently, the transit management projects were evaluated only from the standpoint of cost of deployment and as part of the overall institutional assessment. The automatic vehicle location technology and mobile data terminal installed on the transit vehicles, especially when linked with incident information from the AZTech server, are expected to provide more efficient operations and greater safety and security for passengers.

1.3   RECOMMENDATIONS

To build on the successes and address areas where AZTech deployments may have fallen short, AZTech partners and other interested readers can examine the results of the evaluation efforts for areas that warrant attention. Some of the recommendations made in this report include:

- Assessment of agencies' institutional capacity should be undertaken to determine their ability to support on-going operations of the AZTech elements for which the public sector partners are responsible. Are agencies staffed appropriately to operate and maintain the systems? Is staff at all levels supportive? Surely budgets as well as roles and responsibilities need to be aligned with AZTech systems for them to continue to evolve and perform as expected, such as the staffing requirements for agencies to supply traffic information on arterial streets to the Roadway Closure and Restriction System (RCRS).
- Greater attention needs to be paid to the role of advertising or other promotional activities in raising awareness and usage levels of traveler information services. Given the overall low level of usage of the traveler information service, AZTech partners need to determine what they might be able to do to alter the picture. Public and private sector partners should strategize and devote sufficient resources to informing the target customers about their services.
- Effective use should be made of the demographic (age or gender, for example) and psychographic (attitudes and values) attributes of users of traveler information services revealed in the customer satisfaction research. Such information will be helpful not only in devising effective marketing campaigns but it can also help designers to gear their services to appeal to their target markets.
- Attention should be paid to areas for improvement identified by users of the travel information services that would make the services more valuable or accessible. For example, users suggested that better use be made of icons and that more information on arterial streets be provided. ATIS service designers would do well to take advantage of those recommendations to enhance the appeal and marketability of their services. For a broader appeal products need to be perfected and the suggestions presented for AZTech ATIS indicate areas in which development efforts could be focused.

- The Smart Corridors deserve further evaluation to measure the impact of more fully deployed coordinated signal timing than was available during the period covered in this report. Coordinated signal timing is a fundamental step advocated by ITS proponents, and, therefore, the limited impact in AZTech warrants further investigation to be sure that positive benefits are measured in the future.
- Additionally, traffic engineers should investigate the optimal signal timing needed to achieve desired impacts along each Smart Corridor. In the Scottsdale/Rural Road investigation, one jurisdiction adopted the signal-timing plan of its neighbor. As simulation of hypothetical implementations of optimized re-timing plans demonstrated, it is possible that another plan, when deployed along the entire corridor, would provide even greater impacts than the timing plan that was implemented at the jurisdictional boundary.
- Benefits of deployment of technologies aimed at improved transit operations were not measured in this evaluation study. It is recommended that the impact of automatic vehicle location and mobile data terminals be assessed as a sufficient number of vehicles become equipped and that the role of information on traffic conditions as used by transit operators be assessed for impact as well.

1.4   ROADMAP TO THE AZTECH EVALUATION RESULTS

This AZTech evaluation report is designed to provide the reader with a detailed summary of each MMDI project and the national evaluation efforts that were undertaken to evaluate them. The results are organized into two primary sections: *Institutional Issues* (Section 3) related to AZTech program development, management, and implementation and how the project team addressed them; and *Individual Projects* (Sections 4-6) organized by major ITS components. Section 7 provides conclusions that can be drawn from the evaluation results and recommends a number of actions for the future.

Table 1.5 provides a roadmap to guide the reader to the results for the fifteen individual projects that were evaluated.

Table 1.5: Roadmap to Evaluation Results for Fifteen AZTech Projects

AZTech Projects	ITS Component	Evaluation Scope	Details in Section
Personalized Messaging System	Advanced Traveler Information Systems	Cost and benefit/cost evaluations conducted; project included in institutional assessment	4.1
Trailmaster Web Site & Roadway Closure and Restriction System (RCRS) Web Page		Customer satisfaction; cost and benefit/cost evaluations conducted; project included in institutional assessment	4.2
Commercialized Web Page		Cost and benefit/cost evaluations conducted; project included in institutional assessment	4.3
Traffic Check Cable TV		Customer satisfaction study; cost and benefit/cost evaluations conducted; project included in institutional assessment	4.4
In-Vehicle Navigation		Project included in institutional assessment	4.5
Fastline PCD		Cost and benefit/cost evaluations conducted; project included in institutional assessment	4.6
Transit Status Information		Cost and benefit/cost evaluations conducted; project included in institutional assessment	4.7
Kiosks		Cost and benefit/cost evaluations conducted; project included in institutional assessment	4.8

AZTech Projects	ITS Component	Evaluation Scope	Details in Section
Scottsdale/Rural Road Corridor Signal Coordination	Advanced Traffic/Incident Management Systems	Throughput and efficiency, fuel consumption, emissions, and safety evaluated; cost and benefit/cost evaluations conducted; project included in institutional assessment	5.1
Southern Baseline Corridor Signal Coordination		Cost and benefit/cost evaluations conducted; project included in institutional assessment	5.2
Bell Road Corridor Signal Coordination		Cost and benefit/cost evaluations conducted; project included in institutional assessment	5.3
Computer-Aided Incident Investigation		Cost and benefit/cost evaluations conducted; project included in institutional assessment	5.4
Transit Vehicle Dispatch with AVL and MDT	Transit Management System	Cost and benefit/cost evaluations conducted; project included in institutional assessment	6.1
Service Vehicle Dispatch with AVL		Cost and benefit/cost evaluations conducted; project included in institutional assessment	6.2
Paratransit Vehicle Dispatch with AVL and MDT		Cost and benefit/cost evaluations conducted; project included in institutional assessment	6.3.

2. Introduction to the AZTech Metropolitan Model Deployment Initiatives (MMDI)

The AZTech Metropolitan Model Deployment Initiative (MMDI) focuses on improving multimodal transportation in the greater Phoenix metropolitan region, an area spread out over 1,817 square miles and containing 19 municipalities, where more than 2.5 million people live, work, and travel. The US Bureau of the Census reported that Phoenix was the fastest growing city in the country between 1990 and 1998[1]. Phoenix is crisscrossed with a network of interconnected freeways and major arterials, offering travelers more route choice options for getting from point A to point B, compared, for example, with another Metropolitan Model Deployment Initiative city, Seattle WA.
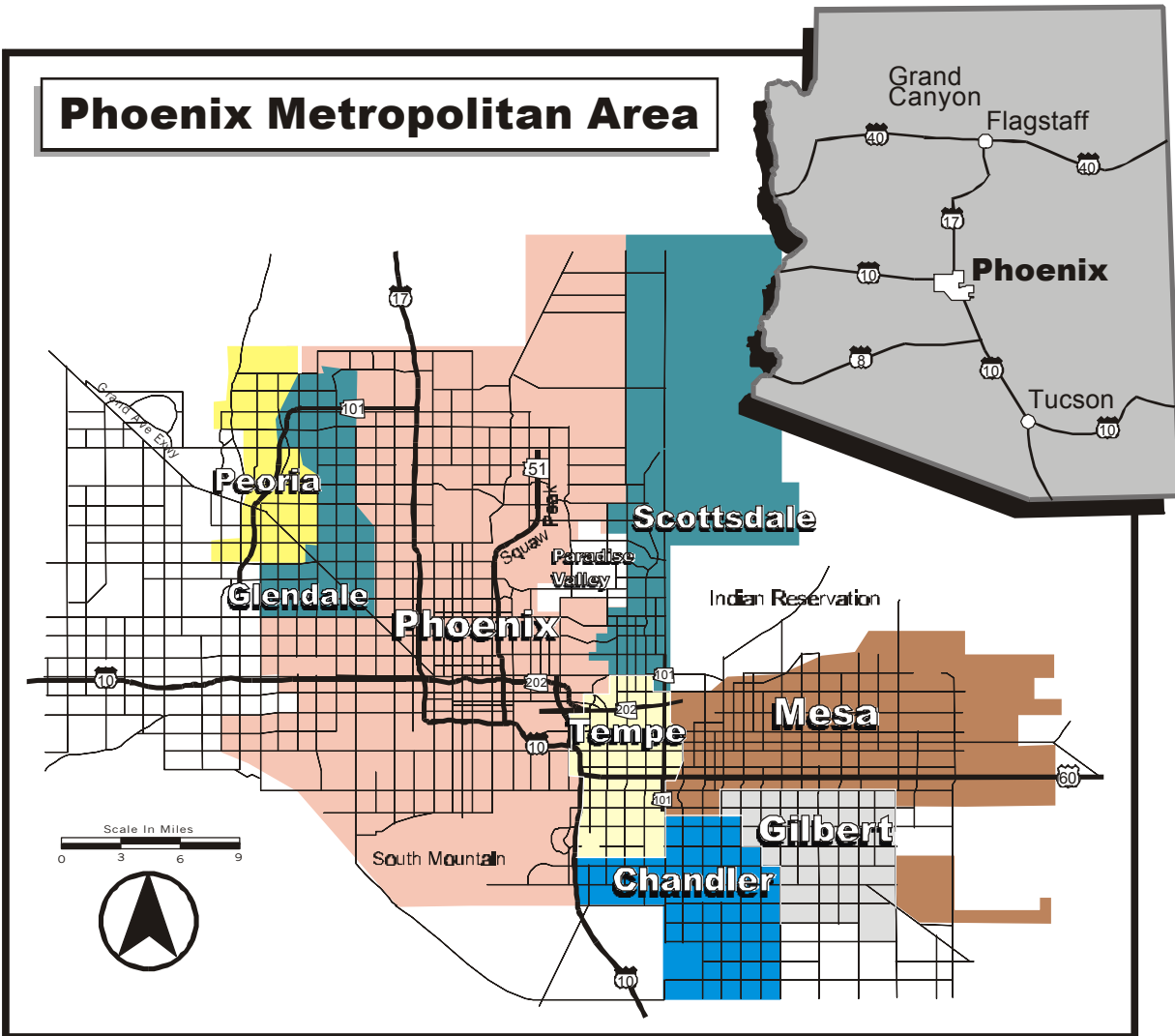
Figure 2.1: Map of Phoenix Metropolitan Area

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[1] The US Bureau of the Census released on 6/30/99 the most recent population estimates for selected places (see: http://www.census.gov/Press-Release/www/1999/cb99-128.html). For cities with populations of 1 million or more, the two fastest growing cities are Phoenix and San Antonio, with population growth of 21.3% and 14.1% respectively between 1990 and 1998.

The dispersed locations of major businesses, colleges, and centers of recreation and culture throughout the metropolitan area create a highly mobile commuting public. Moreover, the Phoenix region has become a major business and tourist destination, experiencing a seasonal influx of visitors during the winter months. Fueled by these trends, continued residential and industrial expansion into previously undeveloped parts of the region is placing increasing demands on the outlying arterial street system. The AZTech program provides an opportunity to address the region's transportation needs through the use of Intelligent Transportation Systems (ITS). Differences in the geographic and demographic characteristics of the three MMDI sites appear to be related particularly to differences in patterns of traveler information use at each of these sites, suggesting that the context within which ATIS is deployed is an important factor in helping explain ATIS use. Table 2.1 presents some of these characteristics and Chapter 4 discusses the implications in more detail.

Table 2.1: Selected Characteristics of Metropolitan Model Deployment Initiative Sites

Site Attribute	Seattle	Phoenix	San Antonio
1990 Population for MSAs/CMSAs[2]	2,559,164	2,122,101	1,302,099
1997 Population Density for MSAs[3]	466.2	194.8	454.3
Rate of Population Growth for MSA/CMSA: 1990-1997[4]	13.4%	26.9%	14.1%
Miles of Instrumented Roadways[5]	120 miles	50 miles	26 miles (plan to increase to 191 miles)
TTI Congestion Index and Rank[6]	1.27 (6th most congested city in US)	1.24 (15th most congested city in US)	0.99 (44th most congested city in US)
TTI 1997 Travel Rate Index[7]	1.43 (Rank #2)	1.28 (Rank #16)	1.15 (Rank #46)[7]
VMT per Freeway Lane-mile (1996)[8]	16,870	15,085	12,705
Congested Freeway Travel (%)[8]	80%	65%	45%

[2] The 1990 US Census of Population, Metropolitan Statistical Areas, available at: http://venus.census.gov/cdrom/lookup

[3] Persons per square mile for Metropolitan Statistical Areas, 1997, available at: http://www.census.gov/Press-Release/metro06.prn

[4] Rate of change in population for Metropolitan Statistical Areas, available at: http://www.census.gov/Press-Release/metrolis.htm

[5] Centerline miles, based on discussions with transportation experts at each site.

[6] A description of TTI's Roadway Congestion Index can be found at: http://mobility.tamu.edu/study/rci.stm. This discussion states in part, "The resulting ratio indicates an undesirable level of areawide congestion if a value greater than or

[7] In 1999, TTI developed a new index of mobility called the Travel Rate Index (TRI). The TRI measures the amount of extra time it takes to travel during the peak period. An index value of 1.43, using Seattle as an example, means that it takes on average 43% longer to travel during the peak than during free-flow conditions. The TTI report is available at: http://mobility.tamu.edu/study/report.stm.

[8] Data provided by the Texas Transportation Institute at: http://mobility.tamu.edu/

In order to understand how travelers respond to the model deployments, it is important to know how much congestion occurs in the city as well as what travel options are available to travelers. The Texas Transportation Institute (TTI) has created a congestion index that is based on the kinds of factors shown in Table 2.1 (plus a number of other factors incorporated into the congestion index). Based on the TTI congestion index, and on TTI's most recent Travel Rate Index, Seattle's freeways and arterials are more congested and mobility is more impaired than in Phoenix, for example. Figure 2.2 shows how Phoenix, San Antonio, and Seattle compare in the Travel Rate Index rankings.
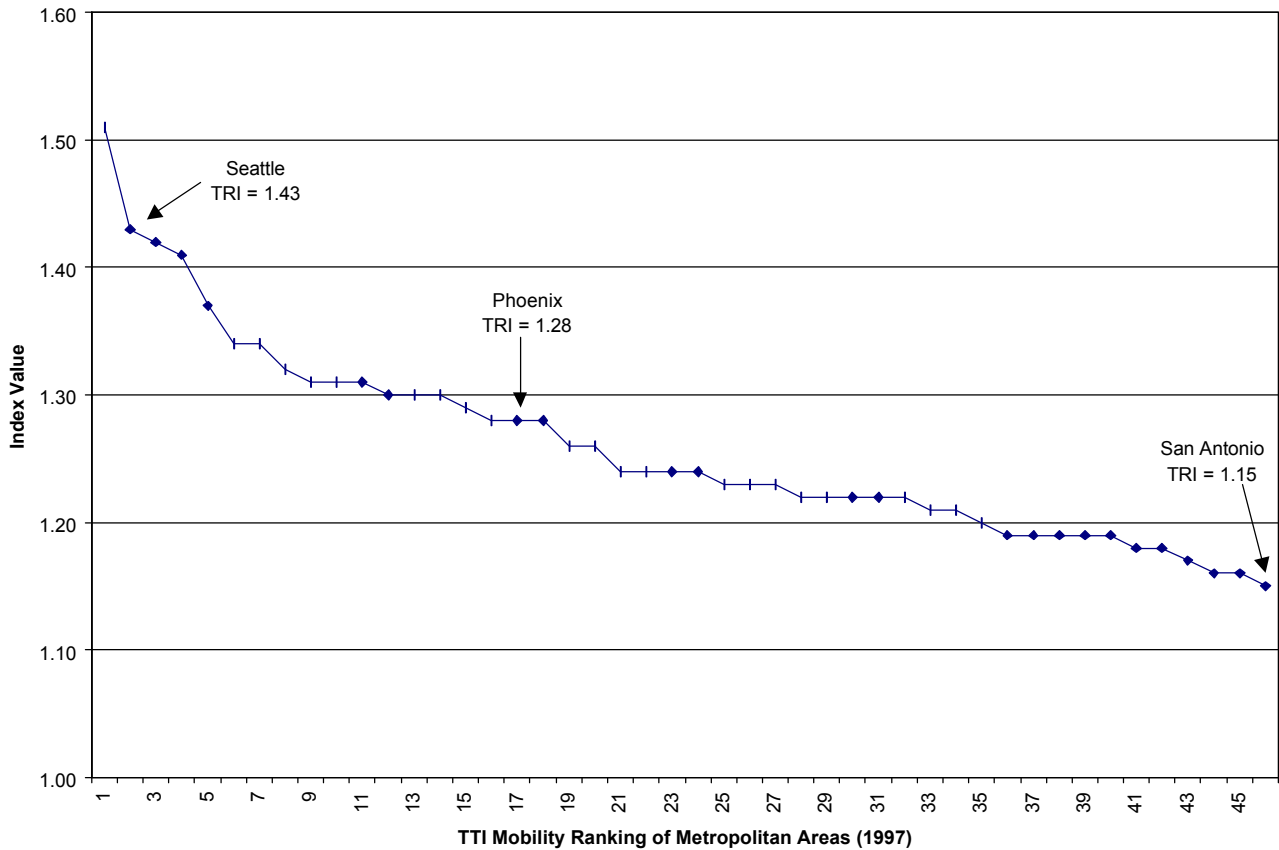
Figure 2.2: TTI 1997 Travel Rate Index

Analysis of the 1990 Nationwide Personal Transportation Survey (NPTS) emphasizes that the increase in vehicle miles traveled (VMT) is responsible for the congestion that is occurring in urban areas. This has been caused by a number of factors, including longer trips, more trips per person, mode shift into driving, reductions in vehicle occupancy (including less carpooling), and population growth. However, population growth between 1983 and 1990 accounted for only 13% of the growth in VMT.[9] The Surface Transportation Policy Project examined the 1999 TTI data and the 1990 NPTS findings and concluded that urban sprawl is a principal factor that helps explain these trends.[10] It appears that rapid growth in VMT (rather than population growth per se) is a major cause of increased congestion that motivates individual travelers to use and benefit from ATIS and related model deployments. In spite of fairly high levels of VMT experienced in Phoenix, the impact of ITS may be

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[9] U. S. Department of Transportation, Federal Highway Administration. 1992. *Travel Behavior Issues in the 90's*, (July).

[10] Surface Transportation Policy Project. 1999. *Why Are the Roads So Congested?* (November).

mitigated by other factors at work. The city's spread out urban geography, a network of highways and arterial roads that offer travelers many options to avoid congestion, and lower overall levels of congestion compared with many other metropolitan areas help explain the levels and patterns of ATIS use that are discussed in Chapter 4.

2.1 OBJECTIVES OF METROPOLITAN MODEL DEPLOYMENT INITIATIVE

The U.S. DOT sponsored the MMDI to foster public-private partnerships that would showcase fully integrated metropolitan-area ITS infrastructure. From a total of 23 responses to a notice published in the February 26, 1996 Federal Register, four sites were selected to receive federal funding of approximately $38.7 million for this initiative. In each site, non-federal partners funded 50% or more of the total cost of the project they were proposing. The AZTech project in the Phoenix region was chosen as one of four sites to receive funding under the national ITS MMDI. The other sites are San Antonio, Texas; Seattle, Washington; and the New York/New Jersey/Connecticut Metropolitan Area.

The MMDI was designed with several objectives. The MMDI was intended to demonstrate measurable benefits that result from the application of integrated, region-wide approaches to transportation management and the provision of advanced traveler information services. The model deployments were expected to provide improved transportation management and increased levels of service to the traveling public through the integration of traditional functions of traffic signal control; transit management; freeway management; incident management; emergency services management; and regional, multimodal traveler information services. In addition, the model deployment would demonstrate the benefits of ITS products and services to the public and to key local decision-makers across the U.S. and demonstrate institutional benefits, including organizational, modal and public/private sector cooperation. The sites also were expected to provide a setting for rigorous evaluations of the benefits of an integrated deployment of intelligent transportation systems in a metropolitan setting.

Tailoring the national objectives of MMDI to the Phoenix environment, the local project team envisioned AZTech as a program that would integrate the region's intelligent transportation infrastructure. Such integration would help achieve a multimodal transportation system that would better manage growing regional transportation demand while at the same time minimizing impact on the environment. Public and private partnerships were to be used to accomplish this mission. AZTech objectives centered on providing improved safety and regional mobility through enhanced traffic management and regional, multimodal traveler information. AZTech MMDI participants built on existing infrastructure and organizational relationships to achieve their objectives. The MMDI integrated systems of traffic management, incident management, and transit agencies, which previously were isolated systems.

2.2 EVALUATION OBJECTIVES

The MMDI sites provided unique opportunities to determine the impact of not only new ITS components but also the integration of new and existing ITS components. To this end an evaluation program for the MMDI was established that had the overriding goal to test the hypothesis that "the whole is greater than the sum of the parts." This hypothesis was based on the assumption that the integration of deployed ITS infrastructure would result in greater total benefits than if the different parts of the infrastructure acted independently. The MMDI Evaluation program was developed to test that assumption. Other corollary objectives of the evaluation included:

- Documenting the benefits of successfully addressing potential non-technical (institutional) impediments;
- Determining the incremental effects of increasing the levels of ITS deployments on some key transportation system attributes such as customer satisfaction, traffic flow, travel demand, and safety;
- Conducting an economic analysis of costs versus benefits of ITS deployment.

The evaluation was intended to furnish information to U.S. DOT, Congress, States, MPOs, industries, public interest groups, and others regarding the effectiveness of ITS investments and corresponding enhancements to national, state, regional and local transportation programs. Moreover, the study would facilitate comparisons among alternative investments, including between ITS alternatives and between ITS and non-ITS programs.

To achieve the evaluation objectives, U.S. DOT developed an evaluation program designed to obtain scientifically substantiated findings on deployment of nine ITS services and their integration. The services are: (1) traffic signal control systems; (2) freeway management systems; (3) incident management; (4) electronic toll collection; (5) emergency management; (6) transit management; (7) electronic fare payment; (8) railroad grade crossing; and, (9) traveler information systems. Based on the number of projects planned for each ITS service across all four sites and the specific features of each project, a national evaluation plan was developed that would optimize the use of available evaluation resources. Within the evaluation plan, all projects were evaluated in certain respects (cost, cost/benefit, and institutional aspects) but some projects were selected for in-depth investigation. With input from the MMDI deployment teams, the evaluation plan was developed that enabled information to be obtained across all the ITS services while, at the same time, it avoided unnecessary redundancy.

AZTech implemented national objectives by serving as a testbed for assessing the benefits to be achieved from integration of ITS components. Moreover, the AZTech project team wanted to use the evaluation to measure the effectiveness and benefits of AZTech technologies and services to help guide the expansion of the AZTech system in the future. Using common resources, the local project team and the national evaluation team were able to achieve their objectives. An evaluation plan developed together by the national evaluation team and local project team identified the following objectives within the six categories of benefits ("few good measures") of the national framework:

- *Crashes and fatalities*
  - Reduce crashes on major arterial corridors
  - Reduce secondary accidents on freeway and arterial streets

- *Throughput and efficiency*
  - Increase traffic efficiency on major arterial corridors
  - Increase transit ridership
  - Increase freeway and arterial throughput by managing demands
  - Reduce incident-related freeway congestion by improving incident management

- *Travel time*
  - Reduce travel time/delays on major arterial corridors
  - Reduce wait time for transit passengers
  - Increase travel time reliability with better pre-trip and en-route information

- *Customer satisfaction*
  - Increase overall level of customer satisfaction on major arterial corridors
  - Improve transit operation, efficiency, safety, and on-time performance

-   Increase transit user satisfaction
-   Increase user's satisfaction, acceptance, and awareness of ITS.

- *Emissions and fuel consumption*
    -   Reduce vehicle emissions on major arterial corridors

- *Cost savings*
    -   Reduce travel costs on major arterial corridors
    -   Reduce travel costs for users of AZTech traveler information services.

The evaluation has achieved both the local and national objectives by providing valuable information on benefits and methodologies for measuring ITS benefits. The AZTech project team will use the results in making resource decisions regarding future enhancements to AZTech, and the results will help U.S.DOT with future direction of ITS deployment and integration efforts.

2.3   AZTECH OVERVIEW

The AZTech ITS MMDI is a seven-year project to develop and integrate ITS projects for the Phoenix metropolitan area. With a pre-MMDI investment of about $250 million in intelligent transportation systems, the AZTech MMDI received approximately $7.5 million from the U.S. DOT and leveraged an additional $30 million from the public and private sectors. The breakdown of funding among U.S. DOT, the public sector project team, and private sector participants is shown in Figure 2.3.

Legend:
- FHWA
- State and Local
- Private Sector

$24,315,882
$7,520,000
$5,439,805
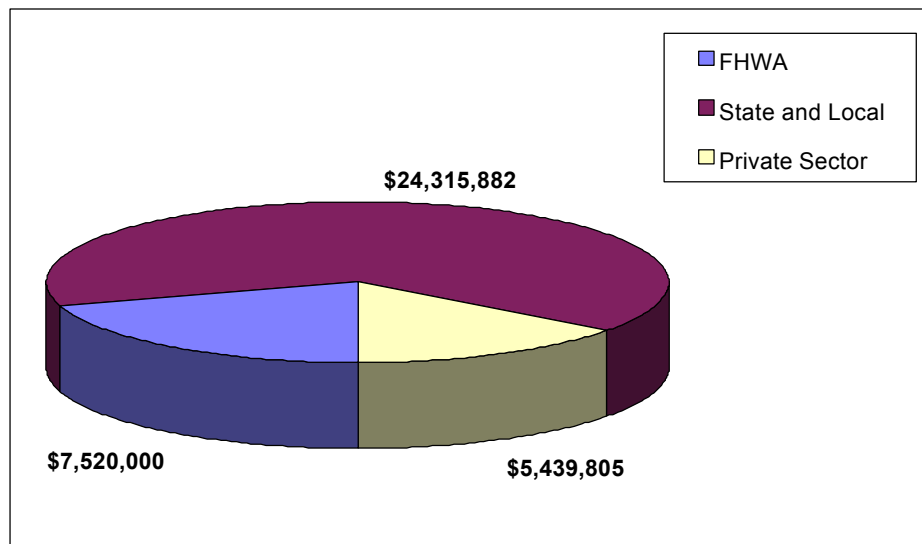
Figure 2.3: Share of AZTech Funding

The AZTech MMDI was designed to produce freeway and arterial street networks that are safer and more efficient for the traveling public, thereby decreasing travel times and enhancing mobility. A privatized traveler information system was developed to provide multimodal traveler information on a variety of services, including cable TV, in-vehicle navigation devices, personal communication devices, personalized messaging (e-mail), Internet Web pages, and information kiosks. Based on the successes of AZTech to date, the local project team, led by the Arizona Department of Transportation (ADOT) and the Maricopa County DOT (MCDOT), has already funded and embarked on an extension dubbed AZTech 2.

2.3.1 AZTech's Development of a Public-Private Partnership

Through a wide partnership between the public and private sectors, the regional ITS system will serve a majority of the state's population, which is concentrated in the greater Phoenix area. Management of traveler information and client development is administered through a cooperative, multi-agency and private sector effort. Table 2.2 details the role of the AZTech public sector partners and Table 2.3 describes the private sector partners.

Table 2.2: Description of Public AZTech Partners[11]

Public Partner	AZTech Role
ADOT	AZTech project administration. Integrated ADOT Trailmaster Freeway Management System (FMS) with AZTech server. Housed AZTech and RCRS servers. Implemented enhancement of Trailmaster Web site for real-time traffic information service.
Arizona State University	Provided traffic research and evaluation support to AZTech.
City of Chandler	Implemented Smart Corridors for traffic detection, surveillance, and signal coordination. Integrated Chandler traffic signal system with AZTech server.
City of Glendale	Implemented Smart Corridors for traffic detection, surveillance, and signal coordination. Integrated Glendale traffic signal system with AZTech server.
City of Mesa	Implemented Smart Corridors for traffic detection, surveillance, Changeable Message Signs, and signal coordination. Integrated Mesa traffic control system with AZTech server. Involved public transit in MMDI.
City of Paradise Valley	Implemented Smart Corridors for traffic detection and signal coordination via City of Scottsdale traffic management system.
City of Phoenix	Implemented Smart Corridors for traffic detection, surveillance, and signal coordination. Integrated Phoenix ATMS with AZTech server. Involved public transit in MMDI through implementation of transit components of AZTech.
City of Peoria	Implemented Smart Corridors for traffic detection, surveillance, and signal coordination.
City of Scottsdale	Implemented Smart Corridors for traffic detection, surveillance, and signal coordination. Integrated Scottsdale traffic management system with AZTech server.
City of Tempe	Implemented Smart Corridors for traffic detection, surveillance, and signal coordination. Integrated Tempe traffic management system with AZTech server. Provided staffing support to AZTech project team.
Department of Public Safety (DPS)	Implemented a Total Station incident investigation system.
Federal Highway Administration (FHWA) – Arizona	Oversaw, coordinated, and provided administrative support for AZTech implementation.
FHWA – Washington, D.C.	Oversaw AZTech implementation.
MAG	MPO for Maricopa County, including greater Phoenix metropolitan area. Oversaw MMDI implementation through AZTech executive committee.
Maricopa County Department of Transportation (MCDOT)	AZTech project management. Integrated MCDOT Traffic Management Center with AZTech server. Provided staffing support to AZTech project team. Led contracting and procurement role.
Phoenix Fire Department	Provided data exchange through an AZTech workstation.
Pima Association of Governments (PAG)	MPO for Pima County, including greater Tucson metropolitan area. Worked with the AZTech executive committee in an advisory capacity.
Regional Public Transportation Authority (RTA)	Oversaw transit implementation through AZTech executive committee.
Town of Gilbert	Member of Executive Committee

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[11] Organizations are listed alphabetically, not by importance, level of investment, etc.

Table 2.3: Description of Private AZTech Partners[12]

Private Partner	AZTech Role
Advanced Digital Systems	Provided AVL, mobile data terminal (MDT), bus status information, and transit fleet management systems.
BRW, Inc.	Coordinated national MMDI evaluation activities in Phoenix.
Computran Systems Corp.	Developed RCRS.
Ecotek/Touchvision	Developed AZTech information kiosks.
Etak	Prime contractor for AZTech ATIS. Implemented AZTech ATIS server, Etak TrafficCheck Web site, personalized e-mail service, and communication interface with other information service providers.
Fastline	Developed software and provided traveler information services for Windows-CE based handheld computers.
Katherine Christensen and Associates	Provided public relations services to AZTech project.
Kimley-Horn and Associates	Developed ADOT Trailmaster FMS. Integrated FMS with AZTech server.
KJZZ/KBAQ FM radio station	Provided FM subcarrier broadcast for dissemination of traveler information. No information receiving devices were developed in the first phase of AZTech development.
Metro Network	Partnered with Etak to operate the ATIS server and to provide additional real-time traffic information for distribution on ATIS services.
Scientific-Atlanta, Inc.	Original subcontractor of in-vehicle navigation system in rental cars. Project cancelled in 1997.
TRW Transportation Systems	Prime contractor for AZTech system development and integration. Developed central AZTech server and AZTech workstation for participating jurisdictions/agencies. Provided integration for various AZTech components.
US West	Implemented integrated digital video and data communication network between AZTech server (at ADOT TOC) and jurisdictional TOCs.

2.3.2   Components of AZTech

The major components of AZTech are briefly described below, and Figure 2.4 shows the overall AZTech system design.

AZTech Server - a computer server that integrates the existing ADOT Trailmaster FMS, the Smart Corridor arterial network, and the transit AVL system. The AZTech server fuses information from various sources and produces multimodal traveler information for dissemination through privatized traveler information services.

Smart Corridors - a large-scale arterial street signal coordination and traffic detection system for providing traffic information on the arterial network. For signal coordination, seven jurisdictional TOCs are being networked through a joint partnership between AZTech and US West, the communication service provider. On two Smart Corridors, changeable message signs were used for diverting traffic between freeways and Smart Corridors. Traffic data are being shared by all jurisdictions. CCTV was deployed on arterials and linked to the AZTech server.

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[12] Organizations are listed alphabetically, not by importance or level of investment.

Figure 2.4: AZTech MMDI System Architecture

Advanced Transportation Management System

Transit Management System

Computer-aided incident investigation using "Total Station" to reduce incident clearance time

Computer-Aided Incident Investigation

- Network 7 traffic operation centers
- Instrument 8 arterial corridors with detectors, close circuit TVs, and changeable message signs
- Coordinate traffic signal timing across jurisdictions

Smart Corridors (Arterial)

Instrument buses with GPS-based Automatic Vehicle Location (AVL) system and Mobile Data Terminal (MDT) for transit management and provide bus status information at transit terminals

Transit AVL

Arizona DOT's Trailmaster Freeway Management System is being integrated with AZTech server to provide freeway traffic information

Existing Freeway Management System

Freeway Data
RCRS Data
Arterial Data
CCTV Video
Bus Status

- Manual input of arterial street closure information on RCRS terminal
- Data sharing with other jurisdictions

Roadway Closure & Restriction System (RCRS)

ADOT's existing Trailmaster web site is enhanced by AZTech to include RCRS and other information

ADOT Trailmaster Web Site

AZTech Server

Highway, Arterial, Bus Status Data

Bus Status

Advanced Traveler Information System

Supplemental Traffic Information from Helicopter, Rovers, etc.

Metro Traffic Operator fuses AZTech data with supplemental traffic information

ATIS Server

Transit Status Information

Traffic Check Cable TV

A computerized system produces real-time traffic report on City of Tempe's cable TV channel

Personal Communication Device (PCD)

A software for use on handheld computer to access real-time traveler information via internet

Personalized Messaging (E-mail)

Provide personalized traffic alert message (incidents) via e-mail

Traffic Check Commercial Web Site

A commercial web site operated by ETAK to provide real-time traveler information

Information Kiosks

Deployed at selected business and public locations to provide real-time traveler information

Bus Status on CMS

Bus Status on Kiosk

Provide bus status information on kiosk & Changeable Message Signs at Phoenix transit terminal

Cox Cable TV subscribers in City of Tempe

Windows CE users with internet access

State and Maricopa County employees

Internet users

General public

Transit patrons at Phoenix downtown transit terminal

Transit GPS-Based Automatic Vehicle Location (AVL) System - for providing real-time bus status information to users, and improvement of transit management. A minimum of 94 buses on several fixed routes in Phoenix and Mesa will be equipped with AVL to provide real-time bus location information. A schedule adherence algorithm on the AZTech server generates the bus status information.

Incident Management - "Total Station" computerized accident investigation system to reduce incident clearance time. The AZTech "Total Station" system is a highly mobile, integrated field survey and computer device that allows accident investigation units to complete a comprehensive accident report in a significantly reduced time.

Privatized Multimodal Advanced Traveler Information System (ATIS) - private sector participant Etak is providing an ATIS server with interfaces to the AZTech server and various information service providers. Metro Traffic Networks, a commercial traffic information service firm, is providing supplemental information to the government data for dissemination (via ATIS server) on various devices, including cable TV, in-vehicle navigation devices, hand-held computers, personalized messaging (e-mail), Internet, and information kiosks.

2.4 OVERVIEW OF COST INFORMATION USED IN THE REPORT

To prepare the reader for the evaluation results in Chapters 4, 5, and 6, an explanation about cost calculations is needed. Cost information provides a basis for a comparing one AZTech project with another. It also facilitates project-specific cost evaluations, such as analyzing the components of start-up cost or comparing start-up to operation and maintenance costs.

This section explains how the cost analyses were performed and the assumptions that were made by the evaluation team. Cost information was obtained from a combination of sources provided by the project team: invoices, spreadsheet budgets, and/or project team estimates. As described below, the evaluation team needed to create various cost sharing formulae for allocating the costs of resources central to the AZTech integration effort. The diverse sources of cost information were not always easy to reconcile with each other in performing this task.

Each project cost description includes:

- Expenses unique to the project
- Costs shared with other projects.

Allocating shared costs is necessary in a complex deployment effort like AZTech where multiple projects are integrated with each other using the same traffic detection and information processing infrastructure. For example, the AZTech Server mentioned in Section 2.3.2 supports many of the AZTech projects in one way or another. Therefore, its costs are allocated among the integrated systems.

Shared costs include two categories: onetime start-up costs and annual amortized operation and maintenance (O&M) costs. Both categories may include capital, contractor services, and labor depending on the particular project. Note that the evaluation team developed the allocation formulae for shared costs with input from the AZTech project team. To apportion the shared costs fairly among projects, the evaluation team made certain assumptions about the cost data since it could not obtain all necessary technical details needed to make a project-by-project allocation. These assumptions will be explained below. In many cases, the solution was to apportion costs equally across projects related through shared infrastructure.

Although the shared costs include multiple expenses, the cost tables for each individual project group them into single line items, which are labeled consistently throughout the report. The breakdown of these costs and the naming convention is explained below. The shared cost categories include:

- Smart Corridor Shared Costs
- AZTech Server Shared Costs
- Advanced Traveler Information System Server Shared Costs
- Transit Operations & Maintenance Shared Costs.

The development of O&M cost estimates for the MMDI sites proved to be a challenge. In many cases, the local jurisdictions simply had not yet begun to develop an O&M plan or cost estimates for the post-deployment phase of their MMDI projects. In some cases, through interviews with the MMDI participants, O&M plans and associated hours/costs could be developed. However, in many other cases the local knowledge base and available data simply were not sufficient to allow for an O&M cost estimate to be made. In these cases, the cost analysis relied on the use of "standard O&M factors" to provide a ballpark O&M cost estimate. These factors estimate annual O&M costs based on a percentage of relevant deployment costs. As an example, changeable message sign annual O&M costs are estimated to be 10% of the cost of the changeable message sign hardware.

The standard O&M factors utilized in the MMDI cost analysis were derived from a variety of sources including the ITS National Architecture Costing Report[13] and the Seattle Wide-area Information for Travelers (SWIFT) Deployment Cost Study.[14] Additionally, where ITS-specific guidance for factors was not available, factors utilized in Department of Defense cost studies for technology development were utilized as appropriate.

2.4.1 Smart Corridor Shared Costs

The first shared cost category is called "Smart Corridor shared" (and this label will be used in the remainder of this document). The three Smart Corridors evaluated in this document - Southern Baseline, Scottsdale/Rural Road and Bell Road – each share 12.5% of total AZTech Traffic Operations Center operating costs. This percentage was established based on the fact that costs for the 10 regional traffic agencies, which will have AZTech workstations, are divided among all eight of the planned Smart Corridor projects. In other words, when all of the Smart Corridors have been deployed, each will share 1/8 of the total region-wide operating costs for the 10 AZTech workstation locations. Implicit in this cost sharing approach is the assumption that all 10 of the locations and all eight of the Smart Corridors should be weighted equally in terms their value to the overall AZTech effort. AZTech Smart Corridor cost components, both start-up and operating, and their actual dollar values are shown in Table 2.3.

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[13] *National ITS Architecture Documents: Cost Analysis*. Lockheed Martin Federal Systems & Odetics ITS Division. Available on the U.S. DOT's ITS Joint Program Office's Electronic Document Library, Document No. 5398, http://www.its.fhwa.dot.gov/scripts/cyber2/LibInit.exe?PCDOCSLibrary=EDL. January, 1997.

[14] *Seattle Wide Area Information For Travelers: Deployment Cost Study*. M. Jensen, SAIC. Available on the U.S. DOT's ITS Joint Program Office's Electronic Document Library, Document No. 7403, http://www.its.fhwa.dot.gov/scripts/cyber2/LibInit.exe?PCDOCSLibrary=EDL. October, 1998.

Table 2.4: Smart Corridor Shared Costs

Start-up	Total Shared Costs	Annual O&M	Total Shared Costs
Traffic Operations Center Development, Acquisition, and Installation	$676,220	Traffic Operations Center Communications Expenses	$125,494

2.4.2 AZTech Server Shared Costs

The second category is "AZTech server shared" (a label which will be used in the remainder of this document). The AZTech server costs are shared among projects because the server is the core component that integrates AZTech's transportation information system.

The AZTech server is so central to ITS in the Phoenix region that, as noted below, some projects that were not funded through the MMDI shared its costs. Most of the individual project costs will include a 4.2% share for deployment and operation of the AZTech server. The AZTech server costs are divided equally among the 24 elements/agencies to which it sends information. These include 12 MMDI projects, 10 planned AZTech workstation locations (which are not part of AZTech MMDI but will benefit from the AZTech server), and two fire dispatch centers (also not part of AZTech).

Implicit in this sharing methodology is the assumption that the 24 elements and agencies for which the AZTech server processes and sends information should be weighted equally in terms of value to the system. The only exceptions are the Roadway Construction and Restriction System, Computer-aided Incident Investigation, the Paratransit AVL, and the Supervisory AVL, which are projects not integrated with the AZTech server. AZTech server cost components and dollar totals for all projects combined are shown in Table 2.4.

Table 2.5: AZTech Server Shared Costs

Start-up	Total Shared Costs	Annual O&M	Total Shared Costs
AzTech Server Hardware & Installation		AZTech Server Recurring Costs	$209,551
AZTech Server	$35,154		
AZTech Network Management Server	$26,434		
AZTech Workstation	$6,786		
WAN/CODEC	$364,856		
Video Switch Expansion	$20,257		
AZTech Server Planning and Development Labor Costs (TRW System Engineer Contract)	$1,166,659		
Operator Training	$72,281		
Total	$1,692,427		

2.4.3   Advanced Traveler Information Systems Server Shared Costs

The third category is called "advanced traveler information systems server shared" costs (again, a label which will be used in the remainder of this document). Four projects - *Traffic Check* Tempe Cable TV, Fastline Personal Communication Device (PCD), Personalized Messaging System, and the Etak Commercialized Web Page – are each allocated 16.7% of these costs because they are among six advanced traveler information systems (ATIS) products and services being provided under AZTech.[15]   Among the costs itemized in Table 2.5 below, this category accounts for traveler information provided by Metro Networks through Etak/Metro Networks' own traffic information sources and its traffic workstation. This traffic information is keyed in by Metro Network's staff based on traffic data it collects in the Phoenix area.[16]   As in the other shared cost categories, the evaluation team assumed that all six of these ATIS projects and services being deployed should be weighted equally in terms of value to the overall AZTech system. ATIS server shared cost components and actual dollar totals are shown in Table 2.5.

Table 2.6: Advanced Traveler Information Systems Server Shared Costs

Start-up	Total Shared Costs	O&M	Total Shared Costs
Etak Advanced Traveler Information Systems Server/AZTech Feed Implementation		*Etak/Metro Networks Advanced Traveler Information Systems System Recurring Costs*	
Advanced Traveler Information Systems Server and Communications Hardware	$7,848	Recurring Value of Metro Networks Content	$196,809
Etak Development	506,800	Etak Ongoing Operations Labor (3 FTE's)	369,017
Etak Management	37,400	Hardware Maintenance @ 10% of Equipment Cost	322
Total	$552,048		$566,148

2.4.4   Transit Operations & Maintenance Shared Costs

The final category of shared costs is called "transit operations shared" (a label which will be used in the remainder of this document).   Only a single operation and maintenance cost (a full-time information technology specialist) is shared among the three transit projects: Transit Vehicle Dispatch with Automatic Vehicle Location and Mobile Data Terminal; Paratransit Vehicle Dispatch with Automatic Vehicle Location and Mobile Data Terminal; and the Service Vehicle with Automatic Vehicle Location. The shared costs are shown in Table 2.6, and the allocations are 50% for Transit Vehicle, 35% for Paratransit Vehicle Dispatch, and 15% for Service Vehicle Dispatch. This split is based on a rough approximation of total vehicles included in each project. It also takes into account that two different agencies are deploying the Transit Vehicle Dispatch using somewhat different technologies.

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[15] Based on information obtained from Etak, the other Advanced Traveler Information Systems projects are TouchVision kiosks, traffic e-mail (separate from the Personalized Messaging System e-mail), and Traffic Touch.

[16] This is information is collected by Etak, from non-AZTech sources throughout the Phoenix region.

Table 2.7: Transit AVL Systems Shared Costs

Start-up	Total Shared Costs	Annual O&M	Total Shared Costs
N/A	N/A	AVL System Maintenance (full-time IT Specialist)	$102,056

2.4.5   Calculation of Operation and Maintenance Costs

To calculate annual, amortized operation and maintenance costs, both for shared infrastructure and individual projects, several parameters were used when estimating equipment replacement. A five-year net present value was calculated in constant 1998 dollars using a 7% discount rate for amortization purposes. Although equipment life spans were considered, they were not used directly in calculating the net present values.

2.5   AZTECH SITE REPORT ORGANIZATION

The remainder of the AZTech site report is designed to provide the reader with a detailed summary of each MMDI project and the national evaluation efforts that were undertaken to assess its benefits. It is organized as follows:

Institutional Lessons Learned: Chapter 3 provides a synopsis of how the project team addressed institutional issues, and it provides useful background on some of the institutional factors in AZTech program development, management, and implementation.

Individual Projects: In Chapters 4, 5, and 6 the evaluation results for each individual AZTech MMDI project are presented. Projects are organized into three major ITS component clusters: Advanced Traveler Information Systems in Chapter 4; Advanced Traffic Management Systems in Chapter 5; and Transit Management Systems in Chapter 6. For each project, a description and evaluation history are presented along with the results of the evaluation.

Conclusions and Recommendations: The report concludes by summarizing the results of the AZTech deployment and the benefits identified in the evaluation.

3. Institutional Lessons Learned

The Institutional Benefits Study of the national evaluation of the Metropolitan Model Deployment Initiative (MMDI) was designed to answer four questions:

- What institutional and other non-technical impediments did the public sector MMDI participants encounter?
- What institutional changes were made to address these impediments?
- What benefits did the public sector MMDI participants achieve from making these changes?
- What costs were involved?

While seeking to answer these questions, the study team identified specific actions taken at the four MMDI sites (Phoenix, San Antonio, Seattle, and NY/CT/NJ) that facilitated the deployment of ITS products and services.[1]

- Program Development
  - Build on existing relationships
  - Reach non-traditional participants
  - Reach the general public
  - Reach elected and appointed officials
  - Promote staff involvement
  - Encourage private sector participation
- Program Management and Staffing
  - Define intra-agency management and staffing requirements
  - Address intra-agency training needs
  - Develop the management structure for the MMDI
  - Assign agency roles and responsibilities
- Program Implementation
  - Assign intellectual property rights
  - Select the appropriate procurement mechanisms
  - Ease the transition from development to operations
  - Develop policies that govern operations
  - Plan for the future.

The findings illustrate that the successful actions taken at a particular MMDI site were, in many cases, taken at the other sites as well. The fact that a common set of actions emerged among MMDI programs suggests that these steps are highly facilitative, if not requisite, to successfully implementing an ITS program.

Although the study identified a common set of actions at all four MMDI sites, it also revealed that the manner in which the MMDI program participants employed them differed. Furthermore, within an MMDI program, the project participants placed different levels of emphasis on the various actions determined by the appropriateness of the action to the site. Also, the execution of some actions may have started before the MMDI program and were enhanced by it. These three circumstances resulted in some actions being more noticeable than others. In the Phoenix MMDI, eight actions, which are applicable to other sites deploying ITS projects, were exemplary in facilitating the AZTech MMDI:

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[1] See the following report for additional information on institutional strategies based on an assessment of the MMDI deployments: A. DeBlasio, Jackson, D., Tallon, A., Powers, G., and O'Donnell, J.P. 1999. *Successful Approaches to Deploying a Metropolitan Intelligent Transportation System.* (Final Report, FHWA-JPO-99-032) Prepared for the Federal Highway Administration. John A. Volpe Transportation Center: Cambridge, MA. (March) [This report is available through the ITS Electronic Document Library at: http://www.its.fhwa.dot.gov/, and is also available on a CD-ROM]

- Build on existing relationships
- Reach the general public
- Reach elected and appointed officials
- Define intra-agency management and staffing requirements
- Develop the management structure for the MMDI
- Assign intellectual property rights
- Select the appropriate procurement mechanisms
- Develop policies that govern operations.

3.1   BUILDING ON EXISTING RELATIONSHIPS

Within the Phoenix Metropolitan Area, there has been a great deal of transportation and ITS-related interaction among officials at the transportation agencies. Representatives from the state, county, and municipalities all cited the interaction required to coordinate traffic signal control systems as instrumental in teaching the transportation agencies how to build up interagency and cross-border cooperation.

In 1993, the Metropolitan Area Governments Information Center (MAGIC) study was initiated in the Phoenix area and was the first effort to bring transportation agencies within the metropolitan area together. The MAGIC coalition investigated regional traffic signal control and helped to build up inter-agency and cross-border cooperation. MAGIC membership included the Arizona Department of Transportation (ADOT), the Maricopa County Department of Transportation (MCDOT), the Regional Public Transportation Authority, the Maricopa Association of Governments, and the cities of Phoenix, Chandler, Glendale, Gilbert, Mesa, Paradise Valley, Peoria, Scottsdale, and Tempe.

In 1995, the Phoenix Metropolitan Area received funding for an intelligent transportation systems (ITS) early deployment planning (EDP) study. The EDP process gave the participants a forum for discussing ITS issues and allowed additional coalitions to be built among the members. The EDP study expanded the level of ITS activities and led to a more regional focus.

For over ten years, ADOT has been working on its Trailmaster Freeway Management System and traffic operations center. Deployment of many of the freeway management components has required coordinated efforts between the ADOT and other jurisdictions. Also, while serving as the ADOT District Engineer, the AZTech Chief Administrator developed close working relationships when implementing ADOT construction programs. ADOT staff also benefited from their existing relationship with the staff of the state's attorney general office. The legal staff gained knowledge during previous ITS activities and applied this knowledge to issues related to the MMDI.

Participants in the AZTech MMDI have taken advantage of the MAGIC and EDP studies and of the shared vision that was created. The previously established coordination aided ability of the public sector participants to think regionally in setting priorities for the MMDI project. During the MMDI proposal development, participants determined what technologies and project components needed to be included within the project by accentuating regional, rather than parochial, goals.

Building on existing institutional relationships serves as a starting point from which to develop an ITS program. Because agency representatives in the Phoenix area were already comfortable working with one another, the time to develop a trusting relationship and to overcome other institutional impediments was reduced. Also, parties involved in these existing relationships have an institutional memory that will expedite the progress of a project.

3.2   REACHING THE GENERAL PUBLIC

The AZTech participants created the Public Outreach Committee to develop and implement an effective outreach plan. This committee comprised public information specialists from several organizations in the MMDI and oversaw the internal and external communications for the project.

The committee members used several methods to inform the general public. They kept the media apprised of AZTech activities, which resulted in 30 articles in local print publications and coverage on as many as 50 local and statewide television news broadcasts. Public service announcements were made at college and professional sporting events, information was provided at local libraries, and promotional and educational materials were distributed using a multitude of local businesses, including local utility companies and a supermarket chain. Committee members also established a home page on the World Wide Web and conducted tours of the Trailmaster traffic operations center.

The benefits of this campaign increased the visibility and understanding of ITS and its benefits and assuaged the public's privacy concerns. It helped build public support while not generating expectations that were too great.

3.3   REACHING ELECTED AND APPOINTED OFFICIALS

ADOT and MCDOT officials knew that the Arizona elected officials' support was critical to the success of ITS and therefore, promoted ITS accomplishments in a positive light and worked closely with the media to provide information deemed important to the state and the public. Political and administrative acceptance of ITS products and services has grown gradually throughout the 1990s. Support for each individual ITS effort built on support achieved for a previous ITS effort. Indicative of management support was the creation of the Statewide Transportation Technology Group and the appointment of an ITS Coordinator within the ADOT to direct the ITS deployment and operations throughout the state. The high level of the ITS and AZTech positions within ADOT provides extensive exposure of the MMDI project to other ADOT management and simplifies coordination efforts between ADOT divisions and districts. Statewide, education of management continues to be a key role of the ITS Coordinator. Through briefings and day to day contacts, he kept people informed.

AZTech officials worked closely with city and town administrators to further the MMDI. They stated that one way to reach local elected officials is through the Maricopa Association of Governments, the metropolitan planning organization (MPO) for the Phoenix Metropolitan Area. Through their participation on various MPO committees, elected officials can gain an understanding of ITS and how these systems can be used at the local and regional level. Through her participation on the MPO Policy Board, the mayor of Glendale, Arizona, became aware of ITS and the AZTech MMDI project and was comfortable with her city staff participating in the MMDI project.

To ensure that ITS would not get "lost in the shuffle," the MPO Regional Council decided to institute a separate ITS committee, which includes elected and appointed officials, rather than to add an ITS role to an existing MPO committee. The ITS Committee includes officials from cities that are and are not a part of the MMDI and provides a good opportunity to keep these officials aware of both the MMDI and other ITS activities occurring in the Phoenix area. MPO officials hope that by keeping the officials from jurisdictions not currently involved in the MMDI informed, these administrators will feel comfortable joining at a later stage.

3.4   DEFINING INTRA-AGENCY MANAGEMENT AND STAFFING REQUIREMENTS

To control the ever increasing ITS project workload, ADOT management created the position of statewide ITS Coordinator. The ITS Coordinator, along with the Transportation Technology Group, coordinates the ITS work throughout the state. ADOT management also created the AZTech Chief Administrator position as a result of the MMDI work demand. The former Phoenix ADOT District Engineer filled this position. The reorganization also included ADOT funding four AZTech staff positions, including the coordinators for public outreach, incident management, and advanced traveler information systems, and the transfer of one clerical position. Once the MMDI project is implemented, five to eight more ADOT staff may be needed. These positions will include additional operators, a full-time incident management person, some administrative positions, telecommunication specialists, and a couple of system programmers.

The MCDOT also altered its organizational structure as a result of its involvement in ITS activities. A countywide ITS Coordinator position was created in June 1995, long before the Phoenix Metropolitan Area was selected as a MMDI site. This was the first position within the county to have responsibilities dedicated solely to work on ITS projects, plans, and issues.

In addition, the county's Traffic Engineering Division was divided into an Operations Branch and a Traffic Engineering Branch, which housed the ITS unit. As a result of the MMDI, MCDOT management split its ITS unit to create a section that conducts countywide ITS activities and a section that works directly with the AZTech MMDI. The former ITS Coordinator became the AZTech Program Manager and a new county ITS Coordinator, the Traffic Engineering Branch Manager, was selected. MCDOT staff also fill the transit, communication, and traffic signal coordinators positions for the AZTech MMDI. A MCDOT official added that the greatest benefit from the internal organizational change is that ITS is more visible within the region. The new positions have given rise to an increased awareness and consideration of ITS, not limited to just those components related to the MMDI.

As the projects move from planning to deployment to operations, city and transit agencies are aware that additional staff time dedicated to ITS will be required of their agencies. However, a few positions were added to the local agencies as a direct result of the MMDI. The City of Scottsdale hired an electrical engineer to perform traffic signal systems analysis. The Maricopa Association of Governments added a staff position to accommodate all of its ITS responsibilities, including coordination of the MPO's ITS Committee with the municipalities. In addition, the Arizona Department of Public Safety assigned one officer to the ADOT's Traffic Operations Center prior to the MMDI project. These positions were not funded by the MMDI but rather resulted from staff reassignments or the use of local funds to fill a new or preexisting position opening.

3.5   DEVELOPING THE MANAGEMENT STRUCTURE FOR THE MMDI

The AZTech Executive Committee has the overall responsibility of managing the MMDI project. This committee comprises senior members from partnering jurisdictions and is jointly chaired by the ADOT State Engineer and the Maricopa County Engineer and Director of Transportation. The Technical Oversight Committee oversees the project's technical operations. This committee consists of technical staff from the public sector agencies and private sector participants.

The AZTech project management team is a distinct entity that draws from the staffs of various organizations and balances the number of AZTech positions between the two lead agencies. Leadership responsibilities are divided between a Chief Administrator and a Program Manager. The former Phoenix ADOT District Engineer assumed the responsibility as the AZTech Chief

Administrator. A MCDOT traffic engineer and former ITS Coordinator filled the AZTech Program Manager position.

Each lead agency also provided three task coordinators. They are responsible for the six areas of the project: traffic signal coordination, communication, transit coordination, outreach, corridor, and advanced traveler information systems implementation. Other significant AZTech positions comprise the Incident Management Coordinator, contracting officer, transit implementation task leader, and evaluation coordinator. The administrators and coordinators oversee ten working groups: public relations, emergency management, interagency coordination, evaluation, contracts, system integration, smart corridors and signals, traveler information, and transit.

Project management also looked outside the lead agencies to fill positions. The Smart Corridor implementation task leader was from the City of Tempe Public Works Department. A 24-year veteran with the Phoenix Fire Department was selected as the Incident Management Coordinator. Management also tapped the Arizona State University for the AZTech evaluation coordinator and the City of Phoenix Public Transit Department for the transit task lead.

3.6 ASSIGNING INTELLECTUAL PROPERTY RIGHTS

The assignment of intellectual property rights (IPR) is an issue that arises in many technology or software development projects. During contract negotiations between public sector and private sector participants in the AZTech MMDI, the parties realized that their concerns over the allocation of intellectual property rights differed significantly. There were four areas of concern: (1) preexisting products brought to the MMDI by private sector participants, (2) products developed through the course of the MMDI using private funds, (3) existing products enhanced during the MMDI using public funds, and (4) products developed during the MMDI with public funds.

As a starting point to resolving IPR concerns, AZTech administrators requested a clarification of the Federal Highway Administration's (FHWA) policy on proprietary information. A letter from the FHWA's Associate Chief Counsel stated that the FHWA's use, if any, of the copyrightable or patentable products developed by the private sector for the MMDI is limited to non-commercial purposes. The FHWA does not retain the copyright to these works. The letter further stated that contractors will receive title to any inventions created during the course of the MMDI with federal funds in exchange for providing the Federal Government with royalty-free use.

The public sector participants obligated themselves to conform to the FHWA letter and included it in all contracts between the public and private sectors. Project participants noted that the use of this letter significantly improved the contract negotiation process and helped to resolve the concerns of the contracting parties. The first AZTech contract was signed within two weeks after receipt of the FHWA letter. Earlier receipt of the FHWA letter could have probably cut some significant time from the four-month negotiation period.

To address the principal areas of concern, the AZTech public officials developed two licensing agreements: one for preexisting products and privately-funded developments and one for products developed during the course of the MMDI using federal funds. The license for pre-existing products allows the public sector participants to make limited use of pre-existing products. The private sector partner grants a "non-transferable, non-exclusive five-year license to use the software, data and/or documentation...solely for use on the AZTech Model Deployment." The private sector partner retains all ownership rights, including copyrights, to pre-existing products and privately funded developments.

The second license pertains to government-funded developments on the AZTech Model Deployment. In this license, the public sector participants receive a "royalty-free, non-exclusive and irrevocable

license to reproduce, publish or otherwise use, and to authorize others to use, the government funded software, data and/or documentation ...solely for official governmental purposes." The private sector partner similarly retains all ownership rights, including copyrights.

3.7   SELECTING THE APPROPRIATE PROCUREMENT MECHANISMS

The participants in the AZTech MMDI took steps to ensure the most appropriate procurement methods were used. These steps included choosing the appropriate lead procurement agency, selecting appropriate procurement instruments, and designing flexibility within contracts.

3.7.1   Choosing the Appropriate Lead Agency

The AZTech MMDI provides an example that demonstrates there are other partner agencies, besides state departments of transportation, which can effectively manage procurements because the MCDOT was designated to lead the procurement process. Because of MCDOT's more flexible procurement process and ability to work with the local participants, it was determined that it was more efficient to use the MCDOT for the official procurement agency rather than the ADOT. MCDOT personnel were responsible for developing the requests for proposal, the formal bid and proposal submittal process, and contract negotiations. The County provided one procurement officer, as well as the AZTech Program Manager, to coordinate this work. AZTech representatives noted a benefit from using one primary procurement agency is that it is the most efficient method to ensure that all products are compatible, there is no duplication of effort, and costs are minimized because of quantity discounts.

The ADOT, the transit agencies, and the participating municipalities are also responsible for procuring selected technologies. These other agencies have the flexible option to use the MCDOT as the procuring agency for their selected technologies or procure the products and services themselves through existing or new contracts and be reimbursed by the AZTech project.

3.7.2   Selecting Appropriate Procurement Instruments

Because time was such a factor in the MMDI projects, parties involved in the MMDI wanted to make the best use of available resources and contracts that they either had in-place or were quickest to initiate. In addition to the use of the traditional competitive bid process, the AZTech MMDI participants used three innovative contracting mechanisms: sole-source contracting, on-call contracting, and joint, inter-jurisdictional procurements.

Previous to the MMDI, Phoenix Transit staff had obtained an AVL vendor for their paratransit operations. This agency sought to secure this vendor for the MMDI's AVL component through a sole-source agreement based on the same prices in the current paratransit contract. Another timesaving process cited by ADOT staff is their use of ADOT's and MCDOT's pre-qualified and approved on-call consultants. Generally, the cities made use of existing contracts (including state, city, and county contracts) for their hardware and software acquisitions.

Officials from the TransGuide (the San Antonio, Texas, MMDI) and AZTech worked together on a joint, inter-jurisdictional process for design and procurement. Both AZTech and TransGuide officials procured an open-standard, high-speed sub-carrier transmission and reception infrastructure from a common partner. ADOT staff worked with the Texas DOT staff to develop a common protocol for the in-vehicle navigation units. The AZTech contract with the private sector partner includes language that the AZTech devices and protocols must be the same as that developed for the TransGuide Traffic

Operations Center. Through this action, the AZTech public sector participants were able to leverage work already performed by the vendor for the TransGuide MMDI and reduce development costs of the FM sub-carrier interface control document for the communication system. The cooperative design efforts between the Phoenix and San Antonio MMDI projects provide an example that can be duplicated by many other metropolitan areas, especially those within a single state.

3.7.3 Designing Flexibility within Contracts

Resolution as to the form of payment and the payment schedule presented major challenges for the MMDI participants. The AZTech project contract terms of fixed-price payments for each segment of work allows compromise between the private sector's desire for rate structure payments with flexible contract terms and the public sector's need for fixed-price contracts with detailed scopes of work.

Another contracting issue involved accounting for the equipment purchased by the private sector through the MMDI contracts. The participants had to determine what part of the private sector procurements could be counted toward the private sector match. Through extensive negotiations, AZTech parties eventually resolved the issue of the value of the goods and services provided by the private sector participants and contractors.

3.8 DEVELOPING POLICIES THAT GOVERN OPERATIONS

Policies regarding how advanced equipment and how the data they generate are used are critical components in ensuring that all parties operate under the same manner for regional consistency and effectiveness. In particular, the participants in the AZTech MMDI developed policies in four areas that can be duplicated by others deploying ITS products and services:

* Operation of closed circuit television cameras
* Ownership and maintenance of equipment
* Placement of kiosks
* Use, distribution, and retention of data.

The use of AZTech cameras aimed on accidents is a great concern of the ADOT and MCDOT representatives. Therefore, limitations were placed on the use of closed circuit television cameras. This policy requires the camera operator at the ADOT traffic operations center to "pull back" from an accident scene to avoid displaying "gruesome" details, but still provide enough information to pass along to emergency aid providers and the transportation staff.

The AZTech officials have tried to counteract the concerns involving camera-based traffic monitoring systems. First, ADOT officials made a linguistic change to address privacy concerns related to the use of the cameras, replacing the intrusive-sounding "video surveillance" with "video monitoring." Second, ADOT administrators agreed that the cameras should not play a law enforcement role, even if there is an officer stationed in the Traffic Operations Center. Third, the AZTech managers enacted an informal policy of not retaining any tapes from the camera feeds to avoid them being used in any lawsuits. Finally, the AZTech participants provide open access to the camera feeds via local television and the Web site. The decision by ADOT management to make all cameras feeds used for monitoring available to the public has produced positive results. The major benefit was alleviating or reducing privacy issues. This, in turn, has resulted in an increased amount of public support for the technologies.

The AZTech participants used inter-governmental agreements between the ADOT and each city to address the issue of who is responsible for the operation and maintenance of the equipment used for the MMDI. These agreements cover the transfer of funds; staffing, local funding, and operation and maintenance of AZTech equipment commitments; and the municipal rental of the communication structure. The agreements require the municipalities to operate and maintain the equipment through the official duration of the AZTech project. The County will pay to operate the communications link for three years. Thereafter, through at least 2002, each municipality must take over this responsibility either by renting from the telecommunications provider or by linking into the ADOT network.

Partners at the AZTech MMDI site developed a policy on the placement of kiosks. A participating municipality can receive one kiosk purchased with MMDI funds. The municipality will have to pay half of the approximately $12,000 cost per unit for each additional indoor kiosk requested, with the balance subsidized by the AZTech project. If a private sector entity would like one of the 50 kiosks available, AZTech officials will subsidize those units at 25 percent of the total cost. By requiring financial commitments, AZTech management can be assured that only those entities that truly want to take ownership of the information kiosks will be involved.

Public officials in Arizona believe that transportation information should be easily available and free to the public because the public's funds enabled it to be gathered, implying that it is essentially already in the public domain. Currently, in compliance with ADOT policy, AZTech releases transportation-related data to both the public and private sectors under the Freedom of Information Act. Private sector individuals and agencies that request information are sometimes charged if AZTech incurs a cost in providing the information. Television stations are given live video feed for no cost except for the cost of the communication link.

3.9   SUMMARY

The participants in the Phoenix MMDI demonstrated a number of actions that enabled the AZTech project to move forward to successful implementation. Although the participants faced several obstacles, none of them proved to be insurmountable barriers that would require the public sector to abandon their commitment to ITS deployments. Through the efforts of the MMDI participants, officials from other sites deploying ITS projects can learn from the actions undertaken in Phoenix. One innovative initiative was the resolution of intellectual property rights (IPR) concerns by developing licensing agreements that addressed the concerns of the private sector participants. A second was the effective use of the existing interagency relationships that led to a unique management structure that maximized the efficiencies of two lead agencies. A third positive action was the method that the AZTech management filled its staffing requirements, using experts both within the ADOT and MCDOT and going outside to fill other critical positions, including the positions of Incident Management Coordinator and the Smart Corridor Task Leader. These are only a few of the actions highlighted by the Phoenix participants as being instrumental in the success of the AZTech MMDI.

4. Advanced Traveler Information Systems

The national evaluation team evaluated all of the AZTech advanced traveler information systems projects. Each had a tailored evaluation approach based on a number of factors. These factors included evaluation priorities of the local project team; level of deployment achieved during the evaluation time frame; perspective of the national evaluation, especially contribution to the National Evaluation Strategy[1]; level of integration achieved; and local and national resources for conducting the evaluation.

The AZTech project team introduced a broad range of services making the Phoenix region one of the more extensive deployments of advanced traveler information systems in the country.[2] The project descriptions for this effort are organized roughly according to pre-trip, en route, and in-terminal advanced traveler information systems technologies. The projects include the following:

- Personalized Messaging System
- Trailmaster Web Site, including The Roadway Closure and Restriction System Web Page and Roadway Closure and Restriction System Infrastructure
- Commercial Web Page
- *Traffic Check* Cable TV Service
- In-Vehicle Navigation Devices
- Transit Status Information
- Travel Information Kiosks
- Fastline Personal Communication Devices.

While some projects were chosen for more extensive analysis, the level of integration with other parts of the local ITS infrastructure was assessed for all projects because integration is the key element of the MMDI (MMDI) program. All projects were also included in the evaluation of institutional issues presented in Section 3. Deployment and operating costs for all projects were assessed and can be found in Sections 4.1 – 4.8. A detailed cost-benefit analysis was undertaken for many of the projects; those results will be presented in a separate document.[3]

The project evaluations presented below should be considered in the context of the MMDI site characteristics described in Section 2, which are thought to have an impact on the use of advanced traveler information systems.

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[1] Metropolitan Model Deployment Initiative National Evaluation Strategy. Alexiadis, Carter, DeBlasio, Inman, Perez, St-Onge, and Van Aerde. Report No. FHWA-JPO-99-041, available on the USDOT's ITS Joint Program Office's Electronic Document Library, Document No. 6305, http://www.its.fhwa.dot.gov/scripts/cyber2/LibInit.exe?PCDOCSLibrary=EDL. November, 1998.

[2] In addition to the ATIS services discussed in this report, it should be noted that ADOT implemented a toll-free telephone service for obtaining traffic information prior to AZTech deployment. It was not funded as part of the MMDI and was not included in the evaluation.

[3] Cost-benefit analyses can be found in *Benefit-Cost Evaluation of ITS Projects* which should be available May, 2000, from the USDOT Intelligent Transportation Systems Joint Program Office.

4.1 PERSONALIZED MESSAGING SYSTEM

4.1.1 Project Description and Evaluation History

The AZTech project team planned a personalized paging, e-mail, and fax service for automatically providing real-time traffic information to travelers. The system was intended to allow subscribers to register personal travel profiles so that traffic information could be tailored specifically to their particular travel needs. Profile information was to include regular travel times and commuting routes. Subscribers would then receive a pager, e-mail, or fax notification at specified times of the day, coinciding with their commuting patterns.

Users would subscribe using a touch-tone telephone and specify the receiving device (pager, fax, or e-mail), time (range) and area (by major commute corridors) for which they wished to receive the real-time traffic information. Once specified, the system would automatically send a message to alert the subscriber of any incidents on the selected commuting routes that would affect travel during times specified by the user. A monthly or per-transaction fee would be charged to subscribers.

The traffic information provided by the personalized messaging service is supplied by the advanced traveler information systems server developed by Etak. The server formats the freeway speed and incident information provided by the freeway management system and Roadway Closure and Restriction System obtained through the AZTech server. Additional traffic information on freeway and arterial streets (from aerial surveillance, helicopter, and rover reports) is entered by Metro Network operators into the server and fused with AZTech server information. The advanced traveler information systems server would then provide the interfaces to the three planned distribution media and would "broadcast" the information according to subscriber preferences.

The actual deployment has been limited to providing free e-mail notification to approximately 500 employees of the Arizona Department of Transportation, the Maricopa County Department of Transportation, and the public sector partners' employees. The subscription mechanism has been via the Etak Web page (described in Section 4.3), as the touch tone telephone sign-up system was not implemented.

One potential limitation of this messaging service relates to the registration of user profiles. Users select their commuting routes from a list of pre-defined freeway sections in the form of a drop-down menu on the Web page. A typical commute requires a user to select multiple sections of freeways, which may have the disadvantage of including more information than needed for the actual route.

Etak's AZTech Phase I business plan included a pager program. The plan required that a national paging company contract with Etak to make traffic alerts available to its paging customers. While two or three national paging companies expressed interest in providing traffic information to their customers, none of the companies brought such a service to market anywhere in the U.S. during Phase I of the AZTech program. Company representatives cited different reasons for this, including insufficient transmission capability, difficulty formatting the information for the transmission, and insufficient demand among existing or potential pager customers. As part of AZTech Phase II, however, the Cue Communications paging company will provide traffic information to its customers, including AutoPC subscribers, using the Etak/Metro Networks data.

The fax notification component was abandoned as one of the seven services originally proposed by Etak. This service was replaced by the Traffic Touch Palm 7 device, which will utilize Etak software. The fax service presented a communications logistics problem, whereby traffic information by fax may not be the best way to deliver the time-sensitive information. Since a fax service requires one telephone line for each simultaneous fax, the number of subscriber broadcasts could exceed the

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capacity of the communications server supporting the service and, thus, negatively affect the timeliness of information.

While the evaluation team has limited information about the success of other deployments of fax services, those deployments are believed to have been plagued with problems. For example, Colorado DOT is thought to have had a system of broadcasting faxes to public agencies and trucking companies to alert them to adverse weather conditions or incidents that affect the transportation network. In 1994, Shadow Traffic was promoting a traffic fax subscription service in Southern California called Shadow Fax. The company was targeting corporations as customers, with the argument that employees who knew about traffic congestion delays along their route would leave work later. No information about the number of subscribers was made available, and the service was stopped in 1995.

In general, the national market for personalized traffic information messaging services has been slower to develop than expected. In part, this is related to an evolving (and thus unstable) wireless telecommunications market. There is a variety of technical problems that information service providers have faced in their attempts to bring traffic information to drivers and other mobile customers.

In Phoenix, slow adoption of these services is also related to low consumer demand. Data from the other customer satisfaction evaluations, field operational tests, and user acceptance studies suggest that consumer demand for personalized traffic information is at least partly a function of congestion delay. In greater Phoenix, the relatively low level of traffic delays (discussed in Section 2) may indicate that the traveler information market will be slower to develop than in Seattle, where delay is much greater.

Given the absence of the fax and paging services, and the limited deployment of the e-mail service, evaluation of the personalized messaging service was only able to address costs and institutional lessons learned.

4.1.2   Project Costs for Personalized Messaging System

Assessing the costs of the personalized messaging system was a challenge as it is just one part of the suite of traffic information services that Etak is developing for AZTech. Moreover, these services are connected to Etak's national business strategy, which may further obscure whether a cost is direct or indirect.

Estimated start-up costs, including capital and shared costs, were $213,690. Annual operation and maintenance costs were estimated to be $103,178. The AZTech server and advanced traveler information systems server shared costs described in Section 2.5 account for the majority of all start-up costs, or about 62%. The dedicated costs associated with Etak's e-mail system development and management account for about 38% of the start-up costs, which have been expended largely for software development.

All operation and maintenance expenses come from AZTech server and advanced traveler information systems server shared costs. There are no dedicated operation and maintenance costs reported for this project. The figures shown in Table 4.1 account only for the initial deployment of this system for employees of the Arizona Department of Transportation, Maricopa County Department of Transportation, and the other public sector partners. However, operation and maintenance costs for expanding the system to a wider user group will be minimized, since much of the necessary software and hardware is in place.

Table 4.1: Project Deployment and Operation Costs of Personalized Messaging System

Equipment Description	Quantity	Unit Cost	Start-up Costs	O&M Costs
Etak Traffic Email System Development	N/A	N/A	$36,600	
Etak Traffic Email System Management	N/A	N/A	14,000	
Advanced Traveler Information Systems Server Shared (16.7%)	N/A	N/A	92,008	$94,377
AZTech Server Shared (4.2%)	N/A	N/A	71,082	8,801
Total			$213,690	$103,178

4.2 TRAILMASTER WEB SITE AND ROADWAY CLOSURE AND RESTRICTION SYSTEM WEB PAGE

4.2.1 Project Description and Evaluation History

The Trailmaster Web site, and the Roadway Closure and Restriction System Web page that is part the Trailmaster site, are components of the Arizona Department of Transportation's public advanced traveler information system. This system has been significantly enhanced through integration into the AZTech initiative. The main information sources for the Web site include:

- The Arizona Department of Transportation's extensive freeway management system, which was originally deployed in the early 1990s. The freeway management system provides freeway speed data from its traffic detectors and the text from its changeable message signs.

- The Roadway Closure and Restriction System, which allows regional traffic managers to provide incident, road closure, and traffic speed information to the AZTech server via computer workstations located within their agencies.

- The closed circuit TV camera network that has been deployed throughout the region is the result of integrating the feeds from numerous cameras installed for the original Freeway Management System and on a number of MMDI and non-MMDI Advanced Traffic Management System projects, including the Smart Corridors discussed in Section 5.

The original Trailmaster Web site contained a traffic flow map and images from selected freeway management system closed circuit TV cameras. The Roadway Closure and Restriction System Web page represents a substantial expansion of this traffic information service. Much of the expansion is due to the deployment of the Roadway Closure and Restriction System infrastructure, which is an extension of the original Highway Closure and Restriction System.

The Highway Closure and Restriction System was originally designed to permit statewide collection and dissemination of roadway closure and restriction information on freeways. The Roadway Closure and Restriction System was designed to expand on the Arizona Department of Transportation's initial system. It includes traffic data collected on arterial streets by AZTech's municipal partners through integrating the regional system with local municipal traffic operations. Integration of the two systems is a critical component to their success.

Although the Highway Closure and Restriction System and Roadway Closure and Restriction System have been integrated with one another, the integration was a challenge. For example, combining data from the two systems, each of which uses different data structures, required extra effort. The Roadway Closure and Restriction System employs street and intersection references while the Highway Closure and Restriction System uses road numbers, mile posts, and freeway exits to record locational data. To use these two data types on the new Roadway Closure and Restriction System Web page, sophisticated data fusion was required.

These components are being integrated by providing participating agencies with AZTech computer workstations, which enables them to enter manually information about travel conditions occurring on arterials within their respective jurisdictions. Plans include adding such information as incidents/accidents; road closures; lane restrictions; road maintenance; road conditions; and weather problems. A special computer interface was designed for this purpose and resides on each AZTech workstation. In most cases, the information is sent from a traffic management center to the AZTech server via fiber optic cable.

The AZTech integrated communications network allows sharing of closed circuit TV camera images, and the fiber optic cable is especially well suited for high bandwidth applications such as streaming video. Using the network will link cameras installed or planned as part of the freeway management system program, which were not funded by the MMDI. The AZTech project expanded closed circuit TV systems in Phoenix and Scottsdale, and added systems in Glendale, Mesa, Paradise Valley, and Tempe. All of these traffic cameras will eventually be linked to the Trailmaster Web site.

The result of this integration will be a wider coverage area and a greater breadth of traffic information for travelers. However, besides being an essential element of the advanced traveler information system, the Roadway Closure and Restriction System network should help improve operational coordination between neighboring jurisdictions. In fact, a number of public works crews in the region are coordinating their projects with projected Arizona Department of Transportation street closures listed on the Trailmaster Web site.

Before providing information on the Trailmaster and the Roadway Closure and Restriction System Web pages, data from the freeway management system, closed circuit TV camera network, changeable message signs, and Roadway Closure and Restriction System are processed by the central AZTech server. After this is done, traveler information is forwarded to the upgraded Trailmaster Web server.

Once fully deployed, the Trailmaster Web site will present traffic data collected through the installation of traffic detection, surveillance, and traffic signal equipment. Data collection will encompass over 50 centerline miles of Arizona Department of Transportation freeways and ramps and an undetermined number of arterial miles. For example, the site currently provides still images from over 45 cameras, and additional camera images are expected to be added to the Trailmaster Web site as they are deployed in the field. Some will offer full motion video. The freeway management system, a major component of the surveillance system, is currently functional on 42 miles of the "inner loop" around downtown Phoenix, which comprises sections of Interstates 10 and 17, U.S. Route 60, Loop 202, and SR51.

First launched in December 1995, the Trailmaster Web site[4] evolved from the Arizona Department of Transportation's experiments with video capture hardware and displays of static traffic images. According to the project team, positive traveler response led to further expansion of the service to include the live video and real-time map displays that are part of the Web site today.

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[4] The Trailmaster Web site can be found at http://www.azfms.com.

Figure 4.1 shows the Trailmaster home page and the links to main pages containing camera images, freeway conditions, and road restrictions information. As the expanded Roadway Closure and Restriction System is deployed to integrate reporting from eight area jurisdictions, more roadway closure information, including speed information on arterials, will be provided on the Web page.

Some of the content that was expected to be available when the site was evaluated was not incorporated during the national evaluation period. Information such as real-time speed information for major arterials, real-time bus status, some roadway closure information from the expanded Roadway Closure and Restriction System, and an on-line "Yellow Pages" was not available at that time.

While much of the field equipment, such as loop detectors, is connected to the Traffic Operations Centers of the individual agencies or jurisdictions, not all centers have been connected with the AZTech server. Therefore, they are not able to provide speed or incident information on arterials to the Roadway Closure and Restriction System database and the Trailmaster Web site. The entire West Valley, which includes Phoenix, Glendale, and the Maricopa County Department of Transportation and Arizona Department of Transportation traffic operations centers, is now connected by fiber optic cable. However, some East Valley traffic operations centers must still be physically linked to the AZTech server.

Another difference between the planned and actual information available on the Roadway Closure and Restriction System is related to data input from the field. Although the system is operational, not all field crews are relaying the incident and road closure information that they are supposed to report. This has resulted in incomplete information being disseminated to the public, thus potentially limiting the effectiveness of the service. For example, Maricopa County Department of Transportation dispatchers want more consistency from field crews in the reporting of information that is intended for the system. Although personnel of the traffic operations center have received training to ensure consistency of reporting, staff resources at individual agencies are insufficient.

Although some features of the Trailmaster Web site were not deployed or available during the national evaluation period, other information sources were incorporated instead. For example, static bus schedules were included via a link to the Phoenix Transit Web site. Live motion video images from selected freeway cameras were added and available during the evaluation. Nevertheless, some members of the project team estimate that AZTech is currently getting only a portion of the benefits that could ultimately be derived from the system. These additional expectations and potential enhancements are hoped to be enough incentive for the region's public sector participants to keep the program operating into the future.

4.2.2 Project Costs for the Trailmaster Web Site and Roadway Closure and Restriction System

There are two categories of costs related to the Trailmaster Web site and Roadway Closure and Restriction System Web page that are discussed in this section. These categories include:

- Upgrading the Trailmaster Web site; and
- Physically expanding upon the existing Highway Closure and Restriction System infrastructure to create the enhanced Roadway Closure and Restriction System.

Trailmaster Main Page
(http://www.azfms.com)
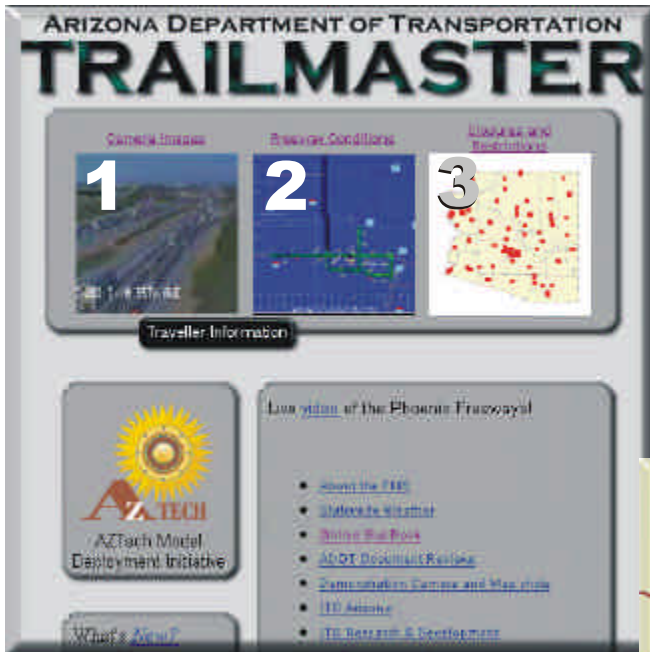
Features

1. Live cameras
2. Freeway conditions
3. Highway and roadway closure information

3. Highway & roadway closure information
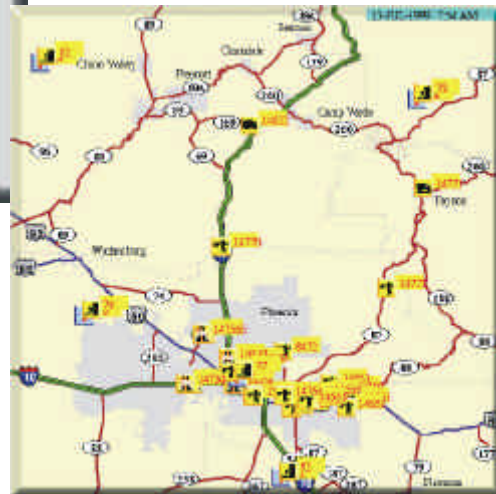
1. Live cameras
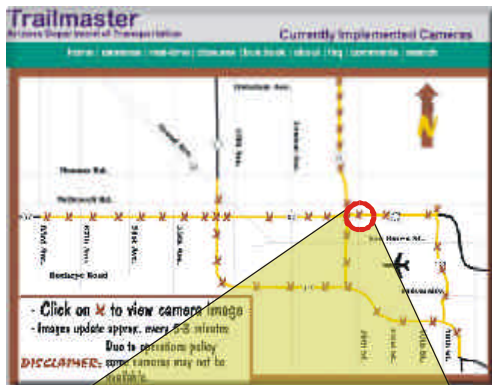
Click on X to view a camera

2. Freeway conditions
(Color coded freeway speed map, CMS sign messages)
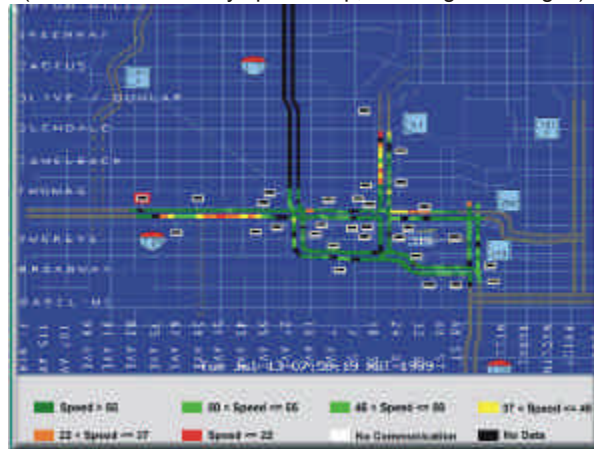
Figure 4.1: Trailmaster Main Page

The major start-up costs for the Trailmaster Web site were upgrading the Web server's capacity, buying new Web-site software, and redesigning the site. The server, which was deployed in 1996, had to be substantially upgraded to handle an increasing volume of use by travelers (a trend demonstrated by the Web log analysis discussed below). The increase in Web server capacity is consistent with AZTech's commitment to continually improve service and ensure that user demand is met. Similarly, the new Web server software was purchased to process the site's information more rapidly and facilitate design changes. Expenditures for site redesign were needed to incorporate additional information sources and to make the site easier to navigate. High-end video cards were another expense required to process an increasing number of closed circuit TV images.

Unlike most of the other AZTech projects, annual operation and maintenance costs are almost equal to the start-up costs. There are several reasons for this.

- Upgrading the Trailmaster Web server instead of purchasing a new one with other supporting equipment like a modem bank kept the start-up costs lower than a completely new installation. In fact, the project team estimates that the start-up costs for the original Trailmaster Web site may have been almost 10 times the start-up costs shown below.

- Changing the existing Trailmaster Web site was cheaper than designing and programming a completely new one from scratch.

- Because of AZTech's commitment to customer services, its replacement schedule for the server is a relatively aggressive two years. This contributes to higher operation and maintenance costs.

- Web page administration, e.g., keeping the site up-to-date and undertaking redesign, is a very labor-intensive activity that also contributes to higher operation and maintenance costs.

- AZTech uses a high capacity T-1 communication backbone that provides better service but is much more expensive than choosing a significantly lower capacity communication link such as Integrated Services Digital Networks (ISDN).[5]

Compared to the advanced traveler information systems Web pages deployed at two other MMDI sites, the Trailmaster Web page appears to lie in the middle in terms of operation and maintenance costs: $32,000 for San Antonio, $116,000 for Phoenix, and $250,000 for Seattle.[6] Three major cost drivers may help explain the differences:

- Level of Automation: The San Antonio TransGuide Web site is the most automated of the three, so its operating cost due to labor is less. The Washington State Department of Transportation's Seattle Web page, which has the highest operations cost, requires significant staff labor inputs for creating real-time traffic maps, controlling video feeds, and generating traffic reports.

- Required Upgrades: As noted above, the Trailmaster Web site has significant costs built into its operation and maintenance budget that allow for the replacement of the main server unit every two years, faster than the other two sites.

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[5] T-1 lines are capable of transmitting data at rates up to 1.54 MB per second, compared to 128 KB per second for ISDN. Roughly speaking, T-1 has 12 times the capacity of baseband ISDN.

[6] The reader is cautioned that exact comparisons among sites are impossible because many factors may not be comparable, such as the accounting methods and related assumptions employed by each MMDI site. For example, amortization schedules or user demand (which affects system capacity) may be very different.

- Use of Real-time Video: The Phoenix and Seattle Web sites utilize more real-time video feeds that lead to higher costs than the San Antonio Web page.

Table 4.2 includes start-up costs and operation and maintenance costs. These include shared costs for systems with which Trailmaster is integrated, which in this case are for the AZTech server, since it processes much of the information that is presented on the Trailmaster Web site.

Table 4.2: Development Costs of Trailmaster Web Site

Equipment Description	Quantity	Unit Cost	Start-up Costs	O&M Costs
Server Upgrade	1	$20,000	$20,000	
High-End Video Cards	2	4,500	9,000	
Misc. Parts	N/A	N/A	2,000	
Software Licenses	N/A	N/A	15,000	
Web Page Design (250 hours)	N/A	N/A	18,700	
Server, Hardware, Software & Web Design Upgrade	N/A	N/A		$29,683
Web Page Administration Labor (416 hours)	N/A			25,585
Communication Costs (T1 line and ISP services)	N/A			52,482
AZTech Server Shared (4.2%)	N/A	N/A	71,082	8,801
Total			$135,782	$116,551

The Roadway Closure and Restriction System Web page obtains much of its information from the upgraded Highway Closure and Restriction System. Its costs are shown in Table 4.3. The overall start-up costs were estimated to be $286,647, and estimated annual operation and maintenance costs were $38,378. The major start-up cost is for services, training, support, and development. A secondary cost driver is the procurement of the 15 Pentium® computer workstations. Compared to other AZTech projects, the annual operation and maintenance costs for the Roadway Closure and Restriction System are relatively low, at approximately 13% of the initial deployment costs (including shared costs).

Table 4.3: Development Costs of Roadway Closure and Restriction System

Equipment Description	Quantity	Unit Cost	Start-up Costs	O&M Costs
Pentium Workstation, Monitor, Modem	15	$4,500	$67,500	
Standard Software & Development Tools	15	1,500	22,500	
Services, Training, Support & Development Labor	N/A	N/A	196,647	
Workstation Labor	N/A	N/A	N/A	$35,426
ISP Costs	N/A	N/A	N/A	2,952
Total			$286,647	$38,378

4.2.3 Trailmaster Customer Satisfaction Evaluation Results

This section describes the customer satisfaction studies undertaken for the Trailmaster Web site, including the Roadway Closure and Restriction System and freeway conditions Web pages. Since similar customer satisfaction studies were planned for advanced traveler information systems services at two of the other MMDI sites, the evaluation was designed to support comparisons with them. The intent was to provide a broader understanding of the factors influencing customer satisfaction of advanced traveler information systems across all sites. Some of these factors are described in Section 2.

The information presented in this AZTech site report highlights the main findings that are especially relevant to drawing conclusions and making recommendations regarding the Trailmaster Web site. The information reported here represents a small portion of the entire customer satisfaction evaluation effort on Trailmaster. The full analysis can be found in a separate document.[7]

Background

Two primary tools were used to evaluate the Trailmaster Web site. The first was a qualitative examination using focus groups to elicit customer response to two particular pages on the Web site, the Roadway Closure and Restriction System and the freeway conditions page. Participants were recruited directly from the Web site using a hyperlink banner. Originally planned to concentrate just on the Roadway Closure and Restriction System page, the low level of response to the on-line solicitation for participants required a broader focus that included discussion of the freeway conditions page. The second tool was an analysis of site usage based on the log files of the Trailmaster Web site.

The focus group analysis was based on two, two-hour focus groups. This form of qualitative research was used to explore users' awareness levels, expectations, usage patterns, effects on decision-making about travel, and perceived benefits and value of the Web pages; and help determine means of improving the pages to better meet users' needs.

Selection criteria for both focus groups emphasized overall experience with the Trailmaster Web site, in terms of duration and frequency of use. The customer satisfaction team took this approach because it had determined from other studies that more experienced users are better prepared to talk about the features of a site and their own experiences using the information. In other words, new users often do not have enough experience to provide the detailed feedback being sought.

The Web log analysis was based on studying the log files that the Trailmaster Web server automatically creates to record activity on the site. These files contain information about all visitors, including where they are connecting from; what time the visit took place; which pages were viewed; and how long the visitor remained connected. For the purposes of Trailmaster Web site evaluation, a commercial software package designed to analyze Web log statistics was used.[8]

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[7] This discussion is elaborated upon in a companion MMDI evaluation document, *ADOT Trailmaster Web Use: Customer Satisfaction Evaluation.* Draft Report (in preparation).

[8] The software used for the Web log analysis was a commercial, off-the-shelf product called WebTrends™. Information on this software can be found at http://www.Webtrends.com/.

Analytical Considerations

There are several factors inherent in the evaluation tools used for this study that readers should take into account when reviewing the results. The purpose of focus groups, since it is qualitative research, is to develop in-depth understanding of attitudes and behavior, and direction for planning further research. Because of the small number of people interviewed and the non-random method of recruitment, the findings cannot be analyzed quantitatively. Nor are they representative of the population of all users of Web page traveler information. Nevertheless, they can provide useful insights into how advanced traveler information systems customers respond to various services such as a Web site. When combined with another research tool such as the Web log analysis, richer interpretation becomes possible.

A Web log analysis can provide information about the overall activities on the site and its constituent pages, including the amount and patterns of use. However, individual users of the Web site cannot be uniquely identified, counted, or tracked as would be done in a more traditional customer satisfaction study such as a survey. This is due to the fact that individuals may visit the Trailmaster site from several times a day to less than once per month. Thus, it is not possible to identify and analyze factors such as demographic characteristics with these data. The Web logs primarily offer a broad picture of levels and patterns of Trailmaster Web site use over time.

Results

The Trailmaster Web site analysis is divided into seven major areas:

- Levels of usage
- Patterns of Web site use
- Most popular page views
- Duration of user sessions
- Learning about the Web site
- Suggestions for improvement
- Interpretation and conclusions.

Levels of Usage

Evaluating the overall level of Trailmaster Web site use provides a context for subsequent analyses and interpretation. In the Web log analysis, use is measured in terms of user sessions. A user session is defined here as either the interval between the time a user first accesses the Web site and the time the user terminates the session by leaving the site; or any 30-minute period of continuous inactivity by the user. In other words, the duration of a user session is the interval between first access and last access just before the 30-minute period of inactivity of any user.[9] This metric reflects

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[9] The WebTrends™ default parameter of 30 minutes for measuring user sessions was used for several reasons. (1) This is the value that is used by the state DOTs in defining user sessions in the analyses they typically make available to the public. To change this value would create unnecessary confusion and make it more difficult to interpret the findings on Web usage across different analyses of the same data or across sites; (2) the number of user sessions identified tends to stabilize with a value of 30 minutes and change relatively little with longer intervals, while the results change substantially for shorter intervals. (3) As the threshold value is shortened below 30 minutes, the risk increases that 'legitimate' single user sessions will be arbitrarily truncated. Thus, for very short intervals, a single session with one person examining traffic information periodically might be represented as many apparent individual sessions due to setting too short an interval of inactivity at that site. (4) As indicated earlier, user sessions are at best a proxy for individual users, and WebTrends™ does not allow us to clearly identify every user, or to distinguish repeat users among multiple user sessions. The number of user

activity for one user of a Web site for a continuous period, and it provides a basis for evaluating overall demand for the service. It is the best available indicator of user activity at this Web site and is, therefore, the primary unit of measurement used in the Trailmaster evaluation.[10]

The number of user sessions in a month approximates the number of separate times users visit a Web site during that month. To reiterate, it is not the number of *unique* individuals visiting the site, a figure which cannot be determined with these data. User sessions at a Web site can vary tremendously in length of time and breadth of activity. This was confirmed by this analysis and is discussed in more detail below.

For the period of May 1998 to February 1999, use of the Trailmaster service ranged from a low of 71,354 user sessions in May 1998 to a high of 99,038 user sessions in February 1999.[11] Figure 4.2 shows usage levels for the 10-month period as measured by the average number of recorded user sessions per day for each month.[12] While there has been variability month-by-month, the general trend in usage levels has been upward during this period.

This trend can be shown by displaying a linear regression trend line through the average daily number of user sessions for the period. This is shown in Figure 4.2 as a single line across the tops of the bars. The average increase in use during this 10-month period is equivalent to about a 50% increase in use over one year.[13] Note that the rate of change for this arbitrarily selected period is not a forecast and may not actually extend into the future. The data themselves cannot be used to predict whether usage will continue to rise at the same rate, increase, level out, or even begin to decline.

However, considering the overall growth of Internet usage for all purposes and at other MMDI Web sites, it is expected that Trailmaster usage will continue to grow significantly. Indeed, results from the focus groups indicate that as more information is added to the site and site navigation is improved, including real-time arterial information and more camera views, use of the site would be expected to increase.

Patterns of Web Site Use

The Web logs provide data on use by day and by hour, allowing for more detailed analyses of usage. Figure 4.3 provides one way of looking at site use, showing the pattern of user sessions by day for the months of May 1998 and February 1999. The patterns shown are quite somewhat typical of the use of other traffic information Web sites studied by the customer satisfaction team. Use is higher during weekdays and much lower on weekends. This is likely because travel levels and congestion are usually higher on weekdays due to commuter traffic, which could have a direct effect on demand for traffic information on this Web site. The fact that this difference is not as pronounced in Phoenix as at

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sessions derived from the log data by WebTrends™ is the best indicator we have to reflect user activity levels at the Web site.

[10] Two other measures were considered for the analysis: hits and page views. However, the user session was judged to be the most appropriate overall indicator of site use. Hits include a large and indeterminate quantity of site activities that may be largely unrelated to a user's on-line actions. Although page views share this characteristic, they are more closely connected to actual user activity on the site. Thus, page views are used as another measure later in the analysis.

[11] This period was selected to include the bulk of the MMDI project deployments, with May 1998 generally preceding those deployments and February 1999 being the most recently available month of log data.

[12] The usage data for the month of August are not shown because they were not available in the Trailmaster Web log archives.

[13] This average rate of change is computed based on a linear regression line run through the nine data points.

other sites could also be due to the fact that the Trailmaster site is used for travel outside the Phoenix metropolitan area, which could attract more weekend travelers.
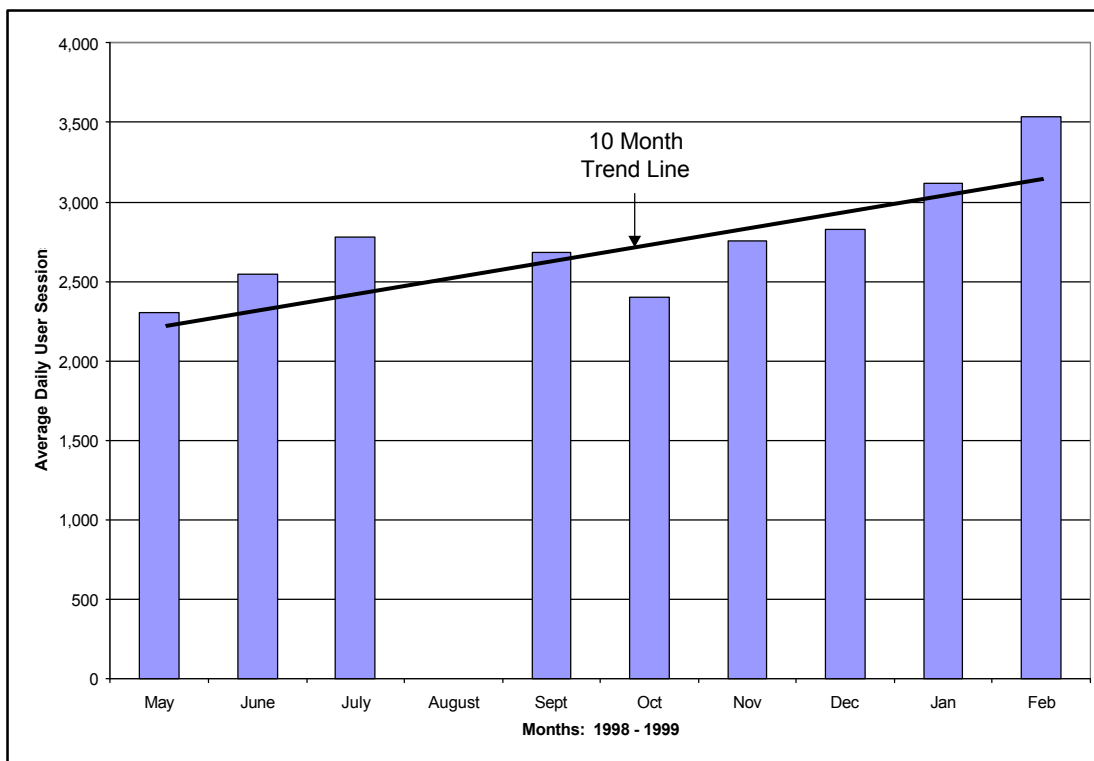
Figure 4.2: Average Number of Daily Trailmaster User Sessions Per Month, 10-Month Trend Line

Also characteristic of weekday use is a peak effect on Mondays and Fridays and a dip during mid-week. However, as Figure 4.3 shows, this pattern is not always present. The peak effect appears to become more prominent in the February 1999 figures. One possible explanation is that as overall site use grows, more individuals are using the site on a regular basis.

Figure 4.4 shows how use of the Trailmaster traffic Web site varies by time of day for both weekdays and weekends. The data displayed in Figure 4.4 show the average daily number of user sessions that occurred in May 1998 and in February 1999, split into both weekdays and weekends. Weekday and weekend use increase proportionately over this 10-month period of observation, with weekend use constituting about three-quarters of weekday use in each month. One might expect that weekday use would increase proportionately more than weekend use over time, if congestion associated with commuting were getting worse. The impact of the afternoon commute appears to be associated with the more pronounced peaking of the Web site at the end of the 10-month period. This may suggest that congestion is becoming more of a problem in the Phoenix area over time, although comments from the focus groups suggest that it remains within tolerable limits.
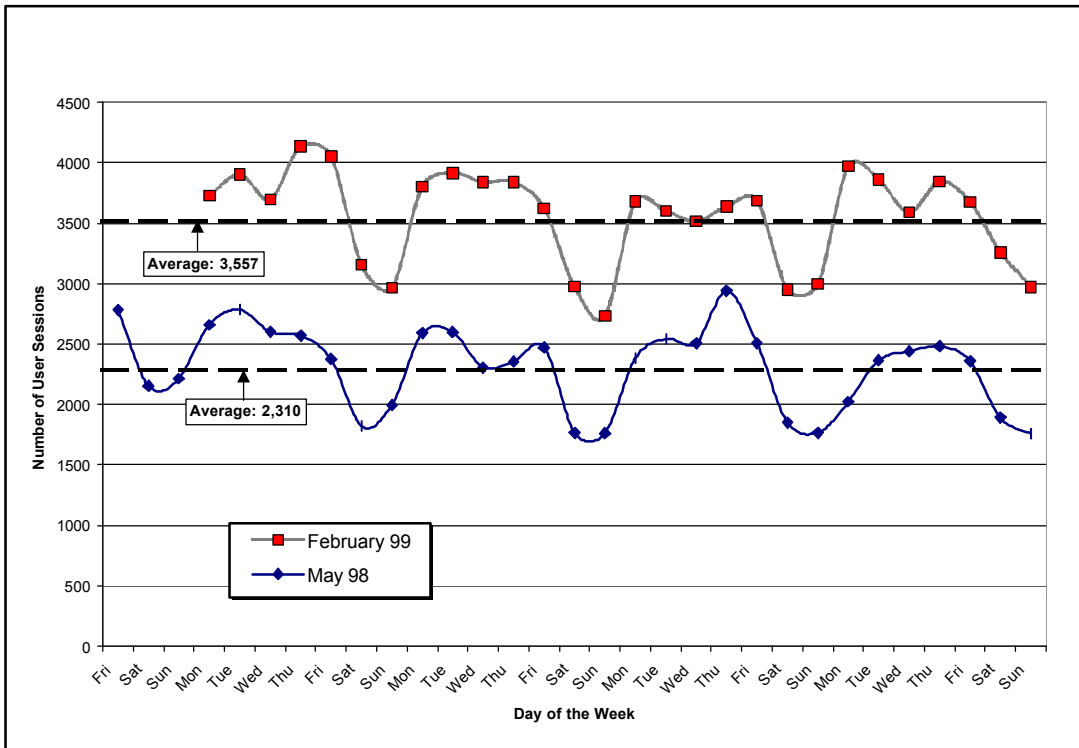
Figure 4.3: Average Number of Daily Trailmaster User Sessions, May '98 and February '99
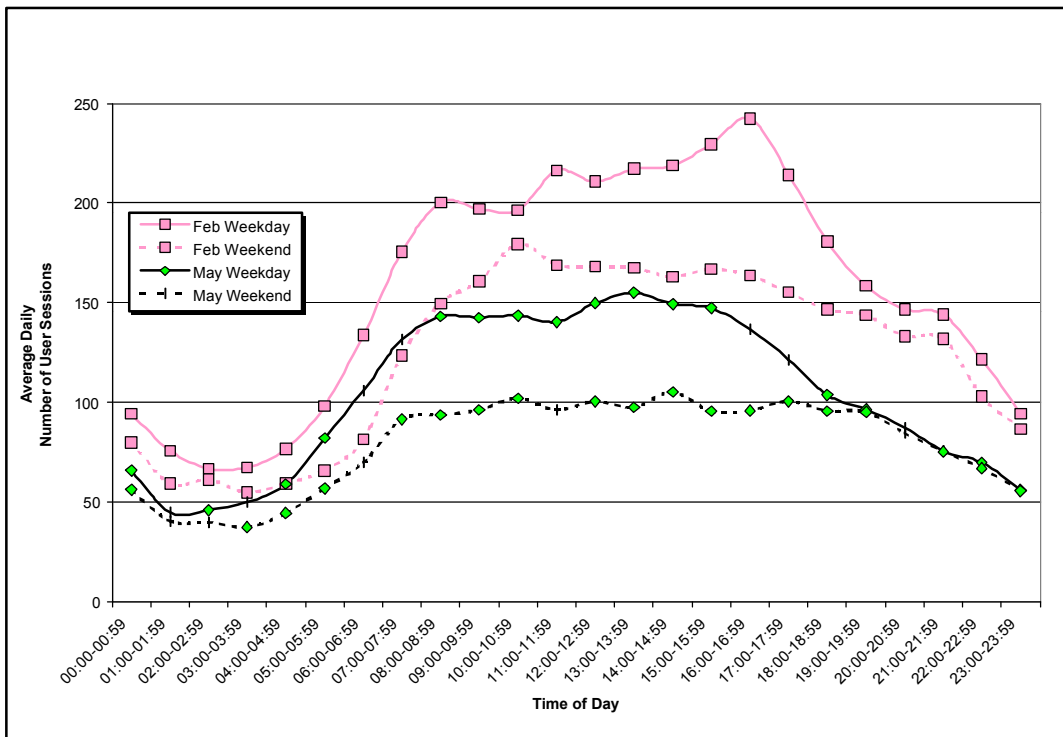
Figure 4.4: Average Number of Daily Trailmaster User Sessions for Weekdays and Weekends, May '98 and February '99

Figure 4.4 also shows some changes in the time-of-day patterns of use. The average weekday use by hour shows a relatively flat distribution between 8:00 AM and 4:00 PM in May 1998. In addition, the chart demonstrates a less pronounced bi-modal distribution centered on the AM and PM rush hours than has been observed in traffic information usage in other metropolitan areas. In those locations, there are clearly separate peaks in the morning and the afternoon and a dip in usage during midday. Figure 4.4 does show a rise in use during the afternoon rush hour between May 1998 and February 1999. This trend is consistent with the fact that commuters would be expected to consult the service for their afternoon commute home using Internet access at their offices.

However, by February 1999 a more pronounced afternoon peak starts to emerge between about 2:00 PM and 4:00 PM. This could be due to increased travel and commuting-related congestion in the afternoons; increased awareness of the Web site by commuters; or increased access to the Internet by commuters at work. It is likely that some combination of these factors is influencing the changing use patterns and causing them to be more like the patterns observed in Seattle. There, the severe afternoon traffic congestion causes a much more pronounced peaking of usage on the Washington State Department of Transportation traffic information Web site. While not all months of Trailmaster data were analyzed at this level of detail, samples of several other months confirm that these general trends and patterns hold true for weekdays.

Similar to the day of week comparison, this emerging pattern of Web use in Phoenix is characteristic of more congested cities. However, the absolute level of Web usage, as measured by the number of daily user sessions, remains well below the high levels seen in Seattle, a very congested MMDI site. Section 2 presents more details on this site-to-site comparison of congestion.

Most Popular Page Views

During a user session, an individual can look at one of many separate page views on a Web site. The specific pages they tend to view most probably indicate user preferences kinds of traffic information. That is, pages containing content that has value for the user will presumably be viewed more frequently than will others.

Figure 4.5 presents the analysis of the Trailmaster Web log files revealing the top 10 page views for the month of February 1999. It shows a number of interesting use statistics:

- Traveler interest in the Trailmaster Web site is concentrated in the top five pages. These five accounted for one-third of all pages viewed, while the top 10 page views accounted for 40.6%.

- The Phoenix current freeway conditions map (see Figure 4.1 above for an image) was the most frequently viewed page, garnering 7.8% of all page views.

- Six of the top 10 page views involved either specific camera views or pages where different views may be selected (see Figure 4.1 above for the camera map).

When looking at these findings, it is important to consider which pages offer actual traffic information. Three of the top five--the Trailmaster home page, the camera map index page, and the camera text page--do not provide any actual traffic information. They exist primarily to guide users to Web pages that have actual traffic information and help them decide what might be useful for their own purposes. These index pages are necessary for newer users to find useful information, but become irrelevant for more experienced users. Therefore, their high rankings may be overstated in terms of the real value to users over the long term.
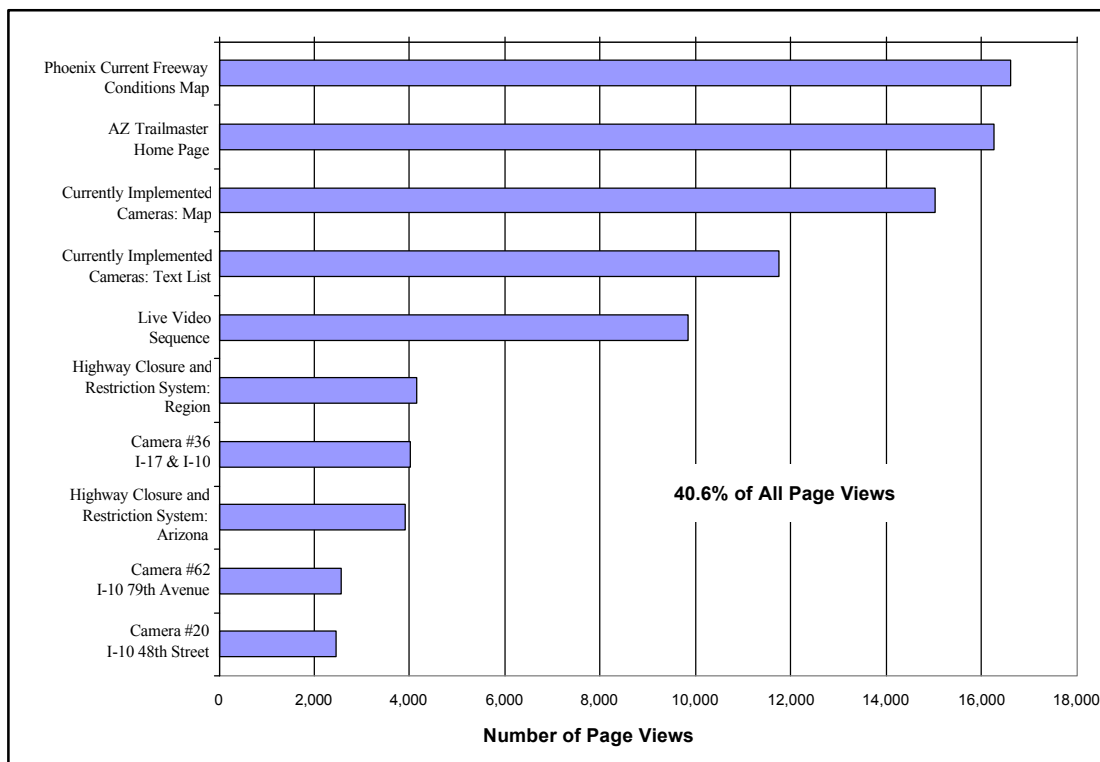
Figure 4.5: Top Ten Page View on the Trailmaster Web Site

Nevertheless, it is clear from both the Web log analysis and focus group findings that camera views are very popular. The Trailmaster site offers over 40 individual camera views showing traffic conditions on different segments of the freeway and arterial system in Phoenix. Four of these are among the top 10 pages viewed (along with the two camera index pages discussed above). Focus group participants indicated that the camera pages were one of the main attractions of the Web site.

In addition to looking for the most popular page views, the relationship between page views and user sessions can be examined to help understand how one facet of users' Web site behavior may be changing over time. The average for May 1998 is 3.5 page views per user session. Over the 10-month period, this ratio declined to 2.1 page views per user session in February 1999. The ratio for the intervening months demonstrates a steady decline, too. This finding indicates that, on average, persons visiting the Trailmaster Web site are looking at one to two fewer pages each user session than a year earlier.

This steep decline in averages pages viewed per session is caused by the components of this ratio changing in opposite directions. Between May 1998 and February 1999, the number of monthly user sessions *increased* by almost 39%, while the number of pages viewed *decreased* by about 16%. In other words, either more people were using the Trailmaster site and/or existing users were visiting more frequently. In either case, users focused their attention on fewer pages during each visit.

One possible explanation is that, as users become more experienced with the Trailmaster site, they identify several pages of specific interest and do not spend time looking at other pages, especially index pages such as the Trailmaster home page. In general, it is common for more experienced Web users to save direct links to their favorite pages (called bookmarks in one popular Web browser software), enabling them to bypass the index pages. As noted above, one could conclude that the

Trailmaster home page's second place ranking is due more to the behavior of newer users than experienced users.

Duration of User Sessions

Prior studies of customer satisfaction indicate that travelers generally place a high value on their time and do not want to waste unnecessary time planning their travel. While the acquisition of traveler information is valuable to them, a safe presumption is that they want to get that information as quickly and efficiently as possible.

To test this, the length of user sessions was examined. The average user session in May 1998 lasted approximately 7.8 minutes and the average session in February 1999 lasted about 8.5 minutes. Although longer user sessions would be expected for sessions involving more page views, page views per session were shown to decrease in the previous section. This indicates that although users are viewing fewer pages, they must be spending more time on the Web pages that they *do* access.

Several factors can confound these data. For example, the transportation and safety agencies in the region are users of the Web site, and their use patterns may be very different from the average traveler. Also, some users may keep their computers connected to the site for long periods of inactivity, and the idle time is counted in a user session up to the 30-minute threshold set for this analysis. For these reasons, it is difficult to attribute some of these use patterns directly to end-user preferences and behaviors.

There are several other possible explanations for longer user sessions that are not related to user behavior. These include factors beyond the users' control that slow site use. For example, inadequate Web site capacity and processing speed, slow speed of the Trailmaster Internet service provider, or increases in general Internet traffic could slow down access and response time on the Trailmaster Web site, increasing the length of user sessions. This could explain the apparent contradiction to the earlier suggestion that users would be expected to become more efficient (both in terms of pages viewed and total time for a user session) in obtaining information as they gained experience on the site over time. In other words, it may just be taking them longer to retrieve the information they want.

Anecdotal evidence among members of the evaluation team tend to support this hypothesis of slower site access, although the issue of access speed did not come up during the focus groups. As indicated in the cost analysis for this project, the AZTech project team is planning to aggressively upgrade the needed hardware and software to ensure that the level of service on the site remains high.

Learning about the Web Site

Awareness of a traveler information service precedes usage, and there are two important components of awareness: whether potential users are able to find out about the service and the means by which they find out about it. Participants in the Web page focus groups found both the roadway closures and freeway conditions pages primarily in two ways, one 'active' and one 'passive.' The active approach involved a user deliberately doing a Web search for traffic information (e.g., typing in

Arizona Department of Transportation" in a Web search engine). For this method to be most successful, AZTech may want to ensure that its site is indexed by all of the major Web search sites.[14]

Web "surfing," the popular term for browsing the Web, was the second method. In this case, users are not necessarily looking for traffic information directly but may discover it as they move from one Web site to another using hyperlinks. A common way of surfing is to start with a Web portal. Web portals are commercial Web sites that provide users with an index and links to a variety of popular topics.[15]

Either way, focus group participants found the Trailmaster Web site without too much difficulty. Several respondents even recalled hearing about the pages from friends or co-workers. Unfortunately, the Web log analysis does not provide any data to inform this issue further.

Suggestions for Improvement

Suggestions for improving the Web page are derived primarily from focus group responses but are generally supported by the Web log analysis. While participants provided many ideas for improving the site, they generally felt that the Web pages were a helpful, interesting new way to obtain information that could improve their travel experiences.

Some of the specific suggestions for improvement included the following:

- Increase the amount and scope of "real-time" information, especially on the freeway conditions page. Respondents felt they could not depend on the information being timely and relevant. Examples cited included obsolete camera views and not knowing when a page was last updated.

- Increase the amount and type of information on the freeway conditions page and present it more clearly. Additional information could include conditions on major arterial streets, more detailed and accurate speed information, and extension of the traffic speeds map beyond the city limits. The lack of arterial information is consistent with the project description above. It indicates that not all municipalities are connected to the Roadway Closure and Restriction System nor are those who are connected necessarily inputting adequate information.

- Improve the use of icons, numbers, formatting, and symbols on the Web pages. According to focus group participants, the Roadway Closure and Restriction System and freeway conditions Web pages seemed "jumbled" and not designed with the average traveler in mind. For example, the numerous temperature symbols on the Roadway Closure and Restriction System page were distracting and not as relevant as information on dust storms would be, something which can have an impact on traffic but is currently not available.

- Make it easier to "drill down" to additional information. That is, improve the navigation of the site from general to more specific information. This idea is supported by the previous statement regarding the Web log analysis which indicated that about half of the top 10 pages viewed have no actual traffic information on them.

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[14] Web search sites include locations such as AltaVista® at http://www.altavista.com/, Infoseek at http://infoseek.go.com/, etc. Web designers for sites such as Trailmaster can register with these services to help make sure their own site is found when users search the Web.

[15] One of the first and most popular Web portals is Yahoo! The Yahoo! home page can be found at http://www.yahoo.com/.

- Decrease the amount of "scrolling" needed to obtain complete information. For example, the "minus" signs indicating changeable message sign information required users to scroll down to read a text message - which might be blank. On the camera pages, respondents indicated that the camera's direction of focus should be easier to ascertain. These suggestions might underscore some of the Web log findings that show longer than expected user sessions involving these pages.

- Add "links" to make the Trailmaster Web site more useful by allowing users to access additional, relevant information about public telephone locations, schedules for sporting events, restaurants, etc.

Interpretations and Conclusions from Trailmaster Web Site Analysis

Perhaps the key finding of the Trailmaster Web site comes from the focus group results. It suggests that travelers in the Phoenix region do not generally experience severe traffic congestion. This is consistent with local anecdotal evidence and findings in the Tempe *Traffic Check* project discussed later. The regional factors discussed in Section 2 are also important for interpreting the Trailmaster study's conclusions since it is presumed to have a direct bearing on the level of demand. Conclusions are divided into two sections: site use and customer satisfaction.

Site Use

The level of Trailmaster Web site use appears to have grown steadily over the study period and can be expected to continue growing in the near future. Factors in this growth include increasing the miles of instrumented roadway, adding real-time arterial information, and including other information on the site. Users seem most attracted to real-time information with a high level of specificity, such as camera views. An important consideration for this trend is for AZTech to ensure that the Web site has sufficient capacity to quickly serve all users. Improving site navigation, as suggested in the focus groups and likely supported by the Web log findings, would make it easier for travelers to locate the information they need more quickly.

The Trailmaster usage data appear to support the typical pattern of advanced traveler information systems Web site use by commuters. For example, they show a somewhat pronounced peak in use during the afternoon commute on weekdays. However, in Phoenix the effect seems to be more recent, not as pronounced, and shows less weekday/weekend difference than Web sites in some cities. Demand will likely grow as congestion increases.

The Trailmaster Web site is characterized by fairly smooth patterns of use of traffic and road restriction information. These patterns appear to be relatively unaffected by spikes in use that are observed at the other sites. In Seattle and San Antonio, Web usage can be dramatically impacted by unusual weather conditions or significant traffic events, causing a surge of use. In Seattle focus groups and surveys, respondents noted that, during times of heavy Web site usage, navigating the site is often slower than normal. This is probably due to excessive demands on Web server's capacity. This suggests that more detailed analysis could be conducted on AZTech to determine the peak demand during a major traffic or weather event to test that system capacity is sufficient (even if these incidents are relatively infrequent in Phoenix). Peak demand planning of this nature is analogous to shopping center parking lots that always seem inordinately large until the holiday shopping season fills them to capacity.

Customer Satisfaction

At present, the traffic information provided on the Trailmaster Web site is only an adjunct to users' general sense of traffic patterns and decisions about which routes would be best to take. Focus group participants were aware of many alternative routes available for avoiding congestion. However, they still found the roadway conditions map very helpful in assessing potential construction and other related delays. Although they found the Trailmaster Web site helpful in making travel decisions, it is not yet sufficiently comprehensive to motivate them toward a more regular pattern of use. This was particularly true of those using the freeway conditions page, where more information on non-freeway (e.g., arterial streets) alternatives is desired. The lack of dependable real-time information deterred participants from using Trailmaster to plan travel on a daily basis.

Similar to other traffic Web sites, travelers have a strong preference for dynamic traveler information. For example, real-time camera views of traffic conditions are extremely popular, a fact supported by both the focus groups and Web log analysis. Six of the top 10 page views on the Trailmaster site involved camera-related material. Although focus group participants reported that the camera pages of the Web site were not very helpful with specific traffic problems, they were still attracted to these pages because they liked "visual" traffic information and because they could identify directly with it. The popularity of the camera pages is clearly supported by the Web log analysis. This information may suggest that the AZTech project team would increase demand for, and hence, satisfaction with the Trailmaster Web site by adding as many camera views as become available, especially if it provides more live video.

Recently on the Trailmaster Web site, the average of page views per user session has dropped dramatically while the length of the average user session has increased. This is consistent with the assumption that more experienced and frequent users focus on a few select pages they find most useful and may indicate that users continue to visit the site for information over time. If this is the case, and results from the San Antonio and Seattle studies support this claim, the AZTech project team would be well served by finding ways to promote the site. Perhaps it should install promotional signage on roads near camera locations so that travelers would know that they could check the location from the Internet before travelling there.

The fact that the "Yellow Pages" information was never added may have detracted from use of the site and subsequent customer satisfaction. Focus group participants wanted the Web site to provide access to non-traffic information, which they said would draw them to the site more frequently. For example, some respondents felt that they would use the Trailmaster site more if it provided entertainment information (e.g., restaurants and hotels). One feature that other (non-traffic) Web sites provide is a link to itinerary planning pages such as MapQuest™ and MapBlast™, which allow users to obtain highly specific driving directions from one place to another.[16] MapQuest™ has recently added real-time traffic information links to its Web site, suggesting the potential value of AZTech seeking to create links with other Web sites.

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[16] MapQuest can be located at http://www.mapquest.com and MapBlast™ can be found at http://www.mapblast.com.

4.3 COMMERCIALIZED WEB PAGE

4.3.1 Project Description and Evaluation History

Besides the Trailmaster Web site, AZTech's traveler information services include a commercial Web site developed by Etak as part of its nationwide Web-based, real-time traffic information services.[17] The Etak Web site contains much of the same information as the Trailmaster Web site, although in a different format. The site also includes other traveler information services described below. The existence of Trailmaster and the development of a commercial Web site are in accord with the AZTech business model. It calls for providing traffic data to as many information service providers as possible to maximize the public benefit of the information.

The Etak Web site, with its different interface and bundled information, provides an alternative to the Trailmaster Web site for AZTech users. The site will also provide a gateway for the personalized information services Etak is offering via wireless media, e-mail, and wireline telephones. Because of the complementary nature of the two Web sites, there have not been concerns about competition between the private and public sector Web efforts.

Similar in concept to Trailmaster, the Etak Web site represents traffic speeds as color-coded dots on a freeway map. Real-time incidents and road closure information can be obtained on maps covering the region, including Phoenix, Glendale, and Mesa. Descriptions of incidents or road closures can be viewed by clicking the icon of interest.

As for integration efforts, the Etak Web site has a beta page to pilot test providing real-time bus arrival information for all four of the vehicle-location-equipped transit routes in Phoenix and Mesa. It uses the same data feed and information as the Transit Status Information project described in Section 4.7. The difference in Etak's bus status information service is that it can currently only be used on a pre-trip basis, although it can be accessed from any Internet-connected computer. As part of AZTech Phase II, CUE is planning to send the information to pagers.

Like Trailmaster, static transit schedule and route maps can be obtained on the Etak Web site via a link to the Phoenix Transit Web site. As noted above regarding the personalized messaging service, there is a Web page for recruiting participants for beta testing the traffic e-mail notification service, although the initial recruitment was limited to employees of AZTech public sector agencies. The beta site is still active and anyone with a username and password could participate.

The Etak Web site is integrated with both the advanced traveler information systems server and the AZTech server. The advanced traveler information systems server fuses information from Etak and the AZTech server and formats it for the Etak Web site. The AZTech server provides freeway speeds and incidents from the freeway management system and information on arterial closures from the Roadway Closure and Restriction System.

External links to other Web sites are included to provide access to images from the closed circuit TV camera network (from the Trailmaster Web site), to weather information (on the Weather Channel © Web site), and to airline contact information (from the Phoenix Skyharbor Airport Web site). These services are part of the typical Etak package of traffic information service offered around the country if the information is locally available.

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[17] Currently, the Etaktraffic.com Web site provides access to real-time travel information in 18 major cities in the U.S. The Phoenix site can be found at http://www.etaktraffic.com/Phoenix/.

The Etak commercial Web site was not selected for more detailed evaluation primarily because it was still under development when AZTech projects were assessed for their national evaluation potential.

4.3.2 Project Costs for the Commercial Web Page

The overall start-up costs for Etak's commercial Web site were $234,290, and annual operation and maintenance costs were estimated to be $103,178. Both cost categories include the shared costs of the AZTech server and advanced traveler information systems server. The only costs unique to this project are the Etak development and management start-up expenses. No operation and maintenance costs (other than the shared costs) were reported for this project (see Table 4.4).

Table 4.4: Development Costs of Commercialized Web Page

Equipment Description	Quantity	Unit Cost	Start-up Costs	O&M Costs
Etak Web Page Development	N/A	N/A	$51,500	
Etak Management	N/A	N/A	19,700	
Advanced Traveler Information Systems Server Shared (16.7%)	N/A	N/A	92,008	$94,377
AZTech Server Shared (4.2%)	N/A	N/A	71,082	8,801
Total			$234,290	$103,178

4.4 *TRAFFIC CHECK* CABLE TV TRAFFIC INFORMATION SERVICE

4.4.1 Project Description and Evaluation History

Traffic Check is a traveler information service that is part of the AZTech MMDI. The AZTech project team, Etak, Metro Networks, and the City of Tempe are collaborating to provide real-time traveler information via cable TV. The service is being broadcast on Tempe's Public Access Channel 11 to approximately 35,000 subscribers of Cox Cable Company, or about 50% of the households in Tempe.[18] Although the original AZTech plan anticipated greater regional coverage, Tempe was the first municipality to sign up and has served as the demonstration site in the region. The cities of Mesa, Scottsdale, and Glendale have signed up since the evaluation period and the expansion will be funded through AZTech for deployment in year 2000.

Traffic Check was designed to provide traffic information to an audience that might not otherwise have access to an advanced traveler information system, such as services on the Internet. Another objective of deploying *Traffic Check* was to develop a robust TV production system that would automatically turn traffic data from the AZTech server and advanced traveler information system server into professional quality, multi-media presentations with minimal human intervention. Etak developed its first such system in Atlanta for the U.S. DOT Traveler Information Showcase in 1996. The company initiated a project similar to AZTech in the Bay Area at approximately the same time as the Phoenix project. *Traffic Check* is a standard feature in Etak's national strategy.

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[18] A similar service, also called *Traffic Check*, is currently available in the San Francisco Bay area. More information about *Traffic Check* can be found on Etak's Web site promoting the service at http://www.trafficcheck.com

The information being broadcast is processed by an automatic TV programming system developed by Etak. The system builds on the service presented during the Atlanta Showcase but was upgraded to be more software driven and less labor intensive. The automated system, which resides on the advanced traveler information systems server, converts data to the desired broadcast format. A graphical summary of *Traffic Check* can be found in Figure 4.6.
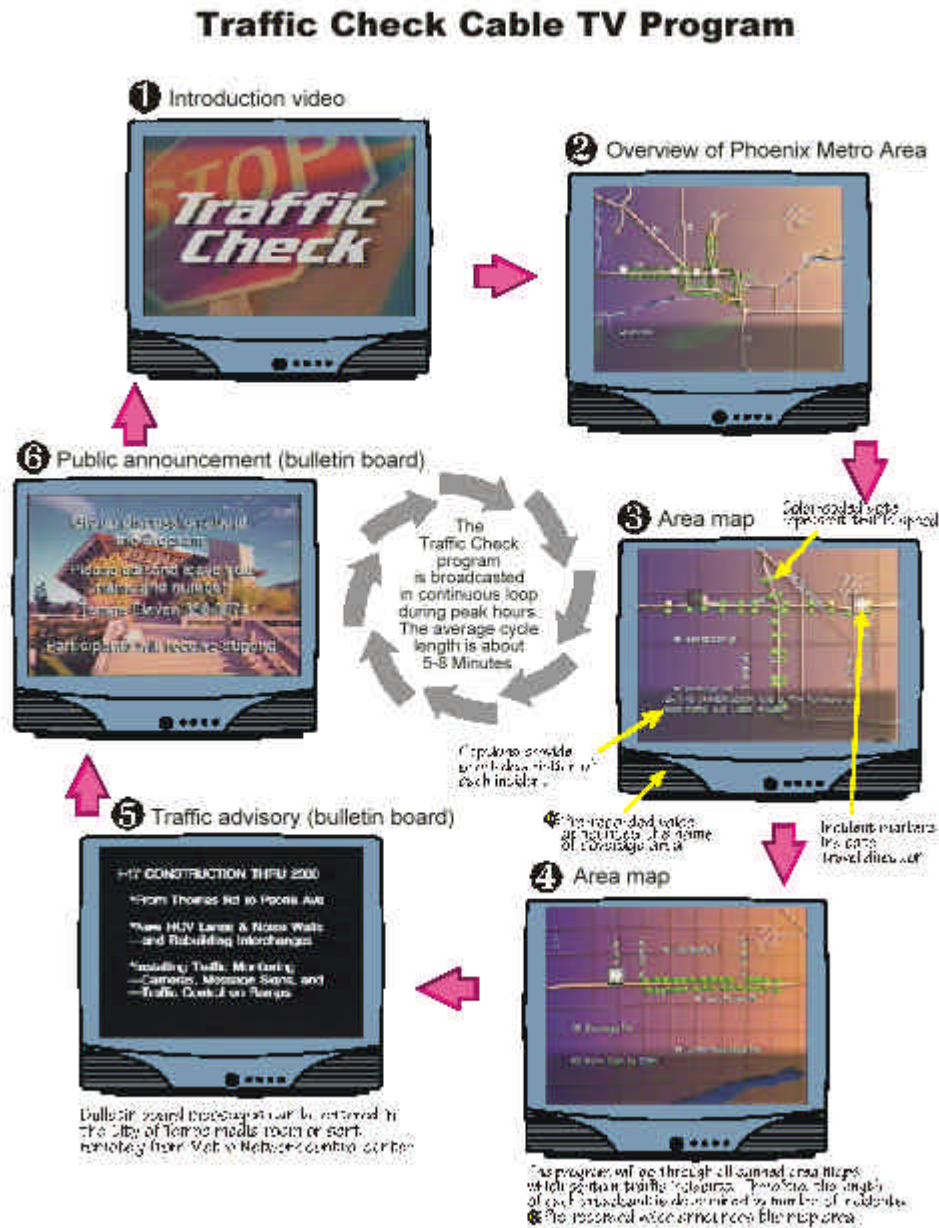
Figure 4.6: *Traffic Check* Cable TV Program

Traffic Check is able to achieve its high degree of automation because it is fully integrated with both the AZTech server and the advanced traveler information system server. This integration facilitates *Traffic Check's* up-to-the-minute, real-time traffic information reporting. The broadcasts also include information provided by Metro Network operators who, from aerial surveillance and rover reports, enter additional data into a workstation that feeds the advanced traveler information system server.

The television program elements include travel speed, incident maps, congestion and incident locations (including accidents, construction, and road closures), brief narrative explanations of traffic conditions, traffic advisory bulletins, and live closed circuit TV clips from the freeway management system and the Roadway Closure and Restriction System. Background music is also added to the broadcast. Traffic reports are supplemented by other information collected by Metro Networks from sources such as the police and fire departments.

Traffic Check began airing in Tempe on June 1, 1998. Traffic information broadcasts are provided continuously during the morning rush hours from 6 AM to 8 AM. Originally, the traffic information was to be broadcast during the morning and evening rush hours. However, the PM broadcast was never implemented because Tempe officials decided that very few people would need the information from their homes during the afternoon peak. Data and video images from the arterial system were not included because of delays in the deployment and integration of the Roadway Closure and Restriction System as well as the Traffic Operations Center network.

Broadcasts are typically repeated every five to eight minutes, depending on the number of incidents to report. In unusual cases, a single cycle of the program can last up to 15 minutes. Members of the national evaluation team questioned afterward whether the broadcast cycle was too long to maintain the interest of viewers.

4.4.2   Project Costs for *Traffic Check* Cable Broadcasting

Total start-up costs for *Traffic Check* were calculated to be $405,142. Operation and maintenance costs were estimated to be $103,178, as shown in Table 4.5. Like Etak's commercialized Web page, the major cost driver is the Etak development and management costs. Purchase of a computerized video player to support automatic processing of the information is also included at $13,052. Only shared operation and maintenance costs were reported for this project (i.e., there were no operating costs unique to this project). One of the significant costs is the recurring cost of Etak/Metro Traffic information.

Table 4.5: Development Costs of *Traffic Check* Cable TV System

Equipment Description	Quantity	Unit Cost	Start-up Costs	O&M Costs
Computer Video Player System and Materials	1	$13,052	$13,052	
Etak Cable TV System Development	N/A	N/A	183,887	
Etak Cable TV System Management	N/A	N/A	45,113	
Advanced Traveler Information Systems Server Shared (16.7%)	N/A	N/A	92,008	$94,377
AZTech Server Shared (4.2%)	N/A	N/A	71,082	8,801
Total			$405,142	$103,178

4.4.3 *Traffic Check* **Customer Satisfaction Evaluation Results**

This section presents and interprets results from the customer satisfaction survey performed for the *Traffic Check* cable TV traffic information program. The results and findings from the survey are interpreted against the backdrop of the relatively low congestion of the Phoenix region. As described in Section 2, the research conducted across the MMDI sites suggests that customer satisfaction is significantly conditioned by several factors.

The information presented in this section focuses on findings from the survey that help advance the understanding of how these factors influence the use of and benefits experienced from traveler information presented over cable TV. These findings provide a rich context for considering the role of cable TV as a traveler information medium and providing specific recommendations for the *Traffic Check* service. The complete results of the *Traffic Check* customer satisfaction survey can be found in a separate document.[19]

Background

The customer satisfaction evaluation of *Traffic Check* began during the month of December 1998 when postcards soliciting participation in the study were included in the monthly billing for all 35,000 customers of Cox Cable TV in Tempe. Questions on the postcard sought to identify individuals in these households who had ever watched the *Traffic Check* broadcast on Channel 11, whether they watched television regularly during weekday mornings or evenings, and how many persons in the household were regular commuters. Incentives were offered to encourage responses to the postcards.

All respondents who reported having watched *Traffic Check* were included in the initial sample and were contacted for a more detailed telephone survey from mid-December 1998 through early April 1999. Half as many non-viewers of *Traffic Check,* who were regular commuters and who watched morning television, were randomly selected into the sample for telephone interviewing.

The key objectives of the customer satisfaction evaluation of *Traffic Check* were to:

- Assess the extent of awareness of this new service;
- Understand who uses the service, when, and how frequently;
- Understand and describe the characteristics of different groups, especially users and non-users, and commuters and non-commuters;
- Compare use of *Traffic Check* with other available sources of traffic information and determine how *Traffic Check* affects travel decisions;
- Assess the value and benefits of *Traffic Check* to users; and
- Identify the most useful aspects of the service and provide recommendations for enhancing the service.

Analytical Considerations

In all, 723 telephone interviews were completed, split almost evenly between those who said they had watched *Traffic Check* and those who said they had never watched it. Readers are cautioned that the

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[19] "This discussion is elaborated in a companion MMDI evaluation document, *, Tempe Traffic Check Cable TV: Customer Satisfaction Evaluation*. Draft Report (in preparation)."

low response rate of 7% to the postcard questionnaires means that an unknown amount of sampling bias has been introduced into the results.[20]

Out of all the postcards returned by cable TV subscribers, 28% of respondents reported they had viewed *Traffic Check.* Since viewers of these broadcasts are more likely to have returned postcards on this topic, the actual proportion in the population that has ever watched *Traffic Check* is likely to be lower than 28%. Therefore, it is difficult to assess how representative this sample is of all Tempe cable TV households. The results from this analysis should be considered suggestive, and extrapolation from the findings presented here to broader populations should not be done in the absence of further research.

Results

The *Traffic Check* survey was designed to investigate the use patterns and benefits of the *Traffic Check* broadcasts to users, incorporating non-users as a control. The analysis is divided into eight areas:

- General characteristics of respondents
- Awareness of having watched *Traffic Check*
- Timing, duration, and frequency of use
- Usefulness and perceived benefits of *Traffic Check* compared to alternative sources
- Travel behavior changes based on using *Traffic Check*
- Suggested improvements and perceived benefits
- Value of *Traffic Check* to users
- Interpretation of survey results and conclusions.

To help readers understand the following discussions, several definitions are provided to identify the sample and its subgroups. The term "respondents" refers to the entire group of individuals who completed the telephone survey. "Users" signifies respondents who had watched *Traffic Check* at least once, whereas "non-users" refers to respondents who had never watched the broadcast. "Commuters" are defined as respondents who travel to work or school at least three days per week. "Non-commuters" commute less than that or not at all.

General Characteristics of the Respondents

Given the data limitations mentioned above, this section provides a brief overview of the major characteristics of the *Traffic Check* sample. One way of looking at general characteristics is to compare users and non-users of *Traffic Check.* Figure 4.7 shows that there are mainly small differences between non-users and occasional users of *Traffic Check* on demographic and attitudinal variables. However, *frequent* users differ from occasional users on several of these dimensions. While many of these differences are not statistically significant, frequent users are likely to be less educated, have lower household incomes, and have less commute flexibility. Both users and non-users of *Traffic Check* want to predict reliably how long their trips will take. They want more accurate reports about traffic congestion on their usual and alternate routes in the area. They like to plan ahead, and they generally prefer to ask someone for information rather than rely on a computer.

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[20] Approximately 2,330 postcards were returned out of the approximately 35,000 distributed to cable subscribers.

As seen in Figure 4.8, frequent users tend to have longer commutes, which includes a larger percentage of the trip caused by traffic congestion. They report a greater likelihood of encountering unexpected congestion on their normal routes, they want accurate traffic information, and they are slightly more likely to say they worry about being late. Frequent users are less likely to report that they are comfortable with high technology compared with occasional and non-users.

The data suggest that about one-third of the respondents encounter unexpected congestion two or more times per week and one-third report that they rarely encounter unexpected congestion. Reports of unexpected congestion are actually higher among the Phoenix cable TV viewers than the Seattle cable TV viewers, though other indicators of congestion highlighted in Section 2 suggest that Seattle traffic is much worse than in Phoenix.
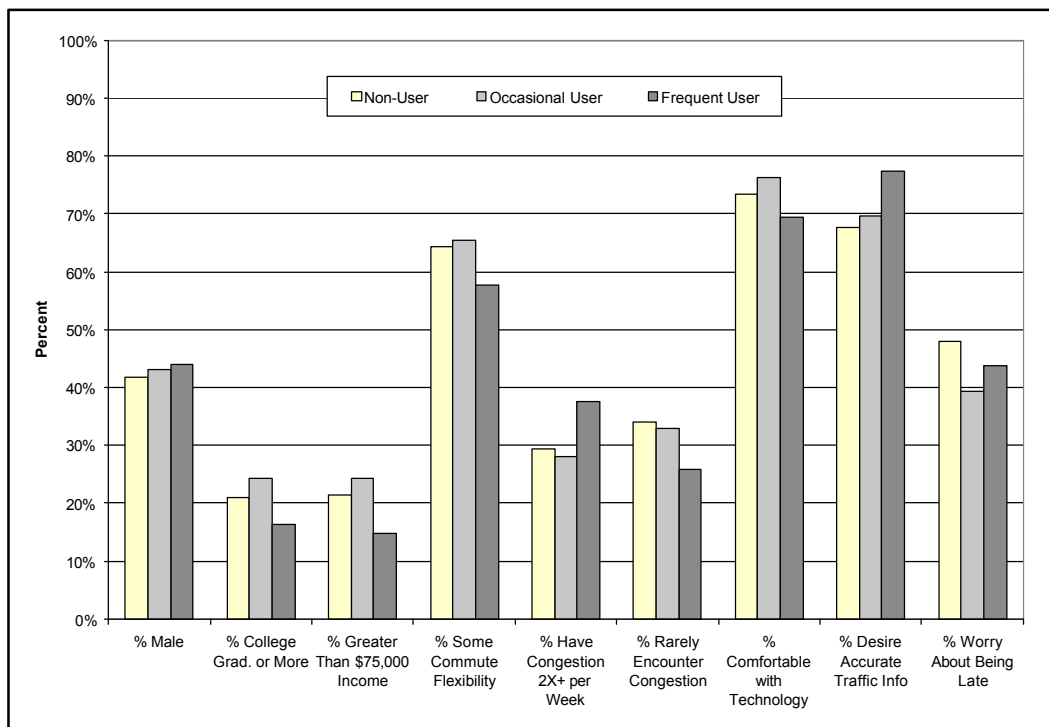
Figure 4.7: Comparisons among Non-Users, Occasional Users, and Frequent Users on Various Demographic and Attitudinal Variables

Another way of looking at the sample is from the perspective of commuters, whether or not they used *Traffic Check*. This group accounts for 75% of all respondents to the survey. About 91% of them report that their primary mode of commuting is a car (or other personal vehicle), typical of metropolitan areas that do not have extensive transit systems or a high transit mode share. About 87% of commuters report driving alone. Commuters indicate that they have alternatives if their normal route to work or school is blocked. This is yet another potential factor in demand for the *Traffic Check* service.
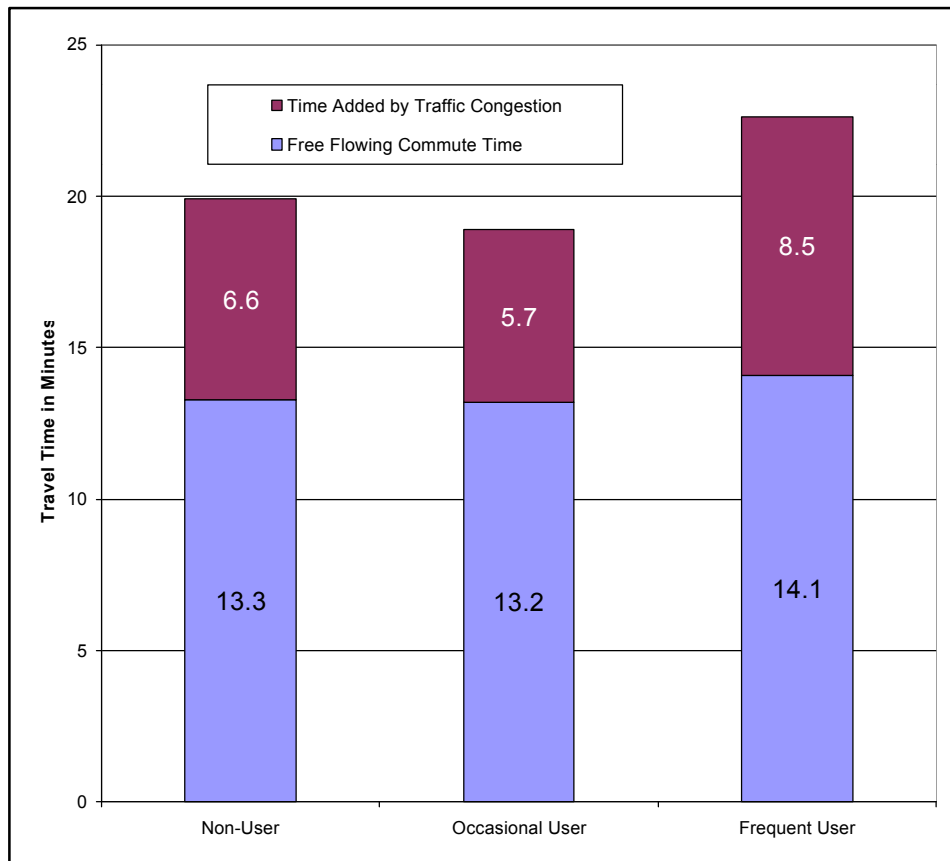
Figure 4.8: Comparisons Among Non-Users, Occasional Users, and Frequent Users on Length of Commute Time and Impact of Congestion on Total Commute Time

How much flexibility commuters have in their arrival or departure time to and from work was considered a possible factor in *Traffic Check* use. About 37% of commuters report having no flexibility in their arrival time at work or school. Approximately 25% say they are relatively free to adjust their start and finish times, and the rest of the commuters report different amounts of flexibility, between 15 and 30 minutes. The arguably high level of arrival time flexibility in this sample could be related to the high academic population in Tempe and/or the existence of a significant number of professional employees who do not "punch a time clock." Reported flexibility in commuters' arrival time at work or school was unrelated to use of *Traffic Check.*

Awareness and Viewing of Traffic Check

Awareness of a traffic information service is an essential consideration for evaluating the attractiveness and effectiveness of an advanced traveler information system. Obviously, if consumers do not know about a service, they cannot use it. This would affect both the type of responses received in a customer satisfaction survey as well as the service's long-term success. In reporting how they first found out about *Traffic Check,* 84% of users said they found the program while flipping through different channels on their TV. This may suggest the potential benefit of more active promotion in increasing awareness of *Traffic Check*, which was minimal during the evaluation period.

The customer satisfaction team hypothesized that regular commuters who report longer commutes, and those whose commute is more likely to be lengthened by congestion, would be more interested in obtaining traffic information and hence would be more likely to have ever watched *Traffic Check* broadcasts. However, there is no significant difference in the proportion of commuters versus non-commuters who had actually watched the traffic broadcasts.

Other differences in average responses between commuters and non-commuters are not very large. Rather, the important and statistically significant differences tend to be related to frequency of use of *Traffic Check,* whether or not the user is a commuter as discussed above. These differences in frequency of use are explored in more depth in the next section and will help provide a context to interpret some of the important characteristics of *Traffic Check* users.

To enrich the findings from the descriptive statistics obtained from individual survey questions and straightforward cross-tabulations between variables related to watching *Traffic Check*, the variable "ever watched *Traffic Check*" was evaluated against several possible predictor variables using a regression model.[21] The model uncovered several predictive attitudes that did show up in other statistics, including the following:

- Comfort using high technology equipment
- Belief that it is worth spending time checking traffic conditions
- Tendency to check traffic information when running late.

All the other variables, including gender, education, and whether or not the respondent is a regular commuter, were not significant in predicting whether a respondent had ever watched *Traffic Check*. Note, however, that these same variables *do* produce meaningful results when analyzed in more detail using different subgroups of the sample.

Duration and Frequency of Use of Traffic Check

In this section, the characteristics of users who have watched *Traffic Check* longer and who watch more or less frequently will be examined. Then, their attitudes toward high technology, traffic conditions in the greater Phoenix area, personal reactions to travel planning and congestion, and the need for traffic information will be explored. Unless otherwise noted, the focus of findings in this section is on *Traffic Check* users, both frequent and occasional.

The number of months that users reported having watched *Traffic Check* is not correlated with education, age, income, length of commute time or the perceived level of congestion. Over half the viewers, or about 57%, report that they have been watching *Traffic Check* for three or fewer months. Another 24% have been watching four to six months, and the remaining 19% for seven months or more. It is important to note, however, that *Traffic Check* first aired June 1, 1998, which was only six months before the beginning of the four-month period of telephone interviewing. This timing therefore limits how long anyone could have viewed the program.

As noted above, about half of the survey respondents reported watching *Traffic Check* at least once*.* Of those who had watched, 39% indicated that they used the program frequently, between twice a week and every day. About 25% of those who ever watched *Traffic Check* used it once a week, and the remaining 38% used it three times a month or less. While few significant differences were found

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[21] A multivariate linear regression model was used in order to identify which variables independently predict whether a respondent says they have watched the broadcast. The model included gender, education, age, commuting, and each of the 18 attitudinal variables.

between users and non-users in the previous section, how frequently users reported watching *Traffic Check* is an important factor when analyzed against a variety of other variables in the survey.

First, demographic characteristics do not help explain frequency of use. How often one watches *Traffic Check* is unrelated to gender, and weakly related to education level and household income. An individual's commute experience—duration, level of congestion, and likelihood of unexpected delays—are better predictors of using *Traffic Check*. For example, as would be expected, those with the shortest average commute time (five minutes or less) are less likely to report watching *Traffic Check* compared to those with longer commute times. The frequency of watching *Traffic Check* is somewhat higher for those who experience more traffic congestion on their average commute.

The average commute time among all commuters in the sample is 20 minutes. About 47% of the sample reported a commute time of 15 minutes or less. In contrast, only 26% of commuters in Seattle experience travel times of 15 minutes or less. The average congestion delay (time difference between normal commute and free flowing conditions) is a little less than six minutes in Phoenix while in Seattle congestion adds almost 10 minutes to the typical commute.

To explore these relationships in greater detail, several regression models that had 'frequency of use' as the dependent variable were run using all *Traffic Check* viewers, with gender, education, age, length of commute, congestion experience, work arrival flexibility, and a set of attitudinal variables as independent, predictor variables.[22] The modeling results show that several variables are statistically significant in predicting how frequently a user reports viewing *Traffic Check.* In particular, the model indicates that longer commutes and greater perceived congestion experienced on the commute are good, independent predictors of how frequently a respondent uses *Traffic Check*.

Education just misses having a statistically significant bi-variate relationship with frequency of use, but when included in the multi-variate regression model, education is shown to have a significant independent effect. A higher level of education is associated with *lower* frequency of use of *Traffic Check.*

Some of the attitudinal variables analyzed in the regression model applied to *Traffic Check* users showed significant effects on viewing frequency. For instance, the likelihood of checking traffic information when running late is associated with higher viewing frequency of the traffic broadcasts. Less comfort using high technology equipment (such as computers, the Internet, cell phones and personal pagers) is also positively related with higher viewing frequency of *Traffic Check.* For instance, those who use *Traffic Check* most frequently are *less* likely than occasional users to report using a computer at home, accessing the Internet at home, or carrying a laptop computer.

These findings are consistent with results of another analysis of traveler information users that found a high proportion of survey respondents who are frequent users of cable TV to obtain traffic information are among "low-tech, pre-trip information seekers."[23] (As already noted, comfort with high technology elicits no significant differences when the comparison is between *users* and *non-users* of *Traffic Check*.) Another finding of the regression model is that getting annoyed easily with traffic delays is predictive of *less* use of *Traffic Check.* This is opposite of what would be predicted, assuming that annoyance with delays would prompt those people to seek out better traffic information more often.

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[22] For most of these models we have used logistic regression with a dichotomous dependent variable (dummy variable) coded as two or more uses per week versus everyone else, in order to investigate what distinguishes the most frequent users of *Traffic Check*.

[23] See: "Traveler Information User Profiles." Customer Satisfaction Evaluation. Draft Report. 10/6/99.

Gender, age, and commute-time flexibility did not emerge as useful predictors in this model, which is consistent with the finding reported above. As for acquiring traffic information, frequent users are more likely to seek out accurate traffic reports and much more likely to report that it is worth checking traffic reports before a trip. Similarly, members of this group are much more likely to say they check traffic information during bad weather or when they are running late, and they are more likely to say they want more accurate traffic reports.

Alternative Sources of Traffic Information, Usefulness and Perceived Benefits of Traffic Check

Regardless of whether they watch *Traffic Check*, 97% of all commuters report using firsthand knowledge of traffic conditions as seen from their private vehicles, and 93% report listening to traffic radio broadcasts. These are the two most widely used methods of obtaining traffic information for this group. Approximately 77% use traffic reports on regular local television, 75% rely on electronic changeable message signs on the highway, and 48% report using *Traffic Check*.

It may be instructive to note that of the five methods described here, three of them provide traffic information en route. Clearly, en route information potentially offers the most current, relevant information that can be applied on-the-spot in various traffic situations, with no delay between acquiring the information and experiencing a traffic problem. In contrast, pre-trip information offers value for making strategic travel route and timing choices. The earlier finding that respondents have good knowledge of local roads may lend credence to the argument that en route information is more useful when congestion is low on average, but occurs unpredictably from time to time. This would make pre-trip decisions less important, an interpretation that is consistent with the Trailmaster focus group finding that participants understand the roads and have no difficulty finding alternate routes when abnormal congestion is encountered during travel.

The notion that pre-trip information has less value in some contexts is further supported by the fact that 60% of commuters reported that seeing congestion for themselves was very or somewhat useful. About 77% said they found radio broadcasts useful while 38% reported local television traffic reports were useful. Similarly, 58% said electronic changeable message signs on the highway were useful. For these information sources, respondents' use of them tends to be matched by how useful they find them. The fact that seeing congestion first hand is perceived to be somewhat less useful than traffic radio is understandable given that commuters may discover congestion after it is too late to avoid it.

Only 29% of *Traffic Check* users reported that the service was very or somewhat useful while 40% reported that it was not very useful. This finding is consistent with the contrast between the high use and much lower reported usefulness of local television reports, a medium that is very similar to *Traffic Check*. In fact, the difference between the two measures is even greater for local television than it is for *Traffic Check*, which could be evidence that *Traffic Check* provides more complete information than traditional traffic segments on regular TV. The reported usefulness of the other traffic information sources listed in the survey (highway advisory radio, telephone calls, and the Internet) was 38%, 13%, and 16% respectively.

The reported usefulness of *Traffic Check* was evaluated further using other variables. For example, users with a high school education or less were somewhat more likely to find the service useful. This could be related to attitudes toward high tech equipment and, as discussed earlier, lower education is associated with higher frequency of use. As with other reported findings, there were no differences in *Traffic Check* usefulness when compared to age or household income. In contrast to factors that motivate some respondents to watch *Traffic Check,* there were no clear effects of congestion experience or commute flexibility on perceived usefulness of *Traffic Check*.

Frequent use of *Traffic Check* by *commuters* emerges again as an essential factor, this time in evaluating reported usefulness of the service. As shown in Figure 4.9, commuters who were frequent users were *much* more likely to report that the broadcasts were very or somewhat useful than infrequent users. When asked whether *Traffic Check* provides more useful information than radio broadcasts, those who said *Traffic Check* was very or somewhat useful also tended to say it was more useful than the radio. This last finding is particularly notable since the utility of radio for obtaining traffic information usually rates very high.
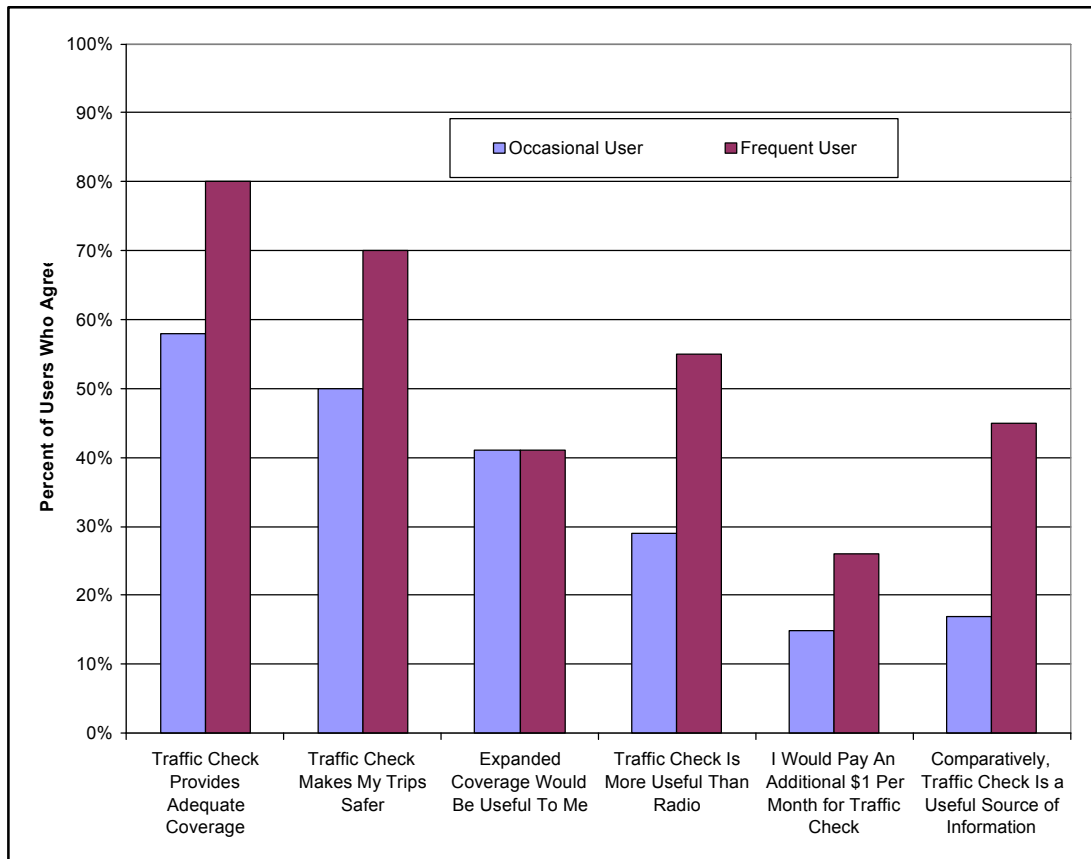
Figure 4.9: Comparisons between Occasional and Frequent Users on Satisfaction with *Traffic Check*

Eighty percent of survey participants who were frequent users of *Traffic Check* stated that the service provided adequate coverage about traffic on the routes that they travel, compared with 58% of the occasional users. Overall, only 12% disagreed with this statement. This is in contrast to the findings in the Trailmaster Web site analysis, where focus group participants felt that the site's coverage needed to be expanded to improve its usefulness. Frequent users were much more likely to rate *Traffic Check* information as more useful than traffic radio (55%) compared to less frequent users (29%). Frequent users also said that consulting *Traffic Check* made their trips safer (70% of the most frequent users said this, compared with 50% of the occasional users).

Users reported watching *Traffic Check* for various types of roadway information. Between 75% and 84% of those who said they had watched *Traffic Check* indicated that they tuned in to get information on road closures, incidents or accidents on their routes, or on other routes that might impact their

travel. For those who reported using *Traffic Check* for these different information types, users found the broadcasts most *useful* for providing road closure information (79%), and for learning about accidents on their route (72%). Reported usefulness among the most frequent users of *Traffic Check* was even higher. It ranged from 84% who said the road closure information was useful to 40% who reported incident or accident information for other roads that could potentially affect their route was useful. For infrequent users, the respective statistics are 71% and 25%.

When asked to rate the usefulness of all sources of traffic information, frequent users of *Traffic Check* were over two and a half times as likely as occasional users to report that these broadcasts offer a useful source of information. Among the commuters who use *Traffic Check* for information on their trips to work or school, 37% indicated they have used it for other non-commute trips they take within the area.

Travel Behavior Changes Based on Use of Traffic Check

All regular commuters (but not necessarily *Traffic Check* users) were asked which travel behavior decisions they had made in the past year in response to traffic congestion or an accident on their normal route, regardless of where they may have obtained their information. The most prevalent travel behavior change to such events was taking a different route, which was reported by 80% of commuters. Approximately 72% had made small changes to their normal commute route to avoid the congestion in the last year. Just over half of commuters indicated that they made no changes and traveled as originally planned. The next most likely travel change made by commuters was to adjust the time of their departure, a strategy employed by 51%. Around 29% said they chose to make other stops that they would not normally have done. Only 10% said they chose to travel by a different mode, and 3% indicated that they decided not to make the trip at all.

Phoenix and Tempe are cities that spread out over a wide area, with a grid network of arterials and many new freeways that offer route alternatives for travelers faced with backups on their normal routes. This would help explain the high proportion of respondents choosing some form of route change as their predominant option (which is consistent with findings from prior research that route changes are the most frequently reported behavior change in response to traffic information). Changing routes also has been shown in other MMDI studies to be the most likely behavioral response to traffic condition information.[24] Other characteristics of the sample, such as knowledge of local roads, would also support this finding.

Commuters who reported having watched the *Traffic Check* broadcasts were asked a similar set of questions about their driving decisions when they learned of problems on their normal route. Of those commuters who had watched *Traffic Check* and learned of traffic problems, 74% had made two or more trip changes since watching the broadcasts. The majority said they made one route change, with 62% changing their entire route and 63% making small changes in their route to avoid congestion. These figures are both less than reported by the entire commuting group.

Commuters who did not use *Traffic Check and* who experienced the largest time differences between congested and non-congested travel times were more likely to elect to change their whole route (69%) or part of it (80%) compared with those who experienced no difference (55% and 59%, respectively). It is also plausible that the extensive network of freeways and arterials in Phoenix makes it easier to avoid congested areas by making small route detours, compared with other cities where the constraints of the network provide fewer such opportunities and may require major route changes under similar conditions.

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[24] This discussion is elaborated upon in a companion MMDI evaluation document, *Customer Satisfaction Evaluation Overview: National Synthesis.* Draft Report (in preparation).

Commuters who use *Traffic Check* and who reported that they encountered unexpected delays on their route at least twice a week are more likely to make small route changes than to take a whole different route. One hypothesis is that individuals who face congestion most frequently have been motivated to learn small detours to get around congestion. Of those who took an entirely different route, 60% said this increased their travel time and 68% said it increased their miles traveled. About 30% said the change decreased stress whereas 23% said their stress had increased. Approximately 47% reported that taking a whole different route made no difference in the stress they would have felt in their usual commute.

An important notion in interpreting these results is that survey participants were asked to compare their normal commute against an alternate route chosen to avoid congestion. Perhaps the findings would have shown greater benefits if respondents had been asked to compare the travel time and stress on their normal route against *the increased congestion they would have experienced had they not known about the problem in advance* and therefore had not taken an alternate route.

The next most prevalent trip change in response to traffic problems learned via *Traffic Check* was to change the time of departure. Approximately 52% of commuters made this choice as a result of learning about traffic problems. *Traffic Check* users who experienced the largest difference between congested and non-congested travel times were significantly more likely to elect to change trip timing (64%) compared with those who experienced no difference (43%). Of those who said they changed their trip timing, 45% said this increased their travel time and 53% said it increased their miles traveled. Again, most said it either decreased stress (39%) or made no difference in the stress they would have felt in their usual commute (42%). The experience of unexpected delay at least twice a week is not significantly related to changing trip timing.

For almost all of these users, any trip change based on *Traffic Check* information either increased or made no difference in trip time and miles traveled. Only a few respondents (6%) chose traveling by a different means of transportation. For the 39% who said they made no changes due to the traffic information, 58% of them said this would make no difference in their travel time. That is, although they were made aware of a traffic problem, they did not think this would affect their trip time.

Figure 4.10 displays what travel behaviors commuters reported selecting in the past. The non-users of *Traffic Check* were asked which of these decisions they made in the past year in response to learning that their normal commute route was blocked due to traffic congestion or an accident. Occasional and frequent users of *Traffic Check* were asked what they have done in response to information obtained from the *Traffic Check* broadcasts. The results suggest that frequent users are more likely to report travel behavior changes compared to occasional users of *Traffic Check*. In particular, frequent users were much more likely than occasional users to make a departure time change. All occasional and frequent *Traffic Check* users are less likely than non-users to make route changes, mode changes, or other stops along their normal route. The users are somewhat more likely than non-users to change departure time.
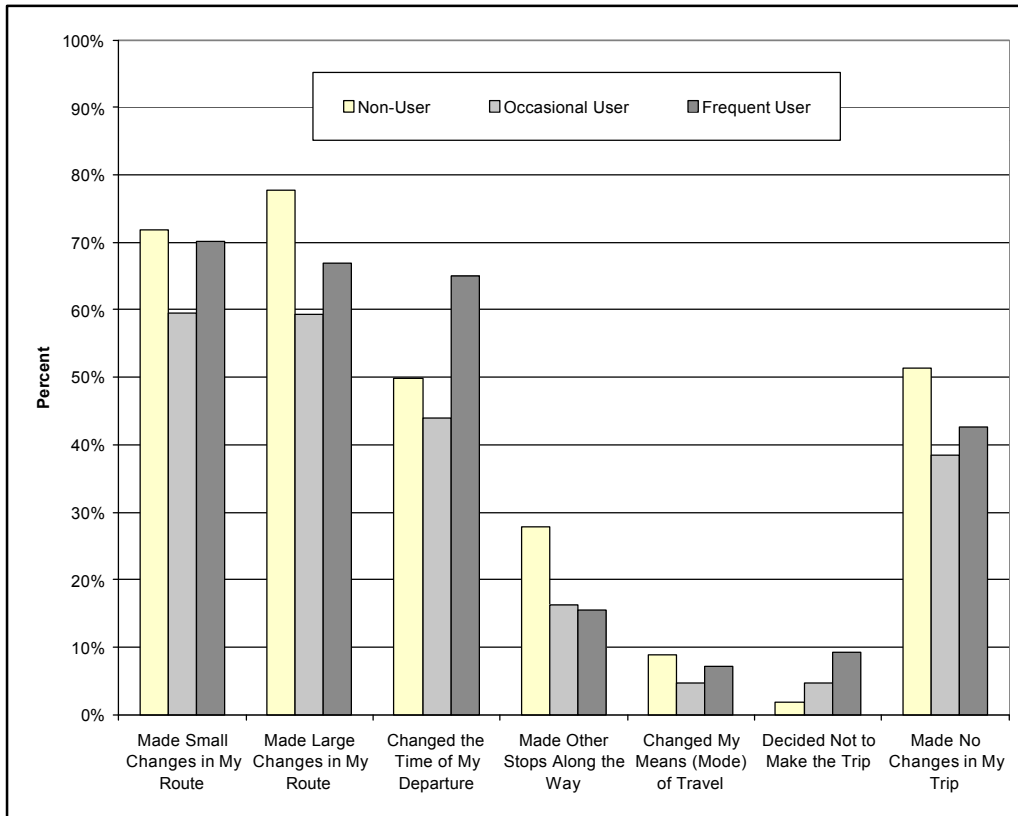
Figure 4.10: Comparisons Between Non-Users, Occasional Users, and Frequent Users Regarding Selection of Various Commuting Trip Decisions

Suggested Improvements to Traffic Check and Perceived Benefits

The customer satisfaction team analyzed what respondents thought could be done to improve the service and enhance their satisfaction with *Traffic Check*. Respondents who had watched the traffic broadcasts were asked to indicate how strongly they agreed or disagreed with several statements about the kind of information provided and how the information was presented.

Of all viewers, 71% agreed that the *Traffic Check* maps are easy to read. About 66% answered affirmatively that the broadcasts provide adequate coverage about traffic conditions along the routes they usually travel. Another 57% of these users stated that broadcast images do not move too quickly. About 40% of users agreed that they generally spend more time listening to *Traffic Check* than watching, and the 35% who disagreed presumably both listen and watch. The rest were neutral. Perhaps the relatively large proportion of users who listen rather than watch indicates that the audio portion of the broadcasts is performing well and providing sufficient information without the visual component.

Users' opinions vary regarding possible changes to the presentation of traffic information on *Traffic Check.* These survey questions resulted in no overwhelmingly endorsed changes. However, users were generally in favor of receiving suggestions for alternate routes when incidents slow or block traffic, with 68% supporting this improvement and 13% not supporting it. It is important to note that this is not an existing feature of *Traffic Check* and is typically a service that transportation agencies are reluctant to provide because of potential liability issues as well as complaints from neighborhoods that might be adversely impacted by increased traffic on local streets.

Offering live camera views of traffic on the major highways and roads was endorsed by 48% of users (vs. 32% who disagreed with this change). Providing color-coded map displays of traffic speeds was attractive to 46% (vs. 24% who disagreed with adding traffic speeds). Although live camera views and color-coded maps attracted the endorsement of less than half of *Traffic Check* users, the responses are consistent with findings from the Trailmaster Web site analysis indicating support for the same features on the Web page. Approximately 46% wanted *Traffic Check* broadcasts on the weekend versus 37% who did not feel that would be useful. Another 41% supported expanding coverage to more hours of the day while 35% did not concur.

On several other suggested changes, these same users were either split in their opinion (neutral) or disagreed with the change. For instance, only 30% supported having a live person describe traffic conditions and 35% wanted the broadcasts to include other information, such as weather. About 26% expressed interest in more graphics on the screen. Users were generally neutral toward suggestions such as having *Traffic Check* describe other travel options available on air quality alert days or having different colors for the symbols that represent different accidents or incidents.

Value of Traffic Check to Users

Currently, subscribers to the Tempe cable TV network do not pay extra to receive the *Traffic Check* broadcasts, since they are provided as a public service. However, in order to have some sense of how viewers value this service, they were asked whether they would be willing to pay an additional $1.00 per month on their cable TV bill to continue receiving *Traffic Check.* The responses reflect strong opposition to paying for the service, with only 19% of users reporting a willingness to pay and 62% unwilling to pay an additional charge. This response mirrors a related question regarding users willingness to pay $1.00 per month to continue receiving the Weather Channel, where 24% were willing and 63% were opposed. Given the presumed greater familiarity with the Weather Channel among respondents, these results lend credence to the assumption that cable TV subscribers are not likely to pay for traffic information like *Traffic Check.* However, this level of willingness to pay is notable considering similar studies by the customer satisfaction team where much lower propensity to pay was reported.

When only commuters who use *Traffic Check* are examined, there is evidence that those who experience congestion delays are somewhat more likely to be willing to pay the extra $1.00 a month as compared with commuters who experience no delays. Following their earlier pattern, frequent users of *Traffic Check* were more likely to be willing to pay for the broadcasts, although with 26% in favor and 54% opposed it is not a resounding endorsement of a fee-based service. Finally, as noted earlier, those who found *Traffic Check* the most useful were also more willing to pay the extra $1.00 per month for the service.

Conclusions and Recommendations

Some of the most significant findings from the *Traffic Check* survey concern external factors that were introduced in Section 2. That is, they focus on overall travel conditions in the Phoenix metropolitan region as reported by survey respondents rather than on *Traffic Check* use, features, or satisfaction with the service itself. These external factors include the following:

- The average length of time spent commuting one way is about 20 minutes, which is 28% less than the average commute time reported by viewers of the traffic cable TV program in Seattle, a much more congested urban area
- Most commuters in the sample do not experience large time delays compared to free-flowing traffic conditions

- Only a small number of respondents reported experiencing unexpected delays while commuting
- Most respondents reported that they have alternate routes if their normal route is blocked, they know the street network well, and they are comfortable asking for directions.

One issue that focuses directly on *Traffic Check* is frequency of using the service. About one-third of respondents in the *Traffic Check* sample use it frequently (i.e., two times or more per week). As highlighted above, it was this subgroup (39% of the viewers) that exhibited the most satisfaction with and motivation for using *Traffic Check*. They also provided the clearest direction for improving the service.

These factors, coupled with the relatively small portion of the total cable TV population in Tempe who view *Traffic Check,* suggest that the potential demand for pre-trip traffic information like *Traffic Check* may be limited at this time for the entire cable TV subscriber population. This interpretation is consistent with the findings from the Trailmaster evaluation discussed earlier, as well as other MMDI studies performed by the customer satisfaction team.

Even with external conditions apparently limiting demand, the study results do show that *Traffic Check* information caused viewers to change travel behaviors. For example, users who experienced the most delay were much more likely to change routes in response to congestion information. Of commuters who had watched *Traffic Check* and learned of traffic problems, 65% had made two or more trip changes within the last year, and 36% said they had made two or more trip changes *in the past week*.

A Market Niche Identified?

Given the consistent response of frequent *Traffic Check* users on many survey questions, one way to interpret the overall study results is to assume that the *Traffic Check* service already has a clearly defined market niche. If this assumption were correct, it would be beneficial to maximize promotion to this market segment, as well as to others with the similar characteristics, as a way to build demand for the service. Frequent users demonstrated that the following characteristics are related to potential demand:

- They were much more likely to find *Traffic Check* useful for planning travel. They rated the information on road closures and accidents most useful.
- They were much more likely to say *Traffic Check* is more useful than the radio for obtaining traffic information.
- They reported that *Traffic Check* provided adequate coverage of the routes they travel.
- They indicated strongly that *Traffic Check* helped make travel safer.
- They were much more willing to pay an additional $1.00 per month on their cable TV bill for continued access to *Traffic Check.*
- They typically have longer commutes, greater congestion on their commute, and more frequent unexpected delays.
- They are less comfortable with computers and high technology than other respondents.

This profile of frequent viewers suggests that their lower comfort with high technology means that a cable TV traffic information service fills a need for the "low-tech" consumer. Frequent viewers of *Traffic Check* are also more likely to use traffic programs on regular local television broadcasts, suggesting that TV may be the information medium of choice for this market segment. Because this sample is limited by its non-random nature and because the population from which the sample is derived is restricted to Tempe households and not the greater Phoenix area, this thesis can not be fully tested with the existing data.

Customer Satisfaction

The *Traffic Check* study showed that the sample was generally satisfied with the content and presentation of the traffic information service, independent of the respondent's subgroup. This is in contrast to several findings from the Trailmaster analysis, where various aspects of the content and user interface appeared to be barriers to use. In general, users found that the *Traffic Check* maps are easy to read, broadcasts provide adequate coverage, images do not move too quickly, and both the audio and video components of the broadcasts are useful.

The somewhat inconclusive responses to travel impacts – trip mileage, duration, and stress – should not be interpreted unfavorably. As stated above, survey participants were asked to compare their normal commute against an alternate route. One hypothesis is that the reported benefits would have been greater if respondents had been asked the question in terms of their expected travel time and stress level if they had actually gotten stuck in the traffic *they avoided* by using *Traffic Check*. One clear benefit of the service is that viewers felt strongly that using *Traffic Check* made their trips safer and the more frequently viewers used the service the greater their perceived safety benefits.

However, these and other findings should be interpreted in the context of relatively low use of the service, which by itself could indicate either a lack of awareness or a lack of satisfaction. While frequent users are generally satisfied with *Traffic Check*, this may be more a function of self-selection combined with low traffic congestion than a sign of actual customer satisfaction. For example, those who are dissatisfied are not likely to continue using the service, and are therefore more likely to be underrepresented in this sample. In Seattle, where traffic congestion is more severe, those who use traffic information services, both on cable TV and on the Web, are much more demanding and have many more suggestions for the services' improvement.

Future Directions

The fact that nearly all respondents discovered *Traffic Check* by flipping through channels suggests the need for more active promotion of the service, whether or not it is targeted to all cable TV subscribers or to particular market segments. However, considering the market niche identified, it would make sense to target promotion to those most predisposed to use and benefit from the service.

One apparently subtle finding may help provide direction for improving and promoting the service. Since a large proportion of *Traffic Check* users primarily listened to the audio portion of the broadcasts, perhaps enhancing the content of the voice-overs would increase satisfaction and demand. In addition, since the audio component is similar to radio, perhaps the information could be broadcast on a radio station, providing a second medium to distribute the information and making the service available to travelers en route as well.

In addition to the several recommendations above regarding service promotion, the survey provides a good foundation for the AZTech team to plan enhancements to the service that could increase satisfaction and generate demand, perhaps beyond the niche market *Traffic Check* currently enjoys. Several suggested improvements are consistent with the Trailmaster findings and/or with other MMDI studies conducted by the customer satisfaction team. These desired features include the following:

- Suggesting alternate routes
- Providing live camera views
- Providing color coded maps of traffic speeds
- Providing coverage over the weekend
- Expanding coverage to more hours of the day.

It is just as important when enhancing the service to avoid features that the survey results suggest will not induce demand for or increase satisfaction with *Traffic Check*. These include adding a live person to the broadcast; providing other information, such as weather or ozone alerts; or incorporating more graphics.

In summary, *Traffic Check* is providing a valued service to those who use it. However, low awareness of the service among cable TV subscribers, combined with relatively manageable traffic conditions, limit the number of commuters who are regular viewers. Increased publicity of the service combined with the improvements recommended by current viewers and the continued growth of the population in the greater Phoenix metropolitan area should increase the number of viewers over time.

4.5   IN-VEHICLE NAVIGATION DEVICES

4.5.1   Project Description and Evaluation History

The AZTech project originally called for installation of in-vehicle navigation devices in 50 rental cars and 20 "project vehicles." The system was supposed to provide vehicle navigation and real-time information broadcasts via an FM subcarrier communication system. The in-vehicle devices would have provided route planning, turn-by-turn guidance, and point-of-interest information.

The project was ultimately cancelled. Scientific Atlanta, an original project participant, ceased producing their proprietary FM subcarrier receiver. This led AZTech officials to cancel the contract and drop Scientific Atlanta as a partner. The participating rental-car company originally agreed to supply 50 vehicles for the project, but never made an official commitment. The company started its own experiment in Florida and moved the cars there. Although AZTech officials wanted a self-sustained, commercially deployed system, they realized that this would not be accomplished within the MMDI deployment period. There was no assessment of cost assessment or evaluation of impact for this project, because it was cancelled.

4.6   FASTLINE PERSONAL COMMUNICATION DEVICE

4.6.1   Project Description and Evaluation History

Fastline, a company that has been involved in value-added traveler information systems for commuters for over five years, developed a system to download real-time traffic information from the Internet to Windows™ CE-based personal communication device. The browser software (formerly called Embarc, now called Personal Travel Companion,) is disseminated free via Fastline's Web site. It was designed to allow users to access information directly from the Internet via their hand-held computer. Fastline maintains its own traffic information server to receive, process, enhance, and disseminate the traveler information from the AZTech server to Fastline users. Fastline responded to the original AZTech RFP and was then included as part of the Etak team.

The service requires travelers to have their own Internet service provider to access the information, and, if they want to use it en route, they must have a personal communication device to do so. During the national evaluation timeframe, Fastline provided travel speed and information from the Roadway Closure and Restriction System. No major enhancements have taken place since the national evaluation period.

An on-line customer satisfaction survey was designed to evaluate the Fastline AZTech project, but a lack of response forced the survey effort to be cancelled. Overall, use of the service has been limited, perhaps because it received little publicity and the personal communication device platform was not widely in use at that time.

The Fastline approach to providing real-time traveler information has not matured. Travelers will not purchase handheld devices and wireless communication services just for transportation applications. Over time, applications will emerge that will justify the ownership of the hardware and communications services needed to deploy this technology for access to transportation information. Until these other applications emerge, handheld personal communications devices will not be a popular or successful standalone traffic information technology. In other words, using personal communications devices to access transportation information is just one function among many that must be available to a user before a serious market for the devices will develop. Further, lack of success could be due to the fact that people may not recognize what a personalized message system like Fastline can do for them. Indeed, little marketing of the service occurred.

4.6.2 Project Costs for Fastline

Start-up costs for the Fastline Personal Computing Device project were $288,985. The major unique cost was for Fastline development expenses, estimated to be $100,071, as shown in Table 4.6. Since users were expected to already own personal communication devices, only $7,932 was budgeted for them.

Table 4.6: Development Costs of Fastline Personal Computing Device

Equipment Description	Quantity	Unit Cost	Start-up Costs	O&M Costs
PDAs with Wireless Modems	6	$1,322	$7,932	
Fastline Development for AZTech[25]	N/A	N/A	100,071	
Etak Fastline Management	N/A	N/A	17,892	
Fastline O&M Staffing	N/A	N/A		$48,792
Hardware Maintenance @ 10% Capital Cost	N/A	N/A		2,500
Software Maintenance @ 5% Software Development Cost	N/A	N/A		37,750
Advanced Traveler Information Systems Server Shared (16.7%)	N/A	N/A	92,008	94,377
AZTech Server Shared (4.2%)	N/A	N/A	71,082	8,801
Total			$288,985	$192,220

Annual operation and maintenance costs of $192,220 are driven primarily by Fastline's costs for staffing, hardware maintenance, and further software development, which total $89,042.

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[25] The Fastline development began earlier in Seattle than in Phoenix. The Fastline Manager suggested that a 60/40 split in development costs would approximate what development spending had been across both sites.

4.7   TRANSIT STATUS INFORMATION

4.7.1   Project Description and Evaluation History

The AZTech project team proposed to provide en route bus schedule status information to transit passengers. The status information is generated on the AZTech server by a schedule adherence algorithm developed by Advanced Digital Systems (the contractor of transit Automatic Vehicle Location system) and integrated with other MMDI components by TRW. A data server was deployed at Phoenix Transit to supply transit information to the AZTech server. The data server is part of the complete replacement of the agency's communication system and schedule software system.

Because the system is integrated with the AZTech server, dispatchers have access to traffic information that the server processes. As discussed above, the Transit Status Information project is also integrated with Etak's commercial Web page, in the form of a beta test to display real-time bus arrival information via the Internet. Etak obtains this information from the Transit Status infrastructure via the AZTech server.

The deployment was originally going to distribute real-time schedule information via changeable message signs at three new transit centers and through the travel information kiosks. At the time of the national evaluation, a single light emitting diode display had been installed at the Central Station bus terminal in Phoenix. The AZTech project team still intends to deploy information devices at five bus shelters with one-line changeable message signs. Additionally, four of these devices will be installed in Mesa and six more in Scottsdale and Phoenix. Mesa officials will provide 50% of the additional project cost for its own installation. The information link will be by dial-up connection from the local city's AZTech workstation.

Given the limited deployment of the Transit Status Information System during the national evaluation period, evaluation focused on project costs and institutional lessons (Section 3).

4.7.2   Project Costs for Transit Status Information

Start-up costs for the transit information system were estimated to be $149,878. The major cost driver was the bus time arrival software development of $73,296. Operation and maintenance costs are estimated to be $8,801, although these are all due to AZTech server shared costs, with no unique operating costs reported for this project. It should be noted that, based on the information provided by the AZTech project team, no costs for the Transit Dispatch Automatic Vehicle Location system deployed to collect the data needed for providing transit status information are reflected in Table 4.7 below.

The cost information only reflects $5,500 for the development and installation of the single changeable message sign at Central Station in Phoenix (the only transit information sign that had been installed at the time of the cost analysis). As described above, several additional signs are expected to be deployed at various terminals and bus stops.

Table 4.7: Development Costs for Transit Status Information

Equipment Description	Quantity	Unit Cost	Start-up Costs	O&M Costs
Status Information Sign	1	$5,500	$5,500	
Bus Time Arrival Software Development	N/A	N/A	73,296	
AZTech Server Shared (4.2%)	N/A	N/A	71,082	$8,801
Total			$149,878	$8,801

4.8   TRAVEL INFORMATION KIOSKS

4.8.1   Project Description and Evaluation History

The AZTech project originally planned to install 50 travel information kiosks around the region. When information was gathered for the evaluation, 22 had been deployed with another six planned for future installation. The reason for the reduction is that the public reaction to kiosks has been difficult to determine (although the request for proposals required the vendors to capture usage data). Also, installation of outdoor kiosks took longer than expected due to unforeseen manufacturing delays caused by the weatherization process.

The kiosks that have been deployed to provide multimodal traveler information fed from the AZTech server at selected public and commercial locations. This includes five units deployed at transit stations (although they are not transit-specific). The kiosks provide access to real-time traffic conditions on freeways and major arterials, and transit schedules, similar to what is found on the Trailmaster Web site. The units have touch-screen user interfaces, audio, and built-in printers. The software is similar to a Web browser application, and the information is updated remotely via a dial-up connection. Sale of advertising on kiosks was allowed in the contract but was never attempted. There are no plans for doing so in the future.

Evaluation of kiosks focused on project costs and institutional lessons (Section 3) because the customer satisfaction team did not observe sufficient user activity to justify further analysis. The national evaluation team selected another MMDI site (San Antonio) for assessment of kiosk benefits.

4.8.2   Project Costs for Travel Information Kiosks

The total start-up costs for the kiosk project were estimated to be $459,732. This includes costs for the eventual deployment of 25 indoor and three outdoor kiosks; $233,350 for hardware and enclosures; $109,100 for software, system development, and project management; $46,200 for shipping, installation and start-up; and AZTech server shared costs. More detail is provided in Table 4.8.

Table 4.8: Development Costs of Travel Information Kiosks

Equipment Description	Quantity	Unit Cost	Start-up Costs	O&M Costs
Kiosk Hardware, Indoor	25	$5,850	$146,250	
Kiosk Hardware, Outdoor	3	$4,600	$13,800	
Kiosk Enclosures, Indoor	25	$2,220	$55,000	
Kiosk Enclosures, Outdoor	3	$6,100	$18,300	
Kiosk Installation & Start-Up	28	$1,500	$42,000	
Kiosk Shipping	N/A	N/A	$4,200	
Kiosk Software	28	$2,200	$61,600	
System Development	N/A	N/A	$10,000	
Project Management	N/A	N/A	$30,000	
Travel	N/A	N/A	$7,500	
Content & User Interface Maintenance	N/A	N/A		$1,771
Operations Monitoring	N/A	N/A		$44,085
Site Maintenance	N/A	N/A		$82,659
Spare Equipment Program	N/A	N/A		$11,480
Communication Line Costs	N/A	N/A		$4,723
AZTech Server Shared (4.2%)	N/A	N/A	$71,082	$8,801
Total			$459,732	$153,519

Annual operation and maintenance costs for the project were estimated to be $153,519, including AZTech server shared costs. In comparison to the kiosks deployed for the San Antonio MMDI, operation and maintenance costs unique to the AZTech kiosk are fairly low, at 37% of the (unique) start-up costs. This is partly due to the use of a commercial-off-the-shelf kiosk design.

4.9   SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS FOR ADVANCED TRAVELER INFORMATION SYSTEMS

The AZTech advanced traveler information system project descriptions highlighted how each element was integrated with other advanced traveler information system efforts, with the overall AZTech initiative, and with existing ITS infrastructure. The descriptions presented a history of the deployment effort, explored deployment challenges, and discussed impacts on the national evaluation. Deployment ranged from cancellation of the In-vehicle Navigation Device project to full deployment and operation of systems such as *Traffic Check*. Where possible, conclusions were drawn and/or recommendations offered. The cost analyses reinforced how the advanced traveler information systems projects were integrated with each other and the overall AZTech initiative, establishing another basis for interpreting project deployments.

The customer satisfaction evaluations of the Trailmaster Web site and *Traffic Check* not only produced useful information about what impact those projects have had, but also offer a context for analyzing the deployment history of the other advanced traveler information system efforts in the Phoenix metropolitan region. Indeed, the AZTech customer satisfaction findings build a bridge to the advanced traveler information system evaluation in San Antonio and Seattle so that richer conclusions

can be drawn about the factors that affect the advanced traveler information system deployment in different locations.

As described in Section 2, an emerging finding across all MMDI evaluations is that a set of relatively consistent factors appears to influence the propensity of travelers to seek out, use, and benefit from traveler information. These evaluations have covered a large number of individual advanced traveler information system products and services, and each service has attracted a particular segment of an area's population as users. Factors that make up particular market segments include demographic and attitudinal characteristics of users, frequency of using a service, local commuting conditions, and what value users place on these services. Some factors have shown similar results, and others have ranged widely across sites. Why do these study results appear to produce such large variation in customer satisfaction?

4.9.1   Factors in ATIS Use

A central finding from the Phoenix, San Antonio, and Seattle evaluations is that the potential of traffic and transit information to satisfy travelers and enhance their travel experiences is mediated by four critical components of the travel experience:[26]

- The regional or situational context
- The quality of the service
- The characteristics of the trip, specifically the travelers' experiences on their trips
- The characteristics of the traveler who uses advanced traveler information systems.

The situational context of Phoenix includes attributes as described in Section 2, such as the road network, accessibility of alternative travel routes, and traffic congestion. This context tends to determine whether travelers are likely to be motivated to learn about and use traffic information products and services in the first place, and may help define thresholds for customer use of these services.

A second critical determinant of advanced traveler information systems use is the quality of traveler information available to users. Quality is an indicator of the ability of the information to meet customer needs with respect to timeliness, relevancy, specificity, frequency, and accuracy. More specifically, information quality is determined by:

- The breadth of geographic coverage
- Whether both highways and arterial streets are included
- The time frame of information (e.g., static, near real-time, or real-time)
- Media characteristics (pre-trip, en route, in-terminal/wayside, or a combination)
- The user interface and resulting ease of using the service.

The elements of quality determine whether, how frequently, and with what level of confidence the user consults traveler information and adjusts travel choices accordingly.

A third factor is trip characteristics. The trip purpose, the time of the trip in relation to peak congestion periods, trip length, and the particular route or route choices available to the individual traveler all have a significant effect on whether the individual will consult traffic information. The availability and convenience of alternative modes for a given trip also affect traveler behavior. Arrival time flexibility,

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[26] This discussion is elaborated upon in a companion MMDI evaluation document, *Customer Satisfaction Evaluation Overview: National Synthesis.* Draft Report (in preparation).

associated with the individual's trip, is another determinant in the choice to consult traffic information in some cases

The fourth factor includes characteristics of the user, or potential user, of advanced traveler information systems products and services. For example, comfort level with high technology equipment and how well a traveler knows local roads are important determinants of user awareness, use patterns, behavioral responses, and valuation of traffic information services.

4.9.2   Phoenix: The Regional Context

The evaluation of the usage patterns of the Trailmaster Web site has offered insights into elements of the regional context that appear to influence how many people use the site, how often they use it, when they use it, and how they use it in conjunction with other information services in the Phoenix area. The differences in use patterns between Trailmaster and comparable traveler information Web sites at the two other MMDI locations, Seattle and San Antonio, shed further light on the nature of these differences in the locational context of each site. Some of these location or context differences were illustrated in Table 2.1.

As seen in this site report, based on interviews with travelers who are users of the *Traffic Check* cable TV program and responses from the Trailmaster focus groups, congestion is apparently not a serious problem most of the time. In addition, based on responses to direct questions about commute experiences, these respondents reported shorter and less congested commutes in the Phoenix/Tempe area compared with reports from commuters in Seattle. Participants in focus group sessions who were users recruited from the Trailmaster Web site reported that their commute and other trips were not especially congested.

Generally, respondents in the Phoenix area customer satisfaction evaluations found the traffic information services to be useful and beneficial. The more frequent users of these services rated them the most positively. Respondents had specific suggestions for improvements that, if implemented, would presumably enhance their satisfaction. It appears, however, that the generally low congestion in the Phoenix region, coupled with the ubiquity of travel route options, reduces the motivation to seek out and adopt advanced traveler information system services.

4.9.3   Advanced Traveler Information System: Marketing and Promotion

Another critical factor that helps determine use rates for advanced traveler information systems is the amount of effort put into advertisement and promotion. Clearly, if potential users of these services are unaware of their existence or availability, then they cannot become users. In Phoenix, several of the traveler information services could not be evaluated because there were too few users. Part of the issue is one of timing, as it typically takes time for new information technologies to diffuse into a population of potential users. In the case of Phoenix, there was little advertising for the services being deployed under AZTech. An outstanding question in Phoenix and elsewhere is whether customers, once aware of a service, could be retained as active long-term users. This is where the other contextual factors described earlier come into play.

4.9.4   Advanced Traveler Information System User Profiles

Individual travelers vary in many ways that influence their potential responses to advanced traveler information system services, including demographic characteristics (such as age, education, income, and family status). Attitudes towards information technologies of the types evaluated under the MMDI

program (such as comfort with computers and the Internet, propensity to take risks with new technologies, personal reactions to deadlines or traffic delays, need to plan ahead) also have an impact on use.

As part of the overall customer satisfaction evaluations, respondents in a long-standing representative household panel survey of travel behaviors and attitudes in Seattle were segmented into eight groups based on their responses to a series of attitude questions.[27] Subsequently, respondents to each of five of the MMDI customer satisfaction surveys were assigned to these segments. One of these surveys is the *Traffic Check* study.

The result of this segmentation of *Traffic Check* survey respondents shows that they are heavily concentrated in two of the categories: control seekers and low-technology pre-trip information seekers. As these names suggest, viewers of *Traffic Check* characterized as control seekers like to plan ahead, desire to be accessible at all times, and want to predict travel time accurately. One-third of these survey respondents (33%) falls into this segment. The next largest segment (17% overall and 21% among the most frequent viewers) is composed of *Traffic Check* viewers who are less interested in new high technology information devices and mostly prefer more traditional pre-trip traveler information.

The results of this broader user segmentation analysis reinforce findings from the direct analysis of the *Traffic Check* survey data. The data indicate that the most frequent viewers of traffic information programming on cable TV express the most discomfort with other high technology ways of obtaining traffic information. For them, television appears to be a particularly comfortable medium for receiving traveler information. The broader implication is that some individuals are likely to prefer, use, and derive benefit from technologies that are simply not attractive to others.

4.9.5   Final Thoughts: Future of Advanced Traveler Information System in the Phoenix Area

It appears important to offer a range of different ways that consumers can acquire traffic information. In some locations, markets, or user segments, customers may desire many options and many prefer to select from a variety of pre-trip and en route traveler information services. Others travelers may prefer to stick with a few information sources with which they are most comfortable.

As the Phoenix regional context was explained in Section 2, especially as it compares to relatively more congested metropolitan areas, the level of demand for traveler information is low to moderate. Major disruptions in traffic appear to be relatively rare. Moreover, the Phoenix grid road network consisting of major and well-managed arterials provides many alternate route choices. This would increase the importance of providing real-time information on arterials, something that AZTech only initiated during the national evaluation period. In such an environment, marketing advanced traveler information system products and services will be challenging.

While there are clearly segments of the population that value the information currently being provided and that use it regularly, many travelers who are aware of these services are only occasional users. By and large, they find that they can cope with regional traffic conditions the old-fashioned way. That is, they proceed with their usual travel or commute plans and take alternative, readily available routes from time to time when they observe firsthand conditions that warrant doing so. In the long run, this picture may change. Continued growth of the region and its impact on travel conditions may lead to greater demand for traffic information services, consistent with patterns observed in regions with greater traffic congestion.

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[27] See the draft user profile report for a detailed explanation of the methods by which these segments were identified. *Traveler Information User Profiles: Customer Satisfaction Evaluation.* Draft Report. MMDI Program. October 1999.

As noted in the Trailmaster study, success of advanced traveler information systems may require integration with more general information sources. This may imply that these services will be more successful as adjuncts rather than stand-alone products.

5. Advanced Traffic Management Systems

One of the unique attributes of the Phoenix transportation system is the extensive mile-grid arterial street network. The rapidly increased population has worsened the traffic congestion experienced on the major arterial commuting routes, which traverse multiple jurisdictions. In response to this situation, AZTech Metropolitan Model Deployment Initiative (MMDI) implemented a cross-jurisdictional arterial street traffic management system, in conjunction with the existing Arizona Department of Transportation's freeway management system. The efforts include the deployment of eight arterial Smart Corridors and the integration of seven jurisdictional traffic operation centers for promoting coordinated traffic control and management across jurisdictions.

The Smart Corridor projects focused on the coordination of traffic management through the integration of jurisdictional traffic control systems and instrumentation of arterials with traffic detection and control capability. The traffic data from the participating jurisdictions are shared via the communication network administered by the AZTech server. Travel information such as arterial street travel speed, incidents, and closures are provided to various traveler information services via the AZTech ATIS server.

Under AZTech, the following eight arterial Smart Corridors, depicted in Figure 5.1, were deployed:

- Southern Avenue (between I-10 and Gilbert Road)
- Baseline Road (between Central Avenue and Gilbert Road)
- Bell Road (between Grand Avenue and Pima Road)
- Scottsdale/Rural Road (between Bell Road and Chandler Boulevard)
- Glendale Avenue (between 99th Avenue and Scottsdale Road)
- Grand Avenue (between Bell Road and Van Buren Street)
- 7th Street and Cave Creek (between Bell Road and Baseline Road)
- Tatum Boulevard/44th Street (between Bell Road and Freeway 202)

The selection of Smart Corridors was based on the recommendations from the previous ITS studies, including the Metropolitan Area Governments Information Center (MAGIC) and ITS Strategic Plan for Maricopa County.

The AZTech Smart Corridor projects include the following major components:

- Implementation of traffic detectors, CCTVs, and changeable message signs
- Integration of seven local traffic control centers with the AZTech server for data and video sharing
- Development of cross-jurisdictional, coordinated traffic signal timing plans on the eight Smart Corridors.

The operational philosophy of AZTech Smart Corridors is based on a peer-to-peer permissive control traffic management scheme. While each jurisdiction retains independent control of its signals, coordinated signal timing plans for various pre-determined scenarios can be implemented based on consensus between participating jurisdictions. Data and CCTV video are shared between the participating cities of Chandler, Glendale, Mesa, Paradise Valley, Phoenix, Scottsdale, Tempe, Maricopa County Department of Transportation, and Arizona Department of Transportation. These data are distributed over the US West integrated data/video digital communication network administered by the AZTech server. This will allow jurisdictions to share real-time traffic information and to change traffic signal timing across jurisdictional boundaries via the communication network with common time reference.
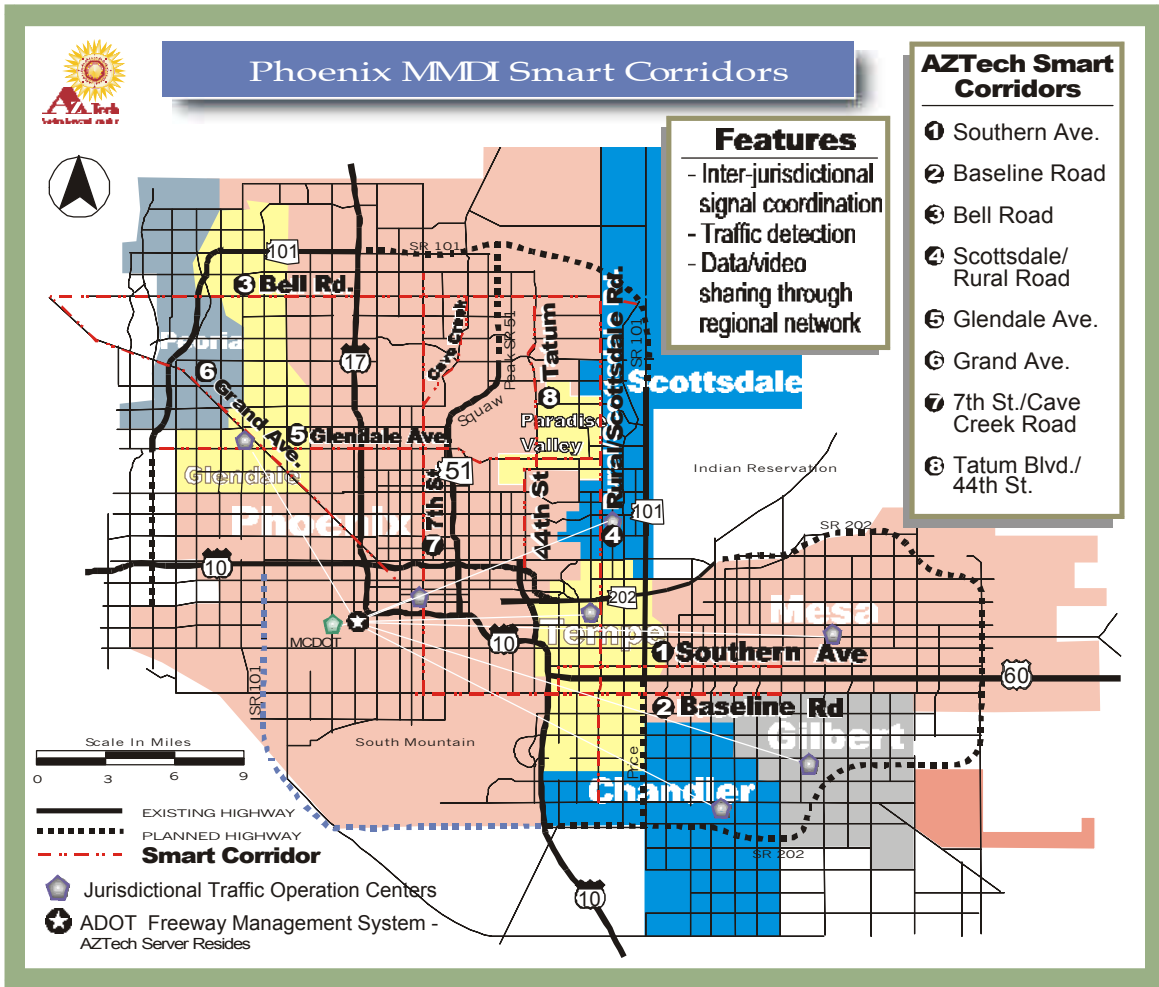
Figure 5.1: AZTech Smart Corridors

In each jurisdictional traffic operation center, an AZTech workstation computer and data communication equipment were integrated with the jurisdictional traffic control systems to establish the AZTech arterial street traffic management network. These systems are intended to provide improved traffic operations as well as supplying traffic information about the arterial network to the various AZTech ATIS systems that are operating or under development.

Many signal controllers and communications were upgraded to support the projects. For traffic detection, AZTech installed a large number of new detectors for collecting traffic information on the arterial streets. A number of CCTVs were installed at selected locations for monitoring traffic conditions. Changeable message signs were installed on Southern and Baseline corridor for diverting traffic between freeways and Smart Corridors.

The evaluation efforts focused on the Scottsdale/Rural Road corridor. Two other corridors were included in the original evaluation plan. However, baseline data collection on Bell Road Smart Corridor suggested to the local project partners and the national evaluation team that an analysis would not be necessary due to the opening of new freeway (SR101), which consequently relieved the congestion on the Bell Road. Baseline data collection was also conducted on the Southern and

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Baseline corridor; however, the coordinated signal timing plan and changeable message sign operations were not in place during the evaluation period.

In addition to the Smart Corridors, AZTech traffic management systems also included deployment of a computer-aided incident investigation system for reducing incident clearance time. Seven Nikon™ "Total Station" incident investigation devices were procured by AZTech for the law enforcement and emergency response agencies across the valley. The Total Station is an integrated computerized survey device which allows incident investigators to conduct traffic accident investigations more efficiently and accurately. The Total Station is a stand-alone system that does not interface with other AZTech systems. A cost data analysis for the AZTech computer-aided incident investigation system is presented in this section.

5.1   SCOTTSDALE/RURAL ROAD CORRIDOR

5.1.1   Project Description and Evaluation History

The Scottsdale/Rural Road corridor is one of the major north/south arterial corridors in the east valley of Phoenix metropolitan area. The evaluation focused on a 9.6-kilometer/5.7 mile section of Scottsdale/Rural Road that traverses Tempe to the south and Scottsdale to the north. It includes a total of 21 traffic signals, 16 located in the Tempe and 5 in the Scottsdale. Among other large generators, the Arizona State University (in Tempe) is served by this arterial.

The MMDI deployment was planned to include coordination between the traffic signal systems operated by ADOT, Scottsdale, and Tempe. To support this, additional traffic sensors were to be installed to detect traffic patterns and congestion, and closed circuit TV cameras were to be installed to provide the traffic operations center with direct visual access to congested roadways, especially during incidents and special events. The necessary communications infrastructure was proposed to connect the detection devices and traffic signal controllers with the traffic management systems in Scottsdale and Tempe. Coordination of traffic operation was to be achieved via a network between the central AZTech server and AZTech workstations integrated with the traffic management systems in Scottsdale and Tempe.

The expected impacts of Smart Corridor projects included the improvement of operational cooperation between jurisdictions and the improvement of traffic movement on the arterial street network. The improvement in operational cooperation has been evident in the active data and video sharing between jurisdictional traffic managers since the debut of the AZTech system. From the evaluation's standpoint, it was difficult to measure the benefits of improved operational cooperation. By comparison, it was feasible to measure the impacts of improved traffic control tactics such as the coordinated signal timing plans being developed by the AZTech. The evaluation,[1] thus, focused on the assessment of the impacts of cross-jurisdictional signal coordination, in terms of throughput and efficiency, fuel consumption, emission, and safety.

The evaluation employs two techniques to assess these impacts:

- a "floating car" field study to measure speeds and stops on the Scottsdale/Rural Road mainline, and

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[1] Detailed in Rakha H., Medina A., Sin H., Dion F., Van Aerde M., and Jenq J. (2000), "Coordination of Traffic Signals Across Jurisdictional Boundaries: Field and Simulation Results," presented at the Transportation Research Board 79th Annual Meeting, January, [Paper # 00-1560].

- a traffic simulation study to estimate impacts at the corridor level (mainline, cross-streets and parallel facilities).

5.1.2 Project Costs for Scottsdale/Rural Road Corridor

Total start-up cost for the Scottsdale/Rural Road Corridor was $322,485. As shown in Table 5.1, the major cost drivers for this project are the cost of one closed circuit TV (CCTV) monitoring system, 175 loop detectors, and the cost of the associated planning activities by the Maricopa County DOT. Shared costs include 4.2% of AZTech server development and 12.5% of start-up costs for the Smart Corridor overall, including the following: development, acquisition and installation of the traffic operations center; communications hardware; a video switch for sharing video among jurisdictions; systems engineering costs; and operator training.

Annual operations and maintenance costs are $30,853. O&M costs for loop detectors and closed circuit TV cameras are estimated to be 10% of the initial non-labor deployment costs. Other operations and maintenance costs apply to the shared elements. AZTech server O&M was estimated to be 12.3% of $71,082, the Scottsdale/Rural Road portion of AZTech server start-up costs. For Smart Corridor shared costs, 18.5% of $84,528 was the estimated annual cost for Scottsdale/Rural Road O&M.

Table 5.1: Development Costs of Scottsdale/Rural Road Corridor Project

Equipment Description	Quantity	Unit Costs	Start-up Costs	O&M Costs
Detection Devices (6 x 6 Loops)	175	$375	$65,625	
Loop Maintenance @ 10% of Capital Cost				$6,562
Closed Circuit TV Monitoring System	1	$60,000	$60,000	
Camera Maintenance @ 10% of Capital Equipment Cost				$6,000
MCDOT Planning (.33 FTE)			$41,250	
AZTech Server Shared (4.2%)			$71,082	$8,801
Smart Corridor Shared (12.5%)			$84,528	$15,687
Totals			$322,485	$37,050

5.1.3 Field Study Results: Mainline Impacts of Signal Coordination

Prior to the Smart Corridor project, the 21 traffic signals along the Scottsdale/Rural Road mainline operated at two different cycle lengths. The five traffic signals located in Scottsdale operated at the Scottsdale standard cycle length of 102 seconds, while the remaining 16 in Tempe operated at the Tempe standard cycle length of 110 seconds. This lack of coordination between the two cities on cycle length resulted in a break in traffic progression at the jurisdictional boundary. Traffic progression is a desired outcome of coordinated traffic control and is achieved by enabling vehicles proceeding along a signalized corridor at a specified speed to arrive at downstream intersections just as the light for their approach turns green.[2]

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[2] Kell and Fullerton (1991), Manual of Traffic Signal Design (Second Edition), Institute of Transportation Engineers.

An initial test of cooperation between the two jurisdictions was to re-time three Tempe signals to match the Scottsdale cycle length. Figure 5.2 shows the study area and the three traffic signals at McKellips Road, Weber Road, and Curry Road. The goal of this limited re-timing was to move the break in progression south to the Red Mountain Freeway where a significant portion of the north/south traffic exits from the Scottsdale/Rural Road arterial mainline onto the freeway facility. The hypothesis being tested was that Scottsdale/Rural Road corridor operations could be improved through a limited, strategic re-timing of lights near the jurisdictional boundary. Implementing these limited changes north of the freeway would avoid conflict with other major Tempe arterial corridors operating with 110-second cycles perpendicular to Rural Road such as Southern Avenue.

The signal re-timing included the change of signal cycle length, phase split, and offsets at the three traffic signals.[3] In order to accommodate the new cycle length, the mainline signal phase split (i.e., percentage of green time for north/south movement on Scottsdale/Rural Road) was reduced while the phase split for cross traffic flow remained the same. Reduction in mainline phase split, independent of changes to mainline progression, typically results in increased delay on the mainline. Therefore, the evaluation sheds light on another key question for the corridor: does improved mainline progression associated with improved jurisdictional cooperation enhance mainline operations enough to compensate for the reduction in mainline phase split?

To examine this question, an enhanced floating car study of mainline travel speeds before and after the signal re-timing was conducted. Rather than a traditional floating car study recording point-to-point travel times (e.g., Southern Avenue to the Red Mountain Freeway), travel time and speed measurements were made using vehicles equipped with Global Positioning System (GPS) receivers. The GPS receivers recorded vehicle location (in latitude and longitude) and speed every second. This more detailed data can be processed to derive not only travel time and delay measures, but energy consumption, emission, and safety measures as well.

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[3] Cycle length is defined as the time required for one complete sequence of traffic signal indications allowing movement from all approaches at an intersection. Phase split is the percentage of cycle length allocated to any combination of traffic movements receiving right of way simultaneously. Offset is the interval in seconds between the start of the green indication at one intersection as related to the start of the green interval at another upstream intersection. These definitions, with minor modifications, are taken from Kell and Fullerton (1991), Manual of Traffic Signal Design (Second Edition), Institute of Transportation Engineers.

[4] Cycle length is defined as the time required for one complete sequence of traffic signal indications allowing movement from all approaches at an intersection. Phase split is the percentage of cycle length allocated to any combination of traffic movements receiving right of way simultaneously. Offset is the interval in seconds between the start of the green indication at one intersection as related to the start of the green interval at another upstream intersection. These definitions, with minor modifications, are taken from Kell and Fullerton (1991), Manual of Traffic Signal Design (Second Edition), Institute of Transportation Engineers.
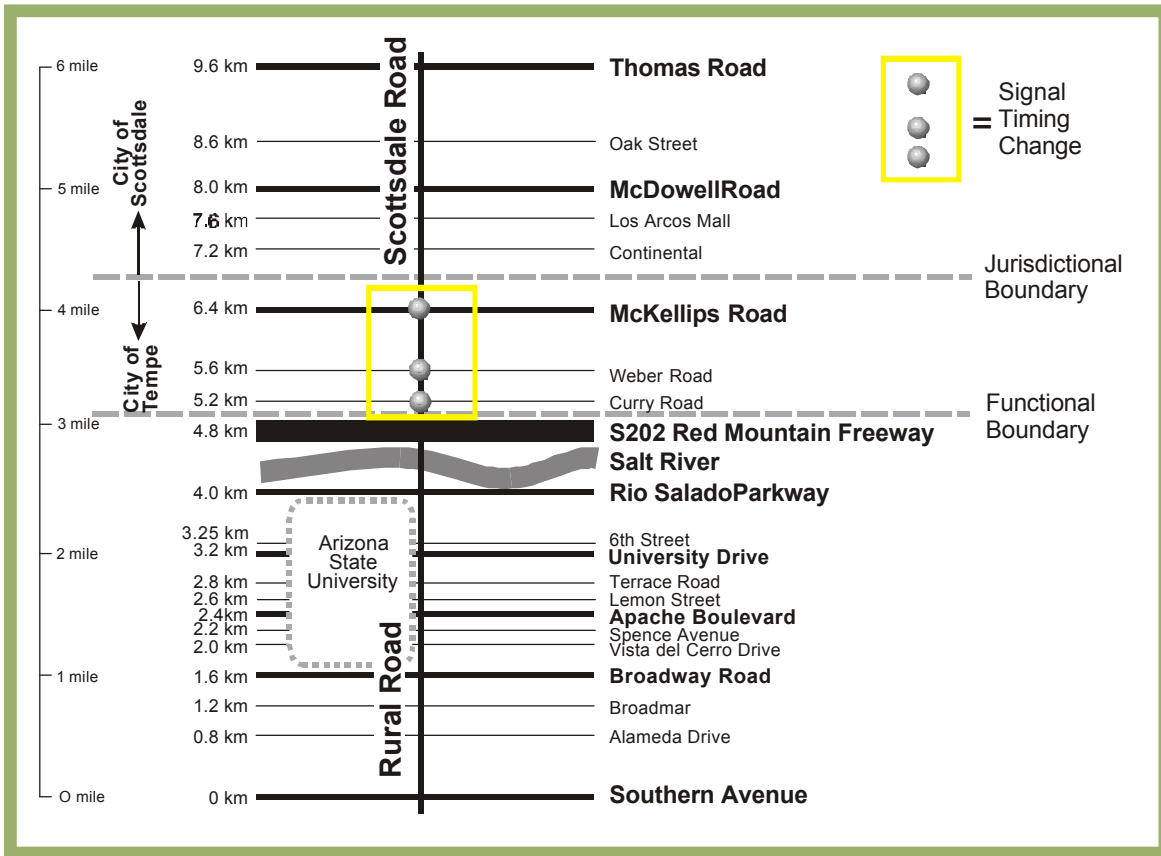
Figure 5.2: Scottsdale/Rural Road Evaluation Study Area

The new signal timing plans were implemented in early February 1999. Two data collection efforts were conducted to characterize mainline performance: a total of 141 corridor traversals (or "runs") in the GPS-instrumented vehicles in January 1999 before re-timing and 160 runs in February 1999 after implementation of the new signal timing plans. Travel demand patterns in the corridor remained unchanged in the corridor between January and February as measured by archived detector data in the period.

Throughput and Efficiency Impacts: Mainline

GPS data were post-processed to quantify the impacts on travel speeds and average number of stops per 9.6 kilometer corridor traversal, as summarized in Table 5.2. The results indicate that mainline speeds increased by 6.2% in the after case, while average stops per trip fell 4.2%. Checking these differences against inherent randomness in the data collection, the change in speed was significant at higher than a 95% confidence limit and that the change in stops fell just short of this confidence limit. Overall, one may conclude that speeds were indeed higher and frequency of stops may have been reduced as well. This indicates that the improvement in signal progression did indeed compensate for the reduction in phase split on the mainline.

Table 5.2: Mainline Speed and Stop Rate Impacts, Floating Car Study

		Northbound			Southbound			Average
		AM Peak	Midday	PM Peak	AM Peak	Midday	PM Peak	
BEFORE	Speed (km/h)	45.4	43.5	38.5	47.5	46.9	29.5	41.9
	Stops (per trip)	6.6	6.6	7.3	6.4	6.2	10.0	7.2
AFTER	Speed (km/h) (% change)	47.9 (+5.5%)	46.0 (+5.7%)	41.0 (+6.5%)	48.2 (+1.5%)	45.4 (-3.2%)	38.7 (+31%)	44.5 (+6.2%)
	Stops (per trip) (% change)	6.4 (-3%)	6.4 (-3%)	7.5 (+2.7%)	6.4 (0%)	6.6 (+6%)	8.1 (-19%)	6.9 (-4.2%)

Examining impacts of the new timing plan by time-of-day, it is clear that the new timing plan performs best relative to the uncoordinated timing plan under PM peak conditions, particularly in the southbound direction. This implies that the break in progression was a significant factor under peak demand and less significant under lower travel demands.

Fuel Consumption and Emissions Impacts: Mainline

After implementation of the new signal timing plan, travel on the Scottsdale/Rural Road mainline was found to be faster and potentially smoother. This combination has implications for both energy consumption and emissions impacts. The evaluation of the energy consumption and emissions impacts involves the processing of second by second speed and acceleration data from a GPS-equipped floating car. As a part of the MMDI evaluation effort, a new methodology was developed that estimates fuel consumption and emissions based on the speed and acceleration trajectories. This methodology[5] is based on data from a study at Oak Ridge National Laboratory[6], where a set of vehicles were systematically paced through a sequence of different speed and acceleration sequences in an instrumented laboratory setting. The key feature of this new methodology is its sensitivity to rapid accelerations in relation to energy and emissions impacts. Traditional approaches in this area have considered only average speeds and aggregated volumes to predict impacts. The new methodology allows the analyst to consider the impact of traffic smoothing on energy and emissions impacts, a key element in a test of the impacts of signal coordination.

Overall, the findings for energy and emissions are a mixed bag of small impacts (Table 5.3). Fuel consumption was reduced by 1.6% on average from 1.20 liters to 1.18 liters per trip. This small change was statistically significant relative to measurement error. A small but statistically significant increase was indicated for CO emissions (1.2%), while no significant impact was indicated for either HC or NOx emissions. Impacts for vehicles traveling southbound in the PM peak (where the largest increases in speed and reduction in stops were observed) were larger: a 8.6% reduction in fuel consumption and a 6.5% reduction in HC emissions, a 3.2% reduction in NOx, and no change in CO emissions.

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[5] Detailed in Ahn K., Trani A., Rakha H., and Van Aerde M. (1999), "Microscopic Fuel Consumption and Energy Emission Models," Presentation at the Transportation Research Board 78th Annual Meeting, January; and in Rakha H., Van Aerde M., Ahn K. and Trani A. (2000), "Requirements for Evaluation of Environmental Impacts of Intelligent Transportation Systems using Speed and Acceleration Data," presented at the Transportation Research Board 79th Annual Meeting, January, [Paper # 00-1133].

[6] West, B., McGill, R., Hodgson, J., Sluder, S., and Smith, D. (1997), Development of Data-Based Light Duty Modal Emissions and Fuel Consumption Models, Society of Automotive Engineers, Paper No. 972910.

Since the underlying travel demand pattern did not change after the new signal plan was implemented, there was no observed short-term secondary travel demand effects. An example of a secondary effect might be that the improved performance of the Scottsdale/Rural Road mainline attracting new travel demand from outside the corridor. Identifying such secondary effects when they occur is a critical element in an accurate energy and emissions estimation. Longer-term travel demand impacts were not estimated.

Table 5.3: Mainline Fuel Consumption and Emission Impacts, Floating Car Study

		Northbound			Southbound			Average
		AM Peak	Midday	PM Peak	AM Peak	Midday	PM Peak	
BEFORE	Fuel (liters/trip)	1.15	1.16	1.23	1.14	1.14	1.39	1.20
	HC (g/trip)	1.17	1.17	1.23	1.19	1.17	1.38	1.22
	CO (g/trip)	15.4	15.2	15.5	15.6	15.3	15.7	15.4
	NO$_x$ (g/trip)	3.13	3.06	3.17	3.18	3.13	3.39	3.18
AFTER	Fuel (liters/trip)	1.13 (-2%)	1.15 (-1%)	1.22 (-1%)	1.14 (0%)	1.17 (+3%)	1.27 (-9%)	1.18 (-2%)
	HC (grams/trip)	1.17 (0%)	1.19 (+2%)	1.25 (+2%)	1.19 (0%)	1.22 (+4%)	1.29 (-7%)	1.22 (0%)
	CO (grams/trip)	15.4 (0%)	15.5 (+2%)	15.7 (+1%)	15.6 (0%)	15.6 (+2%)	15.7 (0%)	15.6 (+1%)
	NO$_x$ (grams/trip)	3.00 (-4%)	3.16 (+4%)	3.27 (+3%)	3.06 (-4%)	3.22 (+3%)	3.28 (-3%)	3.17 (0%)

Safety Impacts: Mainline

Similar to the energy and emissions analysis, the evaluation of the safety impacts involved predicting changes in crash risk and crash severity resulting from increased mainline speed and potentially smoother traffic flow. The evaluation of the safety impacts in the Scottsdale/Rural Road corridor resulted in the development of a new safety impacts estimation methodology[7] based on the recorded second-by-second trajectories of the GPS-equipped floating cars. The new methodology estimates the expected frequency of 14 different crash types per kilometer of travel based on the type of facility the vehicle was traveling on. In addition, the expected damage and injury levels, per crash event, can be estimated based on the speed profiles of the floating cars.

The underlying data for the new methodology is a national crash database of more than 6,000,000 annual crashes, the General Estimates Systems database. This crash database was subsequently supplemented with vehicle exposure data, which were stratified by facility type. The merging of crash frequencies with exposure data resulted in crash rates per unit distance and per unit time for different facility types. The conversion, from crash frequencies into crash frequencies by damage and injury level, was performed by considering speed dependent damage and injury levels for each of the 14 different crash types.

Applying this new methodology to the Scottsdale/Rural Road floating car data, the overall crash risk is predicted to drop by 6.7% as a result of the signal re-timing. In the southbound PM peak direction

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[7] Detailed in Avgoustis A., Van Aerde M., and Rakha H. (2000), "Estimating the Network-wide Safety Impacts of Operational-Level Transportation Improvements," submitted for publication in the Transportation Research Record.

(where the largest impact was observed on mainline speeds and stops) a more substantial 20% reduction in crash risk is predicted. Although these differences in crash risk were found to be statistically significant, accidents in the corridor are infrequent enough that a reduction in actual accidents in the evaluation time frame (1 month) could not be observed. Like all other theoretical estimation of safety, the safety benefits reported in this exercise can only be validated if sufficient accident data is accumulated over time after the implementation of new signal timing. Overall, impacts of the signal re-timing on mainline safety can be characterized as potentially improved as a result of smoother traffic flow, although this prediction could not be reliably validated with the limited field data available.

5.1.4   Simulation Study Results: Corridor-Wide Impacts of Signal Coordination

The floating car study found that the new signal timing plan resulted in increased travel speeds and potentially smoother traffic flow on the Scottsdale/Rural Road mainline, but the study does not shed light on potential impacts on overall corridor performance. Mounting a concurrent floating car study on all of the 21 cross-streets in the corridor was not possible in the evaluation because of resource constraints. However, corridor-wide impacts could be estimated in a simulation study leveraging the detector and floating car data collected as a part of the mainline analysis.

A network model of the Scottsdale/Rural Road was developed for the INTEGRATION™ micro-simulation encompassing the corridor under study from Thomas Road (northern boundary) to Southern Avenue (southern boundary). The network details intersection operations and geometry along the 21 Scottsdale/Rural Road mainline intersections as well as cross-street operations. A micro-simulation was selected because of its ability to model and track simulated vehicles every tenth of a second. Detailed profiles of simulated vehicle trajectories are generated by the simulation as an output akin to the second-by-second vehicle trajectories recorded by the GPS-equipped floating cars. As a result, the energy and emissions estimation methodology developed as a part of the MMDI, as well as the new safety impacts estimation methodology, could be applied at a network level using simulation outputs.

The Scottsdale/Rural Road network was constructed and calibrated to match travel demand patterns and mainline travel speeds in the before case using the baseline (pre-February 1999) signal timing plans. The new signal timing plan implemented in the simulation resulted in a change in mainline performance very close to the observed change: small improvements in speeds and stops per trip outside of the southbound travel in the PM peak period, where much larger improvements to travel performance were seen.

Simulated Impacts: Corridor-Level

Although the simulation replicated the improvements seen on the Scottsdale/Rural Road mainline facility, no statistically significant change in overall corridor-level travel performance was indicated in analysis of simulation results. This finding is explained by the fact that the relatively small overall improvement seen on Scottsdale/Rural Road itself washes out when overall corridor travel is considered. Small improvements to corridor travel time can be detected at the corridor level with the simulation, but they fall below the threshold where they can be confidently discerned from the inherent randomness in the micro-simulation. Similarly, energy and emission impacts, as well as safety impacts are likewise so small they cannot be measured above the inherent randomness in the simulation output data.

Overall, we can characterize the impact of the signal re-timing to be a localized improvement for the Scottsdale/Rural Road mainline that does not significantly impact corridor-wide traffic performance.

Given that small improvements can be expected from limited changes in control at the boundaries, a logical question one might posit is: would a more aggressive, facility-specific optimization on all 21 signals without regard to jurisdictional boundaries yield greater impacts? Or is the after case plan implemented in February 1999 close enough to optimal to imply that small adjustments that do not upset larger cycle length schemes in Tempe and Scottsdale the most reasonable approach? Optimizing the Scottsdale/Rural Road timing plan to a uniform cycle length has implications for operations in both Scottsdale and Tempe that go beyond the corridor in question here. In order to gain perspective on the magnitude of potential benefits of facility-wide optimization, a series of hypothetical re-timing plans were implemented in the simulated network.

Three new optimization plans were developed to examine these issues using the TRANSYT-7F (Release 8.2) offline optimization application. The three plans maintain current signal phase structure and sequencing and either the Scottsdale standard cycle length (102 seconds) or the Tempe standard cycle length (110 seconds):

Plan 1. 110/102: Independent optimization of phase split and offset within the cities of Scottsdale and Tempe without a change in current cycle length operation in the two cities. The optimization in Scottsdale is performed under the assumption that signals in Tempe are not changed from the baseline settings. Likewise, optimization for signals in Tempe is performed under the assumption that signals in Scottsdale operate under baseline timing plans. The two timing plans are then merged into a single plan with signals in Scottsdale operating under settings from the Scottsdale optimization and Tempe signals operating under settings from the Tempe optimization.

Plan 2. All 110: Coordinated optimization of phase split and offset combined with corridor-wide adoption of the Tempe standard cycle length (110 seconds).

Plan 3. All 102: Coordinated optimization of phase split and offset combined with corridor-wide adoption of the Scottsdale standard cycle length (102 seconds).

Because of resource and time constraints, the three new signal timing plans were developed and evaluated for AM peak period conditions only. TRANSYT-7F was configured to optimize phase split and offset for the minimization of fuel consumption, the program default. As shown in Tables 5.4 and 5.5, the plans resulting from TRANSYT-7F optimization can be characterized by an overall increase in cross-street phase split at the expense of mainline phase split when compared to current settings. Increases in phase split of 10% or more are shown in bold, reductions in phase split of 10% or more are shown in italics. Table 5.4 also shows the changes to phase split implemented in the AFTER case from the February 1999 field study.

The three plans generated in offline optimization share some similar attributes. First, the most significant reallocations of phase split from the mainline to the cross streets are clustered along the two-mile stretch between McDowell and Curry (near the jurisdictional boundary). Otherwise, no other significant changes are indicated beyond phase split changes at four minor intersections in Tempe (University, Terrace, Broadway and Alameda). One may note that the most significant phase split change implemented in the after case timing plan is at Curry Road (Table 5.4). Further, the change implemented at Curry is similar to the one identified by TRANSYT-7F.

Table 5.4: Change in Phase Split From Baseline Settings, After Case and 110/102 Signal Timing Plans

Intersection	AFTER				110/102			
	Main Thru	Main Left	Cross Thru	Cross Left	Main Thru	Main Left	Cross Thru	Cross Left
Thomas						1%	8%	-9%
Oak								
McDowell					-8%	-5%	**18%**	-5%
Los Arcos					*-19%*	**10%**	9%	
Continental					*-16%*	6%	**10%**	
McKellips			1%	-1%	-3%	*-11%*	**21%**	-7%
Weber	-2%		2%		*-10%*		**10%**	
Curry	*-11%*	6%	1%	4%	*-12%*	**12%**	1%	-1%
S202					*-15%*	5%	9%	
Rio Salado					5%	-1%	-5%	
Sixth								
University					-2%	-5%	**12%**	-5%
Terrace					**18%**		*-18%*	
Lemon								
Apache					2%	-2%	3%	-3%
Spence								
Vista d. C.								
Broadway					-2%	-3%	**10%**	-5%
Broadmar								
Alameda					**15%**		*-15%*	
Southern					3%	3%	-5%	-1%
Average	**-0.6%**	**0.3%**	**0.2%**	**0.1%**	**-2.0%**	**0.5%**	**3.2%**	**-1.7%**

Table 5.5: Change in Phase Split From Baseline Settings, ALL-110 and ALL-102 Signal Timing Plans

Intersection	ALL-110				ALL-102			
	Main Thru	Main Left	Cross Thru	Cross Left	Main Thru	Main Left	Cross Thru	Cross Left
Thomas		1%	9%	*-10%*		1%	8%	-9%
Oak								
McDowell	-8%	-6%	**19%**	-6%	-8%	-5%	**18%**	-5%
Los Arcos	*-18%*	9%	9%		*-19%*	**10%**	9%	
Continental	*-15%*	6%	**10%**		*-16%*	6%	**10%**	
McKellips	-3%	*-11%*	**21%**	-7%	-3%	*-10%*	**20%**	-7%
Weber	*-11%*		**11%**		*-10%*		**10%**	
Curry	*-12%*	**12%**	1%	-1%	*-13%*	**13%**		
S202	*-15%*	5%	9%		*-14%*	5%	9%	
Rio Salado	5%	-1%	-5%		5%		-4%	
Sixth								
University	-2%	-5%	**12%**	-5%	-3%	-6%	**12%**	-4%
Terrace	**18%**		*-18%*		**17%**		*-17%*	
Lemon								
Apache	2%	-2%	3%	-3%	1%	-2%	2%	-2%
Spence								
Vista d.C.								
Broadway	-2%	-3%	**10%**	-5%	-4%	-2%	**10%**	-5%
Broadmar								
Alameda	**15%**		*-15%*		**14%**		*-14%*	
Southern	3%	3%	-5%	-1%	2%	4%	-5%	
Average	-2.0%	0.4%	3.4%	-1.8%	-2.9%	0.6%	3.8%	-1.5%

Simulated Impacts of Facility-Wide Optimization

Corridor-wide impacts of the modeled AM peak period are presented in Table 5.6, both in terms of absolute measures and the percent change from the before case baseline. Delay, stops, energy and emissions results are reported on an average trip basis for each of the 40,452 vehicles that traverse the Scottsdale/Rural Road mainline or its cross streets in the target 7-9 AM period. Crashes are expressed as a rate per million miles of travel. On a per trip basis, the absolute fuel consumption figures per vehicle are lower than the mainline numbers reported in Table 5.2. This is because the addition of the shorter cross-street trips into the average trip calculation reduces average trip distance and duration.

Two main observations can be made in Table 5.6. First, small improvements in corridor-level improvement can be observed with the after-case signal timing settings in the AM peak. As with the full-day analysis of corridor impacts, however, these results are most frequently too small to be confidently discerned against the inherent randomness in the simulation (here, the small improvements in HC, CO and NOx emissions were found to be statistically significant).

Second, it is clear that all of the more comprehensive TRANSYT-7F timing plans provide substantial improvements to corridor operations over the baseline signal timing plan. Overall, the ALL-102 plan was the most effective, cutting delay by 21% and stops by 10%. The 110/102 "optimization without

jurisdictional cooperation" plan is less effective than the ALL-102 plan, but still represents a significant improvement over the baseline plan. Compared against the baseline, the 110/102 plan reduces delay by 16% and stops per trip by 8%.

Table 5.6: Corridor Impacts of AM Peak Optimization, Simulation Study

Plan	Delay (sec/trip)	Stops (stops/trip)	Fuel (liters/trip)	HC (g/trip)	CO (g/trip)	NOx (g/trip)	Crashes (per 10^6 VMT)
BEFORE	107.7	2.58	0.327	5.79	37.471	0.898	7.099
AFTER	101.0 (-6%)*	2.55 (-1%)*	0.322 (-2%)*	5.72 (-1%)	37.069 (-1%)	0.891 (-1%)	6.858 (-3%)*
110/102	90.0 (-16%)	2.38 (-8%)	0.312 (-5%)	5.648 (-2%)	36.621 (-2%)	0.864 (-4%)	6.473 (-9%)
ALL-110	90.9 (-16%)	2.39 (-8%)	0.313 (-4%)	5.665 (-2%)	36.680 (-2%)	0.864 (-4%)	6.507 (-8%)
ALL-102	85.4 (-21%)	2.31 (-10%)	0.307 (-6%)	5.597 (-3%)	36.306 (-3%)	0.851 (-5%)	6.316 (-10%)

*Not statistically significant at 95% confidence level

The simulation results imply that more significant impacts can be expected from more aggressive re-timing in the Scottsdale/Rural Road corridor. Even if the jurisdictions do not cooperate and optimize their signals independently, corridor operations can be substantially improved. The best performance, however, is realized from a coordinated optimization plan without regard to jurisdictional boundaries.

The projected benefits of these optimized timing plans in this corridor are of sufficient magnitude to warrant serious consideration for field implementation. A useful exercise in characterizing the operational significance of this potential benefit is to examine how quickly the cost of the Scottsdale/Rural Road project can be recovered in terms of AM peak period delay savings alone. Consider the Scottsdale/Rural Road project capital cost ($319,000) and operating costs projected over the next five years ($150,000), for a total cost to recover of $469,000. If we value reduced delay savings at $10 per hour and 220 AM peak period (non-holiday weekdays) per year, we can calculate the number of days required to recover the cost of the project. Keep in mind that we are accounting benefit only from delay reduction. There are also benefits from fuel reduction, reduced emissions and other factors, but we do not include them in this simple analysis. Likewise, we are not accounting for any benefit from signal optimization in any other period of the day (e.g., PM peak or off-peak).

The calculations for the cost recovery period are presented in Table 5.7. Even given the limited focus on AM peak period delay, the dollar-valued benefit associated with the more aggressive optimization plans for the AM peak is between $1,888-$2,506 per AM peak period. At this rate, the total five-year cost of the Scottsdale/Rural Road project can be recovered within 187-248 weekdays (10-13 calendar months). The shortest recovery period is associated with the ALL-102 plan. The ALL-102 plan provides $500 per day in AM peak delay savings over the 110/102 plan that requires no alteration to current cycle lengths in the corridor. Whether or not the adoption of a uniform 102 second cycle length is justified depends on how much disruption such a change would likely engender on east-west travel in Tempe.

Table 5.7: Cost Recovery Periods by Signal Timing Plan

Plan	Delay Reduction Per Vehicle (sec/veh)	AM Peak Vehicle Trips	Total Delay Reduced Per AM Peak (hours)	Monetized Savings Per AM Peak ($/day)	Period to Recover All Project Costs (weekdays)
AFTER	6.70	40,452	75.3	$753	623
110/102	17.70	40,452	198.9	$1,989	235
ALL-110	16.80	40,452	188.8	$1,888	248
ALL-102	22.30	40,452	250.6	$2,506	187

5.1.5   Summary of Findings

The re-timing of the three traffic signals at McKellips, Weber and Curry conducted in February 1999 was found to improve mainline travel speed, particularly in the PM peak period. The projected impacts on energy and emissions measures on the mainline were found to be mixed bag of small changes: 1.6% reduction in fuel consumption, a 1.2% increase in CO emissions, and no significant impact on HC or NOx emissions. A decrease in overall crash risk of 6.7% for mainline travel was also estimated. The impact on overall corridor performance (mainline and cross-streets) was found to be so small it could not be reliably estimated.

In order to better quantify potential corridor-wide impacts from signal re-timing on the Scottsdale/Rural Road facility, a simulation study was conducted to evaluate a series of signal re-timing plans identified in offline optimization. The study indicates that corridor operations may be enhanced if more comprehensive corridor-wide signal re-timing is considered beyond the three signals at the jurisdictional boundary. Delay in the AM peak can be reduced by up to 21% from an optimized fixed timing plan operating at a 102 second cycle length along the entire corridor without regard to jurisdictional boundaries. Optimization within each city without jurisdictional coordination on cycle length results in a 16% reduction in AM peak delay from baseline conditions.

5.2   SOUTHERN/BASELINE SMART CORRIDOR

5.2.1   Project Description and Evaluation History

This corridor consists of two parallel Smart Corridors on Southern Avenue and Baseline Road and the US-60 freeway, which runs between the two arterials. The project area is defined as Southern Avenue between I-10 and Gilbert Road, Baseline Road between Central Avenue and Gilbert Road, and US-60 between I-10 and Gilbert Road. Southern Avenue and Baseline Road along with the US-60 freeway is one of the most congested east-west commute corridors serving the East Valley areas. The AZTech project proposed to coordinate the traffic signals on these two corridors through the network between the AZTech server and the traffic operation centers in Mesa, Tempe, and Phoenix.

Inductive loop traffic detectors were to be implemented to provide congestion information on the arterials. In addition to the detection devices, communications infrastructure, and interface with existing traffic control centers, this project was intended to include deployment of four changeable signs on Southern Avenue, Baseline Road and the major cross-street, Dobson Road, for diverting traffic between the two arterials and the US-60. This implementation is expected to improve the traffic

progression at jurisdictional boundaries and be able to effectively divert traffic to alternative routes during major incidents.

Although this project was originally planned for evaluation, the development of the coordinated signal timing plan and the traffic diversion plan using changeable message signs were not in place during the evaluation period, due primarily to the schedule impacts from the Mesa traffic control system upgrade.

5.2.2   Project Costs for Southern/Baseline Corridor

Total start-up costs for the Southern and Baseline Corridor project were $319,127, and operation and maintenance costs were estimated to be $36,714, as shown in Table 5.8. Major start-up cost drivers for this project were the 65 loop detectors, a changeable message sign, and the associated planning activities of the Maricopa County DOT.   Shared start-up costs include 4.2% of AZTech Server development ($71,082) and 12.5% of start-up costs for Smart Corridors overall ($84,528), which includes the following: development, acquisition and installation of the traffic operations center; communications hardware; a video switch for sharing video among jurisdictions; systems engineering costs; and operator training.

Annual operations and maintenance costs are $36,714.   O&M costs for loop detectors and the changeable message sign are estimated to be 10% of the initial non-labor deployment costs. Other operations and maintenance costs apply to the shared elements. AZTech server O&M was estimated to be 12.3% of $71,082, the Southern/Baseline Corridor portion of AZTech server start-up costs. For Smart Corridor shared costs, 18.5% of $84,528 was the estimated annual cost for Southern/Baseline Corridor O&M.

Table 5.8: Development Costs of Southern/Baseline Corridor Project

Equipment Description	Quantity	Unit Costs	Start-up Costs	O&M Costs
Detection Devices (6 x 6 Loops)	65	$375	$24,375	
Loop Maintenance @10% of Capital Equipment Cost				$2,437
Changeable Message Sign	1	$97,892	$97,892	
CMS Maintenance @10% of Capital Equipment Cost				$9,789
MCDOT Planning (.33 FTE)			$41,250	
AZTech Server Shared (4.2%)			$71,082	$8,801
Smart Corridor Shared (12.5%)			$84,528	$15,687
Totals			$319,127	$36,714

5.3   BELL ROAD CORRIDOR

5.3.1   Project Description and Evaluation History

Like the other two Smart Corridors, the traffic signal system and related communications links were upgraded on Bell Road to automate traffic signal coordination. In addition, the corridor was instrumented with inductive loop traffic detectors and CCTV cameras to collect traffic condition data. Its operation is being integrated with both the AZTech server and the jurisdictional Traffic Operation Centers in the region, including Glendale, Phoenix, Scottsdale, and MCDOT. The upgraded signal system will be used to improve signal coordination within the jurisdiction as well as across jurisdictional boundaries. The traffic condition information is to be provided via the AZTech server to the various ATIS outlets already deployed or under development.

Bell Road Corridor was initially considered for evaluation. However, the baseline data collection in 1997 revealed that the congestion was relieved due to the opening of the parallel Freeway 101 (SR101). Thus, evaluation efforts focused on other corridors where the improvements in traffic flow could be measured.

5.3.2   Project Costs for Bell Road Corridor

The major cost drivers for this project are the cost of one closed circuit TV (CCTV) monitoring system, the 148 loop detectors, and the cost of the associated planning activities by the Maricopa County DOT. Start-up costs, including capital and shared costs, were $312,360. Annual operation and maintenance costs were estimated to be $36,038.

As shown in Table 5.9, dedicated annual operations and maintenance costs for loop detectors and closed circuit TV cameras are estimated to be 10% of the initial capital equipment costs. Operations and maintenance costs for shared elements are estimated to be 12.3% of the Bell Road Corridor portion of AZTech server development ($71,082) and 18.5% of $84,528, Bell Road Corridor's portion of the overall Smart Corridor start-up costs

Table 5.9: Development Costs of Bell Road Corridor Project

Equipment Description	Quantity	Unit Costs	Start-up Costs	O&M Costs
Detection Devices (6 x 6 Loops)	148	$375	$55,500	
Loop Maintenance @10% of Capital Equipment Cost				$5,550
Close Circuit TV Monitoring System	1	$60,000	$60,000	
Camera Maintenance @10% of Capital Equipment Cost				$6,000
MCDOT Planning (.33 FTE)			$41,250	
AZTech Server Shared (4.2%)			$71,082	$8,801
Smart Corridor Shared (12.5%)			$84,528	$15,687
Totals			$312,360	$36,038

5.4   COMPUTER-AIDED INCIDENT INVESTIGATION

5.4.1   Project Description and Evaluation History

MMDI funding purchased two computer-aided incident investigation devices that are part of AZTech's plan to improve incident management. Purchased for the Department of Public Safety, the "Total Station" system was designed to reduce incident clearance time, improve safety of the investigators and the quality of accident investigations.

During field investigation, the Total Station can quickly and accurately survey the accident scene and then automatically generate accident diagrams and summarize field data for accident reconstruction and reporting. It also allows measurements to be taken without impeding the flow of traffic. Back-office operations may include downloading the data to a PC for accident reconstruction and report generation.

As part of the long-term incident management strategy, the AZTech Total Station system represents the first major step toward coordinated incident response and management between transportation agencies, law enforcement, and emergency response. The project includes training for the accident investigation teams that will use Total Station in the field.

Because the Department of Public Safety was very satisfied with the first two units purchased, five additional devices were procured using state and local matching fund. Other Phoenix-area agencies have received the system, including the Phoenix Police Department. At the time of this report, no other quantitative or anecdotal data were available to verify the impact of the systems on incident investigation.

5.4.2   Project Costs for Computer-Aided Incident Investigation

Total start-up costs for this project were $147,000. As shown in Table 5.10, the major cost drivers were the cost of seven mobile Total Station survey units and computer workstations, the associated Auto Integration and AutoCAD software, and the cost of training personnel in the operation of the system. It is important to note that as part of the long-term incident management strategy, AZTech has provided extensive training to participating law enforcement and emergency response agencies for promoting institutional cooperation. Annual operations and maintenance costs were estimated to be $4,305 or approximately 4% of the initial deployment costs (excluding labor). The computer-aided investigation unit is a stand-alone system and, thus, does not include any shared costs of other AZTech systems.

Table 5.10: Development Costs of Computer-Aided Incident Investigation Project

Equipment Description	Quantity	Unit Costs	Start-up Costs	O&M Costs
Nikon Total Station Incident Investigation Unit, Computer Workstation, Tripod, Monopole Antenna	7	$13,000	$91,000	
Auto Integration and AutoCAD Software	7	$2,000	$14,000	
Operations and Maintenance				$4,305
Training			$42,000	
Totals		$15,000	$147,000	$4,305

5.5 SUMMARY OF KEY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS FOR ADVANCED TRAFFIC MANAGEMENT SYSTEMS PROJECTS

One of the concerns in traffic progression improvement is the possible negative impact on the cross-streets. The modeling results of Scottsdale/Rural Road indicated that it is possible to improve the mainline traffic conditions without negatively impacting cross street traffic. In the case of Scottsdale and Rural Road, the re-timing of the three traffic signals compensated cross-streets with more green time while improving the progression on the mainline by adopting common cycle length and optimized offsets.

The re-timing of the three traffic signals had a small, localized impact where the change was made. Due to the extent of change (three traffic signals out of twenty-one on the mainline), the impact on overall corridor throughput, travel efficiency, and other measures was so small it could not be reliably measured or simulated. However, it is important to point out that the technology deployed in the Smart Corridor project permit the development of more extensive and sophisticated traffic control strategies beyond the re-timing of three intersections available during the evaluation period. The simulation study indicated that the corridor operations may be improved if more comprehensive corridor-wide signal re-timing is considered. Specifically, the delay in the AM peak can be reduced by up to 21% with an optimized fixed timing plan using a 102 second cycle length along the entire corridor. Optimization within each city without jurisdictional coordination on cycle length may yield a 16% reduction in the AM peak delay. Thus, more benefits can be expected as AZTech expands its traffic management operations in the future.

Technical and institutional impediments are the traditional barriers to inter-jurisdictional traffic signal coordination projects. The AZTech Smart Corridor project integrates traffic data and surveillance information from various jurisdictions thus allowing local traffic engineers to monitor traffic conditions across jurisdictions for active and dynamic traffic control and management. This inter-jurisdictional cooperation is the major benefit of the Smart Corridor project so far, and this can have long-term benefits that will facilitate continued implementation of the program. This collaborative spirit is underscored by the Computer-Aided Incident Investigation project, in which transportation agencies, emergency response, and law enforcement have integrated their programs around a common technology. Programs such as these will continue to pay dividends in the years ahead, because they have demonstrated the benefits to be achieved through a common technological approach.

6.   Transit Management Systems

AZTech transit management efforts involved the deployment and integration of three transit projects with the AZTech advanced traveler information systems elements described in Section 4. AZTech transit management systems utilized automatic vehicle location and mobile data terminals in the following three projects:

- Transit Vehicle Dispatch
- Service Vehicle Dispatch
- Paratransit Vehicle Dispatch.

Based on the evaluation priorities of the local project team and the national evaluators, the level of deployment achieved on projects during the evaluation period, and local and national resources, the evaluation of the MMDI transit projects focused primarily on project history and costs. As with all AZTech projects, transit management was included within the institutional analysis discussed in Section 3 (although not on an individual project basis). A detailed cost-benefit analysis was undertaken; those results will be presented in another document.[1]

As described below, the transit projects are highly integrated with each other. The Phoenix portion of the Transit Vehicle Dispatch system operates in coordination with the Service Vehicle Dispatch and Paratransit Vehicle Dispatch systems, although different in-vehicle equipment is employed. As shown in the cost analyses below, these three projects share an information technology specialist responsible for the start-up of each system. Most importantly, the Transit Vehicle Dispatch project was primarily intended to provide information to the Transit Status Information project described in Section 4.7. Many other benefits of integration are expected.

The transit management systems are all integrated with the AZTech server, not only providing information but also receiving traffic information that transit dispatchers can use to track incidents and make service changes when necessary. One of the essential links is with the Transit Vehicle Dispatch project, since it provides schedule status information to the Transit Status Information project. Figure 6.1 shows the integration of the transit projects with each other was well as with other AZTech components such as the AZTech server.

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[1] Cost-benefit analyses can be found in *Benefit-Cost Evaluation of ITS Projects,* which should be available May, 2000, from the U. S. DOT Intelligent Transportation Systems Joint Program Office.
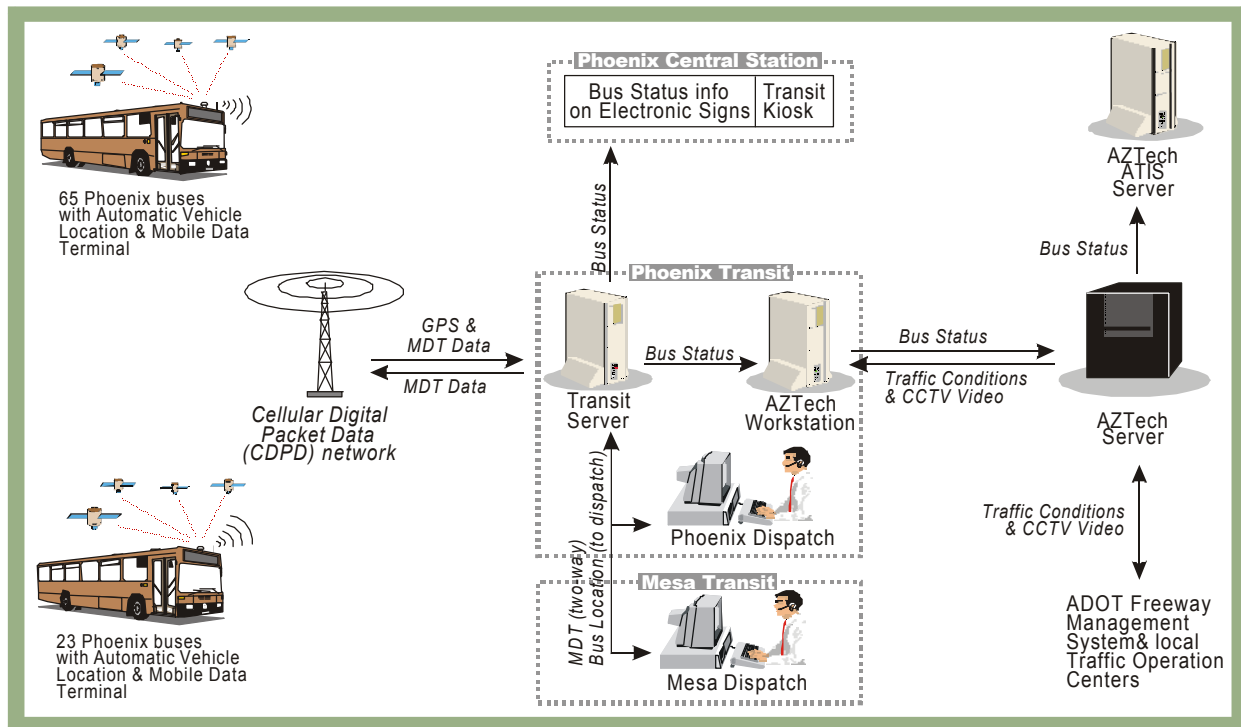
Figure 6.1: Integration of AZTech Transit Management System

6.1 TRANSIT VEHICLE DISPATCH WITH AUTOMATIC VEHICLE LOCATION AND MOBILE DATA TERMINALS

6.1.1 Project Description and Evaluation History

Automatic vehicle location devices and mobile data terminals were originally installed on 65 buses serving the City of Phoenix. The instrumented buses operate on four regional transit routes that serve Phoenix, Tempe, Mesa, and Scottsdale. The City of Mesa also decided to equip 23 of its own buses with a similar vehicle tracking system, which will serve all routes within the city. Mesa provided 50% of the additional project cost for its own installation because its units were not part of the original 65 proposed. The AZTech project team decided to include Mesa to expand the overall transit management system and increase matching funds. Six more buses in the Phoenix fleet were equipped after the national evaluation period to maintain peak vehicle requirements in the event that one or more buses needed maintenance.

The automatic vehicle location equipment uses global positioning system technology. It provides vehicle location data displayed on computer workstations at the bus garage. Location data on the Phoenix system are sent from vehicles to the transit dispatch center via a cellular digital packet data communication link instead of using the existing radio system. The location data are first sent to and processed by a dedicated computer server. The server is networked with a dispatch workstation that has computer-aided dispatching software to facilitate tracking of vehicle locations and schedule status. Schedule status information is then fed to the AZTech server and, from there, is sent to the transit status information signage described in Section 4.7.

The vehicle tracking system was designed to provide real-time bus status information to passengers at selected major bus stops and terminals via the Transit Status Information project. The mobile data terminal system allows more efficient, reliable and secure communication between bus operators and dispatchers. For example, if an incident occurs, the availability of a silent emergency alarm, precise knowledge of vehicle locations, and integration with security and service vehicles speeds the arrival of emergency vehicles, roadside assistance, or replacement buses. This improves both operator and passenger security.

6.1.2 Project Costs for Transit Automatic Vehicle Location

The total start-up costs for the transit automatic vehicle location implementation were estimated to be $587,705. Approximately $358,000 of the start-up costs were due to the purchase of 65 automatic vehicle location mobile units deployed in Phoenix and 23 units deployed in Mesa. Two other significant start-up costs were the AZTech server and transit shared costs, with the latter accounting for $50,000 of the total. No MMDI funds were used for the installation of the mobile data terminals.

It is important to note that the differences in unit costs of the Phoenix and Mesa systems are due to separate procurement efforts, resulting in somewhat different hardware, software and communications system configurations. Estimated annual operation and maintenance costs for the overall project are $113,587. Compared to the other AZTech projects, they are relatively low at only 8% of the start-up costs. Details are shown in Table 6.1.

Table 6.1: Development Costs of Transit Automatic Vehicle Location

Equipment Description	Quantity	Unit Costs	Start-up Costs	O&M Costs
Mesa Fixed Route Mobile Units (23 Units)				
Vehicle Messaging System (Display, Interface & Mounting)	23	$995	$22,885	
Gooseneck Light	23	$55	1,265	
Serial Multiplexer	23	$90	2,070	
GMSK Mobile Transceiver	23	$595	$13,685	
Mobile Antenna Kit with Integral Ground Plane	23	$60	$1,380	
Trimble Svee Six-CM3 GPS Receiver	23	$500	$11,500	
GPS Antenna	23	$100	$2,300	
Installation Costs for Above	23	$350	$8,050	
Mesa Host Equipment (Workstation, Equipment)	N/A	N/A	$16,825	
Mesa Host Equipment Software	N/A	N/A	$23,360	
Mesa System Integration (ADS & TRW)	N/A	N/A	$25,000	
Mesa Data Management System – CDPD	N/A	N/A	$50,000	
Phoenix Fixed Route Mobile Units (65 Units)	N/A	N/A	N/A	
Vehicle Messaging System (Display, Modem & Mounting)	65	$1,590	$103,350	
Gooseneck Light	65	$55	$3,575	
Serial Multiplexer	65	$90	$5,850	
ADS/Tait Wireless Data Transceiver, 15 W, 800 MHz	65	$695	$45,175	

Equipment Description	Quantity	Unit Costs	Start-up Costs	O&M Costs
Mobile Antenna Kit with Integral Ground Plane	65	$60	$3,900	
Trimble Svee Six-CM3 GPS Receiver	65	$595	$38,675	
GPS Antenna	65	$100	$6,500	
Installation Costs for Above	65	$350	$22,750	
Phoenix Host Equipment (Workstation, Equipment)	N/A	N/A	$16,338	
Phoenix Host Equipment Software	N/A	N/A	$7,190	
Phoenix System Interface (TRW & DMS)	N/A	N/A	$35,000	
Phoenix Data Management System – CDPD	N/A	N/A	$50,000	
CDPP Annual Subscription	88	$240		$21,120
Hardware Maintenance Equipment	N/A	N/A		$24,213
Software Maintenance	N/A	N/A		$8,200
Transit Shared Costs (50% 1 FTE IT Specialist)	N/A	N/A		$51,253
AZTech Server Shared (4.2%)	N/A	N/A	$71,082	$8,801
Totals			$587,705	$113,587

6.2 SERVICE VEHICLE DISPATCH WITH AUTOMATIC VEHICLE LOCATION

6.2.1 Project Description and Evaluation History

Automatic vehicle location and mobile data terminal equipment was installed on 15 Phoenix Transit service and security vehicles to assist in dispatching them during incidents. Existing two-way voice radios have been integrated with the mobile data terminals to transmit data between vehicles and the dispatcher. The onboard automatic vehicle location system provides real-time vehicle location to the dispatcher for identifying the nearest service or security vehicle during incidents.

6.2.2 Project Costs for Service Vehicle Automatic Vehicle Location

No federal MMDI funds were used for this project. Instead, the project team procured the system using the local match. Total start-up costs, including AZTech server and transit shared costs, were estimated to be $115,044. Like the other automatic vehicle location/mobile data terminal projects, one of the major costs was for the in-vehicle equipment, about $53,000. This includes the vehicle messaging system (primarily the mobile data terminals) and related hardware deployed on 15 vehicles. The host equipment, including hardware, software, and related costs, accounted for about $62,000 of the total. It is important to note that due to the different functions of the service vehicles, a somewhat different hardware, software and communications system configuration was chosen than for the transit and paratransit vehicles.

Estimated annual operation and maintenance costs for the project are $41,156, as shown in Table 6.2. This includes the automatic vehicle location system and transit shared operation and maintenance costs. At 36%, overall operation and maintenance costs are somewhat higher than transit automatic vehicle location costs relative to total start-up costs.

Table 6.2: Development Costs of Service Vehicle Automatic Vehicle Location

Equipment Description	Quantity	Unit Costs	Start-up Costs	O&M Costs
Vehicle Messaging System (Display, Interface Modem & Mounting)	15	$1,590	$23,850	
Gooseneck Light	15	$55	$825	
Serial Multiplexer	15	$90	$1,350	
ADS/Tait Wireless Data Transceiver	15	$695	$10,425	
Mobile Antenna Kit with Integral Ground Plane	15	$60	$900	
Trimble Svee Six-CM3 GPS Receiver	15	$595	$8,925	
GPS Antenna	15	$100	$1,500	
Installation Costs for Above	15	$350	$5,250	
Host Equipment (Workstation, Equipment)	N/A	N/A	$17,254	
Fleet Management & Dispatch System	N/A	N/A	$12,500	
Data Mgmt. System 2nd License	1	$2,500	$2,500	
MapInfo Professional V4.0	1	$1,295	$1,295	
MapInfo ArcLink V3.1	1	$595	$595	
BLR Street Network 5/6 w/Enhanced Address for Phoenix MSA	1	$1,300	$1,300	
Multiple Windows License Fee & Installation	1	$2,000	$2,000	
Phoenix Map Tables License Fee & Installation	1	$2,000	$2,000	
Oracle Server (5 users), training, service	1	$2,575	$2,575	
System Interface for DMS	N/A	N/A	$20,000	
CDPD Annual Subscription	15	$240		$3,600
Hardware Maintenance Equipment	N/A	N/A		$13,980
Software Maintenance	N/A	N/A		$8,200
Transit Shared Costs (15% 1 FTE IT Specialist)	N/A	N/A		$15,376
Totals			$115,044	$41,156

6.3 PARATRANSIT VEHICLE DISPATCH WITH AUTOMATIC VEHICLE LOCATION AND MOBILE DATA TERMINAL

6.3.1 Project Description and Evaluation History

Phoenix Transit has equipped 60 paratransit vehicles with automatic vehicle location and mobile data terminal systems similar to those installed on the fixed route transit vehicles. This project allows paratransit dispatchers to communicate with vehicles more efficiently and track their location. Automated scheduling and dispatching software will be added in the future to generate each vehicle's daily schedule. Altogether, the system will help Phoenix Transit serve their paratransit riders more effectively.

6.3.2 Project Costs for Paratransit Vehicle Automatic Vehicle Location

Like the Service Vehicle Dispatch project, no federal MMDI funds were used on this project. Instead, the funds were drawn from the local match. The overall start-up costs for the system were estimated to be $377,100. The major start-up cost was $194,470 for the vehicle messaging system hardware (primarily the mobile data terminals) and related hardware deployed on the paratransit vehicles. The data management system and other dispatch hardware and software accounted for $182,630. AZTech server and transit shared costs make up the remainder of the start-up expenses.

Annual operation and maintenance costs were estimated to be $76,127, including 7% equipment maintenance on the start-up capital costs. AZTech server and transit shared costs are also included. Details are shown in Table 6.3.

Table 6.3: Development Costs of Paratransit Automatic Vehicle Location

Equipment Description	Quantity	Unit Costs	Start-up Costs	O&M Costs
Vehicle Messaging System (Display, Interface & Mounting)	70	$1,590	$111,300	
Serial Multiplexer	70	$90	$6,300	
CDPD Antenna Kit w/Integral Ground Plane	62	$60	$3,720	
Trimble Svee Six-CM3 GPS Receiver	70	$595	$41,650	
GPS Antenna	90	$100	$9,000	
Trimble Placer 400/DGPSXT	20	$700	$14,000	
Test Antenna	2	$225	$450	
Installation Costs for Above	N/A	N/A	$8,050	
Data Management System - CDPD	N/A	N/A	$50,000	
Development of Paratransit CAD	N/A	N/A	$51,830	
Microsoft Base System SW Licenses	N/A	N/A	$800	
Interface to CAD	N/A	N/A	$10,000	
Interface to Oracle DBMS	N/A	N/A	$10,000	
Interface to Automatic Vehicle Location	N/A	N/A	$10,000	
Data Management System – CDPD	N/A	N/A	$50,000	
CDPD Annual Subscription	70	$240		$16,800
Hardware Maintenance Equipment	N/A	N/A		$15,250
Software Maintenance	N/A	N/A		$8,200
Transit Shared Costs (35% 1 FTE IT Specialist)	N/A	N/A		$35,877
Totals			$377,100	$76,127

6.4 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS FOR TRANSIT MANAGEMENT PROJECTS

AZTech transit management projects were evaluated by the national evaluation team primarily on the basis of project deployment history and cost. Although more in-depth analyses may have been possible early in the project, the fact that these systems create the foundation for other efforts may have limited evaluation opportunities. A customer satisfaction evaluation of the Transit Status

Information project that obtains information from the Transit Vehicle Dispatch system was considered, but was cancelled, because installation of the signage was delayed.

Installation of the transit management systems has provided both Phoenix and Mesa with a strong foundation for extending the reach of the current Transit Status Information project as well as for undertaking new efforts that provide transit information through a wide variety of dedicated and shared media, both existing and envisioned. The systems themselves afford the opportunity for transit providers to improve the efficiency of their operations and to provide better customer service. The link with the AZTech server will allow dispatchers to use real-time traffic information to help respond quickly and efficiently to traffic incidents.

7.   Conclusions and Recommendations

The evaluation of AZTech took place between 1997 and 1999. During that period a variety of evaluation activities were planned and implemented, and several planned evaluations were not completed due to evaluation budget constraints or limitations in the project deployments. Nevertheless, the successful completion of many of the evaluation efforts provides a valuable picture of the benefits that an integrated ITS program has brought to the Phoenix metropolitan region. The lessons learned will provide a foundation for further ITS deployments in the Phoenix region, and other metropolitan areas can learn from their example. In addition, the results from AZTech contribute to the knowledge about ITS benefits, which is the objective of the National ITS Evaluation Program. This chapter serves to draw together the conclusions that can be reached from the 15 projects covered in this report. All 15 projects were evaluated in some capacity and a number of projects received extensive evaluations.

To reach conclusions from the evaluation results, some overarching questions can be addressed:

What benefits have been achieved?
Have there been any negative effects?
Have national and AZTech objectives been achieved?
How does the AZTech experience compare to other ITS deployments?
How successfully has ITS integration been accomplished in Phoenix?
What should or can be done differently in the future to achieve further improvements?

The sections that follow attempt to address these questions. As a starting point, the benefits of ITS integration are examined, followed by discussion of the evaluation of the four major groups of AZTech evaluation results: institutional lessons, traveler information, traffic management, and transit management.

7.1   THE VALUE OF ITS INTEGRATION

As stated in the introductory Section 2, the MMDI evaluations had as a chief objective an assessment of the benefits of integration, posing the question "was the whole greater than the sum of the parts?" The answer to the question is a qualified yes.

One of the strongest outcomes of integration was the strengthening of institutional ties among public agencies in the region. On the one hand the AZTech MMDI had as an advantage at the outset a pre-existing history of agency collaboration. The MMDI built on that foundation and strengthened the existing relationships so that the region now has a better potential for improving the functioning of the transportation system in Phoenix not only for its operators (i.e., the road and highway, transit and emergency response agencies), but their customers—the traveling public—as well. Travelers now have better and more accessible information on travel conditions and alternatives. Moreover, the potential for improved operations should help travel conditions as ITS continues to be deployed. A good example of this type of integration is the signal timing coordination between the Cities of Tempe and Scottsdale. While the coordination efforts have had a modest beginning, they set the stage for similar coordination as other Smart Corridors come on-line in the months ahead.

Another demonstration of the benefits of integration is the sharing of costs among projects and agencies.   As presented throughout the report, many projects were able to take advantage of investments such as the AZTech server. Sharing of that investment among multiple projects allowed for economies of scale thereby making individual projects more affordable for participating agencies.

Integration of ITS projects into an overall program under the AZTech umbrella provided a critical mass of multiple agencies. When coupled with the spotlight of MMDI funding and external attention from the ITS community, U.S. DOT, and the media, this critical mass served to heighten awareness about ITS among local officials. An individual ITS project would have been unlikely to rise to that level in the consciousness of politicians and decision-makers in the Phoenix region.

Integration has had direct benefits in other ways, as well. An example is the sharing of traffic camera images among public and private sector participants of AZTech. As the ability to share images was enabled by the technology that AZTech provided, it had ramifications in unexpected ways. On the one hand, agencies had to grapple with the need for new policies for how video images would be used, and they successfully developed rules that they are all following for what would and would not be shown from accident scenes. On the other hand, the surprising popularity of the camera images made available on the Trailmaster Web site has helped to bolster support for ITS technologies among the public. Integration also facilitated the adoption of new, more effective procedures and policies across the participating agencies beyond the camera issue. Intellectual property rights for software and flexible procurement approaches are two key examples.

Despite the demonstration of benefits of integration in some aspects of the MMDI, benefits are not uniformly upheld throughout AZTech. For one thing, integration of multiple ITS projects are more complicated than development and deployment of stand-alone projects. Not surprisingly integration has taken longer than optimistic AZTech managers expected. Consequently, some projects, such as the Smart Corridors, are still in the process of completion. Thus, the benefits of those projects were not available to be evaluated within the necessary timeframe of this study.

Another place the value of integration is challenged is the integration with the private sector components of projects. Public/private integration has had only limited success, because of the reliance upon commercialization of services, principally traveler information services. The public sector had hoped that integration of public-provided data sources with private sector fusion and dissemination capabilities would lead to successfully commercialized traveler information services within the Phoenix region. As has been demonstrated from the lack of commercial success to date with the Fastline service and Etak's personal messaging services, marketplace conditions and the ability of private partners to make a business in that market are as important as public sector participation. However, that is not to say that the public sector should not help foster success. For example, one area, which the public and private sectors need to address more effectively, is the promotion of services to travelers.

7.2   INSTITUTIONAL LESSONS LEARNED

AZTech proved fertile ground for lessons on institutional adaptation to meet the challenges of ITS integration. The institutional study identified eight actions that were especially important in Phoenix:

- Building on existing relationships
- Reaching the general public
- Reaching elected and appointed officials
- Defining intra-agency management and staffing requirements
- Developing the management structure for the MMDI
- Assigning intellectual property rights
- Selecting the appropriate procurement mechanisms
- Developing policies that govern operations.

Among these, AZTech's ability to work from pre-established relationships among public agencies in the region proved particularly beneficial. In years preceding the award of the MMDI to the Phoenix metropolitan region, a number of actions had been taken that helped build coalitions to address various transportation needs. Starting in 1993 with the Metropolitan Area Governments Information Center (MAGIC) study and followed two years later by the receipt of an ITS Early Deployment Planning grant, these efforts and others brought agencies together to pursue common interests. The relationships established in these earlier initiatives proved critical by the time of the MMDI program started in 1996. It would have been extremely difficult if not impossible to implement such an ambitious program as AZTech without this collaborative history and network of interpersonal relationships in place.

Similarly noteworthy are the practical steps to the day-to-day challenges that arise in managing a complex program such as AZTech. Creative solutions were found to vexing problems dealing with procurement instruments and contract language relating to intellectual property rights. For example, AZTech MMDI participants were able to draw on three innovative procurement instruments for timely procurement: sole-source contracting, on-call contracting, and joint, inter-jurisdictional procurements. Simply saving time and making progress in deployment is essential for maintaining momentum and showing progress to stakeholders, and AZTech effectively demonstrated ways for removing barriers that impede and do not contribute to the program.

Recommendations

To build on the successes and address areas where AZTech deployments may have fallen short, AZTech partners should re-examine the potential institutional elements that are involved. An example of such an investigation should be made in the area of on-going operations of the systems for which the public sector partners are responsible. Are agencies staffed appropriately to operate and maintain the systems? Is staff at all levels supportive? Surely budgets as well as roles and responsibilities need to be aligned with AZTech systems for them to continue to evolve and perform as expected. A good example of where some attention needs to be paid is in the feeding of traffic information on arterial streets to the Roadway Closure and Restriction System (RCRS). Users of traveler information services view such information as important to improving the quality of the current ATIS services, yet operational staff of local government traffic agencies may not be staffed appropriately to input that information. AZTech partners will need to address these institutional challenges to realize their vision.

7.3   TRAVELER INFORMATION SYSTEMS

Eight traveler information projects were evaluated, with two of them investigated in detail from the standpoint of customer satisfaction. The experience in Phoenix serves to highlight the tremendous promise and the potential pitfalls of deployment of Advanced Traveler Information Systems (ATIS). AZTech implemented three public sector ATIS dissemination technologies (Trailmaster Website and RCRS Web page; transit status information; and kiosks). AZTech's private sector partners deployed four services (Etak's personalized messaging service, Etak's commercial web page, Etak's *Traffic Check* cable TV system, and Fastline's personalized communication device). A private sector in-vehicle system was planned, but canceled.

To their credit, the public and private partners of AZTech clearly wanted to offer travelers a wide range of dissemination technologies for obtaining traveler information. Recognizing the diversity of travelers and opportunities they have for accessing traveler information, AZTech partners' plans encompassed pre-trip and en route services, publicly subsidized and customized commercial services, and high-tech and low-tech approaches that would appeal to all segments of the traveling public. The results of the customer satisfaction studies demonstrate that some of those technologies

have been met with public interest and user acceptance, as will be discussed below. Unfortunately, the commercial services have not been very successful to date. Many evaluations for the commercial services were shelved due to delayed and canceled deployments or limited usage preventing meaningful evaluation.

The Challenges of Commercializing ATIS

The lack of commercial success so far for ATIS in Phoenix may be attributed to several factors. In some cases, the business case has not been made sufficiently to attract private sector investment. At the present time cable operators in the Phoenix region have not chosen to displace other programming on commercial channels with the *Traffic Check* cable program. Consequently, only an advertising-free public access channel assigned to a municipal government by the local cable franchise carried the service during the evaluation period. Similarly, at the time of the evaluation paging companies had not yet been attracted to the opportunity to carry traveler information as part of their offering to paging subscribers. Without partners who control the dissemination technology, such as the cable or paging networks, the service cannot be deployed. Another factor limiting the success of the commercial services is the need for promotion. A case in point is the Fastline service for personal communication devices, which was hampered by the difficulty in promoting the service to potential customers, who are the current base of owners of such devices. Creating awareness of a service and stimulating usage for ATIS services requires resources that private sector partners may not be able to muster. A third factor affecting the potential for commercial ATIS in Phoenix may be the limited appeal of the services given the traffic conditions in the region. Appeal of certain services, fax and e-mail for example, may be limited because users may not be willing to pay the cost that commercialization requires. For a commercial ATIS to succeed, the business case must identify sufficient demand among the target customer segment, and that demand may not have reached a large enough threshold in the Phoenix region to support commercial ATIS enterprises.

Insights from the User Perspective

One of the most productive aspects of the ATIS evaluations in Phoenix is what has been learned about customer satisfaction. The public sector Web site, Trailmaster, was subject to extensive evaluation based on focus groups and Web log analysis. *Traffic Check* Cable TV service developed by Etak and carried on Tempe government's public access channel was investigated using telephone surveys. The studies provide a rich lode of information that can be mined for insights on the market for traveler information services. The research provided support for hypotheses regarding travelers' use of information. Hypothesized relationships are of four general types:

- The regional or situational context. E.g., metropolitan areas with many alternative routes; adverse weather conditions
- The quality of the ATIS service. E.g., ease of access and availability of accurate real-time information
- The characteristics of the trip. E.g., the length of the commute and degree of congestion experienced on the commute
- The characteristics of the traveler. E.g., Education and household income, comfort with high technology, and desire for sense of control.

In the Phoenix region, user response to AZTech traveler information has been usually consistent with these expectations. Some of the important results include the following:

- Usage of the Trailmaster Web site has grown steadily (50% over the 10-month evaluation period) and can be expected to continue to grow as the quality and coverage of travel conditions increase as instrumentation of roadways expands. Users are particularly interested in arterial or non-freeway conditions, and availability of such information could substantially boost regular usage.
- Dynamic is preferred over static information, as exemplified by camera images, which are one of the most popular features on the Trailmaster Web site. Six of the top 10 most visited pages pertain to traffic monitoring cameras.
- Patterns of ATIS usage in the Phoenix region by day of week and time of day are generally consistent with those observed in other locations, although the pattern tends to be smoother, along with generally lower levels of congestion, with fewer spikes of usage observed elsewhere. The absence of dramatic weather conditions during the evaluation period, along with generally lower levels of congestion, may explain this phenomenon in Phoenix ATIS usage.
- With regular usage of Web-based ATIS, frequent users appear to become more efficient and selective in the information they access. Evidence for this is that the number of pages viewed per session has dropped (3.5 to 2.1) while the average duration of a session has increased (7.8 to 8.5 minutes).
- Information on travel conditions available on the *Traffic Check* cable TV program caused viewers to change travel behaviors. 74% of commuters who learned of traffic problems from the program made two or more trip changes within the last year, with change of route the most common change made.
- Although demographic characteristics weren't related to the frequency of use of *Traffic Check* cable TV, commuters who reported congested traffic at least twice a weak or who had attitudinal characteristics such as a desire for accurate traffic information or worrying about being late were likely to be frequent users of the program.
- Despite the utility of traveler information services to those who have tried them, willingness to pay is low. Of *Traffic Check* viewers, only 19% reported they would be willing to pay $1.00 per month to continue receiving the service.

One of the key findings from the customer satisfaction work in Phoenix, when compared to the MMDI evaluation for Seattle, is that traffic conditions are far less problematic for the typical commuter. In Phoenix, commuters did not report significant congestion, knew of alternative routes, and were far less troubled by the potential for travel delays. Thus, there appears to be less of a motivation for seeking out and using information to address commuting problems.

Recommendations

Given the overall low level of usage of the traveler information service, AZTech partners need to determine what they might be able to do to alter the picture. One obvious area to address is simple awareness of the services. The customer satisfaction studies showed that users of both the Web page and cable TV service often stumbled across them by accident by channel or Web surfing. Advertising or other promotional activities is essential for commercial service to be successful, and AZTech private partners should offer sound plans for promoting usage if they are receiving public seed money investment.

It is also recommended that effective use be made of the demographic (age or gender, for example) and psychographic (attitudes and values) attributes of users of traveler information services that were revealed in the customer satisfaction research. Such information will be helpful to designers not only in devising effective marketing campaigns but it can also help in gearing their services to appeal to their target markets.

In surveys and focus groups users offered a number of areas for improvement that would make traveler information services more valuable or accessible. Here, too, ATIS service designers would do well to take advantage of those recommendations to enhance the appeal and marketability of their services. Early adopters of new technologies are often able to overlook the shortcomings of first-introduced products. However, for a broader appeal, products need to be perfected and the suggestions presented for AZTech ATIS indicate areas in which development efforts could be focused.

Finally, the importance of findings from customer satisfaction research done after deployments suggests that research prior to design and implementation of ATIS projects would be extremely valuable. Better understanding of customer needs prior to development, customer reaction to potential service offerings before launching them, and testing of marketing and promotion strategies might lead to improved deployments if built on market research done at the beginning of ITS programs rather than at the end.

7.4   TRAFFIC MANAGEMENT SYSTEMS

AZTech focused its traffic management efforts on improving traffic movement in eight Smart Corridors throughout the region. AZTech also dealt with the incident side of traffic management with the Computer-Aided Incident Investigation project aimed at improved handling of incidents. All of these projects focused on interjurisdictional coordination built around common technological approaches.

Evaluation of the Smart Corridors program was highly focused. Although three corridors were planned for evaluation, extensive evaluation was done on a single corridor, the arterial known as Scottsdale Road and Rural Road at different points along its path. Two jurisdictions, the Cities of Scottsdale and Tempe decided to coordinate the signals at three selected intersections near their jurisdictional boundary in an attempt to ease traffic flow along the corridor. The re-timing of the three traffic signals had a small, localized impact where the change was made. In particular, mainline travel speed improved, particularly in the PM peak. Due to the limited extent of deployment (three traffic signals out of twenty-one on the mainline), the impact on the measures of effectiveness that were tested (speed, stops, delay, fuel consumption, emissions and crashes) was so small that corridor-wide impact could not be confidently detected through the computer simulation that was performed.

On the other hand, simulation results from a hypothetical implementation of aggressively optimized signal re-timing proved much more promising. If all signals throughout the Scottsdale/Rural Road Corridor were re-timed with one of three optimized plans, rather than just the three in the actual deployment, the results suggest that reductions in delay of 16-21% in the AM peak could be achieved. Other measures of effectiveness also improved, but at a somewhat lower level. While implications of optimizing to a uniform cycle length along the corridor has implications for operations beyond the scope of the evaluation, the results warrant further consideration for the potential benefits that could be achieved.

Thus, the evaluation of AZTech's efforts at improving traffic management through the Smart Corridor program was not entirely able to validate those benefits during the evaluation period. Although there is cause for optimism, the deployment was too limited for reliable impacts to be measured. However, it is important to point out that the technology deployed in the Smart Corridor project permits the development of more extensive and sophisticated traffic control strategies beyond the re-timing of three intersections available during the evaluation period. More benefits can be expected as AZTech expands its traffic management operations in the future, and further pursuit of signal re-timing offers a promising course of action.

The Computer-Aided Incident Investigation system also represents AZTech partners' interest in fostering interjurisdictional cooperation to achieve improved traffic management. In this case agencies are adopting the "Total Station" system designed to reduce incident clearance time and improve accident investigations. Although no evaluation data were available to substantiate the impact of the system at the time of this report, the favorable response that agency personnel have had to the technology has resulted in additional installations. A positive experience such as this will help build support for ITS technologies not only among the traditional constituency such as traffic departments, but also in public safety and police departments as well.

Recommendations

Because coordinated signal timing is a fundamental step advocated by ITS proponents, the Smart Corridors deserve further assessment than was covered by this evaluation to measure the impact as coordinated signal timing becomes more fully deployed. AZTech partners should be interested in documenting the improvements from Smart Corridors as such information will be useful for demonstrating the value of ITS investments to both the general public and elected officials.

Additionally, traffic engineers should investigate the optimal signal timing to achieve the desired impacts along each Smart Corridor. In the Scottsdale/Rural Road investigation, one jurisdiction adopted the signal-timing plan of its neighbor. While benefits were achieved on a localized basis from that coordination, it is possible that another plan could be applied that would achieve even greater benefits than what was tested. Further investigation of the potential in this area is recommended.

AZTech partners should continue to foster the cooperative spirit among agencies and jurisdictions that has been stimulated by the ATMS projects. These projects will continue to pay dividends in the years ahead, because they have demonstrated the benefits to be achieved through a common technological approach. They can also serve as a model for integration of other ITS technologies within a metropolitan context where collaboration across agencies and jurisdictions is essential.

7.5 TRANSIT MANAGEMENT SYSTEMS

The transit management projects within AZTech focused on integration among the transit services and integration with the traveler information component of AZTech to provide bus status information to travelers. Three separate transit management projects were undertaken: Transit Vehicle Dispatch, Service Vehicle Dispatch, and Paratransit Vehicle Dispatch. While these projects may have operational benefits to the transit providers and their customers, the evaluation priorities and resources were focused elsewhere within the AZTech program. Consequently, the transit management projects were evaluated only from the standpoint of cost of deployment and as part of the overall institutional analysis. It would appear that the automatic vehicle location technology and mobile data terminal installed on the transit vehicles, especially when linked with incident information from the AZTech server, would enable more efficient operations and greater safety and security for passengers. Thus, it is recommended that some of these benefits be assessed as a sufficient number of vehicles becomes equipped.

7.6   OVERALL CONCLUSION

In conclusion, the evaluation of the Phoenix Metropolitan Model Deployment Initiative known as AZTech has contributed to the national understanding of the benefits of ITS integration within a metropolitan setting and the impact of specific ITS technologies and projects. Perhaps the greatest benefits have been institutional, as public agencies have strengthened their base of collaboration that will enable them to continue to build an ITS infrastructure and improved transportation services for the traveling public. The evaluation has also shown that no negative effects were detected. The effects that were measured were either positive, in the case of customer satisfaction with traveler information services, or have the potential to be positive, in the case of traffic management system impacts. Thus, the evaluation effort has achieved objectives from both the national and local perspective. On the one hand, more is known about ITS benefits than was known before, thereby adding to the accumulating evidence at the national level. On the other hand, the Phoenix metropolitan region has information on which decisions about future investments in ITS can be made.