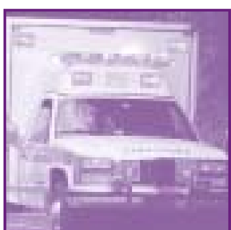
Deploying and Operating Integrated Intelligent Transportation Systems

Twenty Questions and Answers



Guidance from the Evaluation of the Metropolitan Model Deployment Initiative Sites

NOTICE
The United States Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear herein only because they are considered essential to the objective of this document.

Table of Contents

Program Assessment

Executive Summary

Background

This document summarizes lessons learned through the evaluation of four sites selected in 1996 to serve as national models for deploying and operating intelligent transportation systems (ITS) in metropolitan areas. The intent of the document is to assist traffic managers, planners, and other key decisionmakers in metropolitan areas considering similar integrated ITS applications.

The United States Department of Transportation (USDOT) designed the Metropolitan Model Deployment Initiative (MMDI) to foster public-private partnerships to showcase integrated metropolitan area ITS infrastructure. From a total of 23 responses to a 1996 *Federal Register* notice, USDOT selected four sites to receive approximately $39 million in Federal funding for this initiative. The sites selected were San Antonio, Texas; Phoenix, Arizona; Seattle, Washington; and the New York/New Jersey/Connecticut (NY/NJ/CT) area. In each of these sites, non-Federal partners funded an additional 50 percent or more of the project cost.

One of the goals of the MMDI was to demonstrate measurable benefits resulting from the application of integrated, region-wide approaches to transportation management and provision of traveler information. To support this goal, substantive evaluations of potential benefits were conducted at the selected sites. This report synthesizes the results of those evaluations, along with findings from follow-up interviews conducted with site managers in the spring of 2001 (five years after program start).

Summary of Findings

The report uses a question-and-answer format and is organized according to lessons learned and advice received in the areas of performance (i.e., benefits), cost, and overall program assessment. Major findings include the following:

- A strong regional architecture and common data server are critical foundations to the successful integration of ITS.
- Publicly funded traveler information websites that provide information such as travel condition maps and video images are among the best investments of ITS funds.
- The market for commercial applications of traveler information is not yet developed.
- ITS applications, such as information websites and automatic vehicle location (AVL) and tracking, lead to more effective transit management and may help to maintain ridership.
- Intelligent transportation systems reduce delay, crash risk, and fuel consumption.
- Implementation delays are likely to be an unavoidable aspect of integrated ITS applications. However, means exist to mitigate these delays, such as stronger oversight of software development projects and recruitment of a local champion.

- Operations and maintenance (O&M) costs are a major and often overlooked challenge to realizing and optimizing ITS benefits.
- ITS integration can deliver benefits that extend well beyond their original applications.

These findings and others are presented in the following 20 questions and answers that address important aspects of deploying and operating integrated ITS systems. They are intended to offer readers guidance for getting the most out of their own ITS applications.

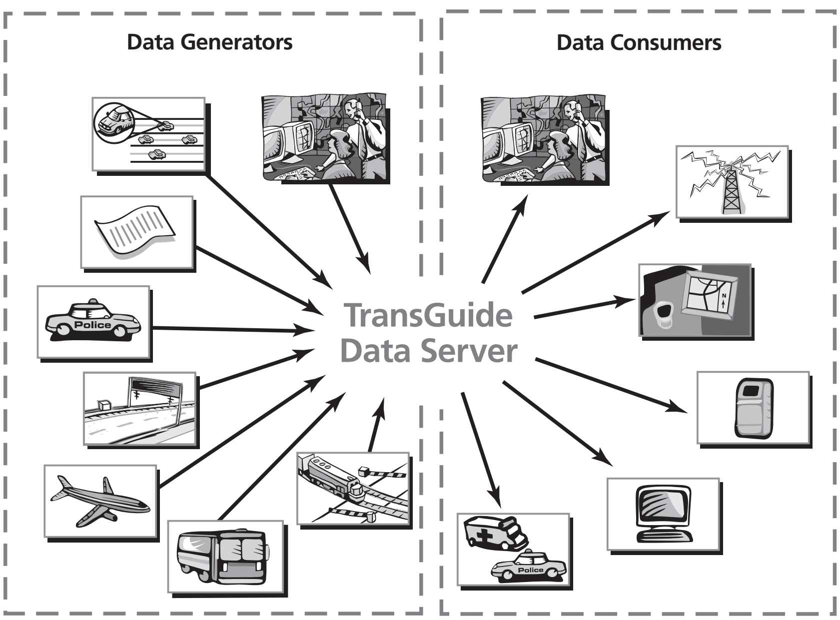


Figure 1. San Antonio's travel conditions database synthesizes data from a wide variety of sources.

Q1 I am considering deploying an integrated Intelligent Transportation System; where should I start?

Develop a regional architecture. Your first step should be to develop a regional ITS architecture. As defined by USDOT, "An architecture is a framework that lays out the boundaries, players, and strategies for [the] process of information management. And in the case of ITS, [the framework] has to have an intimate knowledge of the way transportation works as well, in order to get the new systems to work well with the existing ones. The framework can then serve to guide developing standards and to make deployment decisions that will result in efficiency, economies of scale, and national interoperability."[1] As Rob Bamford, program manager for the NY/NJ/CT model deployment, explained in a spring 2001 interview with the evaluation team, "The regional architecture is the heartbeat of a successful ITS." Further information and guidance on developing an ITS architecture can be found at the following website: www.its.dot.gov/arch/arch.htm.

Bring your architecture to life. Having developed and defined a regional ITS architecture, you should then bring that architecture to life through shared data. Experience from the model deployments suggests that you should work toward developing a comprehensive, regional repository of transportation-related information. According to Pat Irwin, Texas Department of Transportation (TxDOT), "The creation of such a data server is an

[1]*The National Architecture for ITS: A Framework for Integrated Transportation into the 21st Century,* April 1996, USDOT, Washington, DC.

essential early step that I would suggest to anyone desiring a successful integrated ITS deployment."

As an example, consider the structure of the San Antonio model deployment's data server (see Figure 1). All three of the other sites pursued similar designs, including the ITS information backbone in Seattle, the AZTech server in Phoenix, and the transit database in NY/NJ/CT. As the figure illustrates, such servers are characterized by the sharing of data between information contributors and information users. These users can include anyone—from traffic and transit managers to emergency responders to the traveling public. As Pat Irwin notes, "While the public may not see this data server directly, it affects their lives every day."

Consider several factors when designing your site's ITS data repository:

Understand that both central and distributed systems are effective. Traditionally, people believed that a regional data repository had to be located at one spot such as on a single computer. While the Phoenix and San Antonio sites successfully demonstrated this model, a distributed system—such as Seattle's ITS backbone—can also be successful. While both approaches have inherent strengths and weaknesses, one main difference is that a centralized system puts most of the responsibility for interface costs on the agency maintaining the server. In a distributed system, these costs are more spread out among the various data contributors and users.

Be responsive to the needs of different user groups. As previously indicated, an ITS data repository can benefit a number of users, from traffic managers to the traveling public. However, not all groups will have the same data requirements. Consider the example of in-pavement loop detectors. From a purely incident management standpoint, such devices are becoming increasingly unimportant. In San Antonio, as in many other metropolitan areas, fewer than 20 percent of freeway incidents are first detected through loops measuring traffic conditions. Many more incidents are identified through cell phone reports and traffic operators using video cameras. Consequently, traffic managers may be tempted to begin reducing the number of loops deployed and maintained. However, in many areas, data from loop detectors are also used to estimate travel speeds, which, in turn, are disseminated to travelers. This type of traveler information has been well-received by the public. As Brian Fariello of TxDOT notes, "While system speeds from loops are becoming less and less important to our traffic operations, our public appreciates the data and thus we will continue to support their operation."

Be responsive to different data needs within a given user group. The model deployments illustrated that among users of traveler information, some prefer direct receipt of roadway speed data. Other travelers indicated a preference for a visual depiction of how fast traffic is moving. While both of these needs have to do with traffic speeds, they require different data collection and dissemination techniques. For the first group, speed data are usually collected through roadway loop detectors, while visual data are provided by remote camera images.

Ensure timely and accurate information. Providing users with timely and accurate information proved to be an effective way of building and maintaining user trust.

Ensure consistent message sets. Another important consideration of an integrated ITS data system is to provide a consistent message set among the various data providers. For example, terms such as "10-minute delay" or "1 lane closed ahead" need to have the same definition when entered into the system by traffic operators or emergency responders. As NY/NJ/CT's Bamford notes, "This is especially important when dealing with ATIS [advanced traveler information systems], where we are trying to gain and build the public's trust." Not only must these message sets be consistent across jurisdictions and geographical boundaries, but from one scenario to the next.

Q2 I have a good repository of traveler-related data; now what should I deploy first? What was the single most successful type of ITS application observed during the model deployments?

Real-time traveler information was found to be most successful. While success has many definitions, perhaps the most applicable is that associated with widespread deployment and generation of measurable user benefits. Using this metric, the clear winner from the model deployment experiment continues to be the provision of traveler information through real-time traffic condition websites (see Figure 2). Particularly successful are publicly funded websites that provide a combination of traffic congestion maps and access to real-time video images of the roadway system. Deployed and maintained at three of the four model deployment sites,[2] these traveler information websites continue to be popular today for a number of reasons:

Traveler information websites are relatively inexpensive. Consider that total deployment costs for the traveler information websites in Seattle and Phoenix were only $85,000 and $135,000 respectively, compared to a cost of $97,000 for a single changeable message sign in Phoenix. Operations and maintenance costs are also similarly competitive. For example, yearly O&M costs for Phoenix's 50 traveler information kiosks are approximately $167,000, or $50,000 more than the region's traveler website costs, despite the fact that the website reaches far more users.

[2] *The NY/NJ/CT model deployment is focusing on a similar traveler information website devoted to transit users, but as of Fall 2001 it has not yet been completed.*

Data that drive the sites are readily available. Most of the video images and traffic speeds featured on the sites are already being collected for traffic management operations.

Web applications provide benefits to users. For example, the evaluation team determined, through simulation modeling, that users of San Antonio's traveler information website will experience average annual reductions in delay of 5 percent, fuel consumption of 2 percent, and crash risk of approximately 1 percent. In the case of a single, representative severe incident, these improvements are more pronounced, with reductions in delay of 22 percent, fuel consumption of 3 percent, and crash risk of nearly 9 percent. Finally, 85 percent of respondents to an on-line Web survey in Seattle rated the Seattle region's traveler information website as "very useful." Similar ratings were observed in San Antonio and Phoenix.

Such sites can reach a broad and increasingly growing market. Worsening traffic conditions, combined with greater awareness of traveler information websites and improvements in their quality and geographic coverage, are leading to rapid growth in their use. Evidence of this growth appears at all three of the model deployment areas currently deploying websites. For example, in Seattle, where website improvements have been minor (e.g., the addition of information from 10 new cameras), the average number of user sessions per day doubled. As of December 2000, the average stood at more than 22,000 user sessions per day compared to 11,000 in 1999.

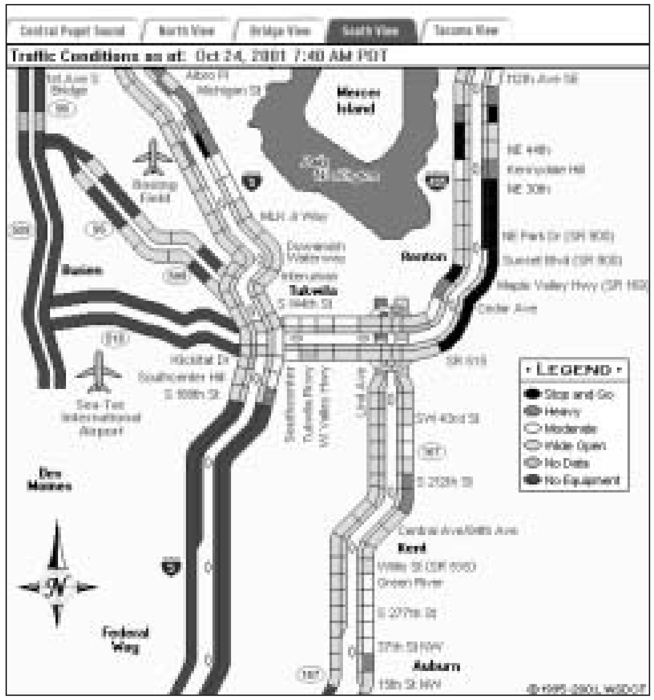


Figure 2. Washington State Department of Transportation's traveler information website was well-received by the public.

Additional website services were also appreciated by users. In San Antonio, TxDOT did not originally offer video images, but added this service to its website (Figure 3) in response to the large number (80 to 90 percent) of website survey respondents who requested this enhancement. TxDOT also added point-to-point travel times. The result has been a dramatic increase in usage, rising from a total of 7.5 million "hits" between mid-1995 and December 1999 to more than 32 million hits in the year 2000 alone.[3]

Furthermore, in San Antonio, as in the other model deployment sites, website

[3]*Note: Hits are a different metric from user sessions. A single user session may be associated with multiple hits.*

usage indicated an even larger latent demand for information. During an ice storm that threatened San Antonio in December 2000, the number of hits on the TxDOT site increased more than 500 percent, to 600,000 hits per day before the server eventually crashed.

Cautionary note: The example presented above raises a caution about deploying traveler information websites. Because these systems are and will remain popular, you must ensure sufficient capacity on your system before you experience a crunch. As Pat Irwin of TxDOT advises, "First determine your maximum expected capacity, then triple it." Failure to do so may result in user attrition.

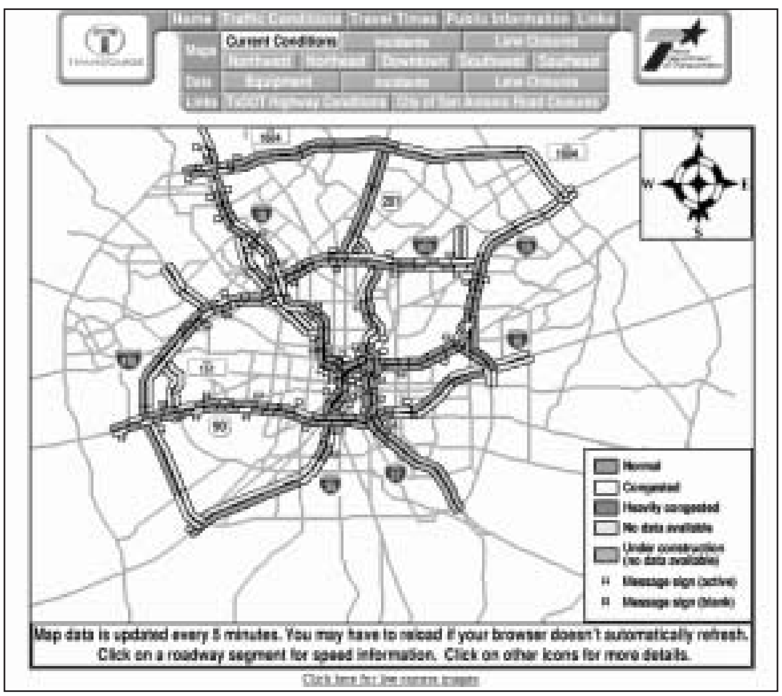


Figure 3. TxDOT's traveler information website has seen a dramatic increase in users.

Q3 Were there any other success stories? Can you suggest other applications that should be considered?

Yes. Other successes included different types of traveler information improvements, as well as successful applications and proof-of-concepts in emergency management. These applications are summarized below.

Additional Traveler Information Improvements

Point-to-point freeway times. One of the most successful ITS improvements in San Antonio was TxDOT's development of a system to provide the public with estimates of point-to-point freeway travel times. Using a relatively simple algorithm, TxDOT converts average vehicle speeds reported by its roadway loop detectors to estimated travel times. These times are then shared with the public over the traveler information website (see Figure 4) and the region's extensive collection of changeable message signs. This improvement has been well-received. For example, the system made front-page news on its first day of operations[4] and, as reported in the previous section, has contributed to dramatic increases in website usage. Finally, when asked to rate the travel times feature on a scale of 1 (totally inaccurate) to 10 (very accurate), more than 65 percent of the 1,100 respondents gave a rating of 8 or higher, with an average response of 7.8.

Web application for transit users. Another set of ITS improvements you may wish to consider are Web-based applications for transit users, such as the BusView and

[4] *Huddleston, Scott, "Motorists to view drive times."* San Antonio Express-News, *Monday, November 1, 1999, Page A1.*

MyBus products implemented in Seattle. Both of these services tie in to AVL capabilities on the region's transit fleet to allow riders to track their buses and to anticipate arrival times at a given stop. Even without significant advertising, usage of these sites has been steadily increasing. As of February 2001, Web page views for BusView averaged 4,500 per day, with a high of 16,600, while page views for MyBus averaged 67,000 per day, with a high of 112,000. Furthermore, user surveys of MyBus' predecessor suggest that these systems can have a measurable effect on the comfort and satisfaction of new transit users and thus may aid in retaining riders.

Web applications for conveying roadway conditions. A third Web-based application that was also found to be successful was Phoenix's Roadway Closure and Restriction System (RCRS). The RCRS allows various State and local personnel to enter information on maintenance, weather, and operations activities (such as road closures) in a common database that other jurisdictions and the traveling public can view and share. Such interjurisdistictional cooperation can help reduce delays for the public, increase safety for travelers and roadway workers, and lead to more effective and less costly maintenance operations. Initiated in Arizona, the system is now expanding throughout the Southwest and beyond, with sites as far away as Oregon considering tying into the database.

Improvements in traditional media communications. Another success story of the model deployments lies in the benefits afforded the public through improvements in traditional media communications (e.g., television and radio). In Phoenix, Dale Thompson of the Maricopa Department of Transportation reports that the media is constantly saying, "Give us more cameras." In fact, co-location of media at the traffic operations centers in both San Antonio and Phoenix has led to more accurate traffic reports and cost savings for the media providers. For example, the need for airborne traffic monitoring has been greatly reduced because of access to ground-based camera coverage.

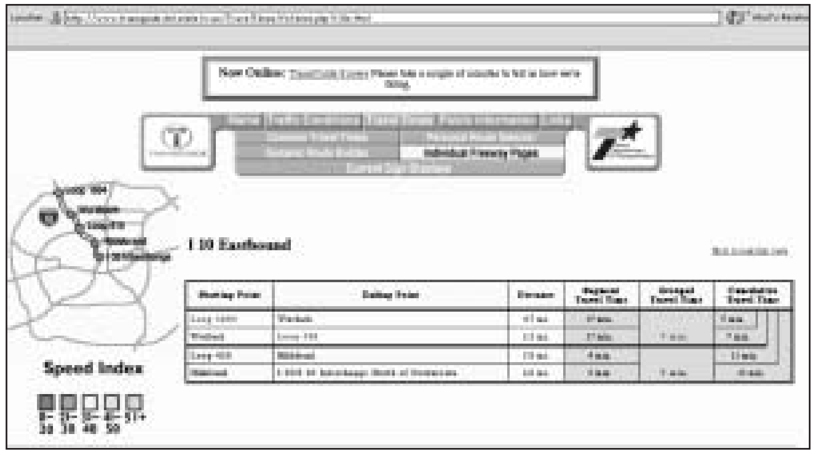


Figure 4. Travelers in San Antonio, Texas, can now access roadway travel times through both variable message signs and over the Web.

Emergency Management Successes

Provision of 800 MHz radios with a common emergency frequency. Proving that ITS solutions can be simple, one of the more successful applications undertaken in Seattle was to provide radios with a common frequency (800 MHz) to allow Washington State Department of Transportation (WSDOT) and emergency response personnel to communicate with each other. When asked if they used these radios during the spring 2001 earthquake in the area, Terry Simmonds, WSDOT emergency management coordinator, responded, "Yes, many of the counties used their 800 MHz radios for transportation status reports on closures, restrictions, and other issues. They also used the system to communicate among themselves for direction and control, and for general emergency communications, especially when the phones didn't work."

Remote communication of voice, video, and data. At the more complex end of the spectrum, San Antonio's LifeLink project successfully demonstrated technology to facilitate remote communication of voice, video, and data between ambulances in the field and receiving hospitals (see Figure 5). While a host of institutional issues (such as doctor workload) prevented any substantial benefits from being observed during the evaluation period, the system is being expanded to other hospitals in the region. It is also being considered for application to a rural environment.

Figure 5. The LifeLink system uses two-way voice and video communication to virtually bring doctors into San Antonio ambulances.

Q4 What about traffic management systems? Were there any success stories there?

Yes and no. The results of the traffic management solutions were essentially mixed during the first years of the model deployments. These systems showed plenty of promise, but generally were accompanied by considerable schedule delays. However, some traffic management systems have finally been deployed, and additional systems are being planned (see Figure 6). The following sections describe the experiences of three of the four model deployment sites with traffic management applications.

Seattle: Regional sharing of arterial data. In Seattle, the focus of traffic management improvements was to collect arterial traffic data (both signal timing and volume/occupancy data) being generated by the 19 different traffic agencies operating in the area and to make these data available to all. This approach would allow any given agency signal operator to see what was happening with adjacent signal systems and the freeway system and thus make regional, rather than simply local, operations decisions. The expectation was that travelers traversing the corridor would experience fewer delays if the roadway were operated in this regionally integrated fashion. This hope was reinforced by simulation modeling of the corridor. Using a traffic analysis tool calibrated to local traffic demands and roadway networks, the evaluation team focused on one of the most heavily traveled corridors in the city, State Route 99 (SR 99), and investigated the impacts of operating it under ideal circumstances that included a common, regional signal timing plan. The results revealed that under these conditions, annualized delay in the corridor would decrease by as much as 7 percent, travel time variability by 2 percent, and crashes by 3 percent annually under a fully deployed and fully integrated system.

Unfortunately, the project met with considerable delays, primarily technical in nature. As Pete Briglia, WSDOT's Seattle site program manager, explains, "The problems with the regional ATMS [advanced traffic management systems] in Seattle are the result of the same problems that traffic engineers have been wrestling with for decades, namely the lack of common protocols for traffic signal systems to communicate with each other and the manufacturers' reluctance to provide access to their protocols." Furthermore, only four of the eight developers of signal systems in the region were willing to participate in the integration activity.

A second major cause for the ATMS delays in Seattle stemmed from institutional issues. Again, as Pete Briglia describes the situation, "There was a 'Catch 22' here in that we wanted to show the benefits of ATMS, but the system data were unavailable. Until the signal system data were available, the ATMS were not useful, but until agencies could make use of the ATMS, they were reluctant to spend the additional money it takes to put data into the ATMS." This situation forced the implementation team to devote much of its effort to conducting outreach and to building and maintaining support for the deployment. (On an interesting note, the positive evaluation results for simulation modeling, described above, were used as part of this outreach activity.)

Phoenix: Cross-jurisdictional signal projects. A similar scenario occurred in Phoenix, with another set of cross-jurisdictional signal coordination projects. Here, it was proposed that so-called "smart corridors" be established as places to integrate traffic signals and reduce delays across city and county lines. As in Seattle, the project experienced a number of delays. First, technical delays ensued from the need to integrate across multiple systems. In some cases, entire signal controllers had to be replaced and upgraded. Finally, once these delays were overcome, the challenge remained of determining what to do with all the data that was suddenly available.

Recognizing the need to demonstrate system benefits, the Phoenix model deployment managers concentrated on getting a single corridor up and running—with successful results. The evaluation team conducted a combination of simulation modeling and field observations, which revealed an initial 6 percent reduction in average delay, with reductions as high as 21 percent under the modeling of different signal coordination plans. According to Maricopa County's Dale Thompson, this demonstration caused a "change in

"The problems with the regional ATMS [advanced traffic management systems] in Seattle are the result of the same problems that traffic engineers have been wrestling with for decades, namely the lack of common protocols for traffic signal systems to communicate with each other and the manufacturers' reluctance to provide access to their protocols."

—Pete Briglia, SmartTrek Project Manager

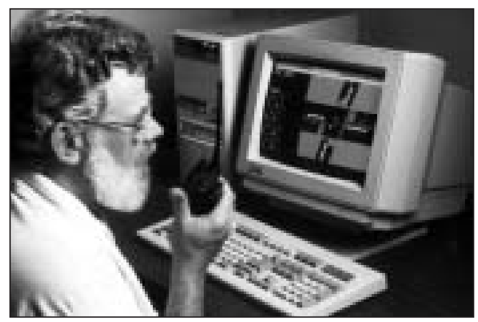


Figure 6. Traffic management systems allow traffic and emergency managers to respond to roadway incidents more effectively.

awareness of the benefits of technology." Rather than re-timing signals on an ad hoc basis, agencies in the Phoenix area are now committing to a more formalized approach that includes coordinating signals across jurisdictions. As a result, plans are underway to expand the original eight smart corridors to 17 by 2002 and to 24 corridors by 2004.

San Antonio: Freeway and arterial management improvements. A similar experience of delays followed by success was also demonstrated in San Antonio, where plans called for two types of ATMS. The first was a doubling of the geographic extent of the original 26-mile TransGuide freeway and incident management system (see Figure 7). The second was a plan to integrate a portion of the expanded freeway and incident management system with signal and variable message sign operations on a parallel arterial route—to create an integrated diversion management corridor. This integrated corridor was known as the Medical Center Corridor. Similar to findings in Seattle and Phoenix, proposed traffic management projects in San Antonio were expected to deliver significant benefits once fully deployed. The freeway management expansion simulation modeling conducted by the evaluation team forecast a 1.7-hour annual reduction in delay through the affected area (or a 5.7 percent reduction in the total, city-wide delay for an average driver). The proposed integration with arterial operations would lead to further reductions amounting to total savings of 1.82 hours per year for the average traveler in the corridor.

Figure 7. Traffic management centers can lead to significant reductions in delay and crash risk.

Unfortunately, as in Seattle and Phoenix, a number of delays occurred in San Antonio, most of which appear to have been due to institutional and contractual issues. As many others have realized, implementing advanced technologies for such purposes as freeway management or signal coordination differs greatly from building a highway. Consequently, many of the existing contracting mechanisms a State has available are ill-suited for this type of work. For example, many such mechanisms are not sufficiently flexible to modify deployments as additional technologies become available and/or as institutional and technical challenges arise. Furthermore, State budgets are simply not set up to begin entirely new projects in the short time frames expected of many ITS deployments.

Fortunately, however, TxDOT has been able to mitigate many of these delays by expanding in-house expertise. This expansion has allowed the agency to work more effectively with selected contractors and to accelerate actual deployment once the contracts are signed. As a result, the initial freeway management expansion is completed, with another 25 miles under construction (as of summer 2001).

Q5 Were there any types of ITS applications that did not work as well as expected? If so, why didn't they work out?

Yes. A number of applications fell short of expectations. These are summarized below.

Underachieving ITS Applications

Vehicle tags and tag readers in the absence of a toll system. One application that did not reach its full potential as deployed in the model deployments was the use of freely distributed, non-toll-based vehicle tags and tag readers to determine vehicle speeds in San Antonio. While the tag-reader system was successful as a proof of concept (capable of estimating vehicle speeds to within 2 percent of actual speeds), it was largely unsuccessful as a practical application. First, because the tags were distributed voluntarily and there are no toll roads in San Antonio, the market penetration was low, often less than 1 percent. This situation, in turn, meant that data was often unavailable for extended periods of time. Second, maintenance costs associated with the system's tag readers were found to be prohibitively higher than expected. For example, the automatic vehicle identification (AVI) tag reader system deployed in San Antonio has been costing TxDOT approximately $1,400 per year per mile of coverage. This cost is 75 percent higher than the average maintenance costs of $800 per year per mile of coverage for loop detectors, which San Antonio has found to be nearly as effective as toll tags for estimating vehicle speeds. However, despite these challenges faced in San Antonio, other sites, such as Houston and the NY/NJ/CT area, continue to support tag readers as a reliable, cost-effective means for estimating vehicle speeds. A common feature at each of these other sites is the presence of an existing electronic toll facility.

Figure 8. Traveler information kiosks have proven to be expensive to maintain and limited in their ability to reach travelers.

Traveler information kiosks. In the age of the Internet and wireless technology, the days of kiosks that provide only traveler information may be numbered (see Figure 8). In Seattle, proposed kiosk deployment never took place. San Antonio and Phoenix proceeded, but with relatively low usage rates and high maintenance costs (more than $1,000 per kiosk per year in San Antonio). Phoenix mitigated some of these costs by employing a commercial off-the-shelf, Internet-based kiosk system. Only New York remains highly supportive of kiosk deployment. However, even in this high-pedestrian, transit-friendly city, traffic information will very likely be bundled with other types of information once the system is deployed.

In-vehicle navigation devices (IVNs). Despite being one of the earliest ATIS applications, many feel as Pat Irwin of TxDOT does that "IVNs are still ahead of their time." For example, an IVN project planned for Phoenix and aimed at the general public was cancelled because of a lack of private sector interest. In San Antonio, a rather extensive deployment of IVN units to public agency staff met with

Figure 9. Many people feel that the time has not yet come for successful traveler applications over wireless handheld computers.

only moderate success and acceptance. This situation is not unique to the model deployments. Nationally, IVN units have failed to move beyond small niche markets in rental cars and luxury vehicles. This limited application may stem from continued gaps in data coverage that impede IVNs from providing accurate real-time routing information. Other obstacles include the relatively high cost of the systems and challenges with the human-machine interfaces.

One notable exception where IVNs were viewed as successful in the model deployments was their use as an improved map and location reference for paratransit and emergency personnel in San Antonio.

Wireless hand-held computers. Many people felt that, like IVNs, wireless hand-held computers were either ahead of their time or not well-designed for traveler information. Deployed in both Phoenix and Seattle, the service experienced extremely low market penetration. For example, estimates are that fewer than 100 travelers subscribe to the service in Seattle. Part of the problem is ever-changing technology requiring a relatively high level of user knowledge and effort to operate. Another obstacle to user adoption and use is a complete lack of marketing in Phoenix and very little marketing in Seattle.

Broadcast fax and personalized pagers. In general, the national market for personalized traffic information messaging services has been slower to develop than expected, in part because of an evolving (and thus unstable) wireless telecommunications market. Information service providers have faced a variety of technical problems in their attempts to bring traffic information to drivers and other mobile customers. Other limitations may stem from the service's fee-based component. In any case, the model deployment sites essentially abandoned these applications.

Traffic television (TV). Seattle and Phoenix both undertook dedicated cable broadcasts of current traffic conditions; unfortunately, the number of viewers of this service was consistently low at both locations (see Figure 9). Again, the service suffered from a critical lack of advertising and marketing. In Seattle, only 13 percent of eligible viewers had ever seen or heard of the service, the majority of these (85 percent) having found out about it by flipping through channels. This problem was further compounded by the lack of a consistent viewing schedule. In Phoenix, a similarly small number of eligible viewers were aware of the service (fewer than 28 percent). Furthermore, of those who were aware of it, only 29 percent described the service as "very" or "somewhat useful," and an even smaller number (19 percent) reported they would be willing to pay $1.00 a month for the service. However, the Phoenix study revealed a possible niche market of "low-tech" Traffic TV users (e.g., those uncomfortable with computers, users of wireless devices, etc.) who value the service's technological simplicity and would be willing to pay for it.

Challenges to Traveler Information Deployments

Overall, various rationales can explain why the above applications were unsuccessful or met with mixed results. In the case of the traveler information deployments, these challenges included the following:

Questionable value of fee-based information. All of the fee-based services deployed or planned as part of the model deployment initiative essentially failed. This result suggests that the perceived value of traveler information is currently too low for travelers to justify paying for the information. This situation is further compounded by the fact that, to date, these fee-based services provide little marginal benefit over free services, such as publicly supported websites and improved radio and television newscasts, which have taken advantage of ITS data.

Failure to sufficiently market services. In addition to competition from free services, the model deployment's fee-based traveler information products also suffered from a nearly complete lack of marketing and advertising. As Seattle's Pete Briglia explains, "The feeling seemed to be that these things [fee-based traveler information services] were so logical and beneficial that they would sell themselves. The marketplace is so competitive, however, that things don't sell themselves, no matter how good."

Inappropriate platforms. Finally, in the same way that travelers are unwilling to pay for access to traveler information, they also seem unwilling to expend a substantial amount of time or effort for this service. This reluctance may, in part, explain the low usage rates of both the traveler information kiosks and the in-vehicle navigation units deployed as part of the model deployments. Both of these platforms require relatively unwieldy human-machine interfaces and are somewhat time-consuming to access. Furthermore, both platforms are typically more expensive to deploy and maintain than other mediums such as websites.

"The feeling seemed to be that these things [fee-based traveler information services] were so logical and beneficial that they would sell themselves. The marketplace is so competitive, however, that things don't sell themselves, no matter how good."

—Pete Briglia (SmartTrek Project Manager)

"In the summer of 1997, an operator at the Arizona Department of Transportation Freeway Management System (Trailmaster) detected a car on the shoulder of a Phoenix freeway. When the operator zoomed the closed-circuit camera into the area, he saw an elderly figure slumped over the steering wheel in the car. He promptly dispatched an emergency vehicle to the scene. The driver had suffered a stroke. He received the necessary medical attention and recovered from his stroke thanks in large part to the Trailmaster operator and the available Trailmaster technology in the Phoenix metropolitan area."

—ITS America News, September 1999

Q6 How did the model deployments affect traveler safety? What was the best application for reducing crashes and saving lives?

The applications fielded during the model deployments had a generally positive impact on traveler safety—with some possible exceptions to be discussed in this section. Overall, the deployments illustrated three ways in which ITS improves traveler safety.

Reducing the opportunity for a crash by removing adverse conditions. It has long been posited that traffic congestion, whether from over-saturated arterial traffic signals, increased freeway demands, or the occurrence of an initial roadway incident, significantly contributes to roadway crashes. Incident management studies show that as many as 50 percent of all freeway crashes are secondary, or the result of an initial roadway blockage.[5] Consequently, any ITS operation that can help restore conditions from congested operations (e.g., through faster incident clearance times or improved signal coordination) should reduce crash risk.

Simulation modeling performed by the evaluation team indicates that San Antonio's incident management system reduces crash risk from 1 percent for a minor incident to as much as 6 percent for a major incident. Similar modeling efforts undertaken by the evaluation team in Seattle revealed that under optimal deployment, a switch to more regionally aware signal operations along SR 99 should help reduce all crashes by 2.5 percent and fatal crashes by 1.1 percent, once the system is in place. Similarly, field and modeled data collected from Phoenix's cross-jurisdictional signal coordination deployment revealed crash reductions from 3 percent to 10 percent, depending on the signal plan selected.

Overall, the evaluators found all the incident and arterial management applications they examined improved traveler safety. In fact, of all the ITS approaches taken at the sites, these applications were typically the most effective in increasing traveler safety. However, caution is warranted when deploying and operating these types of systems. For example, in San Antonio, incident response signal timing plans in the region's integrated freeway/arterial corridor were developed to minimize congestion and crash risk under assumptions of a severe incident and thus heavy diversion to the arterial. If the assumed diversion is significantly less than anticipated, or if the signal plans are applied indiscriminately to both major and minor incidents, then changing the arterial signal plans could actually lead to an overall increase in congestion, accompanied by an increase in crash risk. This increased crash risk could be as high as 3 percent, if, for example, the system were applied during minor incidents, such as a freeway vehicle breakdown. Fortunately, you can avoid this situation by applying ITS technologies in a careful, considered fashion.

[5] *These studies are referenced in* "Incident Management: Final Report," *American Trucking Associations Foundation, Inc., Alexandria, Virginia, 1990.*

Reducing the opportunity for a crash by giving travelers better information. Another method for improving traveler safety is through services that provide travelers with better information about potentially dangerous roadway and weather conditions, such as crashes or other roadway hazards. Having such data can assist travelers in making safer and more informed decisions.

For example, simulation modeling suggests that access to pre-trip traveler information, such as that on the TxDOT website, reduces users' crash risk by as much as 8.5 percent in the face of a major freeway incident. Users of en route information, such as that provided by an in-vehicle navigation device, would experience an 11 percent crash risk reduction in the same incident scenario. The evaluation also revealed that users of these services seem to be aware of their benefits. For example, 70 percent of frequent users of Phoenix's Traffic TV agreed that the service made their travel safer.

As a caution, however, traveler information services may, in some cases, increase crash risk if not used judiciously. For example, the evaluation revealed that when minor incidents on the freeway are conveyed to Web users in San Antonio, some of these users may choose to divert to the arterial even though queuing and thus crash risk on the freeway is not significantly increased. In some situations, such sub-optimal diversion to less safe arterial facilities could actually increase crash risk as much as 5 percent for the traveler. It is important to apply these technologies carefully.

Improving the survivability of a crash (or any trauma) by enabling emergency responders to react faster and more efficiently. Providing roadway video images to public safety professionals can vastly improve traveler safety and lead to faster and more efficient emergency responses. In Seattle, when a tanker truck carrying propane overturned on the Tacoma Narrows Bridge, the fire department, which had access to video feeds from the incident site, was able to detect the accident and respond with the appropriate equipment in time to avert a major disaster. Such examples accord ITS significant support from the public safety community. In San Antonio, police are actively lobbying decision makers for expansion of ITS services, such as freeway management. As Pat Irwin observes, "To them, ITS provides their eyes in the field."

The model deployments also illustrated that ITS can improve the field operations of emergency responders. For example, the IVN project in San Antonio assisted the region's police officers in coordinating pursuits and in providing more accurate information to responders from other agencies. In one example, a police officer used the latitude and longitude coordinates on his IVN unit to direct an air ambulance to a critically injured patient, who survived as a result of this quick intervention.

Q7 What impact did ITS at the model deployment sites have on fuel consumption and emissions?

Results of the model deployment for fuel consumption and emissions applications, while positive, were considerably less significant than for traveler safety. Furthermore, no clear "best application" emerged for these measures.

San Antonio: Limited impact from traffic management and traveler information. Through the use of calibrated modeling, evaluators found operation of San Antonio's expanded freeway management system reduces fuel consumption by only about 1 percent per year. Users of that region's traveler information websites and in-vehicle navigation units experienced similar savings of 2 and 3 percent per year, respectively.

Phoenix: Interjurisdictional signal coordination impact. In Phoenix, evaluators determined that interjurisdictional signal coordination reduces average fuel consumption by approximately 2 percent per trip through the affected corridor, with nearly negligible impacts on emissions of hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NOx).

Seattle: Negligible impact from regional traffic signal operations. The evaluation team in Seattle found that regional signal operations along SR 99 would have no significant effect on energy or emissions once fully deployed, because conflicting factors effectively cancel each other out. Specifically, while signal coordination brings about fewer vehicle stops associated with lower emissions, it also results in slightly more vehicle miles traveled (as travelers divert from minor roads to SR 99) and higher travel speeds, both associated with elevated emissions. These increases and reductions offset each other.

Fortunately, while these effects are small, they are either positive or neutral. One phenomenon for which no overwhelming evidence exists is a feared increase in NOx emissions owing to higher vehicle speeds. For the most part, NOx emissions were unaffected or were offset by reductions in stops, as described above.

Q8 Did the model deployments reduce traveler delay? Which applications were most effective for this purpose?

While most of the applications fielded in the model deployments led to decreased traveler delay, evaluators found the greatest reductions resulted from applications of incident management and signal coordination. Examples are described below.

San Antonio: Integrated Freeway/ Arterial Management. In San Antonio, evaluators used carefully calibrated simulation models to determine that the area's expanded freeway/incident management system reduces delay for all travelers through the corridor by nearly 6 percent annually. This modeling effort revealed additional annual delay reductions from the system's arterial management component. Under severe incidents, these combined systems can result in delay reductions as large as 20 percent for the average traveler.

Phoenix: Interjurisdictional Signal Coordination. In Phoenix, the evaluation team used a combination of field observations and calibrated simulation modeling to analyze that region's interjurisdictional signal coordination. Reported delay reductions ranged from 6 percent to 21 percent, depending on the signal timing plan implemented.

Seattle: Regional Signal Operations. In Seattle, the evaluation team used simulation modeling to study a planned regionwide sharing of arterial traffic data (including signal timings and volume/ capacity data) among individual signal agencies. This study revealed that for the corridor modeled, regional data sharing could bring about delay reductions of approximately 7 percent under full system implementation (including common signal timing plans). The Seattle analysis also revealed a reduction in travel time variation of approximately 2 percent. While less than the reduction of absolute travel time, this variability measure may be more important to the average driver, who, according to recent studies, wants predictable and consistent travel times.

Use of traveler information systems for reducing delay. Delay reductions also resulted from the use of traveler information systems. In San Antonio, modeling conducted by the evaluators and supported by local data collection revealed that website users could expect to experience delay reductions of approximately 5 percent per year. However, the market penetration of this service remains too low to have a measurable impact on overall traffic conditions throughout the region.

In Seattle, 93 percent of respondents to an on-line survey about the traveler information website agreed with the statement that "using traffic information on the Web has helped me save time." Transit users similarly benefited from traveler information systems. Specifically, 46 percent of respondents to a survey about Seattle's transit information website found the site useful or somewhat useful in determining the fastest routes to their destinations.

"Mayor Neil Giuliano, City of Tempe, Arizona, in the fall of 1998 was chairing a council meeting at the University of Arizona when he received a telephone call that his mother was at the West Valley Hospital 30 miles away, needing emergency surgery. Mayor Giuliano got into his vehicle to drive to the hospital and as he was driving on Interstate 202 toward Interstate 101 and the Squaw Peak, he noticed a variable message sign alerting motorists to a deck-tunnel accident. With the alternate route information, Mayor Giuliano was able to divert and bypass the traffic congestion and still get to the hospital to see his mother before she went into surgery."

—ITS America News, September 1999

Q9 Overall how did the public receive the model deployments? What types of ITS applications did they appreciate the most? What further improvements did they suggest or request?

General Reception. Overall, while the public appeared appreciative of many of the individual applications under the model deployments, the degree to which they were actually aware of or valued the deployment program as a whole were mixed. In San Antonio, the model deployment was built upon the already successful, well-known, and highly visible TransGuide freeway management program. As a result of public outreach, excellent media coverage, and the sheer amount of equipment in the field, TransGuide has become a household name. As TxDOT's Brian Fariello notes, "You would be hard-pressed to find someone in San Antonio who hasn't heard of [TransGuide]." Furthermore, not only is the public aware of the service, it also places a great value on it. Numerous communities and agencies are clamoring for TransGuide to be expanded to their areas. In a survey on the program's website, 82 percent of 1,149 respondents agreed or strongly agreed with the statement, "Traffic management in San Antonio has shown a noticeable improvement since the implementation of the TransGuide system." While results at the other model deployment sites were positive, they were not as dramatic.

For example, in Seattle, more than $1 million, or nearly twice as much as any other model deployment site, was spent on communications, outreach, and marketing. During 1997 and 1998, 22 radio or TV spots featured the region's model deployment, along with 58 print articles, including pieces by *The Wall Street Journal* and the *Economist*. In fact, every news release on deployment was featured in the media. Nonetheless, the Seattle deployment, (known as SmartTrek), did not become a household name as did San Antonio's TransGuide. As Pete Briglia explains, "...The most important lesson that I learned is that even the expenditure of $1 million over three years for outreach, communications, and marketing is just a drop in the bucket when trying to introduce new technology or new ways of doing things. So much of our effort went into basic ITS education, (explaining what ITS are all about), which had to occur before explaining a particular application. And much effort went into explaining ITS to transportation officials and elected officials." Phoenix reported similar experiences.

Satisfaction with individual applications. The public showed a great deal of appreciation at all three deployed sites for the benefits of individual applications. Some examples follow:

- Usage of the traveler information Web pages across all three deployed sites has been steadily increasing, with most sites showing annual increases of 100 percent or more.
- Focus group participants expressed great appreciation for San Antonio's variable message signs and were

actively involved in providing suggestions for further improvements.

- More than 80 percent of paratransit operators using in-vehicle navigation systems in San Antonio rated the units as useful or very useful.
- In Phoenix, 75 percent of respondents to the Traffic TV survey reported making use of the area's variable message signs.
- Also in Phoenix, participants in a focus group examining available traveler information websites in the area generally found the pages to be a helpful, interesting new way to obtain useful information to improve their travel experiences.
- In Seattle, 93 percent of respondents to an on-line survey found the traveler information website "helped them to save time."

Customer preferences revealed.
In addition to revealing an overall awareness and appreciation on the part of the public for particular applications, the evaluation also provided a number of general insights into the likes and dislikes of the traveling public at the model deployment sites—at least with regard to traveler information. In general, the evaluation demonstrated the following customer preferences:

- For fee-based ATIS to succeed, it must provide value to customers every day.
- Low-quality ATIS traffic information appears to be largely ignored, while high-quality data are sought out.
- Regional context influences customer demand for traffic information. For example, demand is higher in more congested cities like Seattle than in less congested areas like San Antonio.
- Individual usage rates appear to grow with positive experiences in using the sites.
- All customers want fast, convenient service, regardless of platform.
- Customers want the following services, in priority order:
  - Freeway and arterial coverage.
  - Direct traffic speeds, or reliable, self-selected point-to-point travel times.
  - Camera images.
  - Incident information.
  - Enroute guidance, based on personalized criteria.
  - Design features according to media and location of use.

Finally, the following unique needs were identified for transit users:

- They desire real-time information on bus locations and delays that is available to them on the Web, by phone, en route at bus stops, and via monitor or other platform at locations near transit centers.
- They desire more detailed information on routes, with maps and point-to-point itineraries.
- They want this information to be free. Most transit riders are not interested in paying for better system information.

Q10 What types of ITS applications did traffic managers find the most useful?

Remote-control video cameras. Most of the model deployment's traffic managers found remotely controlled video cameras useful for their daily operations. They also expressed appreciation for the ITS data servers constructed during the deployments. In particular, they reported operational benefits from having access to integrated data sources—such as video images, travel speeds, and incidents—in a single, readily accessible, understandable format.

Co-location of other agencies. A number of traffic managers found they benefited by having other agencies co-located within their traffic operations centers (see Figure 10). Not only does co-location improve their operations in responding to incidents, but, as Pat Irwin reports, "It also helps to strengthen the institutional relationships between agencies." These improved relationships can, in turn, spark activities, such as San Antonio's and Seattle's joint traffic management task forces, that offer benefits well beyond those afforded by ITS alone.

Figure 10. Co-location of traffic and emergency management personnel can strengthen institutional ties.

Technology to ensure consistent messages on dynamic message signs. In San Antonio, managers and other users expressed satisfaction with the automated system that ensures consistent messages on dynamic message signs for similar types of incidents and congestion.

Roadway closure and restriction system. In Phoenix, managers found the roadway closure and restriction system useful in coordinating maintenance activities and in quickly identifying appropriate points of contact when necessary.

Traveler information websites. The model deployment traffic managers also expressed universal appreciation for their agencies' traveler information websites. These sites help traffic managers to more effectively perform their duties by allowing them to reach out with critical information to a larger percentage of the public than they could otherwise. Furthermore, such sites also help to raise the public's awareness of the role and necessity of traffic management operations.

Q11 What types of ITS applications did transit managers find the most useful?

Transit managers at the model deployment sites found a number of ITS applications to be useful in assisting them in their operations.

Phoenix: Automated vehicle location ***technology.*** In the Phoenix area, application of AVL technology to 20 percent of the transit fleet was so successful that the two participating jurisdictions are now planning to install AVL on all their fleet vehicles by the end of 2002. This AVL system includes trip planning, automated fare boxes, and the ability to handle remote diagnostics and smart cards.

San Antonio: In-vehicle navigation ***devices.*** Transit operators in San Antonio reported benefits from the use of IVN devices. In fact, these devices were so popular among paratransit operators in the area that many drivers insisted on driving vehicles equipped with one of the units (see Figure 11). San Antonio transit operators also noted benefits stemming from being co-located in the TransGuide traffic management center, as they could become more quickly aware of roadway incidents and take appropriate action to mitigate potential effects on transit service.

New York: Use of toll tags to track fleet ***performance.*** In New York, in an activity not related to model deployment involving the E-ZPass electronic toll application, transit operators were pleased with the success of using toll tags to track fleet performance and to more quickly respond to deviations in service.

Figure 11. In-vehicle navigation devices have become a valued tool for San Antonio's paratransit drivers.

Seattle: Traveler information ***services.*** In Seattle, transit managers reacted positively toward that site's traveler information services. Pete Briglia, Seattle's overall program manager, reports, "Improvements to King County Metro's transit management system helped to increase the system's accuracy and reliability. These improvements assisted transit managers and helped improve the quality of transit information." (See Figure 12.) Furthermore, the Vessel Watch ferry-tracking system helped Washington State ferries track on-time performance of boats, identify which boat and crew were on a particular run, and respond to customers' questions and complaints.

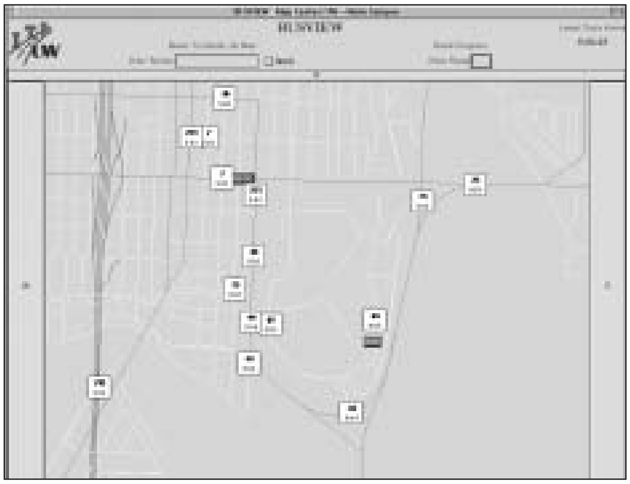


Figure 12. Bus view shows the locations of Seattle's buses in real time.

Costs

Q12 How competitive are ITS deployment costs with traditional transportation improvements? Do the model deployments offer any lessons on how to help keep those costs down? Where can I go for more information on costs of specific elements?

Deployment costs for ITS are competitive when compared to traditional roadway improvements. For example, the total deployment cost of the Phoenix model deployment was less than $30 million. Furthermore, unlike many traditional roadway improvements, the model deployments did not experience significant escalation in costs over the life of the deployment phase (although, in some cases, such as with Seattle's integrated signal system, the functionality of the final product was less than expected). Nonetheless, in this era of strained budgetary resources, you should take the time to investigate methods for conserving *all* costs, including ITS deployment costs. The model deployments revealed the following insights and guidance relative to cost containment.

Maintain strong oversight of software development. A significant finding from the model deployments was the need to provide close oversight of software development, even if it requires using only those developers with a local presence. Without this oversight, it is difficult to translate the customer's preferences into the code being written. Midway through its deployment efforts, the NY/NJ/CT site decided that frequent interaction (at least once per week) helped to keep costs down.

Leverage resources wherever possible. As an example, Pierre Pretorious, former program manager of the Phoenix model deployment, reports significant savings in Phoenix because "the State and the City of Phoenix share some cameras that are placed at locations where both freeways and arterials can be viewed."

Lower costs through integration. The model deployments revealed that ITS integration not only produces great benefits, but can also reduce costs. For example, as previously described, transit operators in the NY/NJ/CT area are now using E-ZPass toll tags on transit vehicles to perform vehicle tracking and schedule maintenance, obviating the need for more expensive AVL technology. Similarly, San Antonio's LifeLink project uses TransGuide's freeway management communication system to transmit audio, video, and data from remote ambulances to receiving hospitals. In fact, without the significant cost savings this integration affords, the LifeLink project would likely not have been deployed at all.

Consider public-private partnerships. While the model deployments raised some doubts about the success of public-private partnerships (to be discussed in a later question), some people still continue to see a role for such arrangements in mitigating ITS costs. As Pierre Pretorius states, "Public-private partnerships allow costs to be shared—there are elements that private industry and the public sector each do best; thus, a sharing is warranted."

Carefully apply low-bid procedure. As Rob Bamford points out, "Software development for ITS is not the same as pouring concrete." Consequently, traditional low-bid procedures may be ill-suited for many types of ITS applications. In fact, depending on the contracting mechanism, such procedures may actually lead to even higher costs or substantially reduced functionality. Some still feel that a low-bid procedure can reduce costs. However, Brian Fariello of TxDOT stresses the importance of a good in-house understanding of the task and "clearly defined specifications."

Invite vendors to negotiate. While not directly tested in the model deployments, one method gaining favor in the procuring of ITS services is the use of an invitation to negotiate. For example, in selecting a vendor for Miami's new traveler information system, the Florida Department of Transportation held a number of iterative discussions with multiple bidders to generate clear specifications and expectations prior to awarding the contract.

Keep systems open and make use of standards. While seemingly obvious, this tenet is often ignored. Closed proprietary systems may be a good investment in the short run, but in the long run, such systems often lead to greater costs, especially with greater ITS integration. As Rob Bamford explains, "You must be careful that you don't end up paying for a system that in the end you don't really own." This approach can lead to substantial costs. For example, in Phoenix, an entirely new computer server system had to be built in part because the existing freeway management server system was proprietary.

To find out specific costs of ITS elements, you may review the individual site reports for each of the model deployments. For an even more extensive and current collection of deployment, operations, and maintenance costs, please refer to the USDOT's ITS unit cost database at www.benefitcost.its.dot.gov.

"Public-private partnerships allow costs to be shared—there are elements that private industry and the public sector do best; thus, a sharing is warranted here."

—Pierre Pretorious, Former AZTech Program Manager

"The benefits of ITS are in the operations."

—Rob Bamford, NY/NJ/CT Program Manager

Q13 How have operations and maintenance costs affected the model deployments?

Operations and maintenance costs have been a major challenge for those attempting to ensure the continued success of the model deployments.

Higher than expected O&M costs. O&M costs are significant and were almost universally higher than initially expected. For example, maintenance costs for San Antonio's AVI readers are approximately $120,000 per year—more than double the original estimate of $59,000 annually. Similarly, costs to maintain kiosks in both Phoenix and San Antonio are much higher than expected.

As San Antonio's Pat Irwin explains, "It is tough to catch all of the maintenance costs at the onset." In general, the estimation process was compromised by the high-tech and often first-generation nature of many ITS technologies. Another problem was that most of the sites were concerned more with deploying everything within two years—a condition of Federal funding—rather than formulating an incremental approach to future operations.

Difficulty attracting O&M personnel. Challenges also lie in the fact that, as Pete Briglia explains, "ITS O&M requires the same personnel resources that are in demand in the private sector. Therefore, it is difficult to attract and retain the personnel needed to develop and maintain the Web-based traveler information applications that are currently so popular."

Difficulty convincing State Departments of Transportation (DOTs) of funding need. Furthermore, it has been difficult to convince budget officials of the critical need for ITS maintenance and operations funding. As Pete Briglia states, "The costs have not been great, but they are a steadily increasing part of an agency's shrinking discretionary budget." State DOTs want to reduce O&M expenditures and increase construction spending, and ITS does the opposite—for while there may be savings in societal costs, direct public agency costs are increased. As a result, some ITS deployments have been forced into making less than optimal funding decisions. For example, in at least one of the model deployment sites, State transportation managers recognized that it was much easier to receive construction funds rather than O&M funds. Consequently, they built their own fiber optic network, even though it may have been more cost-effective to annually lease from an existing private provider.

A further irony is that while budget officials seem to have received the message that O&M plays a critical role in supporting transportation infrastructure, many simply view the deployment of ITS as completely satisfying this requirement. Few funding officials seem to realize that ITS also requires their own O&M support, for as Rob Bamford reminds us, "The benefits of ITS are in the operations." Fortunately, some funding agencies, such as TxDOT, are already aware of the need for solid O&M support. As the benefits of ITS continue to emerge, others will join in this awareness.

Q14 How did applications change from what was planned to what was deployed? How can other sites prepare for similar changes?

The three-to-four-year planning and implementation phase of the model deployments saw a number of applications changed, dropped, or modified, with varying results, as explained below.

Reductions in function or scope. In some situations, a change in the deployment of ITS applications had a negative effect, generally associated with reduced function or scope. For example, budget cuts in San Antonio reduced the number of ambulances and hospitals that could initially participate in the LifeLink project, which, in turn, led to a reduction in potential benefits. In another example, long delays in deploying Seattle's ATMS caused a number of participating agencies to lose interest, which also resulted in reduced benefits and functionality.

Neutral changes in function. While some applications were reduced in scope, others were simply altered to address other goals. For example, in San Antonio, a number of proposed applications faced institutional barriers, including a Texas law prohibiting distribution of IVN units to the traveling public. A proposed highway-rail safety system was also placed in jeopardy by liability concerns on the part of railroads. Fortunately, in both cases, TxDOT was able to take many of the original technologies and approaches and simply apply them to new functions. Specifically, the IVN units were assigned to public-sector operators (e.g., police, fire, and paratransit workers), and the highway-rail project was converted to a traveler information program to warn of railroad delays.

Changes in technology. The third type of change experienced in the deployments actually led to improved benefits. In these cases, function stayed the same, but the model deployments adopted new, more effective or powerful technologies as they became available. For example, the initial focus of New York's traveler information services was telephone access; however, as the deployment progressed, increasing focus was placed on Internet access. The ability to react and adapt to the latest improvements is an important means of optimizing ITS benefits.

Overall, perhaps the best advice for preparing for inevitable changes such as those described above comes from Seattle's Pete Briglia: "Since technology changes at such a rapid pace and since many ITS projects are exploring new ground, they must be flexible. Projects should be implemented in easily deployable phases that allow users to generate benefits as quickly as possible. Projects should also be designed so there is no single point of failure. SmartTrek's 30 project components made it possible for some applications to be cancelled without jeopardizing the success of the entire project."

"Since technology changes at such a rapid pace and since many ITS projects are exploring new ground, they must be flexible. Projects should be implemented in easily deployable phases that allow users to generate benefits as quickly as possible. Projects should also be designed so there is no single point of failure. SmartTrek's 30 project components made it possible for some applications to be cancelled without jeopardizing the success of the entire project."

—Pete Briglia, SmartTrek Program Manager

"I've tried to come up with a good answer to why ITS projects seem to take so long, and there seems to be one common element: software. I think that most engineering consulting firms do not know how to manage software projects and cannot retain sufficient software talent to deliver projects on time. Their clients usually do not know what they are doing most of the time, though I put most of the blame on the consultants because they do not know how to manage expectations. They will tell the client that they can do anything the client dreams."

—Model deployment program manager

Q15 Were there deployment delays in the model deployments? If so, what was the cause of these delays? How could they have been mitigated?

As with most ITS deployments, the model deployments experienced a number of schedule delays caused by a variety of factors, as discussed below.

Overly ambitious schedule. Most project participants viewed the Federal schedule aimed at achieving full deployment in two years as unrealistic. Existing contracting mechanisms and task complexity simply did not support this goal. However, most of the managers agreed that an ambitious schedule had some value. As Seattle's Pete Briglia states, "It's better to have an aggressive schedule and get something out, than to wait forever for the perfect deployment."

Technological challenges. Complex systems like ITS often bring numerous technological challenges and delays, especially applications requiring software development.

Institutional challenges. Another serious challenge to deploying ITS on time—and integrated ITS in particular—lies in coordinating among the numerous agencies involved in the task. During the model deployments, two general approaches managed these relationships. The first, used in San Antonio and to some extent in Seattle, was the "lead by example" approach. In this scenario, a central lead champion (the State, for example) has a dominant role. This champion consults with other members of the transportation community and engages in a constructive exchange of ideas; however, no formal arrangements are made. Furthermore, when it is time for a decision to be made, the lead champion often moves forward on his own, essentially deploying a prototype that others can see and become more involved in. The advantage of this approach is that it may and often does lead to more rapid deployments. The potential downside is that the initial product may not fully address the needs of all participants.

The other scenario, more prevalent in New York and Phoenix, was the "lead by consensus" approach. With this approach, formal agreements take place between all interested parties—as many as 16 in New York—with products developed by agreement of all parties. The strength of this approach is two-fold. First, the ultimate application may, in theory, be of greater benefit to the various parties as a whole. Second, the consensus approach imparts more of a sense of ownership that challenges all participants to offer their own ideas, money (in some cases), and commitments. The potential downside, of course, is that significant delays may result. For example, as of the summer of 2001, the NY/NJ/CT deployment has yet to be fully deployed (although software issues are also to blame). Still, NY/NJ/CT's program manager, Rob Bamford, states that if they had to do it all over again, they would stick with this approach, observing that, "In the end, it will lead to a better product that is acceptable to all."

Minimizing Delays

Some level of deployment delay on large, complex ITS deployments may be inevitable, and the model deployment experience offers advice for meeting these challenges.

Recognize that there will be challenges. One of the most important pieces of advice is to keep projects flexible. As reported earlier, Pete Briglia feels, "Projects should also be designed so that there is not a single point of failure. SmartTrek's 30 project components made it possible for some applications to be cancelled [or delayed] without jeopardizing the success of the entire project."

Get something out. The model deployment program managers suggest that it is better to deliver a tangible product, even a prototype, and refine it later than to wait for the perfect application. For example, much of the early delay in the NY/NJ/CT deployment is attributable to a nearly endless cycle of writing and reviewing design specifications, rather than building a product.

Specify function, not technology. Another mechanism for avoiding delays is to specify product function—and not necessarily technology—when contracting for ITS services. As NY/NJ/CT's program manager Rob Bamford states, "Part of the challenge in trying to schedule the projects (contracts, etc.) and, at the same time, marry that with a technology you plan to use, is that new and better technologies may come out before you are ready to proceed. Technology outpaces the contracting mechanisms, and you can find yourself in an unproductive cycle of constantly modifying contracts in an attempt to keep up instead of pursuing an actual deployment." Consequently, when contracting for its personalized service application, NY/NJ/CT specified just what the service should accomplish, not how to accomplish it.

Provide strong oversight of software development. As stated earlier, strong oversight of software development leads to better interaction and eliminates multiple translation problems. In general, greater interaction with the developer leads to faster and less expensive development.

Choose a careful balance between consensus-building and leading by example. The final advice from the model deployments for dealing with schedule challenges is to choose your approach carefully, whether it is one of consensus-building or leading by example. You should consider the benefits and potential drawbacks of both approaches early on in the development process.

"In ITS deployment, the first 95 percent is relatively easy; the last 5 percent is where the frustration lies."

—Rob Bamford, NY/NJ/CT program manager

Q16 Did the model deployments clearly illustrate the benefits of deploying integrated ITS?

Yes and no. While the model deployments did illustrate some significant benefits of integrated ITS, the results frequently were less significant than anticipated. The following sub-sections illustrate this situation.

Benefits of Integrated ITS

Integrated traffic signal control. Travelers in both Phoenix and Seattle benefited from integrated traffic signal control across jurisdictions. In Phoenix, integration reduced delay on an average trip by 6 percent, compared to cases where signals were optimized independently within each individual jurisdictional boundary. In Seattle, simulation of regional signal timings predicted delay reductions of up to 7 percent annually, once fully deployed.

ITS integration in the Medical Center Corridor. Evaluators also observed integration benefits in San Antonio. Here, simulation modeling of the combined freeway, incident, and arterial management corridor—known as the Medical Center Corridor—was used to estimate annual delay reductions of 6 percent. Looking only at severe incidents, ITS integration in the corridor reduced delay by 20 percent, compared to a 16 percent reduction when the ITS elements work individually.

Traveler information—integrating data from multiple sources. Traveler information—an application that relies on data integration from multiple sources (e.g., cameras, crash reports, roadway speeds) and multiple agencies—provides numerous benefits (see Figure 13). In Seattle, a simulation experiment investigating the potential impact of adding arterial information to the State's website revealed the importance of this integration. This simulation found that adding the information to the website, currently focused on freeways, reduced annual travel times by 1.8 percent. This value is especially significant given that all travelers in the corridor experienced the benefits, not just the small percentage using the Web service.

Cost savings from integration. The model deployments also illustrated how ITS

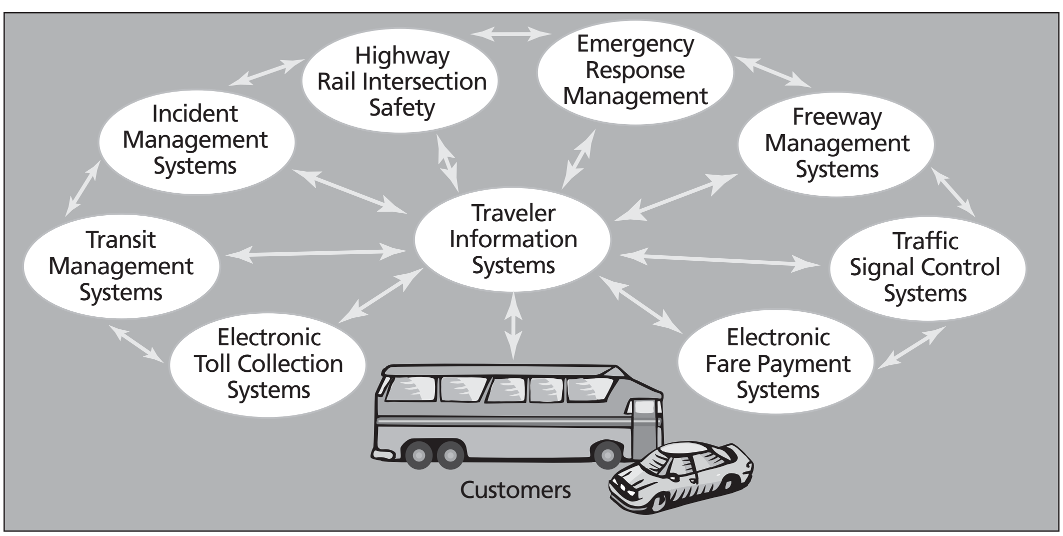


Figure 13. Ultimately, many of the strongest benefits of ITS lie with integrated systems.

integration can help to reduce the costs of ITS deployment and operations. For example, San Antonio's remote ambulance/hospital conferencing application, known as LifeLink, greatly benefited from savings obtained through a pre-existing and planned freeway management communications system. In fact, as previously stated, this project likely would not have been initiated at all without these cost savings. Phoenix realized savings through the strategic placement of remote video cameras providing views of both freeway and arterial locations. In New York, transit vehicles equipped with toll tags and tag readers and placed at various locations along the roadway are tracked and used to estimate current general traffic conditions. This integrated usage supports more efficient freeway and transit management.

Why ITS Integration Benefits Did Not Always Meet Expectations

While these various benefits and cost savings are impressive, they are not as large as those originally predicted for the model deployments, as explained below.

ITS integration benefits take time to reach their potential. Knowledge gained since the evaluation reveals that attempts to assess the results of integration may have been premature. It appears that integrating ITS is like priming a pump. The early output is not the same as the later constant output. Furthermore, the evaluation time frame allowed consideration only of very early results. As Rob Bamford states, "The real benefits may lie months and years later in the applications that were, perhaps, not even dreamed of in the initial integration, but whose very conception was made possible by the integration."

A good example of this occurrence is the REACT project in Phoenix. One of only a few such systems in the nation, Maricopa County's REACT team responds both to incidents and special events on area surface streets to assist the local police with efficient lane closures, diversion of traffic, and identification of alternative routes. The project, based on the success of their freeway courtesy and incident response patrol, came about because of the institutional and technological integration occurring under the area's model deployment. Specifically, the success that various partners observed in working together to coordinate signals across boundaries made them all more aware of the benefits of working together and more comfortable doing so. Consequently, the REACT project has the unique distinction of being administered by Maricopa County but applied to both county and non-county roadways.

Q17 What do the model deployments tell us about the success of public-private ITS partnerships?

One of the most important outcomes of the model deployments is a more realistic expectation of the benefits of public-private ITS partnerships, especially as applied to traveler information. Overall, the initiative revealed that while such partnerships may help to reduce the costs and risks associated with ITS applications, they have not met the high expectations many originally had for them. In general, these partnerships fell well short of their intended goal of enabling public agencies to provide high-quality traveler information through partnering with the private sector under a viable and profitable business model.

Reasons Behind Unsuccessful Public-Private ITS Partnerships

The model deployment evaluations identified several reasons, summarized below, why public-private ITS partnerships were not generally successful.

The public's unwillingness to pay the private sector for traveler data. At the outset of the model deployments, a commitment existed to provide improved traveler information to the public. At the time, project participants also recognized that one method for improving the quality of this information was through integration. Specifically, the deployments sought to provide various types of information (e.g., weather, crash data, traffic volume) from various sources and multiple jurisdictions, to cover different roadway types, such as freeways and arterials. Furthermore, the private sector was thought to be interested in helping with collecting and disseminating these integrated data, eliminating costs to public agencies, and perhaps even providing these agencies with profits to spur additional ITS deployment. A central tenet of this philosophy was that traveler information would be of sufficient quality and importance to travelers that they would be willing to pay the private sector for it. The model deployments revealed that this is not the case, at least not to date.

Failure of the private sector traveler information services. No private sector traveler information application proposed during the model deployments met with any significant success. For example, broadcast fax and paging services were cancelled in Phoenix. Wireless handheld personal computer services met with very low subscription rates in both Phoenix and Seattle. And in San Antonio, Pat Irwin reports, "Only one or two of our seven original private sector partners for traveler information systems are even still in business." In fact, practically the only traveler information services that were uniformly successful were the publicly funded and maintained traveler information websites. These failures have many possible explanations:

San Antonio's Pat Irwin suggests, "It may simply be a matter of time, that the market is still developing." Supporting this stance, a number of proponents have suggested a need for additional marketing and advertising. In fact, this was a major finding in the analysis of the I-95 Corridor Coalition's now defunct regional traveler information Web service known as TravTips.

It may be that the underlying data are simply not high quality or valuable enough on their own for travelers to justify the cost. Consequently, regions such as NY/NJ/CT are moving toward bundling traveler information data with other services like e-mail.

It may simply be that fee-based services cannot compete with the free services provided by the public sector and by the traditional radio and television media, which are also using ITS to provide better data.

*Failure of public-private partnerships not **unique.*** Whatever the reason, failure of self-sustaining ATIS business models is not unique to the model deployments. To date, few (if any) examples of successful public-private traveler information partnerships exist in the United States. Currently, 18 or more firms are pursuing this market, either by packaging traveler data with other information or by direct marketing to the customer through advertisement-supported websites or subscription-based personalized services. But as Jane Lappin reports in "What Have We Learned about ITS?"[6] these firms face a number of challenges, including the following:

The underlying "product"—real-time traffic information—cannot be manufactured in a controlled environment; instead, it must be collected by individual agreement with each state and transportation authority, or, in some cases, with private companies across the country.

The data are variable in scope and quality and are provided in nonstandardized formats. This condition creates an obstacle for information wholesalers and telematics service companies who require their consumer services to be uniform in quality and available nationwide.

No established consumer market exists for real-time traffic information other than radio broadcast reports.

A Place for Public-Private Partnerships

Do these findings mean there is no place for public-private partnerships in traveler information operations? The short answer is "No." Many transportation officials, such as Phoenix's former program manager Pierre Pretorious, would argue, "While it may be unlikely to develop a fully self-sustaining traveler information public-private partnership, there still may be benefits to the public in such enterprises." The following are two examples of beneficial public-private partnerships.

*Possibility of mitigating costs and reducing **risk.*** Public-private partnerships could still help to offset or reduce costs, which may, in turn, allow public agencies to collect more data. Such partnerships could also help to mitigate risks. In Phoenix, transportation officials felt that the AZTech

"While it may be unlikely to develop a fully self-sustaining traveler information public-private partnership, there still may be benefits to the public in such enterprises."

—Pierre Pretorious, Former AZTech Program Manager

[6]*Sussman, Joseph, et al.*, "What Have We Learned About ITS?" *Washington, DC: USDOT (Publication Number FHWA-OP-01-006) December 2000.*

business model helped to mitigate risks by, as Pierre Pretorious explains, "letting those who know the market best [the private sector] lead [new product development]." In this way, State and local agencies may reduce their risks of being stuck with old technologies having limited utility.

Growing private sector interest in public data. The model deployments also indicated that the entire paradigm of the private sector paying for public data may be shifting. For example, San Antonio has already been approached by a number of private vendors, such as cell phone companies, exploring the possibility of selling privately collected data from sources such as cell probes to the public sector.

Q18 What techniques were successful in raising awareness of ITS benefits at the model deployment sites and elsewhere?

A number of techniques were used to raise awareness of the benefits of integrated ITS among local citizens and officials and throughout the world. These techniques included the following:

Making use of public relations professionals. All four sites made at least some use of in-house or external public relations professionals to prepare press releases, collect benefits and promotional information, coordinate with the media, and track press coverage.

Making sufficient funds available to effectively perform awareness activities. The Seattle model deployment spent over $1 million on marketing, outreach, and advertising. However, as Pete Briglia explains (see Question 9), even this relatively large sum was "just a drop in the bucket when trying to introduce new technologies or new ways of doing things." Furthermore, sites need to budget for marketing efforts not only to launch the application, but also to sustain awareness of the technology during its operation phase.

Engaging professional media. All four sites worked through local, regional, and national media outlets to "get the story out." Consequently, the model deployments made front-page news at several sites and were featured nationally on television.

Hosting of scanning tours. Following the philosophy that the best way to describe the benefits of a system is to show it in operation, the model deployments, with support from USDOT, organized numerous tours of actual model deployment facilities. These "scanning tours" were extremely popular. For example, Dale Thompson estimates that representatives from at least 25 states and 10 countries have toured the Phoenix model deployment facilities. Similarly, Seattle has hosted 17 formal scanning tours and hundreds of informal tours. San Antonio has had visitors from as far away as Australia and Japan.

Participation in reverse scanning tours. All model deployment leaders found reverse scanning to be successful. For these tours, model deployment representatives traveled to other sites and shared their deployment experiences.

Showcasing events and conducting outreach. Events that included presentations, technical interchanges, and media kick-offs have also been successful. Most model deployment sites have also reached out to their peers through conference presentations, brochures, and CD-ROM publication. For example, the Seattle model deployment conducted 48 stakeholder interviews and four industry forums.

Making use of traveler information websites. Traveler websites have also been used to provide more information on the model deployment program to users in the various regions.

Participating in national evaluation. A number of sites reported that participation in and promotion of the USDOT-sponsored independent national evaluation was helpful in raising awareness of the benefits of ITS and ITS integration.

Q19 Overall, were the model deployments a successful demonstration program? How important is ITS integration in the host sites today?

Yes. The model deployments contributed significantly to demonstrating the benefits of ITS integration and to raising awareness of these benefits, as illustrated below.

Plans to expand ITS in Seattle. Perhaps the best proof of this success lies in Seattle, where a "Blue Ribbon Transportation Commission" strongly affirmed the need to continue and expand the ITS program within the State. Specifically, the commission recommended that 5 percent of all freeway improvement funds be committed to ITS, which, if adopted, would represent a significant increase in overall ITS funding. While impressive, this increase is even more remarkable in light of the recent loss of a large portion of the WSDOT's revenue stream because of a car tax repeal.

ITS integrated in construction projects in San Antonio. San Antonio, like the other model deployment sites, has a long history of ITS success outside of the model deployments. There, ITS is regularly integrated into construction projects, and the State is not only committed to the provision of O&M funds for ITS, but has doubled the amount available for this purpose.

Commitment to ITS integration in NY/NJ/CT. In the NY/NJ/CT area, where long delays in the model deployment have frustrated some, Rob Bamford reports, "There is still a strong commitment to ITS integration." Much of this commitment emanates from acceptance of the regional ITS architecture, which has united agencies technically and institutionally.

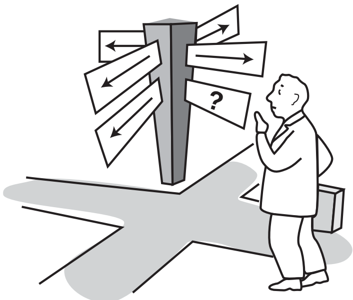
Increased awareness of ITS benefits. As Pete Briglia explains:

> "SmartTrek increased WSDOT's awareness of ITS and its popularity with the public...all of our regions are working on ATMS and ATIS projects, many in rural areas. Our major cities, as well as Vancouver, which is included in Portland's commute-shed, have all implemented freeway management systems. Support for providing ITS matching funds and the CVISN [Commercial Vehicle Information Systems and Networks] program is strong despite voter-mandated reductions in transportation funding."

An increased awareness of the benefits of ITS—particularly integrated ITS—has occurred at the other sites as well. In Phoenix, Pierre Pretorious reports that ITS integration is becoming a regional philosophy, with a "recognition that AZTech is not just a project, but rather a program." In early 2001, Phoenix issued a new request for proposals for continued AZTech development. Four major cities—Phoenix, Tempe, Mesa, and Scottsdale—have reaffirmed their support for the regional ITS vision.

ITS benefits extend beyond model sites. The model deployments have also had significant effects beyond the four original participants. For example, as of spring 2001, NY/NJ/CT's regional architecture is being considered as an input to a similar architecture in Northern California. Also, Phoenix's roadway closure and restriction system is expanding to other States, such as Nevada and Oregon, while its special events system is being considered for Virginia. Finally, San Antonio's Automated Vehicle Identification Tag software is being used in Georgia, and the LifeLink remote ambulance communication application is being considered for use in New York.

Q20 What directions are the model deployment sites taking today?



The various model deployment sites remain committed to ITS deployment and integration. Anticipated future directions for the sites (as of spring 2001) are summarized below.

New York/New Jersey/Connecticut: Testing transit information applications. The NY/NJ/CT model deployment is still working toward deployment of its transit information applications and is currently in the testing and acceptance phase. Full deployment of real-time Web and phone-based transit information service, personalized transit itinerary service, and transit advisory trip planner will likely occur by winter 2001. The NY/NJ/CT region is also expected to complete a regional ITS architecture by this time.

San Antonio: Expanding freeway management system. In San Antonio, expansion of the TransGuide freeway management system is continuing, with 63 miles in operation, 25 miles under construction, and a total of 191 miles planned. Another application receiving additional focus is the LifeLink ambulance/hospital remote communications system. Plans are under way to expand the medical service not only to additional hospitals and rural environments, but also to police, fire, and courtesy vehicles. San Antonio is adopting an increasingly regional view, with plans to deploy additional ITS services to the Austin corridor and surrounding border crossings. Finally, San Antonio is working toward developing an integrated maintenance management system.

Phoenix: "Growing" commitment to ITS. In Phoenix, the AZTech Program has "allowed ITS to bloom in the desert," according to a marketing brochure prepared by the project. Dale Thompson reports that "AZTech will carry the banner for long-term regional operations and interjurisdictional cooperation for ITS." As a tangible expression of this commitment, in spring 2001, Phoenix issued requests for proposals for a new round of AZTech deployments. Furthermore, as previously stated, the region is also in the early stages of perfecting the unique REACT arterial management program.

Seattle: Completing basic ATMS infrastructure. In Seattle, the basic infrastructure for the regional ATMS is nearly complete. While some partner agencies (city governments) have lost interest because of project delays, a significant expectation of benefits remains. In addition, Seattle continues to "push the envelope" with traveler information by providing traffic congestion maps over the latest generation of hand-held personal computers and transit arrival information over cell phones. Finally, Seattle is intensifying efforts to provide integrated weather and roadway information to the public, and its "rWeather" road-weather information website has attracted much user interest.

Final Thoughts

As one looks back at the model deployment initiative, it is clear that this ambitious experiment has been successful in teaching us a number of lessons. These lessons can be learned not only from the initiative's successes, but also from its failings. In terms of success stories, the deployments clearly demonstrated that improvements in travel time, safety, energy conservation, and customer satisfaction can be achieved through deployment of integrated ITS applications such as publicly funded traveler information websites and cross-jurisdictional signal coordination.

At the same time, the initiative also revealed that these positive results are not guaranteed, nor are they typically achieved without confronting significant challenges. For example, nearly all of the privately funded traveler information services proposed or implemented in the deployments failed, questioning the viability of public-private partnerships for this application. Furthermore, O&M costs were significantly larger than expected in many cases, ultimately leading to the failure of such deployments as traveler information kiosks and use of non-toll-based tag readers for determining vehicle speeds. Finally, perhaps the greatest challenge faced by the deployments was the difficulty of maintaining schedule. As of spring 2001 (five years after the initial kick-off of the model deployment effort), several major planned traffic management applications are still awaiting full deployment in San Antonio, Phoenix, and Seattle, while NY/NJ/CT is still working toward deployment of its transit information applications.

Fortunately, however, the deployments also left a wealth of guidance for others to draw from when facing similar challenges. For example, project managers at the deployment sites now recognize that for public-private partnerships to have any chance of success, they must be sufficiently advertised. As Pete Briglia pointed out, "…things don't sell themselves, no matter how good." There is also a growing recognition that perhaps the goal of fully self-sufficient operations for traveler information services has been too ambitious, and that perhaps a business model where costs are simply reduced, not fully recovered, may be a more appropriate target.

In terms of preparing for O&M costs, prospective ITS implementers are encouraged to make more of an effort to include such considerations in their planning processes. They are also encouraged to undertake more intensive efforts to educate decision makers on the importance of ensuring funding for ongoing operations. For help in predicting the extent of these costs, you can consult the USDOT's ITS Unit Cost Database at www.benefitcost.its.dot.gov.

Finally, the initiative also provided the transportation community with a number of recommendations for mitigating the widespread challenge of deployment schedule delays. These recommendations include the following:

- ***Think "outside the box" of traditional government procurement.*** Investigate your procurement procedures and what you can do to make them more flexible. Move away from the traditional procurement cycle .

- ***Be aware that software implementation is a new world.*** Keep your software developers close and plan to interact with them more than once a week. Ensure that open systems are deployed. If you are not careful, you could end up developing a system that you do not own.

- ***Start with a prototype and proceed from there.*** You can waste time trying to design the perfect "mousetrap." People get a lot more involved once they start looking at demonstrations instead of documents.

- ***Focus on "what," not "how to."*** Leave the "how" to the experts. Be flexible to ensure the greatest return on investment. Give the vendors flexibility to use whatever technologies they prefer to develop ITS services.

- ***Recruit a local champion.*** Recruit a proponent who will invest the time and commitment to see a long-range project through to completion.

- ***Manage expectations.*** Avoid overly ambitious promises as to what can be delivered by when. Raising expectations in this way only brings disillusionment in the long run and ultimately undermines support.

While no set of guidelines or lessons learned can guarantee success, the preparers of this report hope that its findings can assist others in realizing the full potential of integrated intelligent transportation systems.

Bibliography

American Trucking Association Foundation, Inc. *Incident Management: Final Report.* Alexandria, Virginia: American Trucking Association, 1990.

Carter, Mark, et al. *San Antonio Metropolitan Model Deployment Initiative Evaluation Report.* Washington, DC: USDOT (Publication Number FHWA-OP-00-017, EDL #12883), May 2000.

DeBlasio, Allan J., et al. *Successful Approaches to Deploying an Integrated Intelligent Transportation System.* Washington, DC: USDOT (Publication Number FHWA-JPO-99-032, EDL # 8483), March 1999.

Huddleston, Scott. "Motorists to View Drive Times." *San Antonio Express-News*, (November 1, 1999): A1.

Jensen, Mark, et al. *Seattle Metropolitan Model Deployment Initiative Evaluation Report.* Washington, DC: USDOT (Publication Number FHWA-OP-00-020, EDL #13071), May 2000.

Lappin, Jane. *What Do ATIS Customers Want?* Paper presented at the ATIS Data Collection Guidelines Workshop. Phoenix, Arizona, February 9-10, 2000.

The National Architecture for ITS: A Framework for Integrated Transportation into the 21st Century. Washington, DC: USDOT (Publication Number FHWA-OP-96-012, EDL #4847), April 1996.

Southwest Research Institute. *TransGuide Model Deployment Initiative Design Report.* San Antonio, Texas: Southwest Research Institute, September 1998.

St. Onge, Charles, et al., *Metropolitan Model Deployment Initiative National Evaluation Strategy*. Washington, DC: USDOT (Publication Number FHWA-JPO-99-041, EDL #6305), November 1998.

Sussman, Joseph, et al. *What Have We Learned About ITS?* Washington, DC: USDOT (Publication Number FHWA-OP-01-006, EDL #13316), December 2000.

Vanderwilden, Phillip, and Allan J. Deblasio. *Intelligent Transportation Systems Assessment of ITS Deployment, the New York-New Jersey-Connecticut Metropolitan Model Deployment Initiative: A Review of the Initial Negotiations Process.* Washington, DC: USDOT (Publication Number FHWA-JPO-98-033, EDL #4309), July 1998.

Zimmerman, Carol, et al. *Phoenix Metropolitan Model Deployment Initiative Evaluation Report.* Washington, DC: USDOT (Publication Number FHWA-OP-00-015, EDL #12743), April 2000.

ITS Web Resources

Phoenix (AZTech) Model Deployment
www.azfms.com/index.html

San Antonio (TransGuide) Model Deployment
www.transguide.dot.state.tx.us

Seattle (SmartTrek) Model Deployment
www.smarttrek.org/index.html

NY/NJ/CT (Trips 123) Model Deployment
www.xcm.org/services/tech%20development/trips123/Trips123.html

ITS Cooperative Deployment Network:
www.nawgits.com/icdn.html

ITS Joint Program Office
www.its.dot.gov

ITS Professional Capacity Building Program:
www.pcb.its.dot.gov

Electronic Document Library
www.its.dot.gov/itsweb/welcome.htm

ITS Resource Guide
www.its.dot.gov/guide.html

ITS Benefits and Costs Database
www.benefitcost.its.dot.gov

Federal Transit Administration
Transit ITS Program:
www.fta.dot.gov/research/fleet/its/its.htm

"When you look at the stand-alone pieces that make up most intelligent transportation systems, there doesn't seem to be anything new. What's new, however, is the integration that modern computer and communications systems [allow]. This integration makes it possible to operate transportation systems in ways that no one even considered a few years ago, but which today are in demand by the public and their elected officials."

—**Pete Briglia, SmartTrek Program Manager**

Intelligent
Transportation
Systems

U.S. Department of Transportation
400 7th Street, SW
Washington, DC 20590

Federal Highway Administration
Room 3416, HOIT-1
Phone: 866-367-7487
Facsimile: 202-493-2027

Federal Transit Administration
Room 9402, TRI-10
Phone: 202-366-4995
Facsimile: 202-366-3765

FHWA-OP-02-023 December 2001 EDL #13599