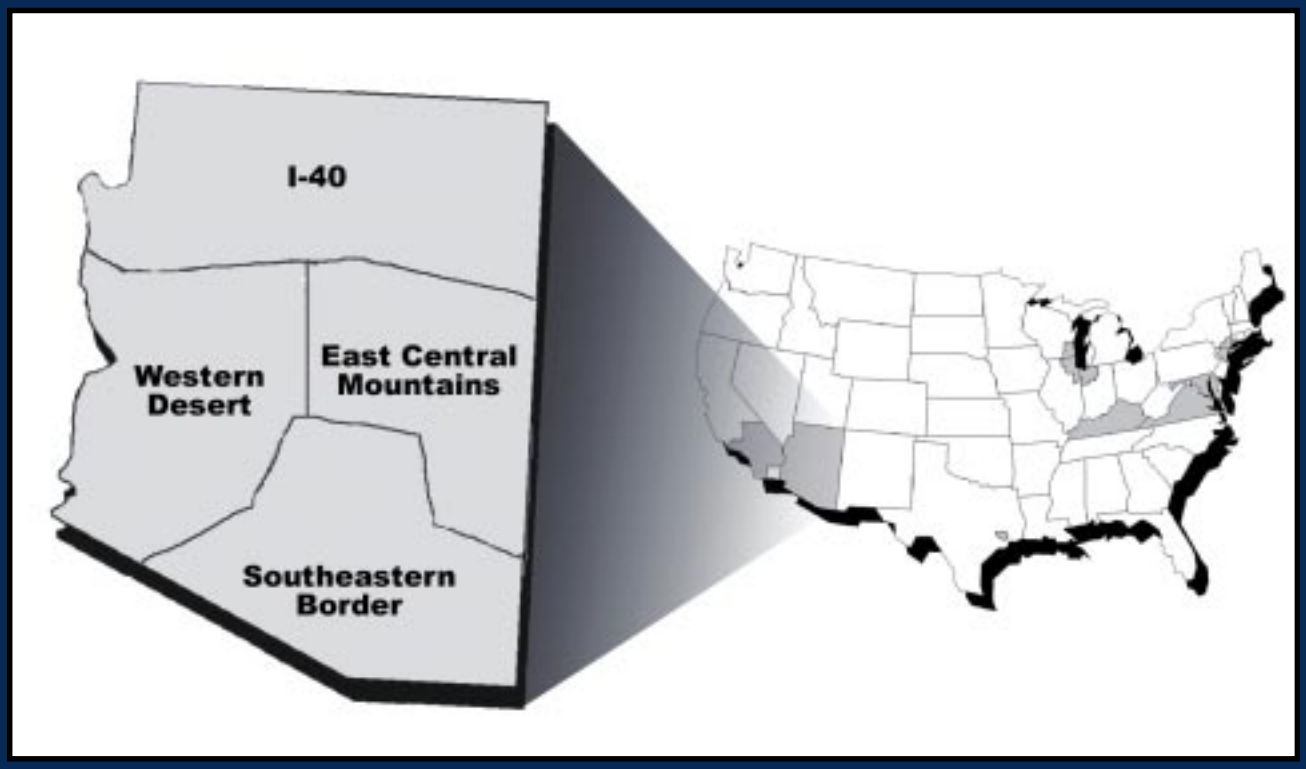
Statewide ITS Architecture Development

A Case Study

Arizona's Rural Statewide ITS Architecture



Building a Framework for Statewide ITS Integration

September 1999

Foreword

Dear Reader,

We have scanned the country and brought together the collective wisdom and expertise of transportation professionals implementing Intelligent Transportation Systems (ITS) projects across the United States. This information will prove helpful as you set out to plan, design, and deploy ITS in your communities.

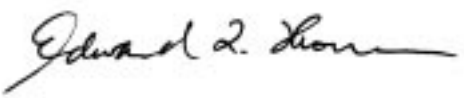
This document is one in a series of products designed to help you provide ITS solutions that meet your local and regional transportation needs. We have developed a variety of formats to communicate with people at various levels within your organization and among your community stakeholders:

- **Benefits Brochures** let experienced community leaders explain in their own words how specific ITS technologies have benefited their areas;
- **Cross-Cutting Studies** examine various ITS approaches that can be taken to meet your community's goals;
- **Case Studies** provide in-depth coverage of specific approaches taken in real-life communities across the United States; and
- **Implementation Guides** serve as "how to" manuals to assist your project staff in the technical details of implementing ITS.

ITS has matured to the point that you don't have to go it alone. We have gained experience and are committed to providing our state and local partners with the knowledge they need to lead their communities into the next century.

The inside back cover contains details on the documents in this series, as well as sources to obtain additional information. We hope you find these documents useful tools for making important transportation infrastructure decisions.

Christine M. Johnson
Program Manager, Operations
Director, ITS Joint Program Office
Federal Highway Administration



Edward L. Thomas
Associate Administrator for
Research, Demonstration and
Innovation
Federal Transit Administration

Purpose

This is one of seven studies exploring processes for developing ITS architectures for regional, statewide, or commercial vehicle applications. Four case studies examine metropolitan corridor sites: the New York, New Jersey, and Connecticut region; the Gary-Chicago-Milwaukee Corridor; Southern California; and Houston. The fifth case study details Arizona's process for developing a rural/ statewide ITS architecture. A cross-cutting study highlights the findings and perspectives of the five case studies. The seventh study is a cross-cutting examination of electronic credentialing for commercial vehicle operations in Kentucky, Maryland, and Virginia.

Six of the studies were conducted by U.S. DOT's Volpe National Transportation Systems Center under the sponsorship of U.S. DOT's ITS Joint Program Office, with guidance from the Federal Highway Administration and Federal Transit Administration. The Houston case study was conducted by Mitretek Systems, with support by the Volpe Center.

This study was prepared for a broad-based, non-technical audience. Readership is anticipated to include mid-level managers of transportation planning and operations organizations who have an interest in learning from the experiences of others currently working through ITS architecture development issues.

Case Study Overview

In December 1998, the Arizona Department of Transportation (ADOT) completed a comprehensive effort to develop a *Strategic Plan for Statewide Deployment of Intelligent Transportation Systems* (ITS). As one of the first in the nation, Arizona's Statewide ITS Strategic Plan represents the culmination of an institutional commitment to build a statewide ITS infrastructure to improve both the safety and efficiency of the state's transportation system. This case study offers insights on:

- How using the National ITS Architecture can save time and resources, guarantee that potential links between systems are not overlooked, and assure consistency with federal-funded requirements.
- How ADOT used their Community Relations Office to solicit input from a large and diverse group of stakeholders which contributed to the success of both the statewide and earlier I-40 Corridor architecture development efforts.
- How incorporating input from non-traditional stakeholders such as the National Park Service, the National Weather Service, and the railroad agencies created a final product diverse and flexible enough to meet, and prioritize, the short and long-term needs of the entire state.
- How the lessons learned during development of the Early Deployment Plan for the I-40 Corridor in northern Arizona served as the framework for the subsequent statewide effort.

Background

Rural roadways account for over 70% of total roadway mileage in Arizona and over 90% of ADOT's highway network. Arizona also contains the second highest percentage of federally or Native American controlled land in the country. Dealing with sovereign Indian nations, and the land use restrictions on federally protected parklands, further complicates transportation planning efforts.

In Arizona, 57% of all fatal crashes occurred in rural areas although this accounts for only 19% of the total crashes in the state.

Extreme weather and geography, coupled with few urban centers, makes thousands of miles of Arizona's rural transportation network difficult to access. Safety is a primary concern since emergency services are limited. On average, the emergency response time in Arizona's urban areas is 6.7 minutes compared with 16.2 minutes in rural regions, almost 2.5 times longer. Statewide crash statistics show that 57% of all fatal crashes ocurred in rural areas although this accounts for only 19% of the total crashes in the state.

Since Arizona is predominately rural, ADOT was an early and active participant in the development of the national Advanced Rural Transportation Systems (ARTS) strategic plan. Hosted by the Intelligent Transportation Society of America (ITS America), these efforts addressed distinctly rural needs in the context of the National ITS Architecture that, although developed with both metropolitan and rural context in mind, initially provided more detail only on metropolitan applications.

ITS Architecture Development Process

Pre-Statewide ITS Architecture Deployments

The Arizona Department of Transportation, in conjunction with the Federal Highway Administration (FHWA) Arizona Division Office, has spent the last portion of the decade deploying various elements of the statewide Intelligent Transportation System. These include the following:

Advanced Traveler Information Systems (ATIS) Initiatives:

- *Arizona TripUSA*. ADOT negotiated with private companies to build a traveler information system for Northern Arizona that includes information on road closure, weather, local attractions, and services to travelers in that region. The information is disseminated through kiosks, personal computers, radios, televisions, a toll-free number, and the Internet.

- *The Trailmaster Highway Closure and Restriction System (HCRS)* allows transportation and highway patrol personnel to enter real time highway closure and restriction information into a central system and then provide that information to the traveling public through toll free phone numbers, the Internet, and strategically placed kiosks.

- *AZTech kiosks for I-40*. Four kiosks were installed at truck stops and tourist information centers along Interstate 40 as part of the Phoenix metropolitan Model Deployment Initiative (MDI).

- *Variable Message Signs (VMS) in Rural Areas*. To date, ADOT has installed 7 VMS units to provide motorists with information on incidents, weather, and traffic conditions. The signs advise motorists of upcoming hazards and alternative routes. Due to the success and cost-effectiveness of the initial 7 VMS units, ADOT plans to install 24 more signs in the next 2 to 3 years, followed by an additional 24 signs in the future.

Commercial Vehicle Operations (CVO) Initiatives:

- *The Heavy Vehicle Electronic License Plate Program (HELP)* is a multi-state, multi-national effort to design and test an integrated heavy vehicle monitoring system based on ITS technologies. Arizona was a partner in this project and served as an operational test site.

- *PrePass* is a technology that electronically weighs trucks and verifies their identities as they approach weigh stations. In 1996, Arizona added to the existing California and New Mexico PrePass network by adding ten Arizona sites and introducing the service to Arizona ports of entry.

- *Expedited Crossing at International Borders (EPIC)* is an automated truck clearance system set up to electronically check vehicles at the increasingly congested Nogales crossing of the U.S.-Mexican border.

Arizona Statewide ITS Architecture Timeline

1994 Strategic Plan for ITS Communications initiated

1995 ARTS Workshop

1996 I-40 Corridor ITS Strategic Plan initiated

Rural ITI Plan developed

1997 ADOT receives $250,000 from U.S. DOT for statewide ITS Early Deployment Plan

Statewide ITS Strategic Plan initiated

1998 Statewide ITS Strategic Plan completed

1999 ADOT considering options for incorporating metropolitan ITS deployment plans to establish a comprehensive statewide ITS deployment framework

ITS Architecture Development Process

Communications and Standards Initiatives:

- *The ITS Communications for Arizona* project identified communication technologies that are suitable to support the deployment of ITS service in the state.

- *ENTERPRISE and the International Traveler Information Interchange Standard (ITIS)*. As a member of ENTERPRISE (a coalition of states with rural ITS interests), ADOT sponsored the research and evaluation of communications standards for traveler information dissemination. The ITIS standard, which is used in Arizona's traveler information systems, allows ATIS systems to exchange traveler information between in-vehicle systems, traffic and transit information providers, traffic control centers, police and fire departments, and transit authorities.

Traveler Safety Initiatives:

More information about the Intelligent Variable Speed Limit Device is available at: http://www. cse.nau. edu/~adot

- *Intelligent Variable Speed Limit Device* is an ADOT-sponsored Northern Arizona University research project to develop a fuzzy logic control algorithm for highway speed limits. By analyzing road condition and weather variables, the algorithm can change speed limits to meet safe speed guidelines developed by highway maintenance staff and state public safety officers.

- *Road Weather Information System*. Ten weather stations were installed along areas of the I-40 corridor most prone to snowstorms and freezing. Collected between October and May, the weather and road condition data allows District Engineers to optimize their allocation of snowplows to areas that need it most.

All of these projects improved the safety and efficiency of rural transportation and raised the awareness of ITS technologies. However, because of the constraints associated with rapid advancements in ITS technology, funding, institutional coordination, and evolving state level ITS program guidelines, these deployments have been made without a detailed plan or underlying architecture. Moreover, since the majority of these projects were developed to address specific, often regional, needs that were identified under separate studies, the synergy associated with an integrated ITS network could not be realized.

The Early Deployment Plans

In an attempt to create an integrated ITS infrastructure, several ITS champions at ADOT led efforts to develop three Early Deployment Plans (EDPs) — one each for the Phoenix and Tucson metropolitan areas and, significantly, one for the rural I-40 corridor in northern Arizona.

ITS Architecture Development Process

The federally funded plans played a pivotal role in building awareness of ITS technologies. The prospect of receiving federal funds brought together a broad array of decision-makers from federal, state, and city transportation and planning agencies. The 1996 selection of Phoenix as one of only four MDI sites further increased the awareness of ITS technologies at ADOT headquarters. However, because many of the issues dealt with in the metro areas were unrelated to the rural context, the lessons learned from the I-40 experience established the impetus and framework for the subsequent statewide ITS planning effort. The following section examines in detail many of the dynamics of the I-40 process to enable readers to benefit from that experience, as well as the statewide architecture development process.

"Without federal funding for the earlier EDPs, the statewide ITS architecture would probably never have been developed."

— Timothy Wolfe, ADOT Assistant State Engineer and Director of ADOT ITS Projects

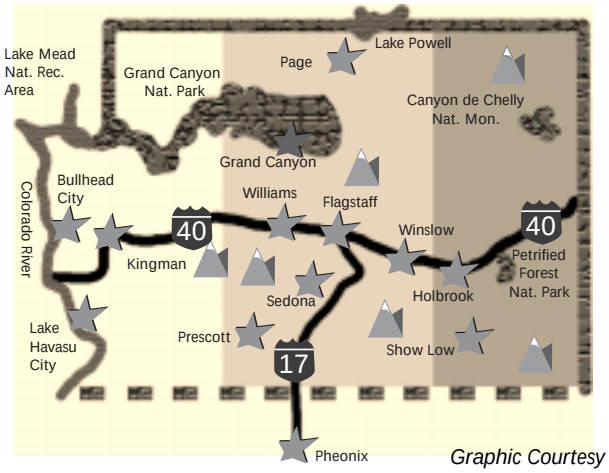
The I-40 Corridor ITS Strategic Plan

Begun in March 1996, the I-40 ITS strategic deployment planning and architecture development process is a story of influential ITS champions, dedicated stakeholder participation, diverse roadway users, and, most of all, common interests based on a 359-mile stretch of highway.

The I-40 corridor stretches across Northern Arizona, traversing some of the most variable terrain in the country. From an elevation of approximately 600 feet at its desert beginnings in Western Arizona, the corridor rises to 7,330 feet at its highest point near Flagstaff. This variability makes it possible that, within only a few hours, a driver will experience both warm weather and winter driving conditions along different portions of the highway.

Temperatures along the corridor can range from over 100 degrees Fahrenheit in the summer to subzero winter lows, with Flagstaff receiving an average annual snowfall of 100 inches.

Besides weather variability, the I-40 corridor frequently experiences the full gamut of weather phenomena ranging from winter blizzard conditions to severe thunderstorms that can produce large hail and winds in excess of 60 mph. These winds pose particular hazards to high profile vehicles such as trucks and recreational vehicles. Winds throughout the corridor can also shift unexpectedly, causing smoke from controlled forest burns or desert dust to blow across the roadway and reduce visibility. The steep grades also reduce sight distances and create hazardous speed gradients between truck and passenger car traffic.



Graphic Courtesy of Arizona TripUSA

ITS Architecture Development Process

"Pileups kill 6, hurt dozens on icy I-40 near Flagstaff: Lawmen describe carnage as worst they've ever seen."
— **The Arizona Republic, December 31, 1989**

Architecture for the I–40 Corridor

Graphic Courtesy of Arizona TripUSA

I-40's weather and geography affect an unusual range of drivers. As one of the nation's primary east-west interstate corridors, large commercial vehicles account for 35-40% of I-40's traffic, 70 -80% of which are "long-haulers" traveling through the state. With thousands of trucks carrying goods across northern Arizona every week, any I-40 delays can disrupt commerce from Southern California to the Midwest.

Tourist traffic also makes up a significant portion of I-40 users. Northern Arizona is blessed by a remarkable diversity of natural treasures, many of which are preserved in protected areas accessible along the length of the corridor. These include nearly 20 major parks including the Grand Canyon and the Petrified Forest National Parks. The Grand Canyon alone receives nearly 5 million visitors a year.

Other tourist attractions along I-40 include the longest remaining segment of U.S. Route 66 which parallels the corridor, as well as the Hopi, Navajo, Hualapai, and Havasupai Indian tribal communities that adjoin the corridor and also attract visitors. The special needs of tourists for travel information, coupled with the reliance of I-40 communities on tourist dollars, played a driving role in development of a rural ITS architecture for the I-40 corridor.

I-40's combination of weather and geography, commercial traffic, and tourist destinations made the corridor an excellent location for rural applications of ITS technologies. Begun in March 1996, the goal of the 12-month effort was to create a strategic plan for ITS technologies along the I-40 corridor while creating a cohesive coalition of stakeholders in both Arizona and neighboring corridor states (California and New Mexico), with the possibility of expanding it along the entire route.

Funding came from a combination of state and federal sources. ADOT contributed $80,000 of its federal-aid highway planning and research funding, and received an additional $200,000 in ITS funds (plus state matching funds) to begin what was then one of the first rural EDP efforts in the country.

The first task was to identify the people, organizations, and agencies with vested interests in finding solutions to transportation needs along the I-40 corridor. This was a considerable undertaking. The consultant compiled a list that contained around 450 individuals representing a wide cross-section of public and private stakeholders who were invited to participate in the process. About 50 people responded and became the core constituency. The others who did not express interest in being active participants were kept updated through quarterly newsletters.
The consultant also worked closely with the ADOT Community

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Relations Office, which has a full time staff member assigned to ITS-related projects. Together they organized a series of public forums and a public workshop which helped introduce ITS and the goals of the I-40 Strategic Plan to interested stakeholders. The most effective means of coalition building proved to be bringing in influential "key stakeholders" early on in the process because they were the most effective recruiters of other participants.

Key Stakeholder Involvement

The development of the I-40 strategic plan and statewide architecture is a testimonial to the importance of ITS advocates. From the very beginnings of the process, a few influential stakeholders used their foresight and awareness of the benefits of an integrated ITS architecture to catalyze the development process. Convened with the help of a dedicated and enthusiastic ITS consultant, and united in their appreciation of the potential of ITS applications to solve their unique transportation problems, these stakeholders defined the needs of their community and created a realistic blueprint to achieve it. The ITS champions involved in the I-40 Strategic Plan illustrate three categories of advocates for a successful development of a rural ITS architecture and strategic plan:

"ITS Technology has the potential to greatly improve the safety and efficiency of rural transportation systems."
— Rodney E. Slater, Secretary of Transportation

Early Champions

The first category is **early champions**, often transportation professionals who successfully convinced their peers to consider adopting and integrating ITS technologies to make the existing transportation system safer and more efficient. Of the several dozen people interviewed for this study, the vast majority mentioned that they were initially introduced, and brought into the process, by a relatively small group of individuals. These few people were the early visionaries, individuals with the foresight, enthusiasm, and drive necessary to motivate the development effort. In the Arizona case, the early champions also went on to play leading roles throughout the process by providing technical, political, or policy support to the Technical Advisory Committee, the primary executive oversight group.

"To have new, innovative ITS technologies operational throughout the I-40 corridor, providing a safer and more efficient intermodal transportation system, meeting the short and long-term needs of visitors, local communities, commercial operators, and the traveling public."
— I-40 Corridor Vision Statement

The earliest visionaries came out of ADOT's Transportation Research Center. Their position as managers of most of the ITS research and planning in ADOT allowed them to appreciate the benefits of developing a statewide strategic deployment plan. Moreover, they understood how an underlying architecture could help ensure that future projects would be designed to accommodate existing ITS technologies and be deployed in a coordinated way. The statewide architecture's short-term (1999-2001), mid-term (2002-2007), and long-term (2008 and beyond) plans also created the necessary blueprints showing how to best prioritize and integrate future ITS projects.

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The ADOT Transportation Research Center managers were also aware of the development of the National ITS Architecture and could see that future ITS projects funded with federal dollars eventually needed to fit within the national framework. Expected to continue their leadership role at ADOT post-development, several observers felt that the Transportation Research Center is now the de facto custodian of the statewide architecture, and are confident that the Center would continue to be a positive unifying force during the 20-year implementation phase.

The primary consultant was also instrumental in both the I-40 and statewide efforts. By all accounts, the consultant went "above and beyond" what was expected of a consultant, and further championed the process through leadership roles with ITS Arizona, a public/private organization formed as a state chapter of ITS America.

The Federal Highway Administration's (FHWA) Arizona Division office also was essential to early facilitation of the development process. Cognizant of the intent of the National ITS Architecture development process, the FHWA worked hard to get the Arizona transportation community thinking about ITS, and supplied them with useful information. As part of this effort, FHWA representatives served on the Technical Advisory Committees and attended many of the outreach sessions. Another important contribution from the Arizona FHWA division was arranging for the U.S. DOT National ITS Architecture course to be given in support of the development of the statewide architecture. Many of the stakeholders cited the architecture course as extremely significant in developing their own awareness and understanding of the National ITS Architecture.

Federal EDP guidelines determined much of the development process. Moreover, although a strong initial motivation for developing the statewide architecture was the availability of federal EDP funding, the process allowed stakeholders to realize the inherent value of an ITS architecture, and they are now considering how to integrate the statewide and metropolitan frameworks.

The transportation planning community also played an important role by contributing a planning perspective emphasizing that the process could never reach its full potential unless it was very open and extremely participatory. These views were consistent with the intent of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) and its 1998 reauthorization as the Transportation Equity Act for the 21st Century (TEA-21), which emphasizes public review and participation in transportation planning efforts. The planning perspective also advocated focusing on multimodal strategic plans, rather than just on highways.

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Local Advocates

The second category is local advocates, transportation professionals who appreciated the potential of ITS applications to solve their local issues and actively participated in the planning effort. Without buy-in from local and regional transportation professionals, developing and implementing a regional ITS architecture would be impossible. Local governments know best the unique needs of their regions and know who needs to participate in the process for it to be successful. During the I-40 plan, local ADOT staff used their established professional and personal relationships to bring together a diverse group of stakeholders.

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With no alternative routes and the corridor's severe weather and geography, the local District Engineers already had a history of relying on technology to improve traveler safety and minimize road closures. As early as twenty years ago, radios were used by the state police and highway districts to share road condition information, however, this tapered off as the agencies upgraded independantly to incompatible systems. Over the years, the districts added other technologies such as weather sensors and variable message signs (VMS) and have continued to improve their communication links along the corridor. In fact, some of the District Engineers were such strong ITS advocates they were using their limited discretionary funds for ITS technologies even before the development of the I-40 Strategic Plan.

"We used our discretionary funds on ITS projects because I-40 incidents can cause life and death situations. Once you get a major accident, there is no way to access people stuck in the queue and they have no access to facilities. People have had heart attacks and even babies while stuck out there."
— Jeff Swan, Holbrook District Engineer

The District Engineers were also instrumental in gathering the third category of ITS advocates, the proactive stakeholders. With decades of experience working in the area, the Engineers were able to access their professional and personal networks to include interested parties into the development process.

Proactive Stakeholders

The third category is **proactive stakeholders**, interested parties who are not directly involved in building or maintaining the transportation infrastructure. Typically, they are individuals associated with transportation issues, politicians or concerned citizens, or other interested parties who understand how ITS applications can help solve their own issues and concerns.

Non-traditional Stakeholders

Beyond ADOT transportation professionals, other stakeholders contributed valuable perspectives to the development of the I-40 Strategic Plan. The Arizona Department of Public Safety (DPS) was all too aware of the unusual and sometimes hazardous driving conditions in Northern Arizona. Having dealt with tourists stuck in snowstorms wearing only the summer clothing they had on when they headed to the mountains from desert regions, DPS staff recognized how ITS technologies could help disseminate weather and road condition

"The key to the success of the I-40 Plan was that people felt like they were in this together."
— Lt. Jim Gerard, Flagstaff Patrol District Commander, Arizona DPS

information. Moreover, deployment promised to create a more efficient system that better utilized the existing work force and gave the traveling public a better appreciation and trust of the law enforcement community. Existing relationships played a significant role in DPS's participation. The DPS, which in the past had been co-located with ADOT district offices, had a history of working closely with ADOT on issues such as snowplow coordination.

"I-40 stakeholders participated as professionals, but everyone at the table had friends, family, and loved ones who use the corridor and will benefit from the process."

— Michael McCallister, BNSF Field Engineer, and I-40 Coalition Chairman and TAC Member

Burlington Northern Santa Fe Railway (BNSF) was another proactive stakeholder. Although not readily apparent, BNSF has significant interactions with the I-40 Interstate. Their tracks parallel much of the corridor allowing them to benefit from highway-based ITS advances such as accurate weather information. Additionally, BNSF relies on the I-40 to shuttle train crews to where they are needed. In fact, the enthusiastic participation and ability to engage others made a participating BNSF Field Engineer the consensus pick for chairing the I-40 Coalition. In many ways, he was an ideal choice. He was an objective facilitator who did not support any pet projects at the expense of others and he listened to the diverse input of Technical Advisory Committee participants. The chair benefited from having the time and support necessary to prepare for meetings and related responsibilities. Burlington Northern Santa Fe supported his efforts, while the consultant provided logistical and secretarial support and handled the technical details of architecture development.

Non-transportation Stakeholders

A number of non-transportation stakeholders also collaborated to develop the I-40 Strategic Plan and Architecture. The National Oceanic and Atmospheric Administration (NOAA), which maintains a weather service forecasting office near Flagstaff that covers the I-40 corridor, was invited to participate by the Flagstaff ADOT District Office. This was another example of the admirable diversity of the I-40 stakeholder coalition.

The relationship turned out to be beneficial for everyone involved. ADOT and the I-40 coalition realized that they could receive and utilize weather forecasts rather than just current weather conditions. Additionally, NOAA helped ADOT determine optimal sites for weather-related road sensors. For NOAA, their participation furthered their public safety mission to disseminate timely weather warning and forecast information to the public. Incorporating weather services into the regional architecture also allows them to receive data back from the field that can be incorporated into their forecasting models. For example, since NOAA collaborated with ADOT's northern districts, ADOT has installed upgraded radios in snowplows that allow operators to hear the latest warnings and forecasts via NOAA's Weather Radio. Additionally, the operators can now relay real time meteorological information back to NOAA's forecast office allowing the meteorologists to verify the accuracy of their information as well as provide input to improved warning and forecast models.

For NOAA, their participation furthered their public safety mission to disseminate timely weather information to the public.

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The Grand Canyon National Park was also very interested in the potential to share information using ITS technologies. As the region's major tourist attraction, the Grand Canyon is having trouble accommodating the millions of visitors it receives each year. For example, tourists will often travel hundreds of miles to the park assuming that lodging will be available for them when they arrive. Park officials saw using ITS technologies such as Variable Message Signs (VMS), traveler information kiosks, Internet-based dissemination, and weather information systems as innovative and cost-effective ways to help manage the growing number of visitors. Moreover, they realized that linking themselves to the I-40 regional architecture would allow them to better disseminate their own information such as lodging availability, park hours, road conditions, and event notices.

Local politicians were another constituency critical to the success of the I-40 Strategic Plan. Virtually every interviewee cited the mayors of Winslow and Bullhead City as real champions of the development process. Since both cities adjoin I-40 and rely heavily on income provided by tourist traffic, the mayors understood instinctively the opportunities presented by ITS technologies. VMS signs could steer stranded passengers to their city motels or kiosks, and in-vehicle information devices could advertise their businesses and attractions. Moreover, because I-40 was literally their lifeline to the outside world, they welcomed any technologies that could help ease winter travel. As community leaders, the mayors were also able to represent local interests and provide the local support crucial for community acceptance and adoption of ITS technologies. Flagstaff, the de facto capital of Northern Arizona, also participated but to a lesser extent. Although interested in rural applications such as traveler information kiosks, they felt their more immediate needs were best solved by urban ITS technologies like traffic signal controls. Their participation did, however, assure that future projects were equally dispersed between I-40 cities and created an awareness of the regional ITS architecture that will be incorporated into their Transportation Improvement Plan (TIP).

Brought in by the ADOT District Engineers in their respective regions, the mayors understood instinctively the opportunities presented by ITS technologies.

Tribal communities adjacent to the I-40 corridor also participated in the development process. Although their attendance was inconsistent, it was impressive given their need to travel at least 6 hours in each direction to attend. Their story is noteworthy. Initially, the Native American governments felt that ITS technologies were not that relevant to their needs because of their low traffic volumes. However, by participating in the process, the tribes became more aware and interested in ITS, particularly in the areas of Incident Management and MAYDAY technologies.

"It's important to get the communities on board and interested in implementing the technology. It allows us to take advantage of many opportunities to inform the public about our communities."
— Norm Hicks, Mayor of Bullhead City

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Ironically, with so many trucks relying on the I-40 corridor, they have the most to gain from ITS technologies such as weather and road closure information.

Limited Participants

There were, however, notable exceptions:

- Some smaller communities did respond to initial invitations, but most dropped out because, with few staff, they had trouble making the time to take the day off to attend a meeting or read the considerable amount of background material.

- Involvement from the business community was also limited. Although they participated occasionally in the I-40 and statewide development process, their involvement was infrequent.

- The transit community was also involved in the process and their needs were incorporated into the Statewide ITS Architecture. This is significant because transit services are limited in many rural areas of the state.

- The trucking community adopted a wait-and-see attitude to the development process. Their reasons were probably multifaceted. Many of the biggest firms are based in Phoenix and are less interested in Northern Arizona activities. Ironically, with so many trucks relying on the I-40 corridor, truckers have the most to gain from ITS technologies such as weather and road closure information. Additionally, they have a lot of local knowledge and experience to potentially contribute. The lessons learned during the I-40 effort led ADOT and its consultant to intensify their efforts to draw in truckers by contacting trucking company owners and handing out newsletters and information at ports of entry. However, despite their efforts, the trucking community did not participate in the subsequent statewide effort either.

Rural ITS Infrastructure Needs

An ADOT initiative to take stock of its rural intelligent transportation infrastructure needs was another important interim step towards the eventual statewide architecture development effort. Begun a few months after the initiation of the I-40 effort, the initiative resulted from a recognition of the need for a more systematic approach to assessing statewide ITS needs. As a requirements assessment, the study evaluated statewide needs related to 16 different ITS components. For each technology, ADOT identified a specific purpose and criteria with which to identify potential locations for future installations.

The initial meeting to assess ITS infrastructure needs was held at ADOT headquarters in August 1996. Every ADOT District Engineer, Maintenance Engineer, Maintenance Supervisor, and ITS-related stakeholder in the state was invited to attend. In the months that followed, the ADOT Intermodal Transportation Division Technology Group that headed the effort, traveled across Arizona and met with each

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District Engineer to identify the unique needs of their districts. After compiling all of the data they received, ADOT sent each district a list of ITS needs and asked them to rank each need as high (within one to three years, something the district would be willing to fund with their discretionary project money), medium (within four to seven years, to be included in the ADOT 5 year program), or low priority (eight-plus years, would be initiated whenever funds became available). Responses were then analyzed and a 10-year, $33 million ITS strategic deployment plan for rural areas was developed and published in February 1997.

The success of the needs assessment initiative in establishing a comprehensive view of ITS technologies, its recognition of the unique needs of diverse areas, and the incorporation of input from a large number of stakeholders, all laid the foundation for the subsequent statewide deployment planning/architecture development effort.

Statewide ITS Architecture Development

The Strategic Plan for Statewide Deployment of Intelligent Transportation Systems was launched in October 1997, shortly after successful completion of the I-40 Strategic Plan. Although the statewide process built upon the I-40 project, a major effort was made to consider the unique needs of various regions of Arizona rather than accept the I-40 framework. In addition, the Statewide Plan provided an opportunity to affirm ADOTs internal ITS infrastructure needs assesment through broader stakeholder involvement.

An objective of the Statewide Strategic Plan was to create a comprehensive, statewide architecture for deploying integrated and interoperable ITS technologies. The project study area was defined as the state of Arizona, excluding areas already covered by EDPs — Phoenix, Tucson, and I-40. Since Arizona is predominantly rural outside Phoenix and Tucson, the statewide plan focuses almost exclusively on rural issues.

With many of the same key players providing direction and input through a statewide Technical Advisory Committee, the procedural aspects of the effort went smoothly. In fact, the I-40 consultant (who also proposed successfully on the statewide project contract) was able to apply the lessons learned in the 18-month I-40 effort to complete the more extensive statewide process in about a year.

The Strategic Plan consisted of the nine tasks based on the ITS deployment planning process, as outlined in the National ITS Program Plan. These nine steps were collapsed into the following five tasks:

1. Identify Stakeholders and Develop Public Information Campaign

As with I-40, considerable effort went into gathering stakeholders to establish a strong technical and policy-oriented base of support for future ITS deployments. ADOT's Community Relations Office led the

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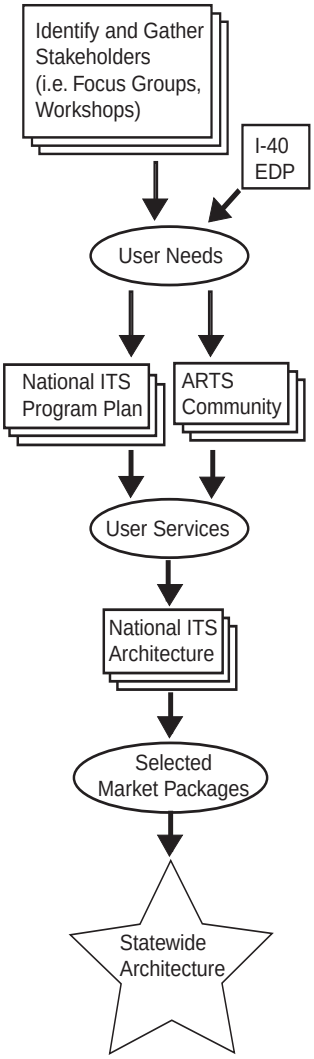

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outreach effort with consultant support. In late 1997, ADOT and FHWA sponsored two Rural ITS Workshops and four focus group meetings around the state that provided attendees with an in-depth look at ITS deployments in rural areas. An effective outreach strategy proved to be getting on the agendas of other meetings that potentially interested stakeholders attended. These efforts identified over 900 potential members for the statewide ITS development coalition, of which about 100 actively participated. Interestingly, the 10% participation ratio was similar to the I-40 effort.

Project fact sheets and quarterly newsletters were the primary means of keeping the 800 or so non-participating stakeholders informed of the process. ADOT also received positive coverage from the news media. Stories were focused primarily on the technologies and how these could affect people's lives, rather than on the integration and architecture aspect.

2. Assessing Rural Arizona's Transportation Needs

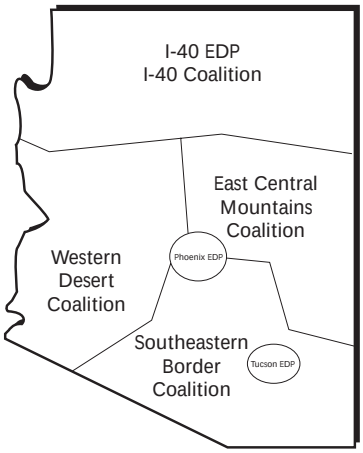
The needs identified from the focus group and coalition meetings formed the basis for the technology assessment and Strategic Plan. From over 200 needs cited, 76 independent need statements were developed. Traveler information based on real-time roadway conditions, such as route information, weather warnings, or detour directions dominated the concerns of the participating rural transportation users. Other desired applications included improved emergency service communications and response time and improved information sharing and communication among agencies. It is important to note that, like the earlier I-40 effort, almost all of the stakeholders focused on particular ITS applications, rather than on systems integration, interoperability, or conformity.

Three regional architectures were created, one for each of the areas in the statewide effort: the Western Desert Coalition, the East Central Mountains Coalition, and the Southeastern Border Coalition. These divisions show a recognition that the ITS solutions for each area would vary based on the unique needs of each region. In fact, ADOT originally divided the statewide effort into two regions, but as the process went along they realized that the state divided more naturally into three regions, in addition to the I-40 corridor.

3. Integrated User Needs Plan

With its needs identified, the study team began matching needs with the 31 ITS user services described in the National ITS Program Plan, and the six supplemental user services defined by the ARTS program. User services were then prioritized and grouped into common deployment timeframes based on common technologies or similar objectives.

Regional ITS Architecture Rural Coalition Areas



Graphic Courtesy of ADOT / Kimley-Horn

ITS Architecture Development Process

Market packages were then selected to provide these services. Market packages provide an accessible deployment-oriented perspective to the National ITS Architecture. They are tailored to fit real world transportation problems and needs. Out of the 56 market packages outlined by the National ITS Architecture, 49 were selected as candidates for deployment in Arizona.

This complex process resulted in a comprehensive set of ITS objectives, technologies, and timeframes that served as the basis for the subsequent system architecture. However, several interviewees felt, in hindsight, that it might have been wiser to exempt stakeholders from the convoluted process of matching needs to user services and market packages. Besides stalling the momentum of the coalition, which caused some people to drop out, direct stakeholder involvement is not critical since trained staff or a consultant can follow the guidelines articulated in the National ITS Architecture and come out with essentially the same results.

4. System Architecture

As in the I-40 effort, the consultant took on the technical burden of mapping user needs to the user services, market packages, and the regional ITS architecture. The consultant relied heavily on the National ITS Architecture and a database that was created to map architectural relationships. Thanks to the National ITS Architecture, some data flows that were not originally considered were identified and included. The chart on the next page graphically represents the Statewide ITS Architecture Concept and shows the interconnections between various agencies and other subsystems.

5. Deployment Funding Requirements

By completing a detailed deployment plan, ADOT was also able to formulate their future budget requirements. They based it on the current prices for communications, field hardware components, and the cost of constructing, operating, and maintaining the system for the next 15 years. The following table is based on the recommendations of the Statewide Strategic Plan:

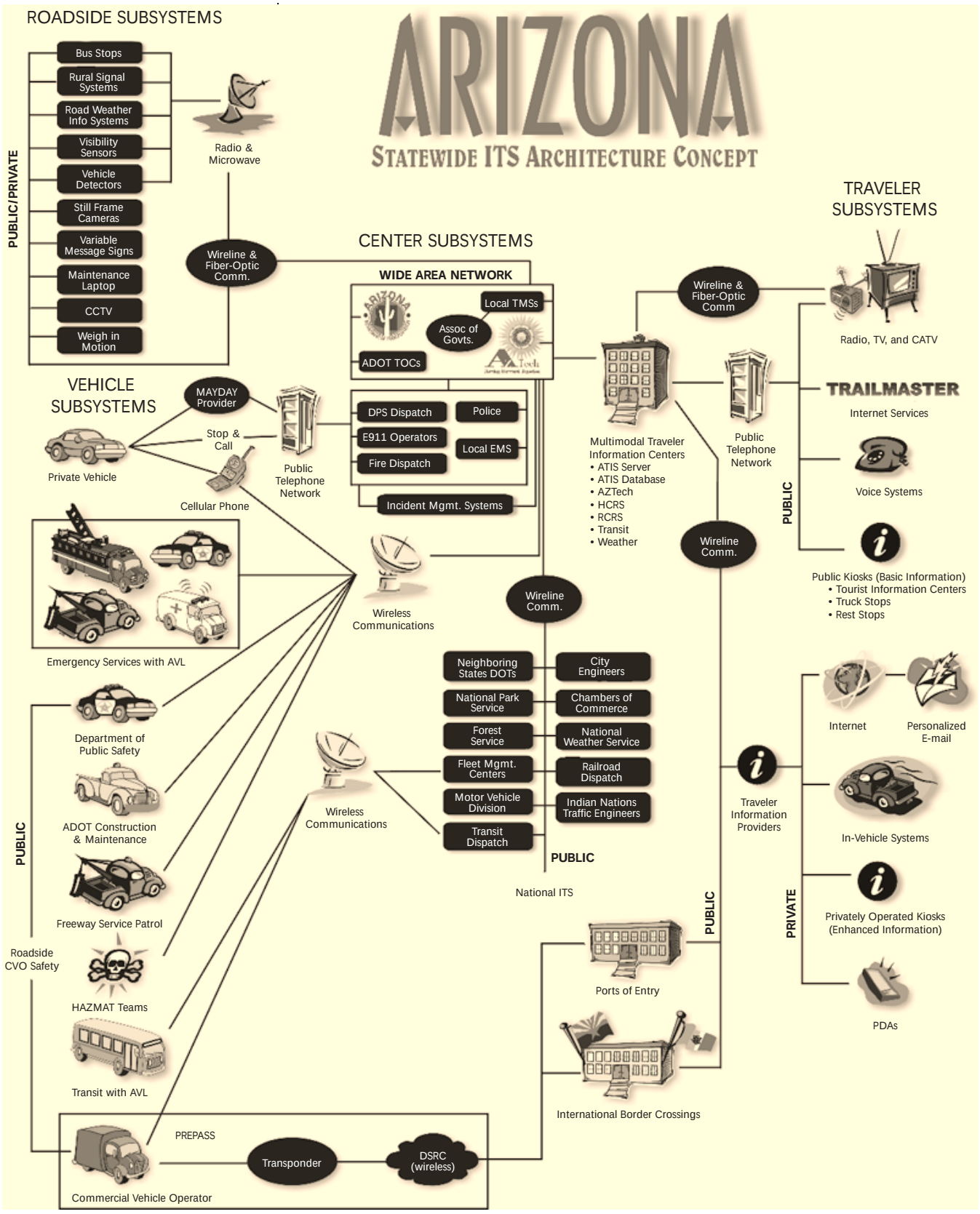
ITS Communication Infrastructure - $4,015,000
Field Hardware/Software - $45,940,000
Other Deployment Efforts - $500,000
System Design, Contingency, Construction Engineering - $20,182,000
Operations and Maintenance - $37,841,000
TOTAL - $108,478,000

Corresponding private investments, estimated to be about twice as much as public investment, are expected to total around $200,000,000 over the next 15 years.

An ITS architecture describes how system components fit together and interact or communicate between themselves.

- The functions that will be performed by a system
- The physical subsystems where those functions reside
- The interfaces and information flows between the physical subsystems
- The communications requirements for the information exchanges.

ITS Architecture Development Process



Graphic Courtesy of ADOT / Kimley-Horn

ITS Architecture Development Process

The statewide ITS strategic plan and architecture is the culmination of a 12 month data collection, technology identification, and feasibility analysis effort. Having a comprehensive, long-term view helps convince legislators of the utility of providing timely, project-specific funding; a dynamic confirmed in the aftermath of a June 1998 accident on Interstate 17, the primary route between Phoenix and Flagstaff. After a collision in the southbound lane, 25,000 people returning home to Phoenix from a weekend in the cooler northern mountains were stuck in a 30-mile queue in the middle of the desert without any services. With cars running out of gas, one boy having to be airlifted for medical treatment, and a woman being airlifted to give birth, the media had a field day. The Governor called for immediate action. ADOT officials responded by showing their statewide ITS strategic plan and promptly received $5 million for new VMS signs to advise drivers during future situations. More importantly, the allocated funds will serve as an investment in Arizona's entire statewide ITS architecture and add value as a piece of an integrated system.

The next step being contemplated by ADOT is the integration of the statewide/rural architecture with those for Phoenix and Tucson. This would create a common blueprint from which to deploy intelligent transportation systems throughout Arizona for the next 15 years. When completed, the comprehensive plan will include detailed ITS project evaluation criteria, a business plan, a management structure for the ongoing statewide implementation efforts, and a framework for integrating existing legacy systems.

ADOT officials responded with their statewide ITS strategic plan and promptly received $5 million for new VMS signs to advise drivers during future situations.

"I would estimate that using the National ITS Architecture cut our development time in half. All you have to do is take the National ITS Architecture and throw out what doesn't apply — what's left is the basis for your architecture."

— Timothy Wolfe, Assistant State Engineer and Manager of ADOT ITS Projects

Lessons Learned

This case study is designed to help transportation planning and operations organizations considering developing statewide or rural ITS architectures to learn from the experiences of the state of Arizona. The Arizona experience shows definitively that although developing a ITS statewide architecture is a complex task, with appropriate scope and leadership it can be accomplished. The findings of this case study are:

Pre-development Steps: Create Manageable Regional Coalitions

- Developing appropriately sized regions based on a common set of transportation issues is essential for building a manageable stakeholder coalition. The unique aspects of the I-40 corridor (weather, geography, tourism, and trucking traffic) provided a common set of issues that united the otherwise diverse I-40 coalition.

- Similarly, localized processes help assure that user needs appropriate to that area are identified. ADOT realized early on that adapting metropolitan architectures to the rest of the state would not have worked because the rural statewide needs and issues were fundamentally different from urban ones. For example, rush hour congestion and air quality are not issues in Arizona's rural regions.

- Although previous ITS deployment helped create an awareness of the benefits of ITS technologies, the difficulty of incorporating existing "legacy" ITS systems (based on proprietary technologies) can hinder the regional architecture development process.

Stakeholders: Cast a Wide Net

- Participation from three types of stakeholders/advocates proved essential in creating the necessary momentum and buy-in to carry the process forward. Moreover, a diverse group of advocates helped assure that user needs were correctly identified. Early Champions, Local Advocates, and Proactive Stakeholders all played vital roles.

- Using ADOT's Community Relations Office from the beginning of the process assured the participation of the widest possible spectrum of stakeholders. Working together with the consultant, they found that personal telephone calls were the most effective means of getting participants. Similarly, using simple graphical representations proved to be the best way to communicate the concepts behind the National ITS Architecture.

Lessons Learned

Creating and Maintaining Agency and Public Buy-in

- Showing non-traditional stakeholders how a Statewide Deployment Plan can be mutually beneficial will help create and maintain diverse coalitions. For example, NOAA was able to better realize their public safety mission while providing the I-40 effort with essential weather information. Likewise, since many non-traditional stakeholders are motivated by financial considerations, emphasizing the cost-effectiveness of ITS technologies proved to be beneficial. Allowing non-traditional stakeholders to assume leadership positions is another way to validate the contribution of diverse participants. It also helped alleviate concerns that ADOT was controlling the process.

- Maintaining coalition momentum proved difficult during the complex and somewhat abstract exercise of mapping user needs to user services, market, and equipment packages. The vast majority of stakeholders were focused on ITS applications and deployment, rather than architecture development. Since the process is relatively straightforward and does not require public input, having a competent consultant, or agency staff, map the user needs to the National ITS Architecture may be a more expeditious approach.

Utilizing Resources

- The complex yet short-term nature of developing a statewide architecture makes it a suitable task to contract out to a consultant. Several of the interviewees for this case study emphasized the value of hiring a competent consultant with demonstrated experience.

- The National ITS Architecture is a superb resource. By taking the National ITS Architecture and extracting what was relevant to the needs of Arizona, the developers saved time and resources, assured eligibility for future federal funding, and gained confidence that the statewide architecture contained all possible links between components.

- Given the vast geographical separation of many stakeholders (including representatives of remote and Native American communities) technological alternatives to face-to-face meetings can facilitate more active participation. While available technology in rural areas is often a limiting factor, the potential benefits of enhanced stakeholder participation can help justify the costs of procurement.

References and Additional Resources

Web Sites

ADOT's Trailmaster:
http://www.azfms.com

Arizona Dept. of Transportation:
http://www.dot.state.az.us

ADOT ITS Projects:
http://www.azfms.com/About/ITSRD/its_rd.html

The Arizona Transportation Research Center [ATRC]:
http://www.dot.state.az.us/ABOUT/atrc/Index.htm

ITS Arizona:
http://www.azfms.com/About/Its/main.html

Arizona TripUSA™:
http://arizona.tripusa.com

U.S.DOT Rural ITS Resource Page:
http://www.its.dot.gov/rural/rural.htm

The Complete National ITS Architecture:
http://www.odetics.com/itsarch

References and Additional Resources

Select Bibliography

Strategic Plan for Statewide Deployment of Intelligent Transportation Systems in Arizona, Kimley-Horn and Associates, Inc, Report #: FHWA-AZ-98-457, December 1998.

Arizona's Successful Statewide ITS Initiatives, Kimley-Horn and Associates, Inc, September 1998.

Arizona Rural ITS, ADOT, Volume 1, Issue 1-3, February 1998-December 1998.

ADOT Statewide Plan Intelligent Transportation Infrastructure, ADOT, Intermodal Transportation Division Technology Group, February 1997.

Strategic Plan for ITS Communications, Kimley-Horn and Associates, Inc., March 1996.

Strategic Plan for Early Deployment of Intelligent Transportation Systems on Interstate 40 Corridor, Kimley-Horn and Associates, Inc., Report #: FHWA-AZ-97-431, May 1997.

Strategic Plan for Early Deployment of ITS on the I-40 Corridor, Swan, J., Harper, J., Joshua, S., National Rural ITS Conference, Spokane WA, September 30-October 1, 1996.

ITS Time!: Intelligent Transportation Systems for Arizona's I-40 Corridor, Arizona Transportation Research Center, Volume 1, No, 1-4, July 1996-May 1997.

Advanced Rural Transportation Systems (ARTS), Strategic Plan, FHWA, August 1997.

National ITS Program Plan, Euler, G., Robertson, H.D., Report #: DTFH61-94-R-00076, March 1995.

References and Additional Resources

Individuals Interviewed

Arizona's Highway Closure and Restriction Information System:
http://www.azfms.com/HCRS/arizona.html
(Toll Free Number: 1-888-411-ROAD)

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ADOT:
Timothy Wolfe, Assistant State Engineer, Transportation Technology Group
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Consultants:
Henry B. Wall, Vice President, Project Manager, Kimley-Horn and Associates
Andrew Kolcz, Transportation Analyst, Kimley-Horn and Associates
Tom Fowler, Transportation Engineer, Kimley-Horn and Associates, Inc.

For further information, contact:

Federal Highway Administration Resource Centers

Eastern Resource Center
10 S. Howard Street, Suite 4000 – HRA-EA
Baltimore, MD 21201
Telephone 410-962-0093

Southern Resource Center
61 Forsyth Street, SW
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