ARIZONA DEPARTMENT OF TRANSPORTATION

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STRATEGIC PLAN FOR STATEWIDE DEPLOYMENT OF INTELLIGENT TRANSPORTATION SYSTEMS IN ARIZONA

Final Report

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16. Abstract
This report presents the methodology and results of a study by Kimley-Horn and Associates, Inc. for Arizona's Transportation Research Center to develop a strategic plan to deploy ITS throughout rural Arizona. This study builds upon ITS strategic plans already completed in Arizona, including the I-40 Corridor, the Phoenix and Tucson metropolitan areas, and a plan for statewide communications.

Needs were identified by various stakeholders at Rural ITS Workshops, focus group meetings, and regional Coalition meetings around the state. These needs were then matched, where possible, to one or more of the 36 FHWA User Services defined in the National Program Plan and Advanced Rural Transportation Systems (ARTS) program. Using the National ITS Architecture as a guide, a conceptual system architecture was developed for Arizona, which includes integration with other architectures developed for previous strategic plans in the state. Arizona's open standards architecture emphasizes interoperability and ease of integration as future market packages come on line in the three deployment timeframes defined for this program.

High priority needs identified by stakeholders included traveler information, enhanced emergency services and response in rural areas, increased agency information sharing capabilities, commercial vehicle enhancements, and port of entry efficiencies. Additional long-term needs included advanced in-vehicle technologies (navigation systems, in-vehicle signing, collision avoidance systems), increased roadway safety and emergency systems, and expanded commercial vehicle systems. Project recommendations were developed based on the needs identified by the stakeholders. Deployment timeframes were also defined (1999-2001, 2002-2007, and 2008-beyond). Cost estimates for technology deployment, operations and maintenance (O&M) over the next 15 years were developed as part of the Strategic Plan.

In addition to project recommendations, a preliminary business and management plan was developed stressing the importance of continued Coalition involvement. The report recommends identifying appropriate ITS champions from around the state to provide leadership and continuity for ITS deployment and ongoing O&M activities.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	0.3048	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
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ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	millimeters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0328	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

Note: Volumes greater than 1000 L shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

These factors conform to the requirement of FHWA Order 5190.1A

*SI is the symbol for the International System of Measurements

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
yd	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
yd^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	millimeters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
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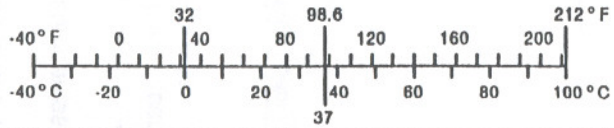
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

This report documents the activities, findings, and recommendations of the *Strategic Plan for Statewide Deployment of Intelligent Transportation Systems in Arizona (Strategic Plan*, for short) study. This twelve-month study began in October 1997 and was initiated and administered by the Arizona Department of Transportation (ADOT) in conjunction with the Federal Highway Administration (FHWA). Project guidance was provided by the Technical Advisory Committee (TAC) composed of representatives from ADOT, FHWA, and Arizona Department of Public Safety. Six separate, stand-alone technical memoranda were prepared and presented to the TAC at strategic milestones during the course of the study. These technical memoranda were reviewed by the Committee and other transportation stakeholders and were revised to incorporate their comments. A copy of the complete set of these technical memoranda is available from ADOT.

The goals of this study were to develop a strategic plan for deployment of Intelligent Transportation System (ITS) technologies in rural Arizona and to build a long-term coalition of stakeholders, both in Arizona and from neighboring states. One long-range goal is to create a compatible and integrated system of ITS technologies throughout Arizona, California, and New Mexico.

Arizona is particularly well suited as a test bed for deployment of rural ITS technologies due to the state's predominantly rural character, the unique transportation characteristics of its highway network (including high commercial and freight truck volumes), significant variations in elevations and weather conditions throughout the state, and high volumes of out-of-state visitor traffic. Combined with the limited availability of visitor and traveler information, and the need for improved emergency management services throughout the state, Arizona presents unique opportunities to test the effectiveness of innovative transportation technologies. This strategic planning effort will result in a number of projects which will be deployed shortly after the completion of the study, and in medium and long-term recommendations for implementation of new technologies and transportation-related services throughout the state over the next 15 years.

1.1 ITS BACKGROUND

The Intermodal Surface Transportation Efficiency Act (ISTEA) signed by the U.S. Congress in December of 1991 called for improvements in surface transportation through technological advancements. The United States Department of Transportation (USDOT) subsequently launched the Intelligent Transportation Systems Program, currently re-authorized as the Transportation Equity Act for the 21st Century (TEA21), which involved research, strategic planning and operational tests of new technologies. These technologies promise to bring much needed operational improvements to the nation's transportation system, and provide safer, more convenient, and more efficient trip experiences for the traveling public.

The National ITS program goals (Adopted from *Intelligent Transportation Systems Act of 1997)* are listed below:

1. Widespread planning, implementation and operation of integrated, intermodal, interoperable intelligent transportation infrastructure, in conjunction with corresponding private sector systems and products, to enhance the capacity, efficiency, and safety of surface transportation;

2. Protection and enhancement of the natural environment and communities affected by surface transportation, with special emphasis on assisting the efforts of the States to attain air quality goals established pursuant to the Clean Air Act, while addressing the transportation demands of an expanding economy;

3. Enhancement of safe operation of the Nation's surface transportation systems with a particular emphasis on aspects of intelligent transportation systems that will decrease the number and severity of collisions and identification of aspects of such systems that may degrade safety, and on in-vehicle systems that bring about a significant reduction in the deaths and injuries by helping prevent collisions that would otherwise occur;

4. Enhancement of surface transportation operational and transactional efficiencies to allow existing facilities to be used to meet a significant portion of future transportation needs, and to reduce regulatory, financial, and other transaction costs to public agencies and system users;

5. Research, development, investigation, documentation, and promotion of intelligent transportation systems and the public sector organizational capabilities needed to perform or manage the planning, implementation, and operation of intelligent transportation infrastructure in the United States;

6. Enhancement of the economic efficiency of surface transportation systems to improve America's competitive position in the global economy;

7. Enhancement of public accessibility to activities, goods, and services, through the preservation, improvement and expansion of surface transportation system capabilities, operational efficiency, and intermodal connections;

8. Development of a technology base and necessary standards and protocols for intelligent transportation systems; and

9. Improvement of the Nation's ability to respond to emergencies and natural disasters, and the enhancement of national defense mobility.

The national ITS program provides a common ground for cooperation among all sectors of the surface transportation community, including state and local governments, motor vehicle manufacturers, commercial vehicle operators (CVO), railroads, telecommunications, universities and other research organizations, consulting firms, and public interest groups. Many operational tests of ITS technologies have been conducted throughout the country since 1991. These tests have helped bring state and local decision makers a greater degree of understanding of the effectiveness of ITS technologies.

1.2 DESCRIPTION OF THE STUDY

This is the second rural ITS study undertaken by ADOT and complements Arizona's ongoing ITS efforts, which include the Early Deployment Plans (EDP) for Maricopa and Pima counties, the recently completed *I-40 ITS Strategic Plan* in Northern Arizona, and ADOT's 1997 Statewide *Intelligent Transportation Infrastructure* Plan. The *Strategic Plan for Statewide Deployment of Intelligent Transportation Systems in Arizona* was launched shortly after the completion of the very successful *I-40 ITS Strategic Plan,* and coincides with the ongoing efforts of the *AZTech* Phoenix Model Deployment Initiative and Freeway Management System in Phoenix.

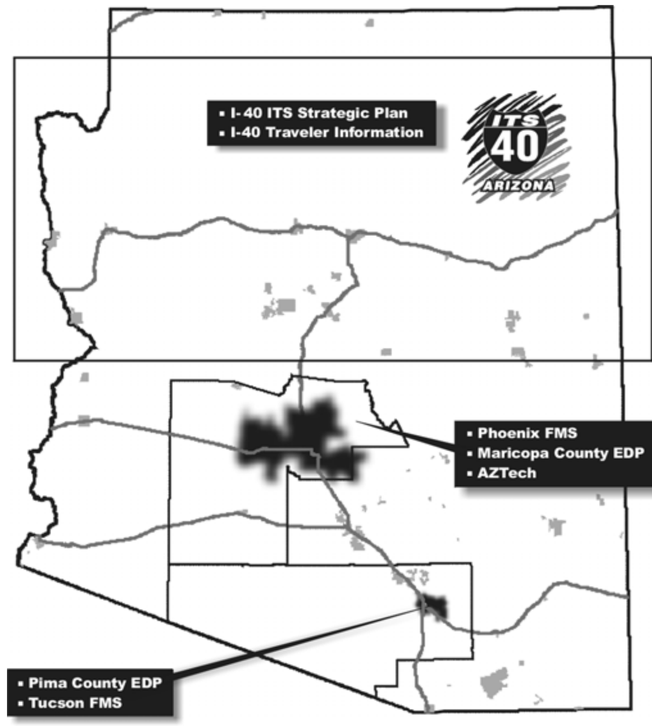

Figure 1.2-1
Arizona's Previous ITS Initiatives

The main objective of this study was to complete the state's ITS early deployment planning efforts by conducting a comprehensive, statewide research of rural transportation-related needs and issues that could be addressed though deployment of ITS technologies. The study area for this project was defined as the state of Arizona excluding the I-40 corridor and metropolitan Phoenix and Tucson as shown in **Figure 1.2-1**.

In order to establish a strong technical and policy-oriented base of support for future ITS deployments throughout Arizona, a large group of stakeholders (over 900) were identified as potential members of Arizona's ITS Coalitions. Coalition members included individuals representing dozens of public agencies and private sector firms throughout Arizona, from statewide organizations based in Phoenix, and agencies from adjoining states.

This *Strategic Plan* will serve as a roadmap for implementing ITS technologies and programs throughout the state. To ensure that the *Strategic Plan* leads to rapid deployment, priority will be given to implementing the short-term recommendations of this study by ADOT, other state and regional agencies, local governments, and private sector partners. Issues such as funding sources, staffing requirements, etc., are being addressed by ADOT in an ongoing planning process. Projects recommended in this study are already being evaluated with respect to their potential to be undertaken through the state's transportation funding process as well as through viable public-public or public-private partnerships.

1.3 PROJECT TASKS

The *Strategic Plan* consisted of nine tasks based on the ITS planning process, outlined in the National ITS Program Plan. These tasks are listed in **Table 1.3-1** and the study process is depicted in **Figure 1.3-1**.

Table 1.3-1
Project Tasks

No.	***Task***	***Task Objective***	***Chapter***
1	Identify Stakeholders and Develop Public Involvement and Information Campaign	Identify people and organizations interested in Intelligent Transportation System solutions for the transportation needs in rural Arizona.	2
2	Identify Transportation Needs and Problems	Identify existing transportation needs and problems of the rural transportation system in Arizona.	3
3	Build Coalitions	Initiate and facilitate the creation of rural Arizona ITS Coalitions.	2
4	Develop Integrated User Service Plan	Identify needed user services by matching the identified needs with appropriate ITS user services. Establish user service objectives and performance criteria and formulate the objectives to be achieved by implementing the identified user services and specify the criteria to be used to measure the degree of success (performance) of the user services when they are deployed. Develop an Integrated User Service Plan: group the needed user services into like bundles; establish interactions among these user services; and categorize the bundles as having short term, medium term and long term potential for implementation.	4
5	Identify Needed User Service Functions and Market Packages	Identify the needed functions of the selected user services according to the Advanced Rural Transportation Systems (ARTS) Strategic Plan guidelines and define the technologies and Market Packages available to support the User Service Plan.	4
6	Define System Architecture and Identify and Screen System Components	Identify functional architecture based on the selected user service functions and specific need priorities. Identify a physical architecture accommodating the specified functions. Derive the specifications of suitable communications architecture as part of the physical architecture definition. Define a set of specific technologies supporting the physical architecture. Describe the statewide ITS Architecture in terms of subsystems and market packages, to facilitate specific project recommendations.	5
7	Develop Strategic Deployment Plan and Define Implementation and Operational Strategies	Prepare a Strategic Plan for Statewide Deployment of Intelligent Transportation Systems in Arizona. The Plan will identify the steps needed to deploy the identified ITS elements, including project descriptions, cost estimates, and deployment time frames.	6
8	Develop Evaluation Plan	Develop a plan for evaluating the effectiveness of the ITS technologies recommended for statewide deployment. The evaluation plan will incorporate the performance measures identified in Task 4.	7
9	Prepare Final Report and Executive Summary	Prepare a final, 100-page, stand-alone report that summarizes the entire project and presents the pertinent conclusions of the entire study in one concise document. Prepare a four-page, camera-ready Executive Summary.	This report and Executive Summary

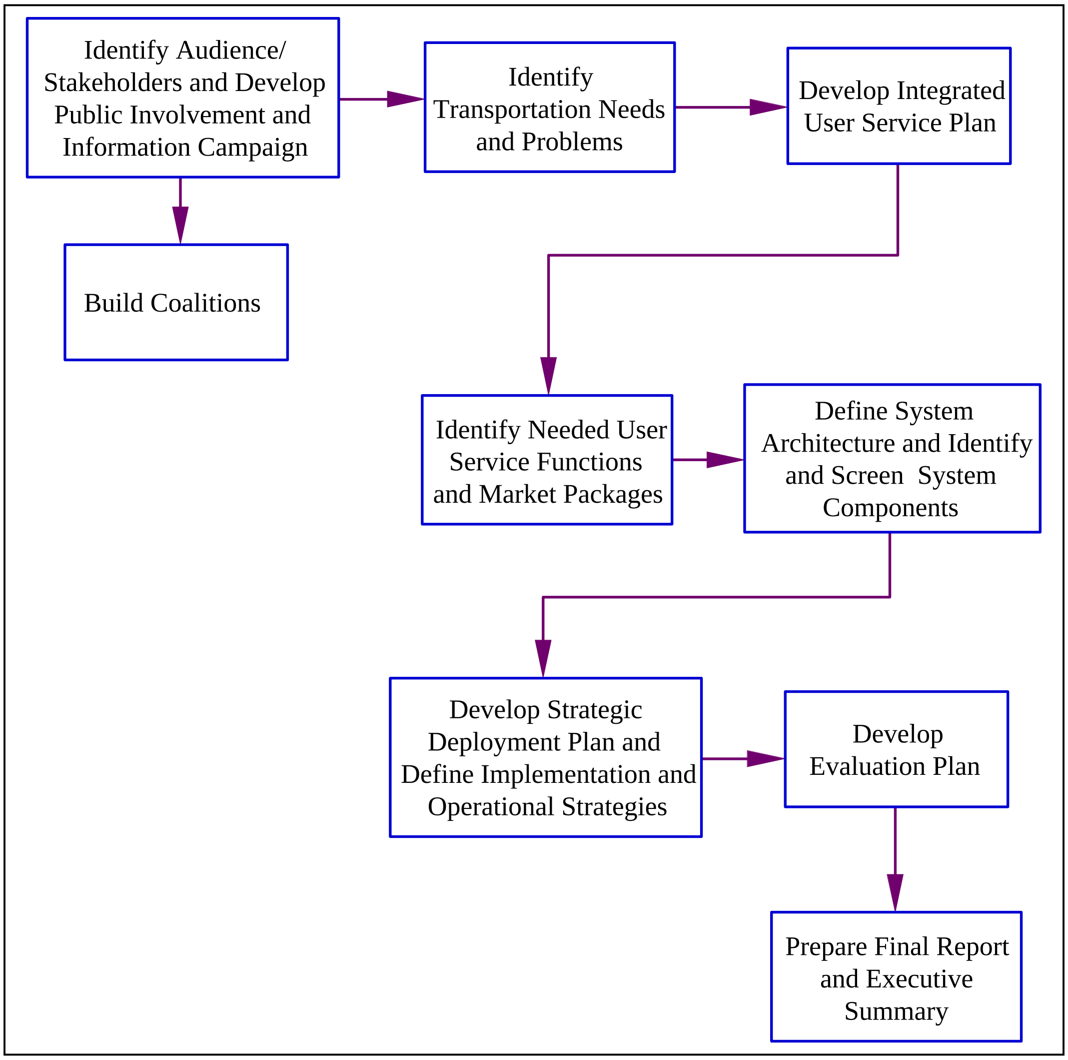

Figure 1.3-1
Project Task Flow Diagram

In the case of Arizona's statewide *Strategic Plan*, at least two valid alternative approaches were available to the project team. The first approach was based on the original Early Deployment guidelines published in the National ITS Program Plan and augmented by the Advanced Rural Transportation Systems (ARTS) program. This methodology was first used in Arizona in the I-40 ITS corridor study. **Figure 1.3-2** shows the architecture definition portion of the ARTS process, which clearly emphasizes the use of market packages as a tool to bridge the user needs, represented by the User Services, with ITS technology solutions.

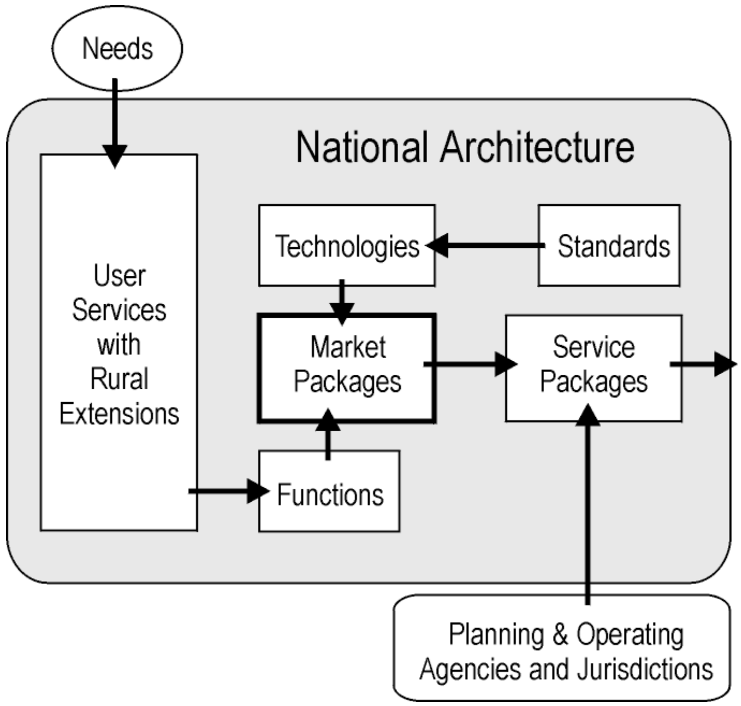

Figure 1.3-2
Defining the Architecture Elements – ARTS Program Plan

Another methodology, described in detail in "Integrating Intelligent Transportation Systems within the Transportation Planning Process: An Interim Handbook" (FHWA, January 1998), and in the "Implementation Strategies" volume of the National Architecture, follows a more direct path towards the selection of needed market packages, as shown in **Figure 1.3-3.**

Since market packages are directly traceable to the architecture definition, once a particular market package is selected for implementation, the required subsystems, equipment packages, and interface requirements may be identified through this traceability. **The benefit of this approach is that it allows the implementor to first consider deployment options and later concentrate on those pieces of the architecture necessary to support the selected deployment**.

While different to some degree, the two approaches are not in conflict in any way. The methodology employed in this study was based on both approaches, employing what was considered the most appropriate portions of each at different stages of the architecture development process.

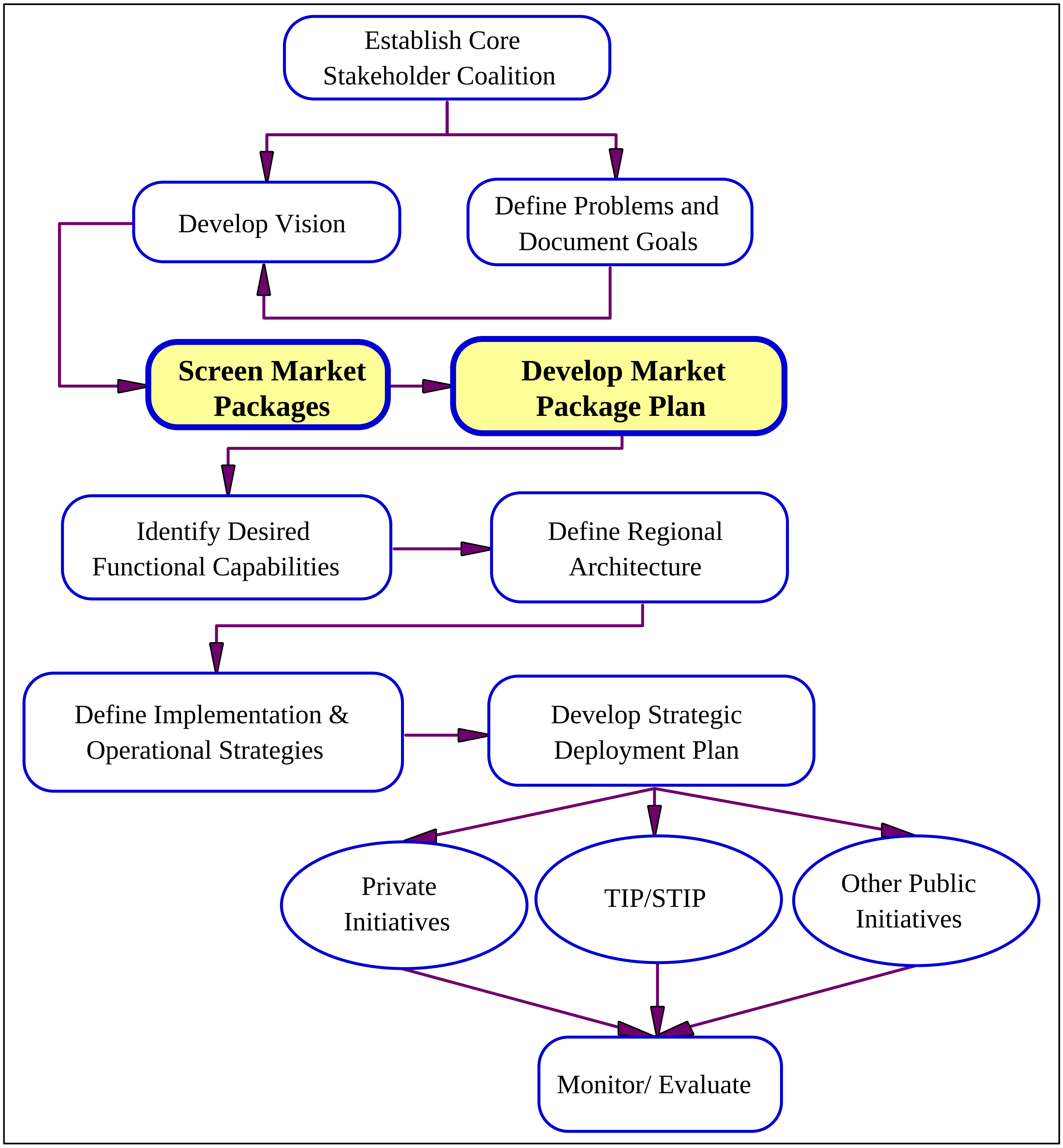

Figure 1.3-3 ITS Planning Process

2.0 STAKEHOLDERS AND PUBLIC INFORMATION CAMPAIGN

2.1 STAKEHOLDERS AND MEDIA LISTS

A comprehensive database was developed of people and organizations interested in Intelligent Transportation Systems (ITS) solutions for the transportation needs in rural Arizona. This list of transportation stakeholders continued to evolve throughout the study. The database was used to involve as many people as possible in the development of the *Strategic Plan*. It was used to identify participants for Coalitions and focus groups, and served as a mailing list for newsletters, flyers, and meeting announcements.

Arizona's ITS stakeholders identified for this study included representatives from:

- Government agencies (federal, state, county, and municipal);
- Regional government councils/planning groups;
- Native American communities and organizations;
- Community, tourist, and traveler information services;
- Educational institutions;
- Private trucking and transportation companies and associations;
- Emergency Management Services (EMS) and assistance providers; and
- Media.

2.2 PUBLIC INFORMATION CAMPAIGN

A public relations plan for the *Strategic Plan for Statewide Deployment of Intelligent Transportation Systems in Arizona* was developed with a focus on rural applications of ITS and their impact on Arizona's transportation system. The public relations plan was designed to inform, educate, and encourage participation of statewide rural transportation stakeholders and the media. The distribution of project information was achieved through a proactive communication program of community outreach, informative presentations, and press releases.

Project newsletters and public forums/presentations were used to inform, educate, and solicit input from highway users and stakeholders throughout the state. Due to the geographic expanse and rural focus of this study, the key information distribution means were by mail, news releases, and scheduled meetings. Participation and input from the users of the statewide transportation system was vital to the success of this study. As such, Technical Advisory Committee (TAC) meetings, Coalition meetings, focus groups, workshops, and outreach presentations were structured to encourage participation from attendees. Stakeholders not attending any of the meetings had the opportunity to provide input to the study team by directly contacting the team members. ADOT Community Relations Office (ADOTCRO) collaborated closely with the project team throughout the execution of this public relations plan.

2.2.1 Public Relations and Outreach

2.2.1.1 Educational Collateral Materials

The project team developed and produced materials intended to:

- Explain the project objectives and scope;
- Educate and inform the public about ITS and its rural applications;
- Provide periodic project status information;
- Identify opportunities for stakeholder input;
- Inform interested individuals about upcoming meetings/events; and
- Summarize study findings.

These materials focused largely on rural applications of ITS, but also discussed how the *Strategic Plan* interfaced with other regional ITS programs already underway in Maricopa County, Pima County, and the I-40 corridor.

The following educational materials were developed:

1. **Fact Sheet** - An 8.5 x 11 inch, double-sided, black and white handout was distributed to members of the media and interested stakeholders. This fact sheet introduced ITS and the *Strategic Plan*, provided information on study objectives, key players, and outlined the study process. This concise fact sheet served as a project introduction and overview of rural ITS in Arizona and was general enough in content to be useable throughout the project's duration. The fact sheet was distributed to media contacts along with news releases in connection with this study.

2. **Project Newsletters** - A total of three project newsletters were developed and distributed at key points in the study. The first newsletter was prepared after the conclusion of the initial phase of the study to report objectives, progress, and to provide for the timely notification of scheduled meetings. The remaining two newsletters were produced after significant work was completed on the needs identification and plan preparation phases. The final newsletter provided a summary of the study's findings and recommendations. All newsletters included contacts, phone/fax numbers, and e-mail addresses for ADOT and other members of the study team.

3. **News Releases** - News releases were issued to statewide media organizations via broadcast fax to inform the public about the study and to encourage interest and attendance at focus groups and other public meetings. News releases were drafted and sent by ADOTCRO with the consultant team providing review of the draft releases, as needed. ADOTCRO performed follow-up calls to media prior to specific events.

All news releases appeared on the ADOT news release letterhead and were handled by ADOTCRO. The purpose of using ADOT letterhead and maintaining a single point of contact was to build continuity and capitalize on ADOT's established working relationships with media organizations statewide. The objective of the media relations campaign was to have issues relating to ITS and the study covered by the media throughout the duration of the project.

2.2.1.2 Public Meetings

Stakeholders were provided several opportunities to participate in the ongoing development of the *Strategic Plan*. Focus groups, coalition meetings, and public workshops served as excellent opportunities to present updated information on the study's progress and findings, as well as new information relative to rural ITS applications. These meetings were structured to encourage input and participation from the attendees.

2.2.1.3 Outreach Presentations

To maximize the opportunities to involve Arizona's key decision makers in the study, six outreach presentations were delivered by the project team. These presentations took place during regularly scheduled meetings of regional planning bodies within the state:

Location	**Meeting Host**
1. Cottonwood	Verde Valley Transportation Planning Organization
2. Bullhead City	"The Gathering XVI"
3. Prescott	Central Yavapai Transportation Planning Organization
4. Payson	Central Arizona Association of Governments
5. Willcox	Southeastern Arizona Governments Organization
6. Parker	Western Arizona Council of Governments

The presentations were delivered by the project team members and included an overview of the ITS program, study objectives, and project progress to-date.

3.0 TRANSPORTATION NEEDS OF RURAL ARIZONA

3.1 INTRODUCTION

The success of this study depended largely on identifying the critical transportation needs, problems, and opportunities within the rural portions of the state and applying the appropriate technological solutions to address each specific issue. These needs and problems of the rural Arizona transportation system were identified through a series of public focus groups. In addition, a set of common transportation issues encountered in rural areas was identified at two Rural Intelligent Transportation Systems Workshops conducted in conjunction with this study. This chapter documents the activities and presents the results of the needs assessment effort.

The needs assessment effort included the following activities:

- Solicitation of input regarding rural transportation needs from the stakeholders;
- Identification of needs and problems that ITS technologies may serve to resolve; and
- Development of a draft vision statement, with the rural Arizona stakeholders, of the future intelligent transportation system in the state.

3.2 USE OF CRITICAL PROGRAM AREAS IN RURAL NEEDS ASSESSMENT

Rural deployments of ITS are guided, from the conceptual and National Architecture standpoint, by the federal government through the Advanced Rural Transportation Systems (ARTS) portion of the National ITS Program. The federal government's role involves developing rural ITS options and managing emerging ITS technologies within rural settings, from conception to viable implementation options. Because of the diversity of needs and varied settings in rural America, the ARTS program developed seven Critical Program Areas (CPA) which group the rural transportation needs based on common interests of rural transportation stakeholders.

The CPAs play an important role in the ITS Early Deployment process which was, followed in this study. The process, developed for rural studies by the ARTS program, leads the states' rural ITS efforts from needs assessments, through technology selection, project selection specifications and deployment. The CPAs played an integral part in the needs assessment process for this study. They provided the necessary focus for the stakeholder brainstorming sessions at the focus groups, thus facilitating definition of the pertinent user needs, and helped to ensure that no transportation-related area was left out from the group discussions. **Table 3.2-1** contains the seven CPAs accompanied by a brief description. **Figure 3.2-1** schematically depicts the ARTS process.

Table 3.2-1
Critical Program Areas

Traveler Safety and Security	Addresses the need for improving driver ability to operate a vehicle in a safe and responsible way and for improving driver notification of potentially hazardous driving conditions (such as poor road conditions, reduced visibility, etc.).
Emergency Services	Focuses on providing improved response when an incident occurs, including reducing the time to notify, as well as providing additional crash details.
Tourism and Travel Information Services	Provides travel information and mobility services to travelers unfamiliar with the rural area they are traveling in or through and at tourist destinations.
Public Traveler Services/Public Mobility Services	Improves accessibility and reduces isolation of travelers using/relying on public transportation.
Infrastructure Operations & Maintenance	Addresses efficient and effective maintenance and operation of rural roadways and signals.
Fleet Operations & Maintenance	Provides for efficient scheduling, routing, locating, and maintenance of rural fleets.
Commercial Vehicle Operations	Addresses regulation, management, and logistics of commercial fleets and agricultural equipment to meet the needs of rural commercial operators.

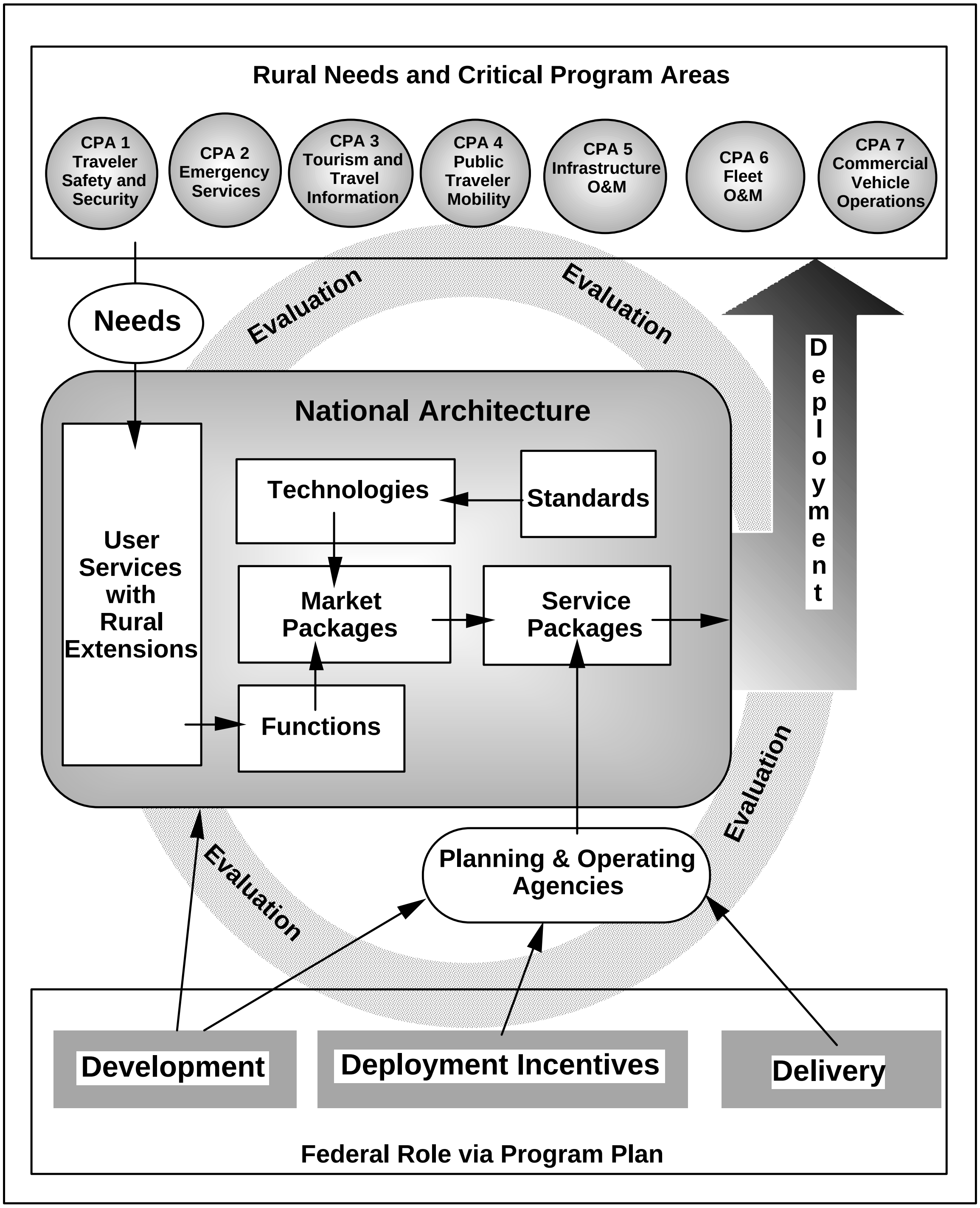

Figure 3.2-1
Schematic of the ARTS Program

3.3 RURAL ITS WORKSHOPS

The project team took part in two Rural ITS Workshops, organized by FHWA's "Peer-to-Peer" program and LTAP in Flagstaff (November 6, 1997) and Tucson (November 25, 1997). The main goal of the workshops was to inform both the public and local government agency staff about the potential to use ITS technology to enhance travel across rural Arizona.

Regional ITS workshops were planned to give rural community government, public safety, and transportation leaders a general introduction to Intelligent Transportation Systems technology. The focus was on common rural transportation problems and on the application of ITS to the specific needs of Arizona's rural areas.

A significant amount of time was devoted to discussing specific user needs for rural Arizona as local agencies presently perceive them, as well as discussing new technology solutions and ADOT's ongoing ITS program.

The primary presenters for the Flagstaff workshop were Stephen Albert with Western Transportation Institute, Christopher Hill with Castle Rock Consultants, and Dennis Foderberg with the University of Minnesota. For the Tucson workshop, Mr. Foderberg returned as facilitator and was assisted by Henry Wall with Kimley-Horn and Associates, Inc., Alan Hansen and Thomas Fowler with FHWA. Leaders invited to participate included:

- Government transportation policy makers and officials involved in operations;
- Business and community leaders involved with transportation or emergency services;
- Rural transit service providers;
- Rural law enforcement agencies at all levels; and
- Tourism and economic development organizations.

3.4 FOCUS GROUP MEETINGS

The focus group meetings constituted the main tool of the needs assessment effort for this study. The objective of these meetings was to identify existing local and statewide transportation needs and problems of the rural transportation system in Arizona. This was accomplished through a series of open-forum public discussions conducted at four locations throughout the state.

3.4.1 Identification of Focus Group Participants

Potential participants of the needs assessment effort were identified from the transportation stakeholders database maintained for this study. At the time invitations to the focus groups were sent, the stakeholder database contained over 500 names. The invitation form included a brief overview of the project and the purpose of the focus groups, and contained a map with focus group locations, meeting dates and times. In addition, a one-page questionnaire was included in the mailer to prepare focus group participants for the types of issues that would be discussed at these meetings.

In addition to the initial set of invitations, the project team continued to contact potential stakeholders whose participation was being sought, including ADOT District and Maintenance Engineers, city mayors and managers, and other public officials likely to take an active part in the project. Invitations to these stakeholders were sent out as they were being contacted, up to just a few days before the meetings. The following summarizes the stakeholder groups invited to participate:

- ADOT District staff
- ADOT Transportation Planning Group
- Mayors, city council persons, and other key city staff
- County supervisors
- Tribal leaders
- Major employers
- Major transportation industry representatives
- Department of Public Safety representatives
- Office of Tourism representatives
- Chambers of Commerce
- National Parks
- Representatives of major private and public tourist attractions
- The general public

3.4.2 Focus Group Locations

Due to the limited number of focus groups that were to be conducted (four), it was important to select locations for these meetings that would maximize participation. Arizona cities that were chosen offered the widest possible area coverage from the point of view of population density, distance, and accessibility: Payson, Globe, Nogales, and Yuma (the northern part of Arizona was studied under the *I-40 ITS Strategic Plan*). **Table 3.4.2-1** shows the dates, locations, and number of participants at each of the focus group meetings.

Table 3.4.2-1
Focus Group Meetings

Location	***Date***	***Place***	***Number of Participants****
Payson	December 10, 1997	Council Chambers	17
Globe	December 11, 1997	Council Chambers	14
Nogales	December 17, 1997	Council Chambers	7
Yuma	December 18, 1997	Council Chambers	17

* Not including the consultant staff or the ADOT project manager

3.4.3 Focus Group Methodology

A team of two to three representatives of the consultant team and Steve Owen, the ADOT project manager, conducted the focus groups. Each participant received a package consisting of a project information sheet, a copy of the presentation prepared specifically for the focus groups, a question-and-answer sheet, and a summary of the Critical Program Areas. The state milepost map was also available to all participants to facilitate more precise locating of specific transportation problems.

Each of the focus group meetings was structured around ITS education and a brainstorming session. Specifically, each meeting included:

- An introduction to ITS;
- Background and objectives of the study;
- A video on rural ITS (*Rural Transportation and Safety: An Evolution of Change,* by Montana State University);
- A demonstration of ADOT's Highway Closure and Restrictions System (HCRS) and the ADOT web page;
- A brainstorming session on local, ITS-related needs; and
- A presentation and a table display of ITS technologies at work.

After the educational portion of the meeting, the participants divided into groups for the brainstorming session. The ensuing discussions resulted in a number of transportation issues that were identified for the areas and agencies represented at the meeting.

3.5 FINDINGS

Following the focus groups and the Flagstaff and Tucson workshops, stakeholder input was integrated to provide a statewide perspective as expressed by all of the participants. A database was developed to manage the 200-plus comments and remarks recorded during the focus group meetings and the Rural ITS workshops.

Needs statements were subsequently developed based on the information contained within this database. This process resulted in 76 need statements. Many of the stakeholder comments, while worded differently, still referred to the same need or problem. As a result, a key task was to identify and combine, where possible, any identical needs statements to make the listing process more manageable. These transportation-related problem statements were then worded in a more succinct language that focused on the ITS need. An example of this process is presented below:

Resulting need statement:

- Need ability to exchange weather and roadway condition information between agencies.

Based on these original statements:

- Free exchange of weather information between all agencies and ADOT (source: Payson focus group).
- Information sharing/networking between agencies on conditions (roadway/weather) (source: Globe focus group).

The 76 unique needs were then matched to critical program areas. **Table 3.5-1** shows the 76 unique needs and their corresponding Critical Program Areas (CPAs). Many of the needs corresponded to multiple CPAs, which was expected considering the broad impact of several of these needs. For example, the need stated “Need advanced traveler information system” represents many different types of drivers (tourists, riders of public transit, commercial vehicle operators, etc.). Accordingly, multiple CPAs are referenced for this need (CPAs 1, 2, 3, 5, and 6). These references to CPAs were used during the next task to develop a list of needed user services. The ITS needs listed in **Table 3.5-1** were grouped based on CPAs, i.e. all of the needs that shared the same set of CPAs were clustered together. This grouping was intended to facilitate insight into the types of need areas that attracted focus among the stakeholders and serve as stepping stone toward the need prioritization activities, conducted in later in the study.

Table 3.5-1
Unique Needs and Their Corresponding CPAs

ID No.	FINAL NEED	CPA 1 Safety	2 Emerg.	3 Info.	4 Transit	5 O&M	6 Fleet	7 CVO
1	Need ability to exchange weather and roadway condition information between agencies	●	●	●	●	●	●	●
2	Need to improve information sharing between agencies	●	●	●	●	●	●	●
3	Need clearinghouse for information	●	●	●	●	●	●	●
4	Need improved inter-agency communications	●	●	●	●	●	●	●
5	Need to make public aware of snow plowing schedules and locations	●	●	●	●	●	●	●
6	Need visibility monitoring and reporting	●	●	●	●	●	●	●
7	Need bridge condition information	●	●	●	●	●	●	●
8	Need to coordinate roadway closure information between agencies	●	●	●	●	●	●	●
9	Need advanced warning of highway junctions	●	●	●	●		●	●
10	Need advanced warning of unsafe roadway conditions	●	●	●	●		●	●
11	Need advanced work-zone information	●	●	●	●		●	●
12	Need to communicate in advance availability of services to the public	●	●	●	●		●	●
13	Need for information to be timely, reliable, accessible, and clear	●	●	●	●		●	●
14	Need detour and road closure information	●	●	●	●		●	●
15	Need more means to communicate with motorists in remote areas	●	●	●	●		●	●
16	Need roadway closure information for streets outside of the ADOT roadway network	●	●	●	●		●	●
17	Need clear and timely alternate route information	●	●	●	●		●	●
18	Need accurate winter road closure information	●	●	●	●			
19	Need icy road detection	●	●	●		●	●	●
20	Need weather conditions information	●	●	●		●	●	●
21	Need advanced information on flooded areas	●	●	●		●	●	●
22	Need roadway conditions information	●	●	●		●	●	●
23	Need remote communications with VMS	●	●	●		●	●	●
24	Need to prevent collisions with wildlife	●	●	●			●	●
25	Need advanced warning of animal crossings	●	●	●			●	●
26	Need to know status of at-grade railroad crossings	●	●	●			●	●
27	Need advanced warning of congestion	●	●	●			●	●
28	Need to accurately determine incident locations	●	●	●			●	●
29	Need advanced warning of rural intersections	●	●	●			●	●
30	Need mayday systems	●	●	●			●	●
31	Need road closures due to forest fires to be included in general road closure database	●	●	●			●	●
32	Need adaptive signal timing	●	●			●	●	●
33	Need to share ADOT video data with other agencies	●	●			●	●	●
34	Need detection of vehicles violating road closures	●	●			●		
35	Need roadside communications in rural areas	●	●			●		
36	Need in-vehicle emergency notification devices	●	●				●	●
37	Need advanced information on flash flooding conditions	●	●				●	●
38	Need real-time traffic conditions detection	●	●				●	●

Table 3.5-1
Unique Needs and Their Corresponding CPAs

ID No.	FINAL NEED	CPA 1 Safety	CPA 2 Emerg.	CPA 3 Info.	CPA 4 Transit	CPA 5 O&M	CPA 6 Fleet	CPA 7 CVO
39	Need traveler information regarding Nogales POE status	●		●		●		●
40	Need surveillance of POE traffic	●		●		●		●
41	Need toll free access to update and receive current roadway and weather conditions information	●		●		●		●
42	Need information on detours/road closures to be disseminated outside Arizona	●		●			●	●
43	Need advanced traveler information	●		●			●	●
44	Need advance warning of inclement weather	●		●				●
45	Need advanced traveler/tourism information at POE in Nogales	●		●				●
46	Need mass media to report up-to date, correct roadway conditions	●		●				●
47	Need to determine locations for information kiosks	●		●				
48	Need rest area security	●		●				
49	Need traveler information at national/state parks	●		●				
50	Need better directions to tourist attractions	●		●				
51	Need tourism/traveler information at rest stops	●		●				
52	Need warning of falling rocks	●		●				
53	Need to make traveler information available to the public.	●		●				
54	Need improved work zone safety	●				●		
55	Need ability to monitor and display traffic speeds to motorists to deter speeding	●						●
56	Need to monitor drivers' condition	●						●
57	Need improved incident notification and response times		●			●		
58	Need HAZMAT incident management		●					●
59	Need to standardize EMS response procedures		●					
60	Need to improve emergency response times		●					
61	Need coordination with statewide emergency management system		●					
62	Need improved dispatch and communications for EMS vehicles		●					
63	Need transit availability information			●	●		●	
64	Need expeditious way to collect fees at state and national parks			●				
65	Need 24 hour tourist information			●				
66	Need tourist information			●				
67	Need multi-lingual tourist information			●				
68	Need to include POE in the information exchange loop					●		●
69	Need to improve coordination between maintenance/construction crews to avoid overlapping of efforts					●		
70	Need commercial vehicle tracking						●	●
71	Need information regarding CVOs entering United States							●
72	Need HAZMAT vehicle tracking							●
73	Need for collision avoidance systems for CVOs							●
74	Need ability to weigh trucks in a safe and quick manner							●
75	Need to enforce CVO weight restrictions							●
76	Need information on emergency parking areas for CVOs							●

3.5.1 Other Needs

3.5.1.1 Transit Needs and Problems

Limited feedback was gathered during the focus groups and workshops regarding transit and commercial vehicle operators'(CVO) needs. In an attempt to further identify needs or issues relating to transit in the rural areas of the state, various transit providers were contacted. The following is a list of comments that were incorporated with the needs identified at the Rural ITS Workshops and focus group meetings, and subsequently included into the overall need structure for the project.

- Improved communication between drivers and home office.
- Signage is not complete, additional coverage is needed.
- Need for kiosks at Sky Harbor and other airports.
- Need for increased funding for rural transit and para-transit providers.
- Need for a transit web site.
- Difficulty connecting with passengers at Sky Harbor (particularly with elderly) due to permitting process for signs with passenger names.
- Weather conditions hotline difficult to use (weather only), as all roadways for the state are on this list; timeliness and accuracy of information is at times questionable.
- Inability to find out about incidents until you are "on them." Most shuttle providers stated that they rely on TV or the radio for information.
- Drivers on some of the more "rural" routes (particularly those on reservations) experience problems with flash flooding. They did concede that roads were adequately barricaded by ADOT maintenance, however, drivers lacked adequate advance notification to adjust their routes to avoid delays.
- Poor schedule adherence as a result of distance and infrequency of trips.
- Need better notification to riders of changing schedules and conditions.
- Transit demand is expanding faster than available funding.

3.5.1.2 CVO Needs

The bulk of the CVO needs assessment was based on materials from the *ITS/CVO Business Plan* study conducted by ADOT concurrently with the *Strategic Plan* study. For the purposes of the needs assessment conducted in this study, a listing of the CVO ITS needs, extracted from the draft report for the *ITS/CVO Business Plans* study, was included. **Table 3.5.1.2-1** lists the CVO needs identified in the *ITS/CVO Business Plans* study.

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Table 3.5.1.2-1
Arizona CVO Needs

Safety Assurance
• Non-compliant carriers evade Ports of Entry, either by passing through when the port is closed or taking alternative routes. • Limited resources to operate Ports of Entry; limited space to conduct roadside inspections; not enough intrastate enforcement. • No access to real-time data at on-site inspections. • No real-time weather and road conditions disseminated to carriers en-route. • Not enough data sources for weather information.
Credentials Administration
• Difficulty in validating carrier compliance due to segmented credentials software. • The Year 2000 will provide problems for information systems software dealing with credentials.
Electronic Screening
• Oversize/overweight vehicles cause significant damage to Arizona roadways. • There is no weigh-in-motion at PrePass sites. • Lack of international field linkages.
Carrier Operations
• Accidents due to speed during inclement weather. • Lack of en-route information.

In addition, the following CVO technical issues pertaining to cross-functional ITS/CVO program areas, (described in detail in the *ITS/CVO Business Plans* study) were identified at the focus groups conducted for that project:

Safety Assurance
• Real-time information is not available to roadside safety inspectors. • Lack of space along the highway corridors to conduct inspections, specifically I-19 and I-40. • Not all accident information is reported, partly due to institutional education and the fact that the accident form does not include all the informational elements that need to be captured. • Privacy is an issue for distribution of motor carrier information. • 90% of all accidents are caused by driver error. • There is no driver information unless there are violations and information does not get back to Arizona if citation is issued. • There is no comprehensive book on CVO duties/activities. • Not enough staff to do inspections. • Not enough training coordination is occurring.

Credential Administration
• ADOT MVD software, TARGATS/VISTA, that handle IFTA and IRP processes respectively, are not integrated, this severely constrains the ability to evaluate and validate carrier compliance. • All states differ in their credentials requirements. • Interoperability standards have not been adopted. • The Year 2000 will provide problems for information systems software dealing with credentials.
Electronic Screening
• Illegal trucks evade port authorities operations. • There is no weigh-in-motion at PrePass sites. Oversize/overweight vehicles inflict significant damage to Arizona roadways. • It is estimated that there will be a significant increase in truck traffic at the border due to NAFTA. • PrePass does not give any information about the individual driver or trailer content. • HAZMAT response teams need to know what was on a particular truck if it is an accident. • There are no compliance strips at POEs to monitor “port runners.” • Federal regulations only allow one transponder on the windshield. • Data are not transmitted from field operations efficiently for enforcement or credentials administration. • NATAP focuses on federal issues and does not consider local issues. • International border crossing safety and high out-of-service rates for Mexican carriers at border are a problem. • There is a high degree of violations with Mexican trucks creating congestion at the border.
Carrier Operations
• Compliant trucks are being stopped. • Lack of communications en-route to drivers regarding weather and other traveler information. • Accidents due to speed during inclement weather. • There are 80 ADOT maintenance offices and 41 are not on the state’s wide-area network. • There are no real-time road conditions, and weather information for interstate/intrastate travelers. • There are not enough data points for real-time weather conditions. • Poor communications with neighboring states regarding interstate closures.

This statewide ITS deployment study used the final needs assessment and project recommendations of the *ITS/CVO Business Plans* in its analysis of statewide ITS needs and project specifications. This approach assured that no duplication of effort took place between these two ADOT projects.

3.6 CONCLUSIONS

The focus group meetings, workshops, and questionnaires identified many issues and concerns related to the Arizona transportation system. A significant number of the comments received can be addressed with the use of ITS technologies. Many of the other issues raised would best be addressed through the programming of roadway improvements to the system. Although the intent of this project was to identify various ITS technologies that could be deployed to address the many rural transportation issues, it was equally important to forward the comments that are non-ITS related to the appropriate agencies for further investigation.

It is also important to note that the stakeholders who provided comments were not necessarily attempting to identify perceived needs only in the vicinity of the meeting locations but shared a statewide perspective. The project team continued to identify stakeholders and solicit further information to assure that the statewide rural ITS infrastructure recommendations resulting from this project addressed the majority of the state's rural transportation needs.

4.0 INTEGRATED USER SERVICE PLAN

4.1 INTRODUCTION

The initial tasks for this ITS Early Deployment project were to first identify the rural transportation problems and needs in Arizona and to select technologies that could be used to address these needs. The ITS technology selection process began with identifying appropriate ITS user services. User services are the functions performed by ITS technologies and organizations for the direct benefit of the transportation users. The National ITS Program Plan defines the term *users* as: "a wide range of individuals and organizations including drivers, travelers, service providers, and transportation policy makers."

The National ITS Architecture currently defines 30 user services. To better address rural issues, the Advanced Rural Transportation Systems (ARTS) program introduced six additional user services. **Table 4.3-1** later in this chapter lists all 36 user services.

The objective of this part of the study was to determine, based on stakeholder input, which of the 36 ITS user services should be implemented in Arizona and when they should be provided (i.e., in the short-, medium-, or long-term timeframes). Furthermore, user service functions and candidate market packages[1] were used to identify the technology groups needed to provide these services.

The FHWA has recognized seven basic functional areas that support user services. Each user service is achieved by applying several technologies that perform one or more system functions. Delivering a user service takes more than just one piece of equipment, and the ITS architecture groups equipment into "market packages." Each market package consists of a group of elements (equipment packages) that work together to deliver a particular user service.

4.2 APPROACH

The activities of this portion of the study were divided into five major steps aimed at producing a well-defined, integrated user service plan:

- Identify and prioritize applicable user services and develop user services deployment timeframes;
- Develop specific system objectives and performance criteria;
- Group selected user services, based on similar objectives and interaction, into an integrated set for each deployment horizon;
- Identify user service functions; and
- Select candidate market packages.

Rural Arizona's transportation-related needs, identified in this study, were cross-matched with the 36 ITS user services. The result was a set of candidate user services to be deployed in the

[1] Market packages represent the "building blocks" or implementation options of ITS that can be deployed over time to efficiently achieve high-end ITS services.

state. These user services were then prioritized based on the relative ranking of each need, developed earlier. Finally, preliminary short-, medium- and long-term deployment timeframes for each user service were identified.

In the next step, system objectives were defined for each identified user service. A system objective identifies the improvements in the system that can be expected to occur as a result of a successful implementation of a user service. To judge the degree of success of the implementation of the user services (including the effectiveness of the deployed service or technology in solving the original problem), a set of performance criteria was developed. These criteria constitute a set of possible measures, which can be used to evaluate the system deployment.

The identified user services were combined into groups based on similar objectives and overlapping functionality, including factors like common technologies and common target user groups (e.g., personal vehicle drivers and passengers, truckers, other fleet operators, travelers in tour groups, and emergency service providers). Common deployment timeframes were then established for each of the user service groups.

Once the user services and their likely deployment horizons were identified, the project team identified the functional areas to support the selected user services. Each user service is achieved through the application of several technologies that perform one or more of the system functions. In this step, a mapping of the selected user services to eight functional areas, defined by the FHWA, was established.

Finally, market packages corresponding to the selected user services were identified. The 56 currently defined ITS market packages will be an important building block of the statewide ITS deployment effort, and they represent specific portions of the statewide ITS architecture that may be required to satisfy the needs identified by Arizona ITS stakeholders.

4.3 IDENTIFICATION AND PRIORITIZATION OF USER SERVICES

The ITS National Program Plan and the ARTS initiative have categorized ITS components into 36 user services, shown in **Table 4.3-1**.

Table 4.3-1
ITS User Services (with rural extensions)

1	Pre-Trip Travel Information	*Provides information for selecting the best transportation mode, departure time, and route.*
2	En-Route Driver Information	*Provides driver advisories and in-vehicle signing for convenience and safety.*
3	Route Guidance	*Provides travelers with simple instructions on how to best reach their destinations.*
4	Ride Matching and Reservation	*Makes ride sharing easier and more convenient.*
5	Traveler Services Information	*Provides a business directory, or "yellow pages," of service information.*
6	Traffic Control	*Manages the movement of traffic on streets and highways.*
7	Incident Management	*Helps public and private organizations quickly identify incidents and implement a response to minimize their effects on traffic.*
8	Demand Management and Operations	*Supports policies and regulations designed to mitigate the environmental and social impacts of traffic congestion.*
9	Emissions Testing and Mitigation	*Provides information for monitoring air quality and developing air quality improvement strategies.*

Table 4.3-1
ITS User Services (with rural extensions)

10	Public Transportation Management	*Automates operations, planning, and management functions of public transit systems.*
11	En-Route Transit Information	*Provides information to travelers using public transportation after they begin their trips.*
12	Personalized Public Transit	*Provides flexibly routed transit vehicles to offer more convenient customer service.*
13	Public Travel Security	*Creates a secure environment for public transportation patrons and operators.*
14	Electronic Payment Services	*Allows travelers to pay for transportation services electronically.*
15	Commercial Vehicle Electronic Clearance	*Facilitates domestic and international border clearance by minimizing stops.*
16	Automated Roadside Safety Inspection	*Facilitates roadside inspections.*
17	On-Board Safety Monitoring	*Senses the safety status of a commercial vehicle, cargo, and driver.*
18	Commercial Vehicle Administrative Processes	*Provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing.*
19	Hazardous Material Incident Response	*Provides immediate description of hazardous materials to emergency responders.*
20	Commercial Fleet Management	*Provides communication between drivers, dispatchers, and intermodal transportation providers.*
21	Emergency Notification and Personal Security	*Provides immediate notification of an incident and immediate request for assistance.*
22	Emergency Vehicle Management	*Reduces incident response time for emergency vehicles.*
23	Longitudinal Collision Avoidance	*Helps prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.*
24	Lateral Collision Avoidance	*Helps prevent collisions when vehicles leave their lane of travel.*
25	Intersection Collision Avoidance	*Helps prevent collisions at intersections.*
26	Vision Enhancement for Crash Avoidance	*Improves the driver's ability to see the roadway and objects that are on or along the roadway.*
27	Safety Readiness	*Provides warnings about the condition of the driver, the vehicle, and the roadway.*
28	Pre-Crash Restraint Deployment	*Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.*
29	Automated Highway Systems	*Provides a fully automated, "hands-off" operating environment.*
30	Highway Rail Intersection	*Provides improvements to automated crossing control systems.*
31	Portable Traffic Management	*The alleviation of traffic congestion, the improvement of safety and the minimization of environmental impact by means of traffic surveillance and control that is flexibly and speedily deployable, for highway and traffic conditions that are accidental, sporadic or seasonal.*
32	Road Maintenance and Management	*The efficient maintenance and rapid repair of roads, including isolated and low-volume routes, for safe and structurally sound operating condition, especially under conditions of severe weather.*
33	Seasonal Harvesting	*The coordination and management of intermodal transportation resources and agricultural production for timely and efficient harvesting of agricultural products.*
34	Economic Development (Business Viability)	*The improvement of transportation efficiency, the reduction of adverse transportation impacts, and the dissemination of information that sustains the viability and desirability of economic production and facility location.*
35	Economic Development (Tourism)	*The improvement of transportation efficiency, the reduction of adverse transportation impacts, and the dissemination of information that promotes compatible enjoyment of parks other tourist sites, and services to tourists.*
36	ITS Planning and Marketing Data	*The collection and processing of information derived from the operation and evaluation of ITS, for purposes of adapting any component of the ITS architecture and promoting deployment of effective ITS solutions to transportation problems.*

The first step focused on identifying the user services appropriate for rural Arizona based on the previously identified statewide needs. A five-step process, illustrated in **Figure 4.3-1**, was used to refine the original statements of problems and concerns and to identify these user services. First, the original statements of problems and concerns from all data collection efforts in this task were assembled into a comprehensive list of over 200 records. Next, this list of original, "raw" statements was reduced and refined through grouping of similar statements into more descriptive, general problem categories. This data reduction step also eliminated those problem statements not directly related to transportation or ITS by placing them in a separate category of non-ITS needs. The generalized problem categories were then used to arrive at specific needs, which were refined and linked to appropriate user services.

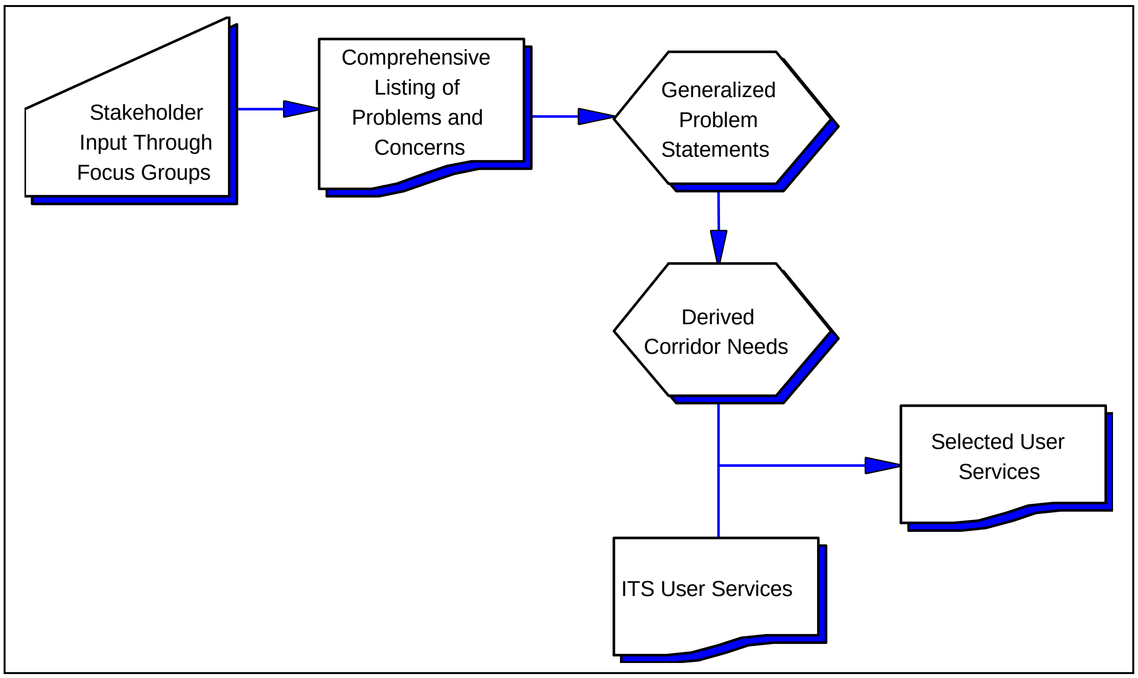


Figure 4.3-1
Derivation of Needs and Identification of User Services

Prioritization of user services was based on the relative ranking of each of the 76 needs assigned by the stakeholders. The needs were ranked during the first round of stakeholder Coalition meetings conducted by the project team in March of 1998. Arizona's transportation stakeholders provided the needs ranking, in terms of importance, during the second series of stakeholder Coalition meetings

The assignment of the need rankings (shown in **Table 4.3-2**) to the matched user services was accomplished by summing the point scores of all the needs corresponding to each matched user service.

Table 4.3-2
Coalition Ranking of Identified Needs (by Score)

ID#	Need	Score
1	Need detour and road closure information	146
4	Need for information to be timely, reliable, accessible, and clear	141
2	Need to improve emergency response times	141
3	Need advance warning of unsafe roadway conditions	140
7	Need improved incident notification and response times	138
8	Need ability to exchange weather and roadway condition information between agencies	137
6	Need improved inter-agency communications	135
9	Need to coordinate roadway closure information between agencies	135
5	Need improved dispatch and communications for EMS vehicles	133
11	Need accurate winter road closure information	131
12	Need toll free access to update and receive current roadway and weather condition information	131
16	Need advance information on flooded areas	128
17	Need more means to communicate with motorists in remote areas	127
18	Need advance information on flash flooding conditions	126
13	Need roadside communications in rural areas	126
14	Need to standardize EMS response procedures	126
10	Need coordination with statewide emergency management system	125
21	Need mayday systems	125
22	Need mass media to report up-to date, correct roadway conditions	124
20	Need to accurately determine incident locations	124
26	Need weather conditions information	124
19	Need to improve information sharing between agencies	123
15	Need clear and timely alternate route information	122
24	Need clearinghouse for information	121
23	Need HAZMAT vehicle tracking	121
29	Need advance work-zone information	120
31	Need real-time traffic conditions detection	120
28	Need improved work-zone safety	119
36	Need roadway conditions information	119
39	Need icy road detection	118
27	Need rest area security	118
25	Need roadway closure information for streets outside of the ADOT roadway network	118

Table 4.3-2 (continued)
Coalition Ranking of Identified Needs (by Score)

41	Need visibility monitoring and reporting	118
35	Need warning of falling rocks	118
34	Need adaptive signal timing	117
30	Need HAZMAT incident management	115
37	Need advance warning of inclement weather	114
33	Need to enforce CVO weight restrictions	113
40	Need ability to weigh trucks in a safe and quick manner	112
38	Need for collision avoidance systems for CVOs	112
32	Need to determine locations for information kiosks	112
49	Need to share ADOT video data with other agencies	112
44	Need ability to monitor and display traffic speeds to motorists to deter speeding	111
42	Need advance warning of congestion	110
45	Need to communicate in advance availability of services to the public	110
55	Need road closures due to forest fires to be included in general road closure database	109
43	Need to make traveler information available to the public	109
48	Need to prevent collisions with wildlife	108
53	Need better directions to tourist attractions	107
47	Need remote communications with VMS	107
51	Need to improve coordination between maintenance/construction crews to avoid overlapping of efforts	107
46	Need tourism/traveler information at rest stops	107
57	Need advance traveler information	106
54	Need to know status of at-grade railroad crossings	106
60	Need advance warning of highway junctions	105
52	Need traveler information at national/state parks	104
50	Need information on detours/road closures to be disseminated outside Arizona	103
65	Need advance warning of animal crossings	102
62	Need detection of vehicles violating road closures	101
59	Need advance warning of rural intersections	99
58	Need information on emergency parking areas for CVOs	99
56	Need in-vehicle emergency notification devices	98
61	Need information regarding CVOs entering United States	98
63	Need commercial vehicle tracking	94
64	Need to monitor drivers' condition	93
68	Need bridge condition information	92
66	Need to include POE in the information exchange loop	89

Table 4.3-2 (continued)
Coalition Ranking of Identified Needs (by Score)

67	Need tourist information	88
70	Need to make public aware of snow plowing schedules and locations	86
69	Need 24 hour tourist information	85
71	Need transit availability information	79
73	Need multi-lingual tourist information	78
72	Need surveillance of POE traffic	76
74	Need expeditious way to collect fees at state and national parks	71
76	Need advance traveler/tourism information at POE in Nogales	66
75	Need traveler information regarding Nogales POE status	64

The score for each user service was expressed in percent of the total score (equal to the sum of scores for all user services), and plotted on a bar chart. **Figure 4.3-2** shows the resulting ranking of the 36 user services.

In addition to the need-based ranking of the user services, members of the project's Technical Advisory Committee also ranked all 36 user services. The objective of this exercise was to gain an understanding of the TAC's perception of the relative importance of each of the ITS service areas represented by the user services. The TAC members were asked to rank the user services as representatives of their respective organizations (ADOT, DPS, and FHWA) and as transportation professionals.

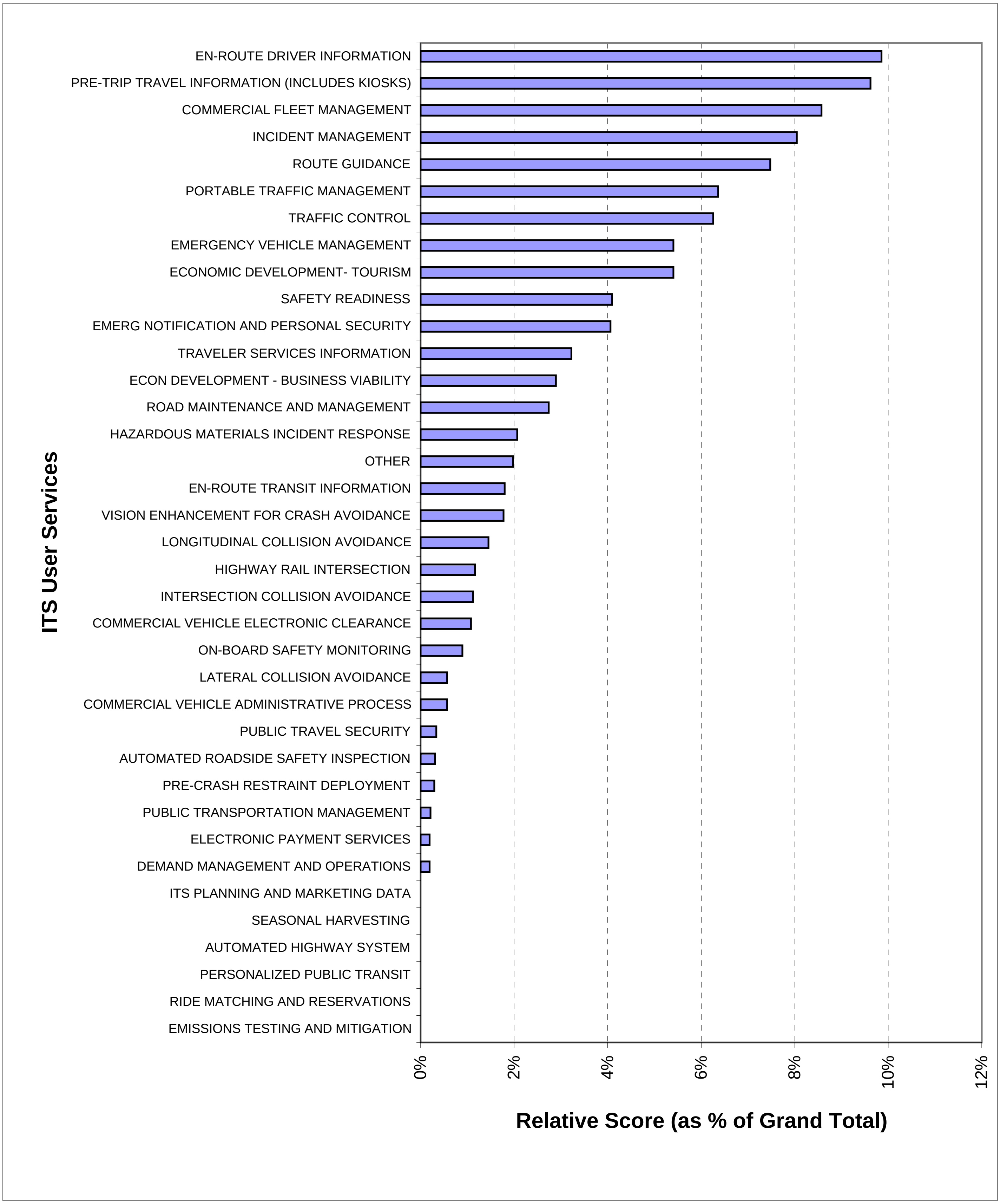


Figure 4.3-2
User Services Ranking
(based on relative importance of associated needs)

This ranking was used as a check against the user service ranking derived earlier from the needs. The final selection, discussed later in this chapter, was based on the two rankings and on the assessment of the applicability and probable deployment timeframe of each user service in rural Arizona. **Table 4.3-3** shows the user services identified in this process.

Table 4.3-3
User Services Identified for Rural Arizona

User Service	% Total Score	Number of Matched Needs
En-Route Driver Information	9.86	32
Pre-Trip Travel Information	9.26	32
Commercial Fleet Management	8.57	28
Route Guidance	7.48	24
Incident Management	8.05	24
Traffic Control	6.26	20
Portable Traffic Management	6.36	20
Economic Development/Tourism	5.40	19
Emergency Vehicle Management	5.41	16
Safety Readiness	4.09	13
Traveler Services Information	3.22	12
Emergency Notification and Personal Security	4.06	12
Economic Development/Business Viability	2.89	10
Road Maintenance and Management	2.74	9
Hazardous Material Incident Response	2.07	6
Commercial Vehicle Electronic Clearance	1.08	4
Highway Rail Intersection	1.16	4
Public Travel Security	0.34	1
Public Transportation Management	0.21	1

The above services were identified as most likely to achieve early deployment success in rural Arizona. This selection was not intended to exclude other user services as needed in specific areas. This list of user services does, however, represent recommendations of statewide services on which the remainder of this strategic deployment plan was based.

A number of user services were not selected despite their non-zero scores. A brief explanation of the reasoning behind the decision not to select a user service or a group of user services is included in **Table 4.3-4**.

Table 4.3-4
User Services Not Selected

User Services by Bundle, with Score	Reason why not selected
Public Transportation Management • En-route transit information, 1.80%	The en-route transit information service provides real-time transit information on-board the transit vehicle to assist the traveler once public transportation travel begins. Wide-spread implementation of this service is based on the availability of affordable technologies needed to provide en-route information inside the transit vehicle, which in turn depends on the demand for this transit, governed by ridership. *This type of service would typically be deployed on fixed routes with high ridership (either commuter or tourist) – neither of which is the case today in rural Arizona. En-route transit information should, however, be revisited at a later time, when rural ridership of public and private transit warrants it.*
Advanced Vehicle Control Safety Systems • Longitudinal collision avoidance, 1.45% • Lateral collision avoidance, 0.57% • Intersection collision avoidance, 1.12% • Vision enhancement for crash avoidance, 1.77% • Pre-crash restraint deployment, 0.29%	The advantages offered by these user services will be delivered by technologies focused on the in-vehicle environment. Car manufacturers will provide the majority of devices for collision avoidance. *As the deployment of these technologies is largely market-driven, it was decided that the rural Arizona stakeholders would be better served by the user services whose implementation is more feasible within the framework provided by ADOT and any public or private partners that may participate in the future implementation phases.*
Commercial Vehicle Operations • Automated roadside safety inspection, 0.31% • On-board safety monitoring, 0.89% • Commercial vehicle administrative process, 0.57%	Automated roadside inspections would allow real-time access at the roadside to the safety performance record of carriers, vehicles, and drivers. Through the use of sensors and diagnostics, vehicle systems, driver requirements, and ultimately driver alertness and fitness for duty could be quickly ascertained. On-board safety monitoring senses the safety status of a commercial vehicle, cargo, and driver. Commercial vehicle administrative process provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing. To facilitate automated mileage and fuel reporting and auditing, this service enables participating interstate carriers to electronically capture mileage, fuel purchased, trip, and vehicle data according to state. *These user services depend heavily on the in-vehicle electronic equipment (such as sensors and computerized transceivers) and will likely require additional advances in related technologies as well as cooperation of the CVO. These services will likely be deployed more successfully in the very long-range timeframe.*
Travel Demand Management • Demand management and operations, 0.19%	As stated in Table 3.2-1, this user service "supports policies and regulations designed to mitigate the environmental and social impacts of traffic congestion." As such, it is more applicable to urban areas. *Even though congested spots exist in many rural areas in Arizona, they tend to be localized and/or seasonal. Global policies and strategies that would be facilitated by this user service are not likely to alleviate those congestion spots, which will need to be addressed more directly.*
Electronic Payment Services • Electronic payment services, 0.19%	*This user service focuses on toll collection. There are currently no toll roads in Arizona.*
ITS Planning and Marketing Data	Zero Score
Seasonal Harvesting	Zero Score

Table 4.3-4
User Services Not Selected (continued)

Automated Highway System	Zero Score
Personalized Public Transit	Zero Score
Ride Matching and Reservations	Zero Score
Emissions Testing and Mitigation	Zero Score

4.3.1 Identification of User Service Deployment Timeframes

The National ITS Plan originally defined the deployment of ITS based upon the following schedule:

Term	Timeframe	Envisioned ITS Deployment
Short	1997-1999	Travel Information/Fleet Management
Medium	2000-2005	Transportation Management
Long	2010	Enhanced Vehicles

The National ITS Plan defined the beginning of the short-term timeframe (1997) to coincide with the reauthorization of ISTEA. Considering the typical planning, design, and implementation schedules of transportation projects, the short-term encompassed a relatively brief timeframe (three years). This schedule reflected FHWA's desire to implement, as quickly as possible, visible and effective ITS projects that would stimulate public support for the funding levels required to implement the future deployment programs.

A number of the short-term ITS deployments have taken place or are underway nationwide. In Arizona, examples of these types of projects include the statewide Highway Closure and Restriction System (HCRS); the soon to be implemented Roadway Closure and Restrictions System (RCRS), aimed at roadways outside of the ADOT highway network; the Public Remote Access System (PRAS); the Voice Remote Access System (VRAS); and the I-40 Corridor Advanced Traveler Information System (ATIS).

For the purposes of this study and taking into account the current status of the ISTEA reauthorization process, the deployment timeframes for the statewide implementation of the selected user services are based on the deployment horizons originally defined by the National Plan, adjusted for the current status of ITS deployment in Arizona, and considering current statewide plans for transportation improvements. The following deployment timeframes were identified:

- Short Term 1999 - 2001
- Medium Term 2002 - 2007
- Long Term 2008 and beyond

Table 4.3.1-1 summarizes the proposed user service deployment schedule based on these timeframes.

Table 4.3.1-1
Proposed Deployment Timeframes for ITS Services in Rural Arizona

Short-Term	Mid-Term	Long-Term
• En-Route Driver Information • Pre-Trip Travel Information • Commercial Fleet Management • Traffic Control • Portable Traffic Management • Traveler Services Information • Commercial Vehicle Electronic Clearance	• Incident Management • Emergency Vehicle Management • Emergency Notification and Personal Security • Road Maintenance and Management • Hazardous Material Incident Response • Public travel security • Public transportation management	• Route Guidance • Economic Development/Tourism • Safety Readiness • Economic Development/Business Viability • Highway Rail Intersection

4.4 SYSTEM OBJECTIVES AND PERFORMANCE CRITERIA

Two of the key tasks in developing an integrated user service plan were to establish system objectives and to develop performance criteria for evaluating the effectiveness of deployed user services in achieving those objectives.

4.4.1 System Objectives

System-wide objectives were established based on the identified needs, and performance criteria were determined to measure the relative effectiveness of the selected user services to achieve these objectives. An example of the formulation of objectives and performance criteria for a sample need is summarized below:

Need:	Need to enforce CVO weight restrictions
System objective:	Ensure conformance with laws
User services:	Commercial Vehicle Electronic Clearance
	Automated Roadway Safety Inspection
	Commercial Fleet Management
Performance:	Citations issued
Criteria:	Life-cycle costs (of paved roadways)
Timeframe:	Short-Term

As indicated in the above example, a system objective is an overall goal that can apply to a wide range of related needs. Therefore, a number of distinct but related needs may share the same system objective. Performance measures, described in subsequent sections of this report, were developed in order to quantitatively or qualitatively assess the effectiveness of the user services in addressing its matching need or needs. The timeframe listed represents the anticipated timing of the deployment of all user services implemented to address the need; therefore, timeframes are need-based, not user service based. The system objectives shown in **Table 4.4.1-1** were established based on the analysis of the 76 streamlined need statements identified earlier in the study.

Table 4.4.1-1
System Objectives (Alphabetically)

• Collect, process, and disseminate accurate and up-to-date: - Traveler information - Transit information - Roadway and weather conditions information - Tourist information
• Ensure conformance with laws
• Improve: - Driver/traveler safety - HAZMAT operations - Inter-and intra-agency coordination, cooperation, and information exchange - Personal security of travelers
• Provide: - Accurate and timely directions to travelers - Centralized storage and retrieval of information - Efficient flow of traffic - Timely emergency services

Table 4.4.1-2 lists the 76 needs grouped by system objective. The number to the left of each need indicates the need ID, for tracking purposes. These ID numbers correspond to the need IDs in **Table 4.3-2.**

Table 4.4.1-2
Needs by System Objectives

Collect, Process, and Disseminate Accurate and Up-to-Date Information to Travelers	
57	Need advance traveler information
Collect, Process, and Disseminate Accurate and Up-to-Date Transit Information	
71	Need transit availability information
Collect, Process, and Disseminate Up-to-Date, Accurate Roadway and Weather Conditions Information	
1	Need detour and road closure information
3	Need advance warning of unsafe roadway conditions
11	Need accurate winter road closure information
16	Need advance information on flooded areas
18	Need advance information on flash flooding conditions

Table 4.4.1-2 (continued)
Needs by System Objectives

22	Need mass media to report up-to-date, correct roadway conditions
25	Need roadway closure information for streets outside of the ADOT roadway network
26	Need weather conditions information
29	Need advance work-zone information
36	Need roadway conditions information
37	Need advance warning of inclement weather
39	Need icy road detection
42	Need advance warning of congestion
43	Need to make traveler information available to the public
50	Need information on detours/road closures to be disseminated outside Arizona
55	Need road closures due to forest fires to be included in general road closure database
68	Need bridge condition information
70	Need to make public aware of snow plowing schedules and locations
75	Need traveler information regarding Nogales POE status
Collect, Process, and Disseminate Up-to-Date, Accurate Tourist Information	
32	Need to determine locations for information kiosks
45	Need to communicate in advance availability of services to the public
46	Need tourism/traveler information at rest stops
52	Need traveler information at national/state parks
67	Need tourist information
69	Need 24-hour tourist information
73	Need multi-lingual tourist information
76	Need advance traveler/tourism information at POE in Nogales
Ensure Conformance With Laws	
33	Need to enforce CVO weight restrictions
44	Need ability to monitor and display traffic speeds to motorists to deter speeding
62	Need detection of vehicles violating road closures
63	Need commercial vehicle tracking
72	Need surveillance of POE traffic
Improve Driver/Traveler Safety	
13	Need roadside communications in rural areas
17	Need more means to communicate with motorists in remote areas
28	Need improved work-zone safety

Table 4.4.1-2 (continued)
Needs by System Objectives

35	Need warning of falling rocks
38	Need for collision avoidance systems for CVOs
41	Need visibility monitoring and reporting
48	Need to prevent collisions with wildlife
56	Need in-vehicle emergency notification devices
58	Need information on emergency parking areas for CVOs
64	Need to monitor drivers' condition
65	Need advance warning of animal crossings
Improve HAZMAT Operations	
23	Need HAZMAT vehicle tracking
30	Need HAZMAT incident management
Improve Inter- and Intra-Agency Coordination, Cooperation, and Information Exchange	
6	Need improved inter-agency communications
8	Need ability to exchange weather and roadway condition information between agencies
9	Need to coordinate roadway closure information between agencies
10	Need coordination with statewide emergency management system
19	Need to improve information sharing between agencies
49	Need to share ADOT video data with other agencies
51	Need to improve coordination between maintenance/construction crews to avoid overlapping of efforts
66	Need to include POE in the information exchange loop
Improve Personal Security of Travelers	
27	Need rest area security
Provide Accurate and Timely Directions to Travelers	
15	Need clear and timely alternate route information
53	Need better directions to tourist attractions
59	Need advance warning of rural intersections
60	Need advance warning of highway junctions
Provide Centralized Storage and Retrieval of Information	
12	Need toll free access to update and receive current roadway and weather conditions information
24	Need clearinghouse for information

Table 4.4.1-2 (continued)
Needs by System Objectives

	Provide Efficient Flow of Traffic
31	Need real-time traffic conditions detection
34	Need adaptive signal timing
40	Need ability to weigh trucks in a safe and quick manner
47	Need remote communications with VMS
54	Need to know status of at-grade railroad crossings
61	Need information regarding CVOs entering United States
74	Need expeditious way to collect fees at state and national parks
	Provide Timely Emergency Services
2	Need to improve emergency response times
5	Need improved dispatch and communications for EMS vehicles
7	Need improved incident notification and response times
14	Need to standardize EMS response procedures
20	Need to accurately determine incident locations
21	Need mayday systems

4.4.2 Performance Criteria

Alternative indicators of effectiveness, referred to as performance criteria or measures, are available to assess the degree to which the selected user services achieve each specific system objective. Performance measures can be grouped into quantitative or qualitative categories, and consist of a wide range of transportation-related, environmental, and other indices. For this project, the formulation of performance criteria involved using a previously developed comprehensive listing of potential performance measures along with an assessment of the relative value of each measure, and a synthesis of the recommended performance measures.

With the similarities between this project and the recently completed *I-40 ITS Strategic Plan*, the performance measures identified in the I-40 study could be used here. Those performance measures were based on a review of numerous sources, including:

- USDOT's National Program Plan for ITS, Advanced Public Transportation Systems: Evaluation Guidelines, and Advanced Rural Transportation Systems (ARTS) Strategic Plan;
- *ITS Architecture* Reports and *ITS America* Proceedings;
- Pima Association of Governments (PAG) Technical Memorandum 5: User Services/Options Study;
- Miscellaneous professional literature; and

- Stakeholder input during the focus group meetings and rural ITS workshops conducted for the project.

The I-40 study produced 34 performance measures (refer to the *Strategic Plan for Early Deployment of Intelligent Transportation Systems on Interstate 40 Corridor - Final Report,* report No. FHWA-AZ-97-431 for a more detailed discussion on the development of the performance measures). These measures are listed in **Table 4.4.2-1**.

It should be noted that the performance measures listed in the table are general in nature. To be meaningful, the measures must be used with the appropriate amount of detailed information that is specific to a particular user service. For example, use of the accident rate performance measure should include accident rates for alternative roadway and environmental conditions.

Table 4.4.2-1
Candidate Performance Measures

QUALITATIVE	QUANTITATIVE
• Accurate incident detection • Availability of traveler information • Conformance/response to messages • Level of Service (LOS) • Maintenance/operations requirements • Accurate and effective detour information delivery to affected drivers • Interagency communication/coordination • Customer surveys: - Understanding of ITS - Utilization of ITS - Satisfaction with technologies	• Accident rate • Arrival time predictability • Citations issued • Emergency response time • Emergency service call-outs • Hazardous material spills • Incident detection rate • Incident notification • Incident removal time • Level of Single Occupant Vehicle use/other modes • Number of accidents involving vehicles leaving the roadway • Number of communications channels • Number of fatal accidents • Number of hours in which information is available • Number of visitor centers • Number of visitors • Person-hours of delay • Rear-end collisions • Tow truck service calls • Travel speed • Truck/fixed object collisions • Vehicle density per lane • Weather station coverage • CVO operations and impacts • Wireless communications coverage • Timelines and traveler data

4.5 USER SERVICE CATEGORIES

The ARTS Program Plan maps all 36 ITS user services to seven rural ITS Critical Program Areas. **Table 4.5-1** maps the user services identified in this study to the CPAs. User services are also grouped into bundles, based on common service area, which is also shown in **Table 4.5-1**.

As can be seen from **Table 4.5-1**, most user services do not have a one-to-one relationship with any one specific CPA. This is because the functionalities described by the CPAs necessarily overlap (see *Rural Intelligent Transportation Systems Program Plan,* Advanced Rural Transportation Systems, March 25, 1998 draft), as depicted schematically in **Figure 4.5-1**.

Table 4.5-1
Mapping of Identified User Services to Rural Critical Program Areas

	Critical Program Area							User Service Bundles						
Selected User Services	1	2	3	4	5	6	7	Public Transportation Operations	Travel And Transportation Management	ARTS	Emergency Management	Advanced Vehicle Control	Commercial Veh. Operations	Travel Demand Management
Pre-Trip Travel Information			●	●										●
Commercial Fleet Management		●											●	
Hazardous Material Incident Response					●								●	
Commercial Vehicle Electronic Clearance							●						●	
Safety Readiness	●			●	●							●		
Highway Rail Intersection	●											●		
Emergency Vehicle Management		●			●						●			
Emergency Notification and Personal Security	●	●									●			
Portable Traffic Management			●	●	●					●				
Economic Development/Tourism			●							●				
Economic Development/Business Viability			●				●			●				
Road Maintenance and Management					●					●				
En-Route Driver Information	●	●	●	●	●				●					
Route Guidance	●	●	●	●					●					
Incident Management				●	●				●					
Traffic Control	●		●	●					●					
Traveler Services Information	●	●	●	●			●		●					
Public Travel Security	●				●	●		●						
Public Transportation Management		●	●	●	●	●		●						

The seven Critical Program Areas are named below, for reference:

CPA 1 - Traveler Safety and Security

CPA 2 - Emergency Services

CPA 3 - Tourism and Travel Information Services

CPA 4 - Public Traveler/Mobility Services

CPA 5 - Infrastructure Operations and Maintenance

CPA 6 - Fleet Operations and Maintenance

CPA 7 - Commercial Vehicle Operations

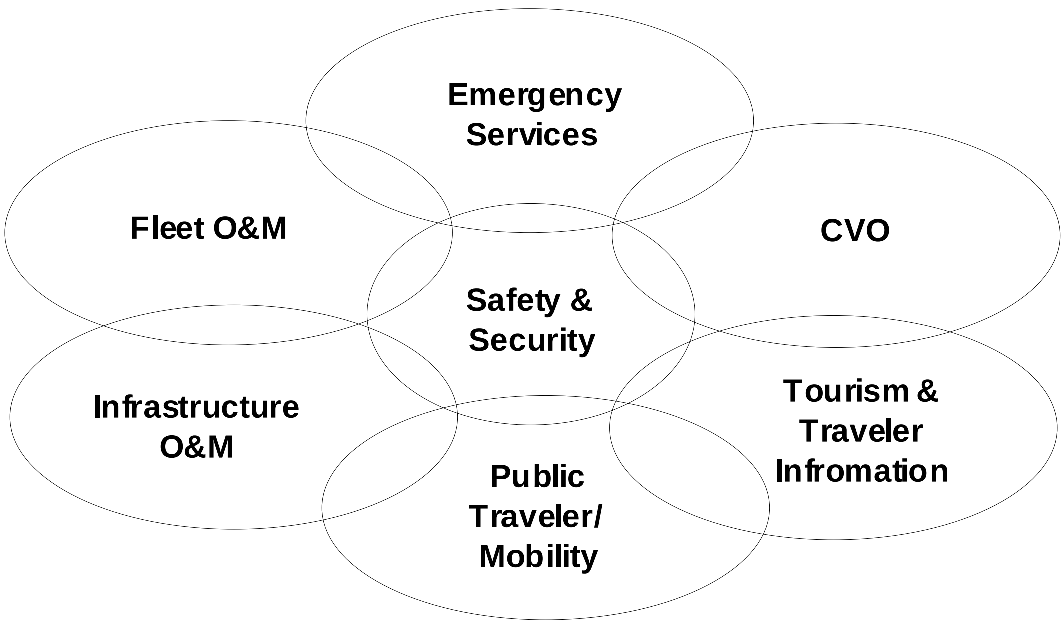


Figure 4.5-1
Conceptual Relationship among Critical Program Areas

To summarize, all seven Critical Program Areas and seven user service bundles were identified through the selection of the user services, as indicated in **Table 4.5-1**. These are:

Critical Program Area	User Service Bundle
Traveler Safety and Security	Travel and Transportation Management
Emergency Services	Travel Demand Management
Tourism and Travel Information Services	Emergency Management
Public Traveler/Mobility Services	Advanced Vehicle Control and Safety Systems
Infrastructure Operations and Maintenance	Commercial Vehicle Operations
Commercial Vehicle Operations	Advanced Rural Transportation Systems
Fleet Operations and Maintenance	Public Transportation Operations

4.6 FUNCTIONAL REQUIREMENTS

This section summarizes the process of matching the selected user services to ITS functional areas.

The FHWA has recognized seven basic functional areas that support user services. Each user service is achieved through the application of several technologies that perform one or more of the following system functions:

Surveillance	*Collection of speed, volume, densities, travel time, queue length, position, classification, weather, hazardous material, and other information for use in providing user services.*
Traveler Interface	*Means by which a user interacts with information sources.*
Navigation/Guidance	*Systems to assist travelers in route planning, position identification, route following, and finding directions when lost.*
In-vehicle Sensors	*Monitoring of vehicles, drivers and the external environment that might affect vehicle operations or driver performance.*
Communications	*Transmission (by wirelines and/or wireless) of voice, data and video information to and from vehicles and travelers, and system infrastructure.*
Control Strategies	*Strategies implemented to help smooth traffic flow, reduce congestion, and ensure traveler safety.*
Data Processing	*Management integration and quality control of all data and algorithms pertaining to ITS.*

4.6.1 Sample Technologies Supporting Functional Areas

The functional areas defined above encompass a number of existing and emerging technologies suitable for supporting both basic and advanced ITS functions. Most of these functional areas can be further subdivided into more specific application groups or functions, each of which might employ a different set of technologies. The functional areas and a small sample of technologies that specifically apply to rural areas are explained in the following paragraphs.

Surveillance is generally described as consisting of traffic, vehicle, and driving environment surveillance. A number of different but often complementary technologies are employed for surveillance purposes. Traffic surveillance collects information about the status of the traffic stream using traffic detectors (i.e., inductive loops, acoustic detectors, etc.). Vehicle surveillance, including weigh-in-motion devices, vehicle identification and classification, and vehicle location technologies, gathers a variety of information about specific vehicles.

Weather and hazard surveillance is an important part of this functional area. Using a variety of traditional and new technologies, weather surveillance collects information such as temperature, wind direction and speed, precipitation, barometric pressure, and visibility. Hazard surveillance consists of identification of road hazards, including hazardous materials, fallen rock, snow drifts or avalanche, other road blockages, and flooded roadways. Technologies used in hazard detection and warning systems include toxic gas and nuclear materials (radiation) sensors, video surveillance, pressure detectors (rock falls), fire sensors, and others.

The area of ***Traveler Interface*** includes fully interactive devices that provide answers to specific travel-related inquiries. Travel inquiries might be placed before departure (out-of-vehicle inquiries) and during travel (in-vehicle inquiries). Technologies facilitating a traveler interface include such widely disparate technologies as: touch screens at traveler kiosks; cable TV; FM sideband radio (or Radio Broadcast Data System); home, office or portable computers with travel information feeds (out-of-vehicle); "heads-up" displays in the vehicle; and cellular telephone and CB radio (in-vehicle).

Navigational Guidance provides real-time position and direction information to the mobile or stationary traveler. Technologies that provide these functions include dead reckoning with sign post update, global positioning satellite (GPS) receivers, toll tag readers, cellular telephone position reporting, and map database matching.

The area of ***In-vehicle Sensors*** covers technologies that focus on navigation and driver safety. Navigation means determining vehicle position relative to the roadway, other vehicles, and other obstacles such as animals in the roadway. Driver safety includes vehicle and driver performance, improvement of vision and adverse conditions, and on-board security monitoring. Examples of navigational technologies include GPS receivers, dead reckoning, and radio frequency (RF) position update. Driver safety can be improved by using crash severity sensors, smoke and fire sensors, and collision avoidance equipment. This whole functional area, while of interest to state and local government from an integration standpoint, is largely a private sector effort and will be incorporated into vehicles as market conditions dictate.

The functional area of ***Communications*** consists of one- and two-way mobile communications as well as stationary communications. One-way mobile communication is used to transmit information to receivers but cannot receive information back from these sites. Two-way mobile communications permits transmission and receipt of information by both ends of the communications link. Cellular phone, broadcast radio and TV, radio broadcast digital services (RBDS), digital spread spectrum radio, and others facilitate mobile communication. Stationary (infrastructure-to-infrastructure) communication is achieved via the use of such technologies as dial-up public telephone, Integrated Services Digital Network (ISDN), jurisdictional Synchronous Optical Networks (SONET), digital microwave, satellite communications systems, spread spectrum, packet radio, commercial wireline, jurisdictional networks (LANs, MANs, and WANs), and hybrid combinations.

Control Strategies in urban applications include a wide variety of signalized traffic controls as well as restrictive controls. Signalized traffic controls permit real-time control of traffic flow, and restricted control employs operational techniques to restrict the use of roadway according to statewide transportation objectives. There are limited applications of such strategies in rural environments; however, origin-destination (O-D) in real-time is being utilized for traffic congestion and travel time prediction with neural networks used to support dynamic O-D matching. As it applies to peak period use of major tourist areas such as the Grand Canyon or Petrified Forest, such predictive strategies might generate considerable benefit in the future. Typical signalized traffic control infrastructures that may apply in rural Arizona include traffic signals and signal systems in the towns along rural corridors, lane designation in the event of major incidents or special events, and ramp/lane closures.

Data Processing involves information processing related to weather, traffic incident, traffic control, and database or routing. Database development and data processing utilize technologies that manipulate, configure, and format transportation and travel data for further use through processes like data fusion, map registration and update, and travel services information processing. Routing data processing facilitates scheduling of drivers, vehicles, and cargo; route selection; commercial vehicle scheduling; and route guidance.

4.6.2 Selecting Functional Areas

4.6.2.1 User Services to Functional Areas Mapping

Each of the user services identified as particularly relevant to rural Arizona was matched with the functional areas described earlier. Functional areas are consistent with the descriptions in the FHWA's National ITS Program Plan. **Table 4.6.2.1-1** presents the matching of each of these user services with functional areas that will be required for implementation. Key activities completed as a part of this task include identifying the functional areas that will be required in rural Arizona and developing a set of matrices matching functional areas with user services.

For each functional area, the user services identified as most applicable to rural Arizona have been shaded. ITS projects addressing these services and functions should be immediately identified. Other cells marked with an "X" identify potentially promising deployment opportunities and should be considered in more medium- to long-term deployment scenarios. Matrices showing the mapping of the selected user services to specific technologies are included in the full text of the project Technical Memoranda, available from ADOT.

Table 4.6.2.1-1
ITS User Services Mapped to Functional Areas

User Service	Functional Areas						
	Surveillance	**Data/Voice Communic.**	**Traveler Interface**	**Control Strategies**	**Navigation Guidance**	**Data Processing**	**In-vehicle Sensors**
Pre-Trip Travel Information	X	X	X		X	X	
En-Route Driver Information	X	X	X		X	X	X
Route Guidance	X	X	X		X	X	X
Traveler Services Information	X	X	X		X	X	
Incident Management	X	X		X	X	X	
Emergency Notification & Personal Security	X	X	X		X	X	X
Emergency Vehicle Management	X	X	X	X	X	X	X
Highway-Rail Intersection	X	X	X	X		X	X
Commercial Fleet Management	X	X			X	X	X
Commercial Vehicle Electronic Clearance	X	X	X		X	X	X
Traffic Control	X	X	X	X	X	X	
Portable Traffic Management	X	X	X	X		X	
Economic Development (Tourism)	X	X	X	X	X	X	
Economic Development (Business Viability)	X	X	X	X	X	X	
Safety Readiness	X	X	X	X		X	X
Road Maintenance and Management	X	X	X	X		X	
Hazardous Materials Incident Response	X	X		X	X	X	X
Public Travel Security	X	X	X				
Public Transportation Management	X	X	X	X	X	X	X

4.6.2.2 Specific Technologies for Functional Areas

Figure 4.6.2.2-1 summarizes the process of matching (or "mapping") the general categories of Functional Areas and user services to the specific technologies that are applicable for each match. This process completes the combining of these three elements: services, functions and technologies.

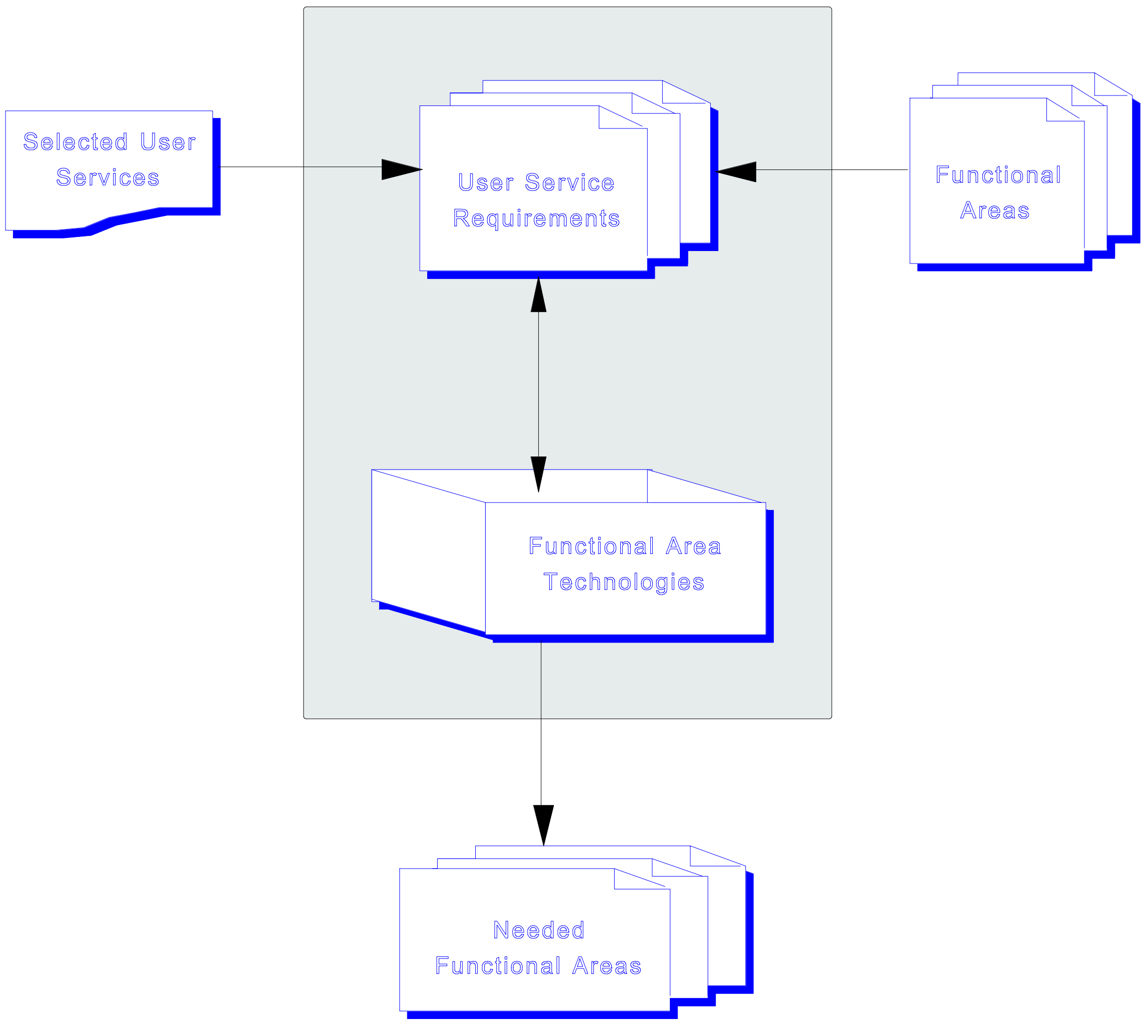


Figure 4.6.2.2-1
Mapping of Functional Areas to Selected User Services

4.6.2.3 Summary of Functional Area Selection

Table 4.6.2.1-1 indicated that the selected user services need the support of all seven functional areas. Based on the number of user services matched with each functional area, data processing, surveillance, communications, navigational guidance, and traveler interface are the most needed functional areas. Traveler interface is among the most needed functional areas in many travel corridors or near tourist attractions in Arizona.

In-vehicle sensors cover a limited number of user services – (i.e., Commercial Vehicle Operations and Emergency Response categories), and will be an important factor in deploying those services. Control strategies, on the other hand, are recognized as having a more limited niche in the ITS technologies that will apply to rural Arizona, both now and in the future.

4.6.3 Information Sharing Among and Within Agencies

Implementing the ITS functional areas will enable participating public and private agencies to collect a wide range of travel and traffic data for all levels and modes of operations. No single agency, however, is envisioned to have direct access to all of that information to support both real-time and long-term decision-making processes. Well-designed relationships and physical connectivity among and within supporting agencies must be part of any statewide system if full benefits of such a system are to be realized.

Effective information sharing among agencies is both a necessary and logical function of an Intelligent Transportation System. Advanced Traveler Information Systems (ATIS) are an integral part of most of the comprehensive ITS deployments, and they require access to a broad spectrum of real-time travel and traffic information to support the transportation user. In addition, information sharing helps form the basis for support and integration of many traffic, transit, safety, and commercial vehicle services. For example, automatic vehicle identification (AVI) supported by many weigh-in-motion (WIM) systems (which are linked to regulatory and safety information databases) serves both the commercial vehicle operators and the state operating agency by saving processing time and paperwork.

Similarly, real-time information exchange between public transit and ITS services, enabled by a common system architecture with real-time interoperability, permits real-time coordination between transit and traffic functions. Traffic conditions information (collected through a system of detectors and processed by a regional traffic operations/management center [TOC/TMC], for example) can be provided to dispatch centers of public transit agencies, thus facilitating schedule generation and up-to-the-minute schedule and route corrections. The same information can also be provided as color-coded displays to other public and private users, including the end user.

Significant cost savings could be realized for the trucking industry, emergency service providers, and perhaps by regional transit services by integrating communications and transportation infrastructure. An integrated traffic and travel information system would incorporate communications, navigation, congestion status and travel time, traveler information, and emergency management. Cost sharing could be achieved by many of these common system elements.

The benefits of information and data sharing also could be realized by many other partners in ITS. City, state and county governments have well-defined information needs which could be fulfilled by inter- and intra-agency data sharing. For example, the real-time traffic data collected by a TOC can also be used for long-term transportation planning and analysis. Current traffic and weather conditions collected throughout the state can be used by municipal traffic engineering departments and ADOT maintenance operations, and accessed by other services such as demand-responsive rural transit providers to help with route planning. Local fire departments and other first responders could use the same condition information to provide better service. Emergency services would benefit from the knowledge of exact location of their vehicles as they travel toward accident sites. Almost all participants in ITS, both direct and indirect, would benefit from a well-planned data and information sharing scheme implemented on the physical communications level as well as on the procedural/institutional levels.

4.7 SELECTION OF MARKET PACKAGES

The National ITS Architecture defines the purpose of market packages addressing specific services that might be required by traffic managers, transit operators, travelers, and other ITS stakeholders. The market packages are tightly coupled with the architecture definition and represent the "building blocks" that can be deployed over time to efficiently achieve high-end ITS services. Several different market packages are defined for each major application area, which provides a palette of services at varying cost. Market packages are also identified to segregate services, which are likely to encounter technical or non-technical challenges from lower risk services. For example, driver warning and vehicle control systems are defined as separate market packages due to the increased technical and non-technical risks associated with systems which dilute the driver's direct control of the vehicle. This approach yields market packages that may be deployed early with low risk. Many of the market packages are also incremental so that more advanced packages can be efficiently implemented based on earlier deployment of more basic packages. In short, market packages represent ITS services and implementation options that may be considered by system implementers.

As an example, **Figure 4.7-1** shows the Broadcast Traveler Information market package, which contains the Basic Information Broadcast equipment package within the Information Service Provider (ISP) subsystem and the Personal Basic Information Reception equipment package within the Personal Information Access subsystem. This market package provides broadcast traveler information to a variety of users.

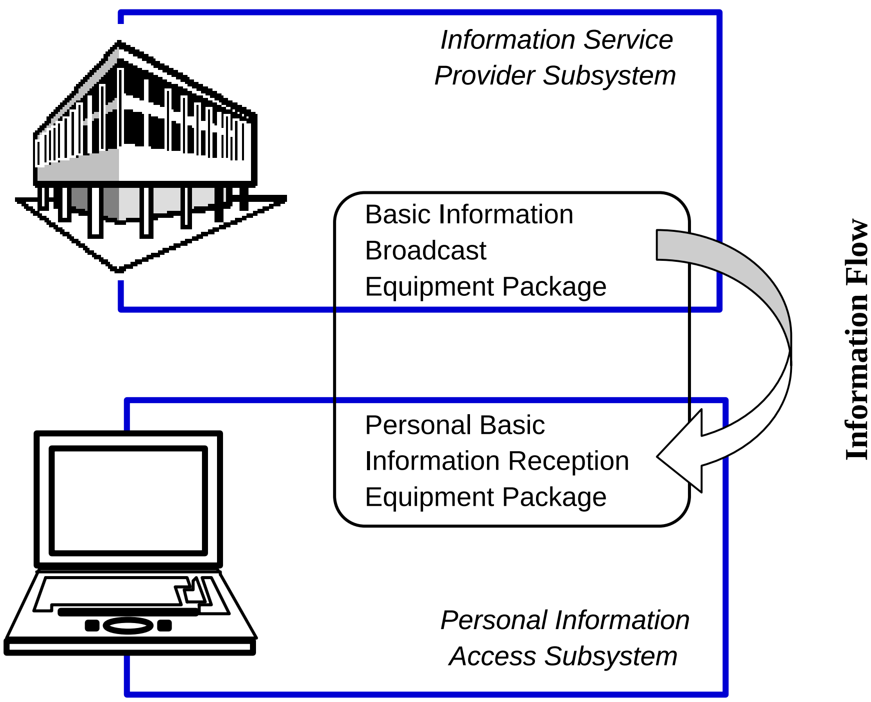


Figure 4.7-1
Broadcast Traveler Information Market Package

Selection of appropriate market packages is an important step in the ITS Early Deployment process. Historically, market packages were introduced in the planning process after user services, which, along with functional requirements, were the last steps in the process before architecture definition. The ITS deployment guidelines have evolved to include both additional steps and alternative paths for urban, regional, or statewide ITS Strategic Plan developments.

The objective of this task was to identify a set of candidate market packages for potential deployment in rural Arizona. The National ITS Architecture provides a traceability matrix connecting the 29 original user services and the 56 market packages. The remaining seven user services considered in this study (highway-rail intersection and the six user services added by the ARTS program) were appended to this matrix and relationships to the market packages were established. **Table 4.7-1** illustrates this traceability matrix.

Table 4.7-1
Market Package to User Service Relationships

	Market Packages	User Services																													Rural Extensions						
		1.1 - Pre - Trip Travel Information	1.2 - En - Route Driver Information	1.3 - Route Guidance	1.4 - Ride Matching And Reservations	1.5 - Traveler Services	1.6 - Traffic Control	1.7 - Incident Management	1.8 - Travel Demand Management	1.9 - Emissions Testing And Migration	2.1 - Public Transportation Management	2.2 - En - Route Transit Information	2.3 - Personalized Public Transit	2.4 - Public Travel Security	3.1 - Electronic Payment Services	4.1 - Commercial Vehicle Electronic Clearance	4.2 - Automated Roadside Safety Inspection	4.3 - On - Board Safety Monitoring	4.4 - Commercial Vehicle Administrative Process	4.5 - Hazardous Material Incident Response	4.6 - Commercial Fleet Management	5.1 - Emergency Notification And Personal Security	5.2 - Emergency Vehicle Management	6.1 - Longitudinal Collision Avoidance	6.2 - Lateral Collision Avoidance	6.3 - Intersection Collision Avoidance	6.4 - Vision Enhancement For Crash Avoidance	6.5 - Safety Readiness	6.6 - Pre - Crash Restraint Deployment	6.7 - Automated Vehicle Operation	7.1 - Highway Rail Intersection	7.2 - Portable Traffic Management	7.3 - Road Maintenance and Management	7.4 - Seasonal Harvesting	7.5 - Economic Development (Business Viability)	7.6 - Economic Development (Tourism)	7.7 - ITS Planning and Marketing Data
ATMS	Network Surveillance						x																								o	o		o	o	o	
	Probe Surveillance						x																														
	Surface Street Control						x	x																							o	o			o	o	
	Freeway Control						x	x	x																							o		o	o	o	
	HOV and Reversible Lane Management						x		x																							o					
	Traffic Information Dissemination						x																									o		o	o	o	
	Regional Traffic Control						x																									o			o	o	
	Incident Management System							x																								o			o	o	
	Traffic Network Performance Evaluation						x		x																										o	o	
	Dynamic Toll/Parking Fee Management								x						x																				o	o	
	Emissions and Environmental Hazards									x																									o	o	
	Virtual TMC and Smart Probe Data		x				x	x																													
APTS	Transit Vehicle Tracking										x	x	x	x																					o	o	
	Transit Fixed-Route Operations										x	x																							o	o	
	Demand Response Transit Operations										x	x	x																						o	o	
	Transit Passenger and Fare Management											x			x																				o		
	Transit Security										x			x																					o	o	
	Transit Maintenance										x																								o		
	Multi-Modal Coordination						x		x		x																							o	o	o	

x - as mapped in the National Architecture documents
o - added mapping

Table 4.7-1
Market Package to User Service Relationships

		User Services																												Rural Extensions						
	Market Packages	1.1 - Pre - Trip Travel Information	1.2 - En - Route Driver Information	1.3 - Route Guidance	1.4 - Ride Matching And Reservations	1.5 - Traveler Services	1.6 - Traffic Control	1.7 - Incident Management	1.8 - Travel Demand Management	1.9 - Emissions Testing And Migration	2.1 - Public Transportation Management	2.2 - En - Route Transit Information	2.3 - Personalized Public Transit	2.4 - Public Travel Security	3.1 - Electronic Payment Services	4.1 - Commercial Vehicle Electronic Clearance	4.2 - Automated Roadside Safety Inspection	4.3 - On - Board Safety Monitoring	4.4 - Commercial Vehicle Administrative Process	4.5 - Hazardous Material Incident Response	4.6 - Commercial Fleet Management	5.1 - Emergency Notification And Personal Security	5.2 - Emergency Vehicle Management	6.1 - Longitudinal Collision Avoidance	6.2 - Lateral Collision Avoidance	6.3 - Intersection Collision Avoidance	6.4 - Vision Enhancement For Crash Avoidance	6.5 - Safety Readiness	6.6 - Pre - Crash Restraint Deployment	6.7 - Automated Vehicle Operation	7.1 - Highway Rail Intersection	7.2 - Portable Traffic Management	7.3 - Road Maintenance and Management	7.4 - Seasonal Harvesting	7.5 - Economic Development (Business Viability)	7.6 - Economic Development (Tourism)	7.7 - ITS Planning and Marketing Data
ATIS	Broadcast Traveler Information	x	x									x																							o	o	
	Interactive Traveler Information	x	x									x	x		x																				o	o	
	Autonomous Route Guidance		x	x																											o				o	o	
	Dynamic Route Guidance		x	x																											o				o	o	
	ISP Based Route Guidance	x	x	x											x																				o	o	
	Integrated Transportation Mgmt/Route		x	x											x																				o	o	
	Yellow Pages and Reservation	x	x			x									x																				o	o	
	Dynamic Ridesharing	x	x		x							x	x		x																				o	o	
	In Vehicle Signing		x				x																								o					o	
AVSS	Vehicle Safety Monitoring																											x	x								
	Driver Safety Monitoring																											x									
	Longitudinal Safety Warning																							x				x			o						
	Lateral Safety Warning																								x			x									
	Intersection Safety Warning																									x		x			o						
	Pre-Crash Restraint Deployment																											x	x								
	Driver Visibility Improvement																										x				o						
	Advanced Vehicle Longitudinal Control																							x							o						
	Advanced Vehicle Lateral Control																								x												
	Intersection Collision Avoidance																									x					o						
	Automated Highway System																													x							

x - as mapped in the National Architecture documents
o - added mapping

Table 4.7-1
Market Package to User Service Relationships

		User Services																											Rural Extensions						
	Market Packages	1.1 - Pre - Trip Travel Information	1.2 - En - Route Driver Information	1.3 - Route Guidance	1.4 - Ride Matching And Reservations	1.5 - Traveler Services	1.6 - Traffic Control	1.7 - Incident Management	1.8 - Travel Demand Management	1.9 - Emissions Testing And Migration	2.1 - Public Transportation Management	2.2 - En - Route Transit Information	2.3 - Personalized Public Transit	2.4 - Public Travel Security	3.1 - Electronic Payment Services	4.1 - Commercial Vehicle Electronic Clearance	4.2 - Automated Roadside Safety Inspection	4.3 - On - Board Safety Monitoring	4.4 - Commercial Vehicle Administrative Process	4.5 - Hazardous Material Incident Response	4.6 - Commercial Fleet Management	5.1 - Emergency Notification And Personal Security	5.2 - Emergency Vehicle Management	6.1 - Longitudinal Collision Avoidance	6.2 - Lateral Collision Avoidance	6.3 - Intersection Collision Avoidance	6.4 - Vision Enhancement For Crash Avoidance	6.5 - Safety Readiness	6.6 - Pre - Crash Restraint Deployment	6.7 - Automated Vehicle Operation	7.1 - Highway Rail Intersection	7.2 - Portable Traffic Management	7.3 - Road Maintenance and Management	7.4 - Seasonal Harvesting	7.5 - Economic Development (Business Viability)	7.6 - Economic Development (Tourism)	7.7 - ITS Planning and Marketing Data
CVO	Fleet Administration																				x													o			
CVO	Freight Administration																			x														o			
CVO	Electronic Clearance															x			x																o		
CVO	CV Administrative Processes															x			x																		
CVO	International Border Electronic Clearance															x			x																o		
CVO	Weigh-In-Motion															x																	o		o		
CVO	Roadside CVO Safety																x																				
CVO	On-Board CVO Safety																	x																			
CVO	CVO Fleet Maintenance																	x			x																
CVO	HAZMAT Management							x												x	x														o		
EM	Emergency Response																						x												o	o	
EM	Emergency Routing																						x												o	o	
EM	Mayday Support																					x	x												o	o	
	ITS Planning										x																								o	o	o

x - as mapped in the National Architecture documents
o - added mapping

The candidate market packages were selected based on the user services identified earlier, using the relationships established in **Table 4.7-1**. **Table 4.7-2** lists the resulting candidate market packages.

Table 4.7-2
Candidate Market Packages

Traffic Management (ATMS) • Network Surveillance • Probe Surveillance • Surface Street Control • Freeway Control • HOV and Reversible Lane Management • Traffic Information Dissemination • Regional Traffic Control • Incident Management System • Traffic Network Performance Evaluation • Dynamic Toll/Parking Fee Management • Emissions and Environmental Hazards • Virtual TMC and Smart Probe Data	**Advanced Public Transportation Systems (APTS)** • Transit Vehicle Tracking • Transit Fixed-Route Operations • Demand Response Transit Operations • Transit Passenger and Fare Management • Transit Security • Transit Maintenance • Multi-modal Coordination
Traveler Information (ATIS) • Broadcast Traveler Information • Interactive Traveler Information • Autonomous Route Guidance • Dynamic Route Guidance • ISP-Based Route Guidance • Integrated Transportation Mgmt/Route • Yellow Pages and Reservation • Dynamic Ridesharing • In-Vehicle Signing	**Commercial Vehicles (CVO)** • Fleet Administration • Freight Administration • Electronic Clearance • CV Administrative Processes • International Border Electronic Clearance • Weigh-in-Motion • CVO Fleet Maintenance • HAZMAT Management
Advanced Vehicle Safety Systems (AVSS) • Vehicle Safety Monitoring • Driver Safety Monitoring • Longitudinal Safety Warning • Lateral Safety Warning • Intersection Safety Warning • Pre-Crash Restraint Deployment • Driver Visibility Improvement • Advanced Vehicle Longitudinal Control • Intersection Collision Avoidance	**Emergency Management (EM)** • Emergency Response • Emergency Routing • Mayday Support **ITS Planning** • ITS Planning

Note that 49 of the possible 56 market packages were identified as potentially deployable in rural Arizona. This is due to the fact that deployment of several of the identified user services will require portions of numerous market packages, as illustrated in **Table 4.7-1**. For example, the user service *Traffic Control* is matched with 11 market packages; similarly, the *Economic Development* user services are related to over 28 market packages each. While this selection may at first sight appear too broad and indiscriminate, one must keep in mind that these market packages represent sets of specific technology applications, called equipment packages, which need not all be implemented in order to deploy a given user service. A more detailed selection process was employed in the next phase of this study, which developed the functional and physical architecture elements of the rural Arizona ITS deployment. In that phase, 43 market packages were identified as the final selection.

5.0 ARIZONA STATEWIDE ITS ARCHITECTURE

5.1 INTRODUCTION

Intelligent Transportation System (ITS) architecture is a framework that describes what a system does and how it does it. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components. This chapter describes the process of developing the Statewide ITS Architecture for Arizona.

The proposed ITS architecture for Arizona was developed through a multi-step process. First, the functional architecture was defined based upon previously identified user service functions and specific need priorities. Next, physical architecture components accommodating the specified functions were identified. In a following step, the specifications of suitable communications architecture were derived as part of the physical architecture definition. Finally, specific technologies supporting the physical architecture were identified. The Statewide ITS Architecture was defined in terms of subsystems and market packages, to facilitate specific project recommendations.

Available information on the system architectures of Maricopa and Pima counties, the I-40 corridor, the Phoenix area Freeway Management System, and the AZTech Model Deployment Initiative was integrated with the overall recommendations for the Arizona statewide ITS architecture.

The architecture for Arizona was developed by defining the portions of the ITS National Architecture needed to support each user need, extracting those portions, and then developing additional levels of detail to define and explain how the elements interconnect. The staged deployment plan for the statewide architecture was developed for the following time frames:

I.	Short-Term	1999-2001
II.	Mid-Term	2002-2007
III.	Long-Term	2008 and beyond

5.2 GENERAL DESCRIPTION OF ITS ARCHITECTURE

The ITS architecture is comprised of two technical layers, a Transportation Layer and a Communication Layer, which operate in the context of an Institutional Layer as shown in **Figure 5.2-1**.

The Transportation Layer includes the various transportation-related processing centers, distributed roadside equipment, vehicle equipment, and other equipment used by the traveler to access ITS services. The Communication Layer provides for the transfer of information between the Transportation Layer elements. The Transportation and Communication Layers together are the *architecture framework* that coordinates overall system operation by defining interfaces between equipment which may be deployed by different procuring and operating sectors. The Institutional Layer introduces the policies, funding incentives, working arrangements, and jurisdictional structure that support the technical layers of the architecture.

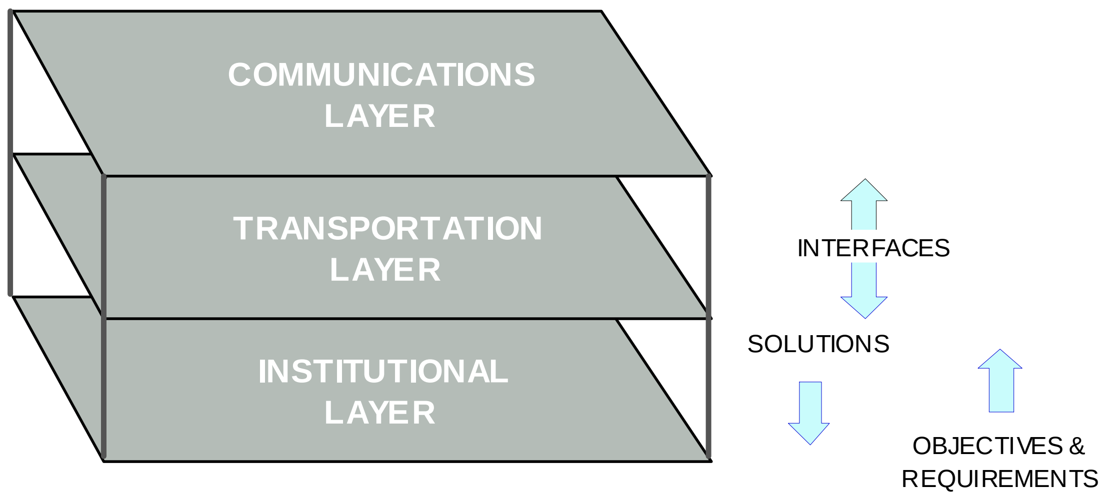


Figure 5.2-1 ITS Architecture Layers

5.2.1 Transportation Layer

The basic elements of the Transportation Layer, shown in **Figure 5.2.1-1**, are ***subsystems*** and ***equipment*** (*technology*) ***packages***. A subsystem is the highest level building block of the architecture. It represents a set of transportation functions (or processes) which are likely to be collected together under one physical agency, jurisdiction, or physical location (i.e. within a vehicle). The interfaces between subsystems represent key communication links, defined by the architecture. The information contained in these key interfaces is defined by data flows. Subsystems are further subdivided into equipment packages, which represent the lowest level of functionality in the architecture.

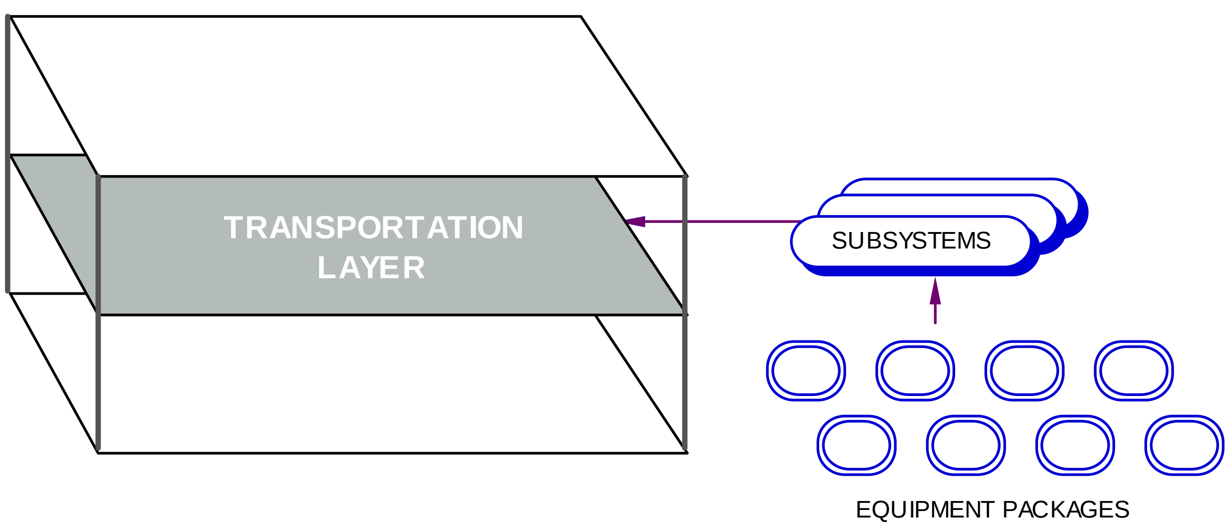
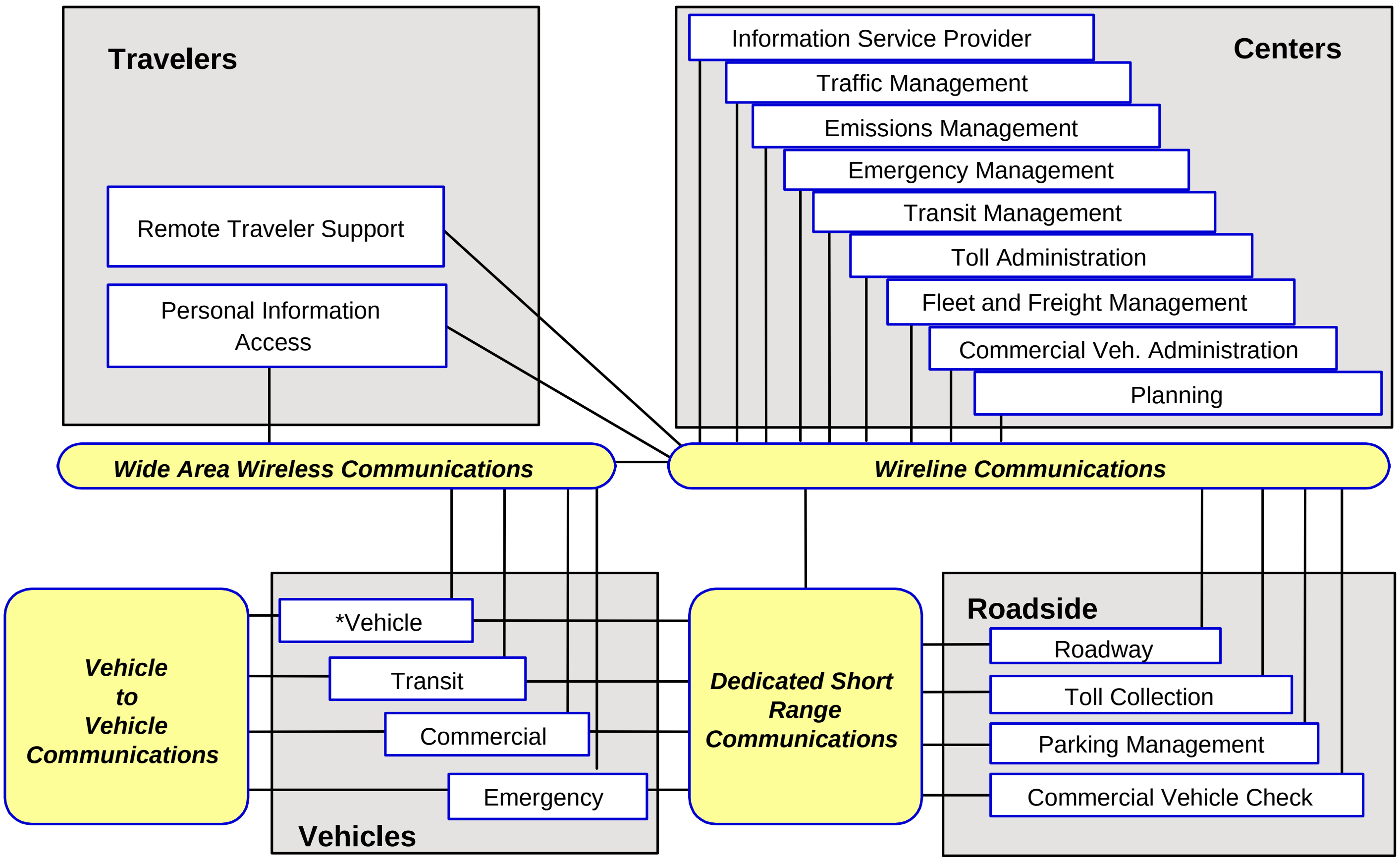


Figure 5.2.1-1 Transportation Layer Elements

The Transportation Layer includes nineteen interconnected subsystems shown in **Figure 5.2.1-2**. A complete description of each subsystem, along with its architecture diagram, is provided in the National Architecture documents.



*"Personal" Vehicle Subsystem

Figure 5.2.1-2 ITS Architecture Subsystems and Communications

5.2.2 Communications Layer

The development of the communications layer focused on two main issues: 1) communications architecture definition (i.e., selection of communications service and media types to interconnect the appropriate Transportation Layer subsystems); and 2) communications analyses to ensure the feasibility and soundness of the architectural decisions made in the definition. The analyses performed included:

- An analysis of the data loading requirements;
- An assessment of communication technologies that are applicable to the interconnections defined in the Communications Layer;
- An analysis of the real-world performance of selected communications technologies; and

- Supporting technical and economic telecommunications analyses of architecture-related issues, such as the appropriate use of dedicated short range communication (DSRC) systems.

In general, the communications layer consists of two components: one wireless and one wireline. The Transportation Layer is supported by one or both of these components. The wireline portion of the network can be manifested in many different ways, and most of them are implementation dependent. The wireless portion of the network consists of these three main classes of services:

- *Wide-area wireless infrastructure supporting wide-area information transfer denotes a wide area wireless airlink, with a set of base stations providing connections to mobile or untethered users.* It is typified by the current cellular telephone and data networks or the larger cells of Specialized Mobile Radio for two-way communications, as well as paging and broadcast systems. A further subdivision of this interface is possible: two-way connectivity and one-way broadcast-type connectivity.

- *Short range wireless infrastructure for short-range information transfer.* This infrastructure would typically be dedicated to ITS uses. The wireless interface to this infrastructure is a short-range airlink used for close-proximity (typically less than 50–100 feet) transmissions between a mobile user and a base station, such as for transferring of vehicle identification numbers at toll booths.

- *Dedicated wireless system that handles a high data rate and has a low probability of error*. It has a fairly short range, and includes vehicle-to-vehicle transceiver radio systems.

5.2.2.1 Communications Services

Communications services define the exchange of information between two points, independent of media and application. In essence, they are a specified set of user-information transfer capabilities provided by the communications layer to a user in the transportation layer.

Communications services consist of two broad categories, *interactive* and *distribution*. Interactive services allow the user to exchange data with other users or providers in real or near-real time (i.e., asking for service or information and receiving it in the time it takes to communicate or look up the information). Distribution services allow the user to send the same message to multiple users.

Interactive services may be either *conversational* or *messaging*. Conversational implies the use of a two-way connection established before information exchange begins and terminated when the exchange is completed. Messaging, on the other hand, works more like electronic mail being exchanged between users. The messages are exchanged without establishing a dedicated path between the two sites. Each message is addressed and placed on the network for transmission, and is intermixed with messages from other users. The communications community labels this mode of communication a “datagram” service.

Distribution services may be either *broadcast* or *multicast* and can be used over wireline and/or wireless communication links. Broadcast messages are those sent to all users, while multicast messages are sent only to a subset of users. Multicast differs from broadcast in its use of a designated address for all users and user groups. Examples of broadcast information might include current weather or road conditions, whereas multicast information might be information sent to all drivers working for a specific company. A changing group membership could be the set of users traveling between two locations or with a certain destination, for which unique information must be transmitted. The services that can be supported using circuit or packet connection mode include voice, video, image, and data. **Figure 5.2.2.1-1** summarizes the concepts presented above.

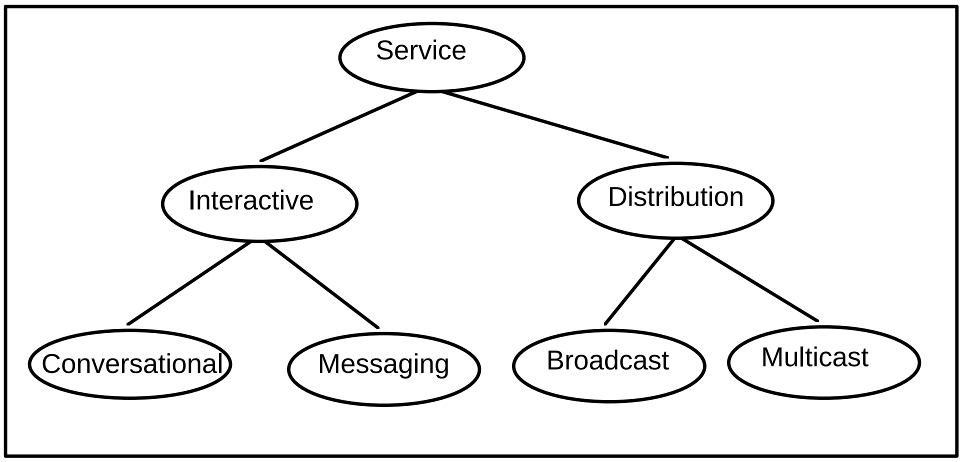


Figure 5.2.2.1-1 Communications Services Hierarchy

Wireline links represent wide area network communications elements, which can take a number of forms. Typically it will be a data network of some kind. Physically, the network can be fiber, coaxial, twisted pair, or even microwave. It can be an ITS dedicated network, such as a communications system installed by a public agency to pass messages between a Roadside Check Station and the Commercial Vehicle Administration Subsystem (CVAS). Alternatively, it can be a privately deployed network owned and operated by a communications service provider, where operators of ITS subsystems pay a service fee for connection to and use of the network or for leasing the lines. More than one network used for ITS may coexist in a region, and these networks will be connected (or networked) to support ITS message communications between subsystems that are attached to different networks.

The wide area network (WAN) wireless communication element can be dedicated to a specific user or agency (and publicly owned or privately owned), or it can be privately owned and operated by a communications service provider who sells access to this data network to many users or agencies for a fee.

Wireless communications systems can be one-way (broadcast) or two-way. For broadcast systems, an example is FM-subcarrier systems. Two-way systems that are private can be SMR (Special Mobile Radio) or E-SMR (Enhanced SMR). SMR and E-SMR require licenses from the Federal Communications Commission for operation, and are typically dedicated to a specific service or agency.

A key feature of most wireless communication elements is that they are or can be networked to a wireline communications system of some sort. In this way, mobile units can exchange ITS messages with Center or Roadside subsystems. It is required that the two-way ITS wireless communications network will have the necessary coverage for a particular user service application, and that the wireless network will be networked to the wireline wide-area communications network.

A simplified view of the communications interface is provided in the Very Top Level simplified Architecture Interconnect Diagram in **Figure 5.2.2.1-2**.

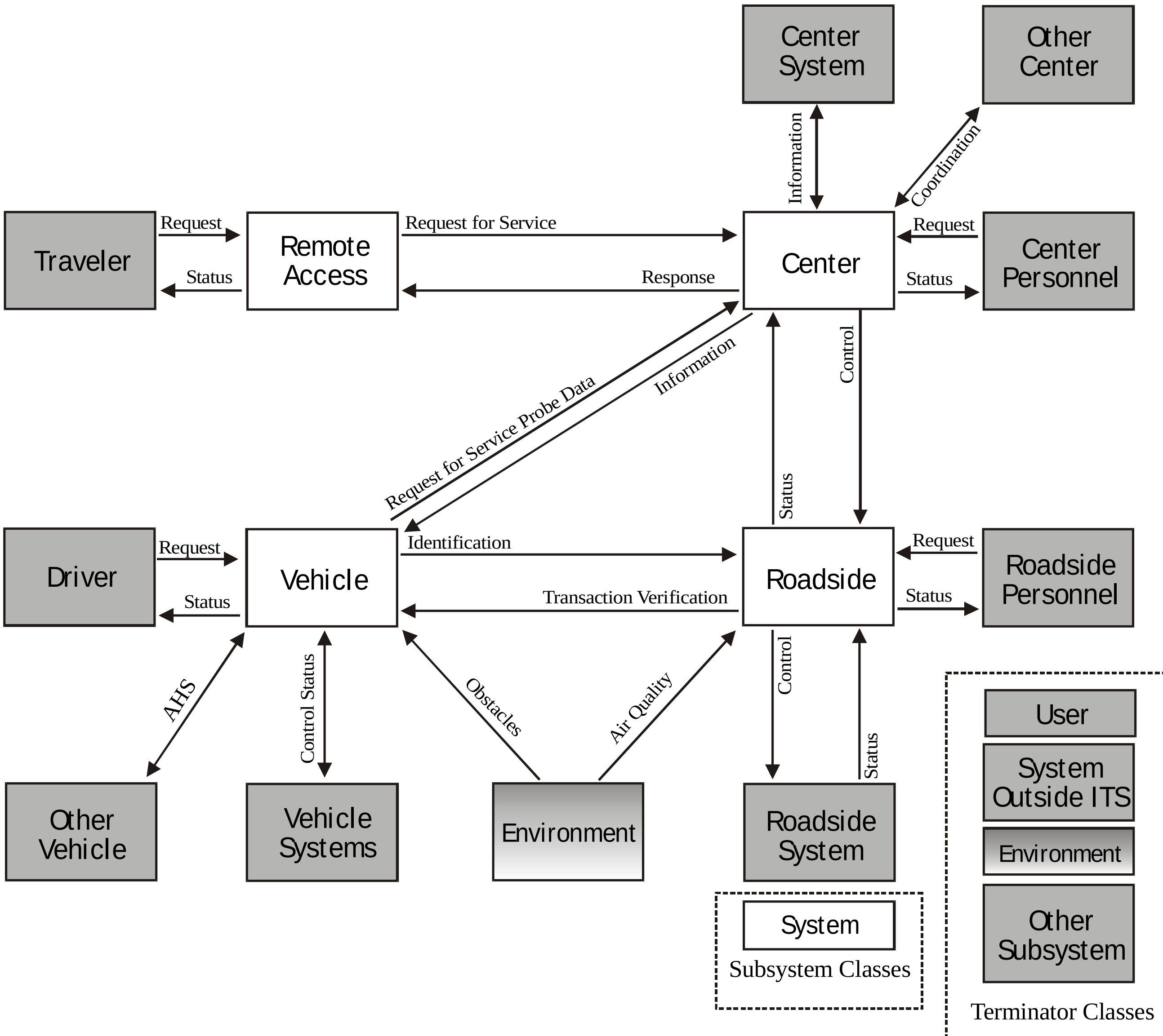
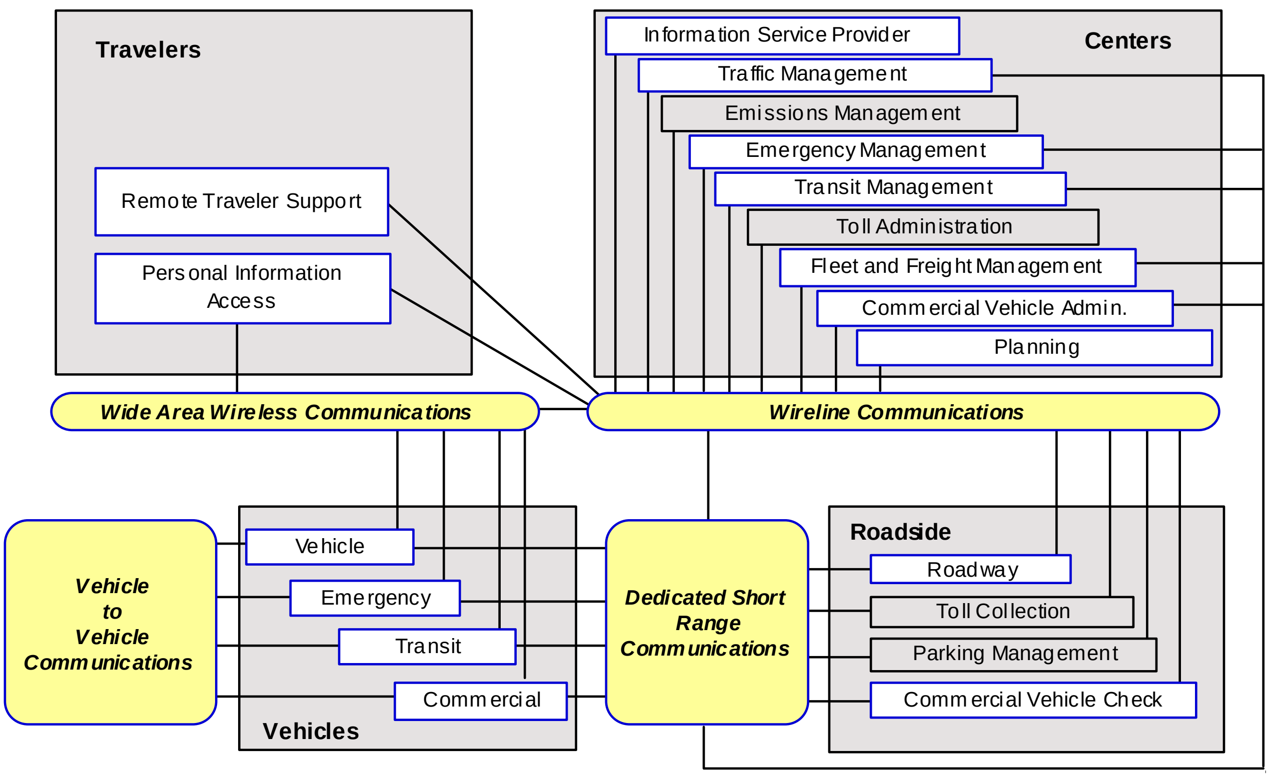


Figure 5.2.2.1-2 Very Top Level Simplified Architecture Interconnect Diagram

Another element of the architecture's three-level structure is the Institutional Layer, which documents the policies, funding incentives, working arrangements, and jurisdictional structure that support the transportation and communications layers of the architecture. The Institutional Layer describes who has responsibility for deployment of the specific market packages and individual ITS projects and programs. It also identifies opportunities for public-public and public-private partnerships that would be necessary for successful deployment and/or operations and maintenance. This layer of the architecture is not time-based (e.g., the institutions do not change over time, except for possibly different vendors of specific technologies). Therefore, this layer is treated separately and is addressed in the management structure discussion portion of the *Strategic Plan*.

5.3 FUNCTIONAL ARCHITECTURE DEFINITION

The functional requirements for the Statewide ITS Architecture were derived from the needs identified in this study. In order to assure consistency with the ITS National Architecture, each need was mapped to its closest equivalent User Service Requirement during the user service identification process. Using the full set of Process Specifications developed for the National Architecture, a subset of process and capability descriptions was tailored to meet Arizona's transportation-related needs. This process resulted in a set of functional requirements specific to meeting these needs, while at the same time consistent with elements of the National Architecture.



*"Personal" Vehicle Subsystem

Figure 5.3-1 Selected Subsystems

These requirements were then used to identify the architecture subsystems, shown in **Figure 5.3-1**, that are needed to deliver the desired system functions. Subsystems that were not selected are shown in gray.

5.4 RECOMMENDED ITS PHYSICAL ARCHITECTURE

Market package selection was facilitated by the Technical Advisory Committee. Each member of the TAC was given an opportunity to select from the entire set of market packages and equipment packages currently defined by the National Architecture. The TAC selected 43 out of the 56 available market packages, eliminating 6 of the 49 candidate market packages identified in section 4.7. The TAC's selection represented the final input into the selection process, which focused on matching Arizona's user needs with appropriate ITS solutions, represented at this stage of the study by market packages. The selected market packages were grouped by anticipated deployment timeframe, and the resulting market package deployment within each of the 15 selected subsystems is summarized in **Figure 5.4-1** below.

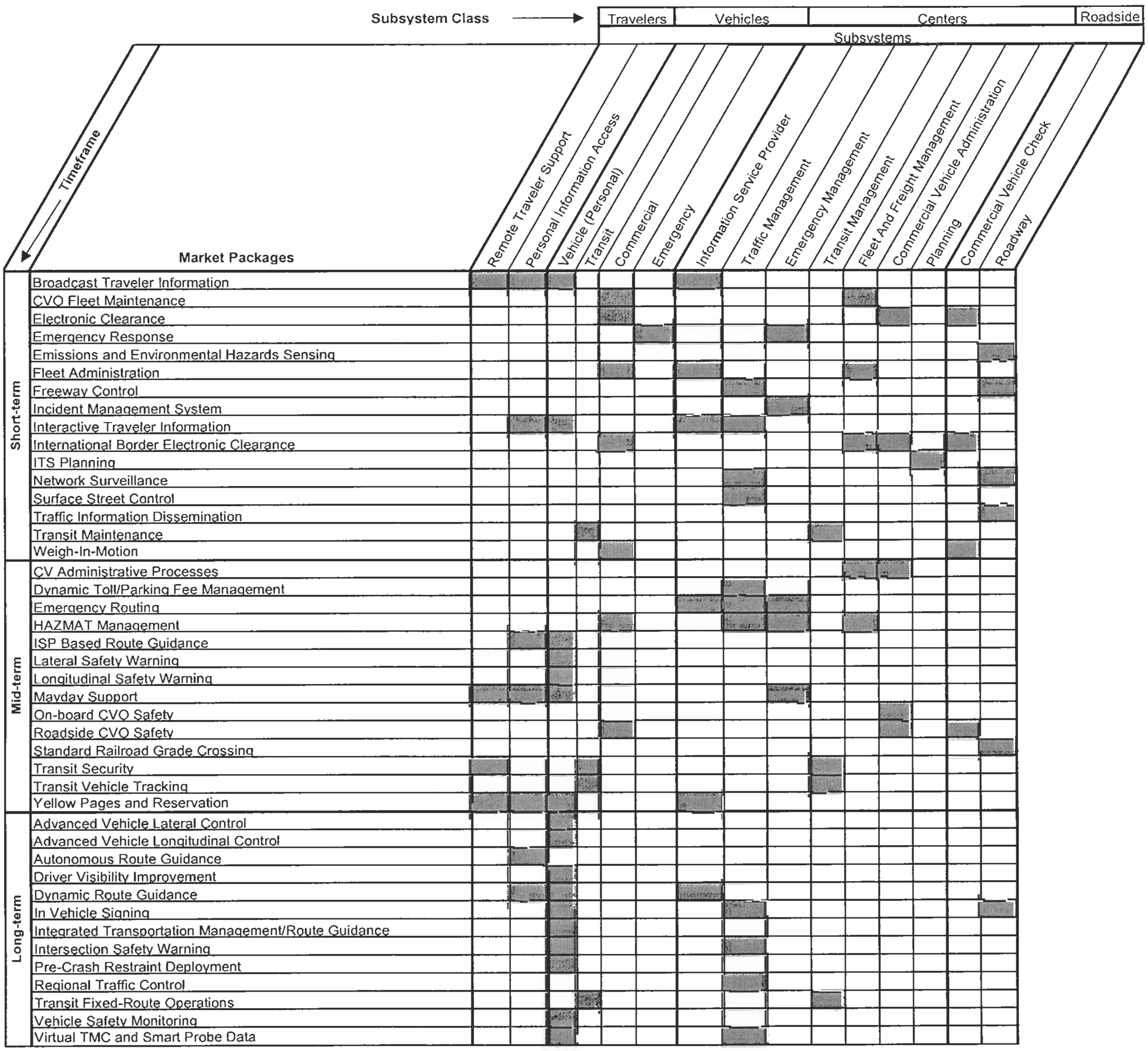


Figure 5.4-1 Market Package Deployment, by Timeframe

5.5 ALTERNATIVE TECHNOLOGIES

5.5.1 Recommended Technologies

This section presents a summary of the technology recommendations in support of the short-term and long-term deployment of ITS in rural Arizona. Only two deployment horizons were selected for this summary to facilitate the identification of the immediate deployment opportunities, and because of the inherent difficulty in predicting the demand for and the state of the various candidate technologies. **Table 5.5.1-1** lists these recommended technologies.

Table 5.5.1-1 Summary of Technology Recommendations

Deployment Horizon	Recommended Technologies
Short-term (1999 – 2004)	Road Weather Information System (RWIS)
	VMS (fixed and portable)
	Broadcast radio (via partnerships with local radio stations)
	LANs and WANs in rural communities
	Twisted pair and co-axial cable
	Advanced Highway Advisory Radio (AHAR)
	Switched public telephone dial-up
	Cellular telephone voice
	AM/FM radio
	Traveler information kiosks
	Wind direction and speed sensors
	Weather sensory systems (ALERT)
	Visibility detectors
Long-term (2005 and Beyond)	SONET backbone with ATM
	Acoustic sensors
	Inductive loop detectors
	RDDS for FM subband
	Client/service TOC architecture
	Broadcast radio terminal
	Broadcast radio FM subband digital
	Broadcast TV
	Cable TV (CATV)
	Variable message and pathfinder electronic signs
	Short-haul microwave
	Video four-channel multiplexer over single-mode fiber
	Radio frequency toll tags, Radio Frequency Identification (RFID), CVO RF "Intellitag" (Advantage Partnership RF tag)
	Cellular telephone, AMPS, CDPD, or digital cellular service (DCS)
	Personal Communications Service (PCS)
	WIM, including fiber optic
	Personal Digital Assistant (PDA)/digital cellular
	RF tag (Type III with display)
	Closed loop signal systems
	170 Controller
	Global Positioning Satellite (GPS)
	Subband FM one-way communications
	Motorist Assistance Patrols (MAPs)
	Impact sensors
	In-vehicle route guidance systems

Table 5.5.1-1 Summary of Technology Recommendations (continued)

Deployment Horizon	**Recommended Technologies**
Long-term (2005 and Beyond) – continued	Collision avoidance - acoustic obstacle detection, ultrasonic obstacle detection, microwave radar, millimeter wave radar, LIDAR, wide-band radar Over speed limit, infrastructure-to-vehicle reporting and vehicle-to-driver alarm system identifying violation Night vision enhancement Anti-lock brake system (ABS) Traction control system, anti-wheel spin regulation, road environment sensor, intersection sensors Pre-crash restraint system – infrared sensors, machine vision sensors, acoustic sensors, heating elements Magnetic lane control, visual TV lane control, infrared imaging lane control, radar and reflectors Steep hill warning (infrastructure-to-vehicle)

6.0 STRATEGIC PLAN

6.1 INTRODUCTION

This study has identified the needs of Arizona's rural transportation stakeholders and has matched them, where possible, to one or more ITS market packages, each representing an ITS solution. Of the 56 market packages currently defined in the National Architecture, 43 were identified as suitable for deployment in Arizona. **Figure 6.1-1** lists these market packages within their anticipated deployment horizons.

SHORT-TERM

- Broadcast Traveler Information
- CVO Fleet Maintenance
- Electronic Clearance
- Emergency Response
- Emissions and Environmental Hazards Sensing
- Fleet Administration
- Freeway Control
- Incident Management System
- Interactive Traveler Information
- International Border Electronic Clearance
- ITS Planning
- Network Surveillance
- Surface Street Control
- Traffic Information Dissemination
- Transit Maintenance
- Weigh-In-Motion

MID-TERM

- CV Administrative Processes
- Dynamic Toll/Parking Fee Management
- Emergency Routing
- HAZMAT Management
- ISP-Based Route Guidance
- Lateral Safety Warning
- Longitudinal Safety Warning
- Mayday Support
- On-board CVO Safety
- Roadside CVO Safety
- Standard Railroad Grade Crossing
- Transit Security
- Transit Vehicle Tracking
- Yellow Pages and Reservation

LONG-TERM

- Advanced Vehicle Lateral Control
- Advanced Vehicle Longitudinal Control
- Autonomous Route Guidance
- Driver Visibility Improvement
- Dynamic Route Guidance
- In-Vehicle Signing
- Integrated Transportation Management / Route Guidance
- Intersection Safety Warning
- Pre-Crash Restraint Deployment
- Regional Traffic Control
- Transit Fixed-Route Operations
- Vehicle Safety Monitoring
- Virtual TMC and Smart Probe Data

Figure 6.1-1
Market Package Deployment Recommendations

The recommended ITS architecture includes 15 of the 19 possible subsystems identified in the National Architecture required to deliver the needed functions of the improved statewide transportation system. **Figure 5.3-1**, discussed previously, summarizes the subsystem selection.

Recommended ITS services, service providers, system users, and communications are shown schematically in **Figure 6.1-2**, the conceptual layout of ITS architecture for Arizona. The remainder of this *Strategic Plan* addresses the following deployment-related items:

- **Technology deployment by phase** – provides a listing of recommended technologies grouped by market package and proposed deployment horizon.

- **Business plan for deployment and management structure for operations and maintenance** – develops a framework for policy, process, and action between the public and private jurisdictions involved in the deployment.

- **Estimates of deployment, operations, and maintenance costs.**

6.2 RECOMMENDED TECHNOLOGY DEPLOYMENTS

Technology deployment phasing was developed by identifying the desired implementation horizon for each of the 43 selected market packages. The recommended ITS solutions were once again cross-checked against the identified user needs, resulting in a more complete set of recommendations. This chapter lists the technologies that should be deployed in order to achieve the desired functionality of each selected market package.

Many of the solutions proposed in this *Strategic Plan* coincide with the recommendations contained in ADOT's February 1997 Statewide Plan for Intelligent Transportation Infrastructure (ADOT ITI). ADOT's Intermodal Transportation Division Technology Group prepared a plan for phased implementation of 16 technologies, listed below, aimed at improving travel conditions on Arizona's highway network. The 1997 ADOT ITI report lists the proposed deployment locations of each of the 16 technologies.

1. Variable Message Signs
2. Closed Circuit Television
3. Weigh-In-Motion
4. Vehicle Detection Systems
5. Non-Port of Entry Enforcement Locations
6. Ports of Entry
7. Road Weather Information Systems
8. Blowing Dust Sensors
9. Elk Signs
10. Traffic Signal Synchronization
11. Ramp Metering
12. Cellular Telephone Coverage
13. Kiosks
14. 1-800 Travel Advisory Numbers
15. Railroad Crossings
16. Mayday Systems

This study has reviewed the results of the ADOT ITI effort and has incorporated its recommendations to the extent validated by the user needs identified in the course of this project, and by the degree to which their implementation will serve to achieve the deployment of the selected market packages. The extent of deployment and location of the recommended ITS solutions were based on the desired locations that stakeholders identified for both this and the ADOT ITI research.

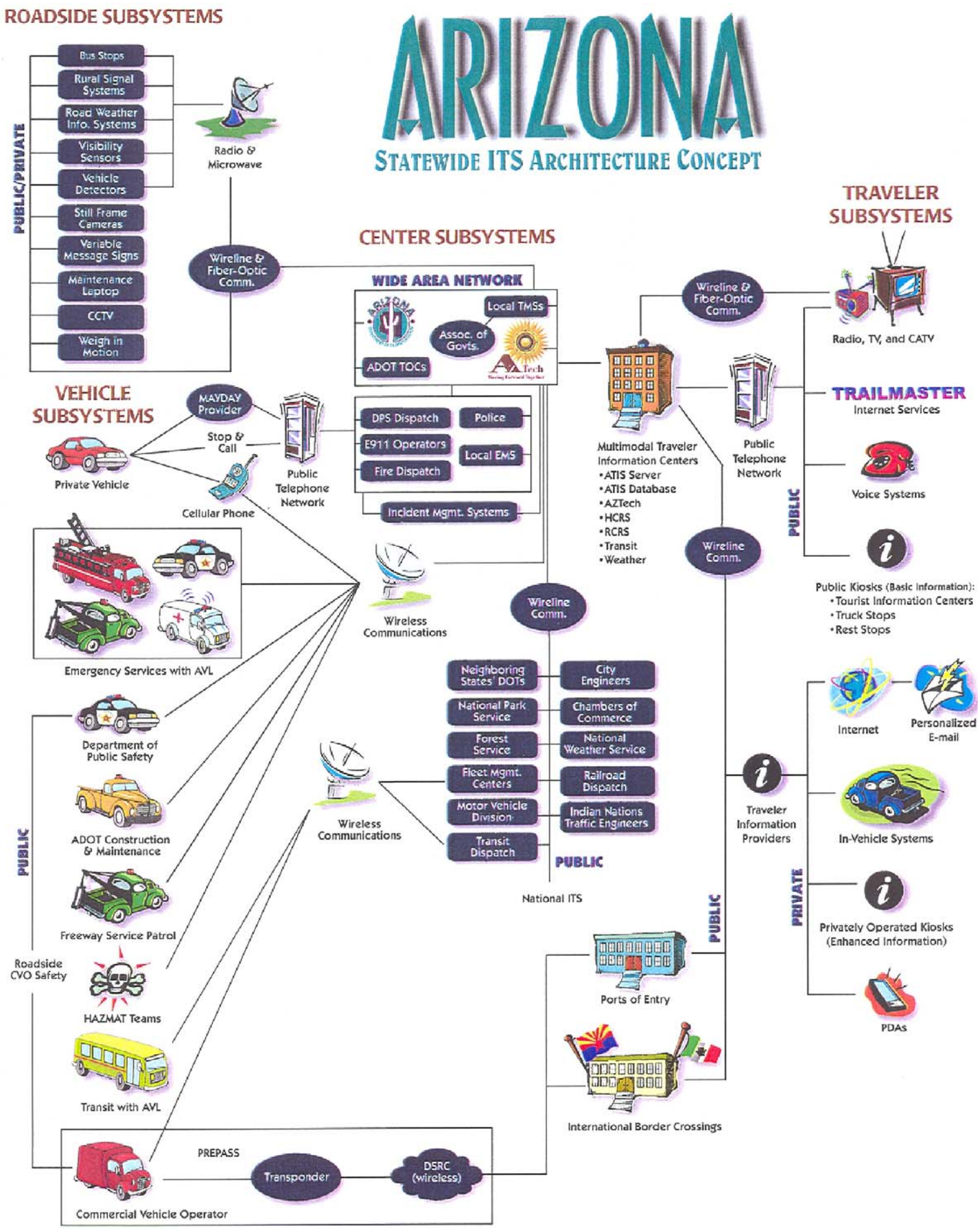


Figure 6.1-2
Arizona's Statewide ITS Architecture Concept

6.3 PROJECTS BY MARKET PACKAGE AND DEPLOYMENT PHASE

Phased statewide deployment of the recommended projects is anticipated to address the vast majority of rural Arizona's transportation needs. These projects are listed in order of their proposed deployment timeframe and the corresponding market package. The deployment timeframes, established earlier in this study, have been replaced here with corresponding "phases":

Phase I: Short-term (1999-2001)
Phase II: Mid-term (2002-2007)
Phase III: Long-term (2008 and beyond)

6.3.1 Phase I: Short-term Market Packages (1999 - 2001)

The following projects, listed by market package, are recommended for short-term deployment in Arizona. Some of these projects are already in the deployment stage, with portions of the projects completed.

Broadcast Traveler Information

- Provide interface to public broadcast media for use and distribution to viewers/listeners including AM/FM radio broadcasters, TV, cable TV, and cellular service providers for Traffic Alerts. Provide FM Traveler Advisory Radio. The FM subcarrier information broadcast would provide data to Radio Data System (RDS) subsystem of FM radio stations and allow transmission of corridor conditions to in-vehicle route guidance systems. Request for a Partnership Proposal (RFPP) is recommended as a viable method to begin implementing these solutions.

- Expand traveler/driver information dissemination to neighboring states to prepare travelers before they enter Arizona. New Mexico, Nevada, California, and Utah are key states to receive this information.

CVO Fleet Maintenance

- In-vehicle devices such as automatic vehicle identification (AVI) and automatic vehicle location (AVL) are needed to support electronic vehicle clearance. The current ADOT program to install electronic clearance stations at most of Arizona's ports of entry, combined with an effort to encourage the trucking industry to use to this technology, will increase the number of trucks with AVI, AVL, and electronic credentials exchange technology.

- Automated vehicle status, mileage, and fuel reporting are features currently implemented by a number of private fleets, and should be considered by ADOT to provide more efficient and timely vehicle maintenance capabilities for its vehicle fleets.

Electronic Clearance

- Additional ports of entry with PrePass technology would provide automated bypass of vehicles meeting selected criteria and provide weigh-in-motion (WIM) to identify potentially overweight vehicles. All POEs should include weigh-in-motion and AVI readers. Digital Short Range Communications (DSRC) continues to be the recommended means of communications between the vehicle and the POE.

Emergency Response

- It is recommended that ADOT evaluate placing free-standing call boxes along some of the remote rural routes in Arizona. The effectiveness of the call box technology is time proven and has been used in southern Arizona on I-19 as well as in other states, notably California.

- Cellular telephones with automatic distress calling function and with GPS are some of the desired features of personal portable communications devices that are available to travelers. This technology is being implemented and marketed solely by private industry. It is recommended that ADOT's and other agencies' EMS-related planning efforts closely observe the direction in which this industry is headed in order to adjust their EMS practices accordingly.

- Provide computer-aided dispatching (CAD) for police, fire, search and rescue, HAZMAT response teams, and the Department of Public Safety, with automated route selection. The potential benefits of providing CAD monitoring workstations to other agencies (ADOT, media) should be evaluated.

- Emergency phones at rest areas and transit stops with free direct dial capability will benefit the security of travelers at these facilities.

- CCTV and audio monitoring of rest areas and border crossings could provide police or security agencies with the ability to monitor the security of these public areas.

- Increase motorist service patrols along remote rural routes, and equipment vehicles with two-way radios, cellular telephones, and GPS.

- Traffic signal pre-emption would allow DPS, fire, ambulance, and other emergency response vehicles to request signal pre-emption along their direction of travel. This would require the installation of both in-vehicle devices (such as strobe lights currently used by some fire departments) and pre-emption equipment at the traffic signals.

- Coordination of emergency management policy and efforts among Arizona emergency management and other agencies.

Emissions and Environmental Hazards Sensing

- Visibility sensors at dust storm areas could provide motorist information on adverse driving conditions due to blowing dust. Installation should be considered at: (1) locations where recorded accidents have persistently occurred due to blowing dust, and (2) locations where the ADOT Districts deem it advantageous. These sensors should be capable of detecting low visibility conditions due to other elements as well, including smoke, rain, and snow. CCTV cameras can be used to visually verify local environmental conditions and the impact they are having on traffic. Those installations should have the capability to get information quickly to the public. Currently, portable VMS are used to warn drivers of blowing dust conditions. These sensors should be coordinated with the appropriate set of VMS in the area. Locations with blowing dust should be researched and catalogued.

  Visibility sensors may be mounted as stand-alone devices or on other roadside installations, if appropriate. The sensors should be programmed to notify the responsible TOC of critical visibility conditions.

- Weather alert systems with flash flood sensors could help a number of areas throughout the state that suffer from violent flash floods each year. Sensors with alert capabilities could be installed to provide early warning of flooded routes.

- Road Weather Information Systems (RWIS), combined with National Weather Service data; could provide updates of weather conditions on ADOT roadways. Through in-pavement sensors, these stations could also provide the current chemical content on the roadway surface. The RWIS could be used to activate snow and ice control measures. RWIS should be considered for locations (1) with elevations over 4000 feet, (2) where predictive information would be beneficial, (3) where, historically, Districts deemed it advantageous to have local weather conditions information, (4) at key point where initial icing occurs, and (5) in locations other than Northern Arizona to track storms. RWIS locations can be more effectively selected using thermal mapping.

  RWIS and other weather monitoring sensor stations should be equipped with automated alarms to notify responsible personnel (e.g. via a pager) of events that require action.

- Still-frame video cameras at RWIS stations could use the communications link used by the RWIS to transmit compressed images of the local conditions (weather or traffic).

<u>Fleet Administration</u>

- Computer Aided Dispatching at fleet management centers could provide private commercial carriers with more efficient deliveries. Knowing where commercial vehicles are and having direct computer links to each operator would provide for more efficient service.

- Coordinated scheduling for ADOT and other maintenance crews, including coordinated snow plowing schedules should be implemented. The coordination of roadway and roadside maintenance between ADOT crews and local municipal teams currently relies on verbal notification. This information should also be made available to travelers.

- Data exchanges between ADOT and public and commercial fleet management centers could provide ADOT with valuable information (fleet centers collect a great deal of up-to-date information through their daily operation). Some of this information should be made available to other fleet centers and to the traveling public.

<u>Freeway Control</u>

- Traffic Management Center (TMC)-to-TMC wireline or high-bandwidth wireless communications for traffic data, information exchange, and control of traffic control measures.

- Improved “truck route” signing. Many routes lack adequate signing on whether or not they can be used by trucks. Improved signing, especially beneficial during detours, is recommended.

<u>Incident Management System</u>

- Incident location determination technologies - ADOT should vigorously continue to study the technologies and solutions that are available to improve the incident location process. ADOT has begun this effort through a pilot Mayday study being conducted for the U.S. 93 corridor (from Wickenburg to the Nevada border).

- Incident management strategies for rural routes should include the use of VMS and media notification to detour traffic to other routes.

- Common communications channels for agencies within Arizona should include standardized radio frequencies for inter-agency communications and high-capacity data channels.

- Common communications channels (wireless and landline) with DOTs in California, Nevada, New Mexico, Utah, and Colorado could help facilitate inter-state coordination and information exchange through high-speed/high-capacity communications links.

- Coordinate roadway closures/alternate routes by providing real-time information about roadway closures.

<u>Interactive Traveler Information</u>

- Highway Closure and Restrictions System (HCRS)—ADOT continues to deploy HCRS throughout the state. The system includes consolidation of roadway conditions and hazards reports from District Traffic Operations Centers and preparation of this information for distribution to the public. The system provides a statewide central data repository of real-time traveler information. The HCRS is used to gather information about construction locations, traffic-related maintenance activities, weather-related road closures, roadway weather information, and traffic accident information collected from different authorized agencies.

  It is recommended that the HCRS provide a number of additional features, including:

  - Marked alternate routes that are suitable for trucks;

  - Multi-lingual tourist information (via its web access); and

  - Storing and displaying of coordinated scheduling for ADOT and other maintenance crews, including snow plowing schedules.

  Public users can access HCRS information via the Voice Remote Access System (VRAS), Information Kiosk System, and Internet web pages (www.azfms.com). The Internet version of the HCRS user interface provides a geographical lookup of traveler information, which is updated automatically at approximately five-minute intervals. It is intended that the system provide HCRS client services to city and county traffic agencies, transit operators, utilities, Bureau of Land Management, US Forest Service, Hoover Dam Authority, the National Guard, Palo Verde Nuclear Power Plant, Tribal Authorities, and other participating organizations statewide.

- Voice Remote Access System (VRAS) provides an interface to the HCRS using cellular/DCS service to provide traffic reports. The project has been deployed statewide by ADOT and the information is accessible through a dial-up number (1-888-411-ROAD).

Once a user dials the 1-888-411-ROAD Travel Information Line, a computerized voice provides information about:

- Current and planned road closures and restrictions
- Alternate routes and detours to handle road closures
- Current incident locations and status
- Current traffic flow levels
- Traffic diversions planned to handle special events
- Weather condition information derived from roadway weather systems

- Road Closure and Restrictions System (RCRS) is an information collection and dissemination system similar to the already operational Highway Closure and Restriction System. The RCRS is currently in development stages by ADOT. While the HCRS provides information for the Arizona highways, the RCRS will cover local (municipal) roads and streets, thus completing the informational roadway coverage in the state.

  - Strategically located information kiosks could provide information about weather, roadway conditions, incidents, transit station locations and schedule information, and various tourist information. They could also be used to promote Arizona to out-of-state visitors. Recommended implementation is through private/public partnerships, based on the I-40 model. Suggested locations include rest areas, ports of entry, truck stops and commercial centers, tourist information centers, chambers of commerce, restaurants, and hotels/motels.

- It is recommended that ADOT seek to partner with cable TV providers to deliver tourist and traffic information and combine it with yellow pages-type information for delivery at such locations as hotels/motels, other businesses, and private homes. Public access channels on cable TV, especially those already used by local agencies, can broadcast a congestion map. As a minimum, such broadcasts can be delivered during the morning and afternoon peak hours.

- Cellular traveler information services could be provided by contracting with a private partner to deliver information to the traveling public via Personal Digital Assistants (PDAs) with communications interfaces and similar portable devices.

Note: Several kiosks deployed during this project and their effectiveness was limited. Based on this fact, ADOT decided to implement other technologies for rural travelers.

<u>International Border Electronic Clearance</u>

- CVO tracking for NAFTA corridors. Enhanced tracking capabilities of international CVO traffic should be part of the electronic clearance equipment recommended for deployment at Arizona's border crossings.

- CCTV surveillance at ports of entry to consistently monitor traffic conditions. Ports of entry routinely experience congestion. Video monitoring of border crossings on both sides of the border should become part of traffic management at Arizona's border with Mexico.

ITS Planning

- ITS data collection and processing for transportation planning would require a planning function of a regional TOC/TMC, agency-to-agency communications (two-way-landline communications), and computer equipment for data processing.

- Central on-line, GIS-based database of traffic information collected from automatic traffic recording stations, traffic engineering study data, freeway management detector stations, and other sources. This data can then be easily provided to planning and operations organizations.

Network Surveillance

- CCTV cameras should be located at major problem areas (locations where more than 10 accidents occur per year within a one mile radius) and where major traffic congestion occurs.

- CCTV at ports of entry is recommended as an integral part of POE traffic management.

- CCTV at strategically located traffic interchanges would provide early incident detection.

- System detectors (loop, acoustic, and video) should be installed at strategic locations along the state's highway network for early incident detection. These detectors should be connected to traffic monitoring stations (manned or automated). See next item.

- Vehicle detection stations with remote communications could determine volumes and speed of traffic and identify sudden changes of traffic conditions for incident detection. Detectors should be located: (1) where ADT > 70,000, (2) where congestion has been known to occur, (3) where CCTV is installed, (4) within cities, (5) near and at ports of entry, (6) at commercial centers, and (7) where levels of service (LOS) at peak time is LOS "D" or worse. Consider using real time data from ATRs (appropriately modified) for incident detection.

- Systems detecting work zone intrusions (vehicle detection with remote alert capability) should be evaluated and installed as needed. These systems could alert the maintenance crews if an unauthorized vehicle has entered a closed-off area.

- A toll-free telephone number could be set up to collect information from motorists. Many incidents are first witnessed by passing-by traffic. A telephone number (other than "911") should be available for motorists to provide information on such incidents.

- Vehicle speed monitoring and display stations are roadside speed detectors with electronic display boards that could communicate to the passing drivers the current speed of their vehicles.

Surface Street Control

- Traffic signal systems to synchronize traffic signal timing within cities and towns could provide better traffic progression and reduce potential congestion. Generally, a signal system provides benefits where four or five signals are grouped together. Where city and ADOT signals are involved, it is recommended that a system to coordinate all the signals be implemented.

- New traffic signals, where warranted, should be installed. Consideration should be given to additional traffic monitoring equipment (CCTV, system loops) at new traffic locations, as needed.

Traffic Information Dissemination

- Portable variable message signs with remote communications could provide important messages on a seasonal basis. For those locations, such signs should be equipped with remote communications which would allow updated advisory messages to be posted remotely.

- Small, scrolling LED-type information displays could be co-located with kiosks or installed as a partial alternative to a kiosk's functionality.

- Variable message signs are electronic signs to communicate corridor traffic status, weather information, and to advise alternate routes. ADOT has already installed a number of rural VMS, primarily in northern and southeastern parts of the state. Placement criteria suggested by the stakeholders include: (1) before highway junctions, (2) ahead of an exit onto an alternate route, and (3) ahead of the first exit into a city. It is recommended that the following additional criteria, developed through the ADOT ITI effort, be used for VMS placement as conditions dictate: (1) on all interstates within five miles of a border or port of entry, (2) two miles before areas of mandatory snow chain usage, (3) at rest areas, and (4) in advance of other trouble spots or other locations as deemed necessary by the ADOT District Engineer. Finally, the placement of VMS near Arizona's borders should be coordinated with neighbor states (California, Utah, New Mexico).

  The recommended message set for the VMS should include messages capable of notification of: (1) maintenance activities, (2) construction activities, (3) accidents, (4) unique roadway conditions, (5) adverse or potentially adverse weather conditions, (6) road closures, (7) suggestion of alternate routes, and (8) pollution advisories.

- To ensure delivery of the correct, intended messages to the motorists, those variable message signs with remote communications should be accompanied by a CCTV camera, capable of delivering the image of the VMS to the TOC.

- Web-based tourist and traveler information systems could provide traffic conditions information (including road closure), weather, and yellow pages. ADOT's initiative to deliver up-to-date traveler information via the web should be continued and coordinated with other public and private agencies interested in this medium.

- Information clearinghouse(s) for weather, traffic conditions, roadway conditions, and tourist information should include a centralized detour/alternate route database (including highway-rail intersections) with route planning algorithms, and be available via telephone, the Internet, and kiosks.

- Inter-agency information exchange and cooperation. Systems and policies should be put in place to allow for exchange of information affecting the traveler between public agencies.

Transit Maintenance

- Automated mileage, vehicle status, and fuel reporting. The vast majority of transit vehicles in rural Arizona are privately owned. Many rural transit providers benefit from the transit program administered by ADOT. Those providers should evaluate using these technologies to ultimately prolong the life of equipment and improve service.

Weigh-in-Motion

- Locations should be provided for enforcement officers to pull trucks over for the purposes of weighing, verifying credentials, and performing safety inspections. These locations should have WIM and AVI screening devices, and should be located on routes that are or can be used to circumvent the ports, and in locations established by the Motor Vehicles Division, the Department of Public Safety, and local maintenance forces. WIM scales should also be placed at all Arizona ports of entry.

  WIM scales are used to weigh vehicles without stopping. In addition to their role in law enforcement, they provide data for pavement design, the Strategic Highway Research Program, ADOT Structures Section, Transportation Planning Group (Data Section), and information on percentage of overweight vehicles.

6.3.2 Phase II: Mid-term Market Packages (2002 - 2007)

Commercial Vehicle Administrative Processes

- State agencies should expand their collection, review, and processing of CVO safety data capability. Increased use of electronic purchase of credentials, and improved other processing/reporting capabilities, as well as agency-to-agency communications, and infrastructure-to-roadside communications should be explored. It is Arizona's intention to become a participant in the Commercial Vehicle Information Systems and Networks (CVISN) program when funding becomes available under the TEA-21 legislation. Present CVO activities will be correlated towards this goal.

Dynamic Toll/Parking Fee Management

- Parking fee collection systems at tourist attractions should be evaluated to improve parking and fare collection operations.

Emergency Routing

- Highway-rail intersections should be equipped with signal preemption status notification for emergency vehicles. Rural emergency vehicles should be notified, while en-route, of an impending railroad crossing closure if that crossing is along their selected route.

- Expansion of rural E911 could improve response time to emergencies in rural areas.

- Coordinated emergency services dispatch among all involved agencies within a region and across regions could greatly help emergency response time in rural areas of the state. Technologically advanced, coordinated dispatching, coupled with appropriate jurisdictional agreements, is likely to improve the emergency services to motorists on rural highways.

HAZMAT Management

- AVL, two-way communications, collision detection sensors, automated incident notification, and CVO RF intelligent tags for HAZMAT warning are recommended to improve emergency response to incidents involving hazardous materials.

- Other technologies to improve HAZMAT management include agency-to-agency communications, infrastructure-to-vehicle two-way communications, Computer-Aided-Dispatching, HAZMAT tracking, inter-agency location, and route database sharing.

Information Service Provider-Based Route Guidance

- The majority of the technologies required to provide this service reside in the vehicle and include stored map databases, processors with routing software, AVL devices, wireless transceivers for data updates, and in-vehicle displays. Updates for the in-vehicle system are provided by information clearinghouses and contain traffic, roadway, weather, and yellow pages information. These information clearinghouses may also include route-planning algorithms, with calculated routes sent to the traveler via two-way radio or cellular communication links. ADOT and other agencies participating in information dissemination should partner with private service providers to include their information in this service.

Lateral Safety Warning

- Safety sensors (including collision sensors). As with most in-vehicle devices, the deployment of various safety sensors is largely in the private domain. It is recommended that ADOT consider using these technologies in their fleet vehicles.

Longitudinal Safety Warning

- Wildlife roadway crossing deterrents could help reduce the number of accidents involving deer and elk crossing rural routes in Arizona. Measures to reduce these types of incidents, such as the installation of roadside equipment to deter wildlife, should be considered.

- Wildlife warning signs could provide information to the traveling public of seasonal migration of elk/deer crossing public roadways. These should be located where 10 or more kills have occurred within a year, or where non-local traffic varies. VMS could be evaluated for effectiveness in reducing wildlife and livestock kills; use of portable VMS may be more effective. If VMS is selected for this purpose, wildlife warnings could be coordinated with the overall VMS system; however, it is not recommended that permanent VMS be installed for the sole purpose of providing wildlife warnings.

Mayday Support

- Coordinated corridor Mayday systems with automated route planning could allow stranded vehicles to notify emergency response units of an incident including location and vehicle description. One criterion for corridor selection for Mayday is average time between cellular phone owners (provide Mayday services if greater than 10 minutes, or approximately 4,000 ADT). These technologies are being developed by car manufacturers.

- Expanded cellular coverage could provide a better means for notification of emergencies. It is desired to have 100% coverage on all interstates and highways in Arizona. A study of cellular coverage in Arizona revealed numerous coverage gaps, especially along remote routes. Private/public partnerships should be considered to improve cellular coverage.

On-board CVO Safety and Roadside CVO Safety

- The deployment of these market packages is controlled by private fleets, with some cooperation from ADOT, which operates the roadside (i.e. POE-installed) RF scanners and databases. These technologies include: audio warning systems, deployable pre-crash safety systems, in-vehicle driver monitoring sensors, roadside data processing devices, and electronic tags (RF) – including AVI. ADOT's role could also include logging the quantity and operation of the trucks' safety equipment upon passage through the POE and thus encourage the CVO to install such devices.

Standard Railroad Grade Crossing

- Passive and active railroad crossing signs should be considered for all locations where railroad crossings are at grade within the Highways of National Significance. This technology still needs to be evaluated.

Traffic Information Dissemination (continued)

- Highway Advisory Radio (HAR) should be considered for at least the interstate routes in Arizona, at locations permitting the selection of an alternate route. Stations at interchanges could reach motorists in each direction to provide critical traffic information.

Transit Security

- Audio and video monitoring of transit stops are recommended to improve security. These monitoring devices should be manned by a private security agency, police or DPS.

Transit Vehicle Tracking

- Automatic transit vehicle location (AVL) and identification (AVI), coordinated transit dispatch, and improved transit routing are recommended to help increase transit efficiency and ridership in rural Arizona.

Note: Off-the-shelf, low-cost, Internet-based fleet dispatch solutions, requiring minimal installation and support, are currently available.

Yellow Pages and Reservations

- Coordinated yellow pages and reservations processing via kiosk, telephone, Internet, interactive TV, Personal Computer, and PDA could be made available alongside the publicly available traveler information (provided by ADOT) to increase usage at the base services. Once improved, in-vehicle data access and display devices and two-way communications become more prevalent in the private vehicle, the dissemination of these services should be extended to these vehicles as well.

6.3.3 Phase III: Long-term Market Packages (2008 and beyond)

Advanced Vehicle market packages, including Advanced Vehicle Lateral Control (lateral collision avoidance sensors, lateral position sensors or lane control), Advanced Vehicle Longitudinal Control (longitudinal collision avoidance sensors, speed control devices), and Driver Visibility Improvement (on-board display hardware such as heads-up display, sensor systems such as infrared sensors) are likely to become widely used in the near future. Many of these types of equipment are being operationally tested or are available today. It is recommended that ADOT participate in the deployment of these technologies by providing test vehicles for operational tests and by installing proven devices in their own fleet vehicles.

Autonomous Route Guidance and Dynamic Route Guidance constitute yet another set of market packages whose deployment depends largely on the private sector. Technologies used include portable processors with GIS software and graphical user interface, in-vehicle data processing and display devices, GPS, and stored map databases. Similar to the Advanced Vehicle market package, ADOT should fill the role of the promoter of these technologies, which will include making appropriate data and communications interfaces (such as FM subcarrier) available to private providers.

<u>Emergency Response</u>

- Interconnected local and wide area networks (LANs and WANs) in rural communities could be used to promote jurisdictional connectivity. The results would be better coordination of emergency notification, dispatch, and other related services.

<u>In Vehicle Signing</u>

- Heads-up and dash-mounted displays and other in-vehicle information delivery technologies are gaining popularity. ADOT should be ready to provide traveler information in a format that would be suitable for distribution to such devices with a minimal amount of conversion.

<u>Integrated Transportation Management/Route Guidance</u>

- In-vehicle data processing and display devices, GPS, stored map databases, GIS software with GUI, and infrastructure-to-vehicle communications (e.g. cellular or mobile satellite phone).

- Traffic, roadway, weather, and yellow pages information clearinghouse, infrastructure-to-vehicle communications

<u>Intersection Safety Warning</u>

- Signal control at the traffic management subsystem level to provide signal priority for emergency and other vehicles. Traffic signal control systems and signal coordination are required to provide this service.

<u>Pre-Crash Restraint Deployment</u>

- These are vehicle sensors (detecting lateral and longitudinal distances, weather and roadway conditions) combined with processors equipped with algorithms to determine collision probability and to activate the deployment of a pre-crash safety system. These detection systems should be supplemented by additional sensors for weather and roadway conditions and roadway geometry. A processor in the vehicle could assimilate this information and determine the probability of a collision with the other vehicle or obstacle. If the collision probability is high, it would deploy a pre-crash safety system either to avoid the accident or to reduce the accident severity. The deployment of these and other in-vehicle devices and systems depends on the car manufacturers and market response to these products. Their use is highly recommended for ADOT and other agency fleets when they become available and affordable.

<u>Regional Traffic Control</u>

- TMC-to-TMC wireline communications, traffic coordination between local and regional jurisdictions.

<u>Transit Fixed-Route Operations</u>

- Two-way, wide-area wireless communications, and display devices could improve two-way communications (including improved coverage) between the transit vehicle and the dispatching center to provide higher quality, real-time bus schedule information. Information displays combining the route and vehicle data are recommended for the transit center to facilitate coordination.

- Transit centers should be equipped with automated route planning and vehicle scheduling algorithms, infrastructure-to-infrastructure communications for current schedule dissemination, CAD software, and computer hardware.

Vehicle Safety Monitoring

- Sensors monitoring steering, braking, acceleration, emissions, fuel economy, engine performance, etc.; on-board processors and display devices; audio warning devices.

Virtual TMC and Smart Probe Data

- In-vehicle processing and audio and video (display) devices for information delivery to the driver.

- Multi-TMC roadway management functions related to weather conditions; traffic, roadway, and weather information clearinghouse; and infrastructure-to-infrastructure communications

6.3.4 Miscellaneous

The following projects did not fit directly into any of the pre-defined market packages offered by the National Architecture, but are included in this *Strategic Plan* due to their importance to improving rural Arizona's transportation system as expressed by stakeholders.

- Improved sign management and signing program for ADOT and municipalities. These programs are recommended based on input from the stakeholders. Signs on a number of rural routes are old and deteriorated or missing altogether. The quantity of multilingual signs, especially near tourist attractions, should be increased.

- Traveler education on available information types and sources would greatly increase the effectiveness of a traveler information program. Traveler information systems can only be successful if they are being used. Educating the travelers on the availability and use of information should become part of ADOT's and private partners' programs.

- Driver education on benefits and capabilities of ITS. The ADOT Driver License Manual should include information on ITS as it is a document that is read by every driver at least once. This information could also be mailed along with the registration renewal packet.

- Automated vehicle guidance systems could greatly help ADOT maintenance activities. ADOT is currently in the process of evaluating in-vehicle navigational aids installed in a snow-plow as part of a field operational test being conducted jointly with CALTRANS. Improved winter road maintenance is an important function for ADOT maintenance crews in northern Arizona, and has significant bearing on the quality of travel, including safety, on the I-40 corridor as well as other major Arizona routes with snowfall.

- The locations of selected projects are shown in **Figure 6.3.4-1**.

Recommended Arizona ITS Projects

Strategic Plan for Statewide Deployment of Intelligent Transportation Systems

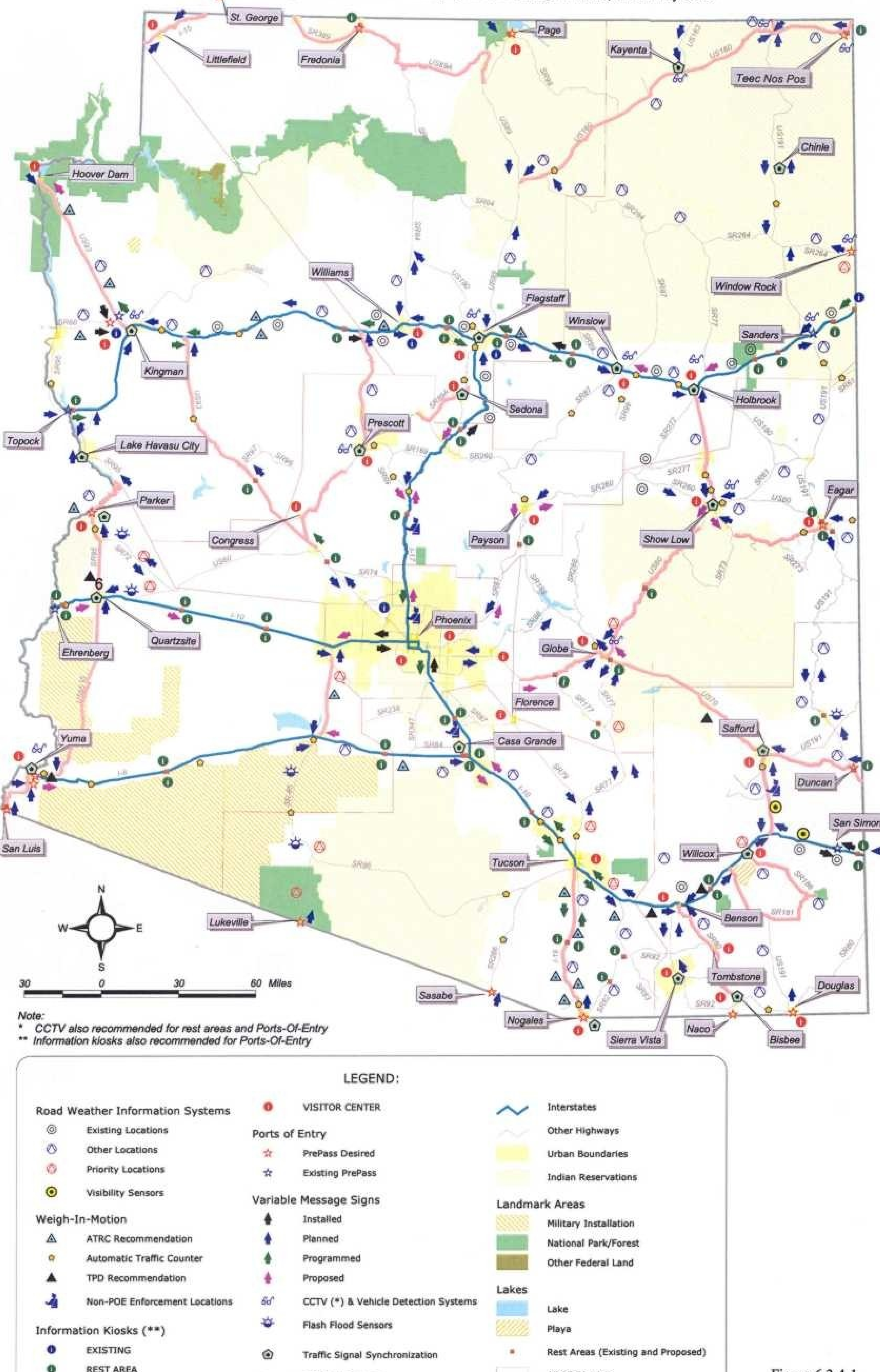


Figure 6.3.4-1

6.4 BUSINESS PLAN FOR DEPLOYMENT

The objective of preparing a business plan and management structure is to establish a framework for policy, process, and action among the public and private jurisdictions involved. By establishing a management structure, the interest and involvement of the stakeholder Coalitions created throughout the development of this *Strategic Plan* will continue. This interest must be maintained in order for deployment of the technologies to become a reality.

6.4.1 Plan Oversight

During the development of the *Strategic Plan*, numerous agencies and individuals became involved with or closely followed the progress of the study through meetings and project newsletters. Those who participated in the workshops, focus groups, and Coalition meetings included representatives from:

- Arizona Association of Governments
- Arizona Department of Public Safety
- Arizona Department of Transportation
- Arizona Division of Emergency Management
- Arizona Office of Tourism
- Arizona State Parks
- Chambers of Commerce
- Cities and towns
- Councils of Government
- Counties
- Department of Corrections
- Federal Highway Administration
- Marine Corps Air Station
- Metropolitan Planning Organizations
- National Park Service
- Native American tribes
- Police
- Private citizens
- Radio Stations
- Railroad
- Rural Fire Department
- Television stations
- Press and media
- Transportation consultants
- Western Transportation Institute
- Transportation Planning Organizations
- U.S. Army
- Universities (ASU, NAU, University of Minnesota)
- U.S. Forest Service

The interaction of the Coalition members was intended to bring about a strengthening of interest in ITS solutions among government and private agencies. Although this study has not produced a structured coalition of individuals, many of the Coalition members, and particularly the Western Desert Coalition, showed remarkable interest in the study. Three coalitions, shown schematically in **Figure 6.4.1-1**, were formed:

- Western Desert
- East-Central Mountains
- Southeastern Border

These groups did not mature into formal organizations; however, several individuals and organizations within each of the three Coalitions have the potential to be the nucleus of the future regional forces that will lead Arizona's statewide ITS effort.

It is suggested that a number of individual ITS technology champions be selected from the present Coalitions and continue to function as the oversight and policy guidance body of the deployment plan within each of three Arizona regions. These individuals should continue to assure that the jointly developed *Strategic Plan* for rural Arizona is meeting the needs of the economy of their respective regions as well as those of travelers through and visitors to those regions. The Coalitions <u>must</u> <u>continue</u> for ITS to succeed in rural Arizona.

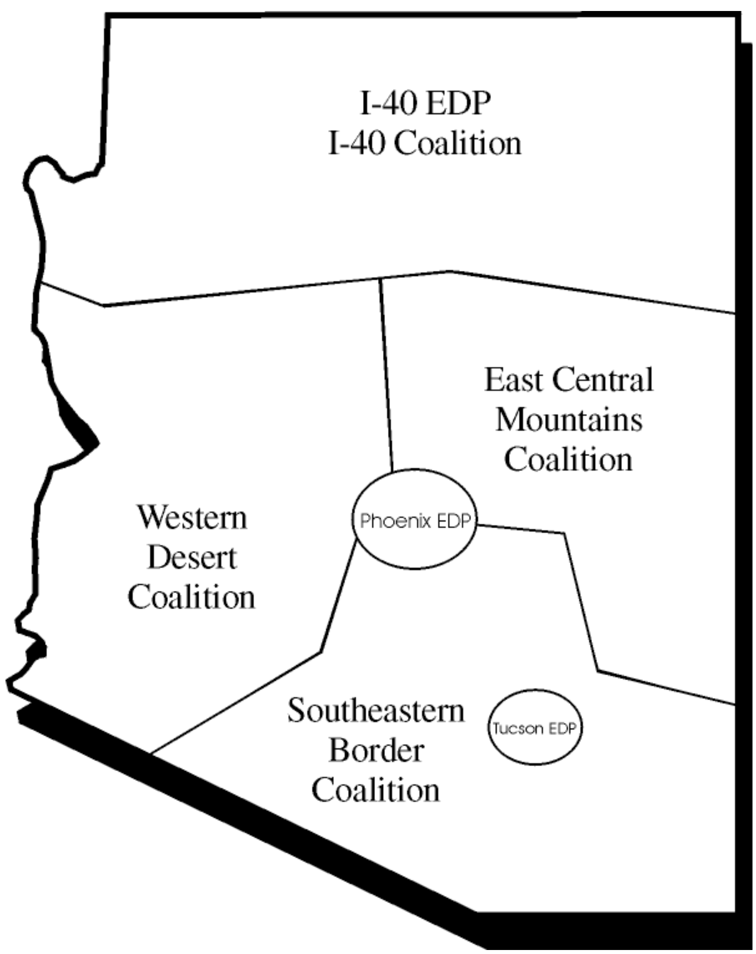


Figure 6.4.1-1
Arizona Stakeholder Coalitions

A second function of the Coalitions would be to review new technologies and new concepts as they become available, and to determine if a change is needed in this *Strategic Plan* as it currently stands. The Coalitions should work directly with ADOT and other state and federal agencies to respond to questions or issues dealing with the direction, funding, administration, deployment, operation, and maintenance of ITS projects as they come on-line.

6.4.2 Rural Arizona ITS Management Team

The management structure is a significant element of any statewide plan. A management team, made up of dynamic individuals from the sponsoring agencies, should be created to serve as the foundation for project implementation. As the Strategic Plan is further developed into specific tactical plans, funding is secured, and implementation proceeds, a flexible approach should be maintained by the management team.

Opportunities may become evident at any time for earlier implementation of projects. These "windows of opportunity" may present themselves in the form of alternative funding sources, local improvements, private initiatives, or higher priorities being assigned by state, federal, or local governments, or by the private sector. As these "earlier than early deployment" opportunities arise, the management team's task will be to review the *Strategic Plan*, in close cooperation with the Coalitions, and set new strategies and priorities.

Additional management responsibilities will include initiating the specific parts of the *Strategic Plan*, getting activities on track, securing funds, scheduling team meetings and project reviews, maintaining control and supervision for all projects, and reporting to top management in each stakeholder organization. Generally, these tasks are most effectively accomplished when assigned to a single, qualified project manager located in an ADOT unit who will be responsible for operation of the built system, or at least part of it. The management aspect of the *Strategic Plan* will define the specific responsibilities, the inter-governmental agreements that must be established, recommendations regarding leadership, the involvement of each agency, and the control hierarchy. Since most projects are interagency and/or public-private initiatives, a more complex situation is evident.

It is therefore suggested that an ITS Management Team be formed to deal with administration of the *Strategic Plan*. It is suggested that this management team be staffed by a "champion" of ITS for each of the three regions who the Coalitions feel have the energy and desire to see the deployment plans carried out, and in a strong position to influence funding priorities for each region. The manager of the ITS Coalitions should be willing, and understand how, to serve under a "matrix" management structure, with policy guidance coming from the independent Coalitions, but administration support coming from ADOT.

It is recommended that the ITS Management Team consist of key agencies involved in funding and implementation. The specific function of this Management Team would be to support the state, local, and private sector deployment teams that would be responsible for deploying the various projects. This Management Team would meet on a more regular basis than the coalitions, perhaps bi-weekly or monthly (depending on issues "on the table") to deal with the actions that assure that this *Strategic Plan* is implemented.

It would be logical that the responsibilities to oversee the ITS program in Arizona be assigned to Metropolitan Planning Organizations and Councils of Governments, with ADOT's lead. There are currently ongoing planning efforts of the AZTech program to become the ITS program for the entire state of Arizona, which will likely result in a statewide ITS management structure that cannot be completely foreseen at this time. It is suggested that "The Gathering" of Arizona's planning executives, which convenes two to three times per year, be the main forum for ITS planning activities in the state. "The Gathering" is chaired by Mary Peters (Director of ADOT) and includes participants from the various regional Councils of Governments, including Maricopa Association of Governments, Pima Association of Governments, Yuma Metropolitan Planning Organization, and the Flagstaff Metropolitan Planning Organization.

6.4.3 Management Structure for Operations and Maintenance and Summary of Implementation and Operations Plan

It would be easy to identify the management structure for operating and maintaining any intelligent infrastructure deployed in rural Arizona as a responsibility of the ADOT District offices in the region. These units will of course be involved, and for a major part of the infrastructure recommended, it will in fact be left up to the District Engineers (who, as suggested previously, should be considered a part of the Executive Committee of the Management Team). Within each of these Districts, these responsibilities should be assigned to an individual with some background in communications systems, or, at a minimum, traffic systems. This individual should be at a fairly high level in the organization, and should have at least five years of experience with ADOT, or similar experience in another state or local transportation department.

The identification of an individual, the preparation of a job description, and the recruiting or promotion within the organization to fill this demanding job are not the only actions that should be taken. First, there are a number of market packages (and thus, projects) that will be the responsibility of a government agency or private-sector company. A review of the input of the Coalitions in working with the consulting team to identify appropriate responsibilities and involvement by various organizations is shown in **Table 6.4.3-1**.

In general, the organization that is responsible for building a system or having ownership of the system is the organization responsible for operation and maintenance (O&M). Obviously, an owner can contract out any services that are needed, particularly in situations where cost advantages or the availability of individuals with special skills are needed and are not available to a system owner/ builder. Such has been the case with some aspects of public-private partnerships to build, operate, and maintain ITI features.

Table 6.4.3-1
Organizations with Responsibility for ITS Deployment

BEGIN DEPLOYMENT (TERM)		NAU	ASU	UofA	Federal Communication Committee(FCC)	All Broadcast Media	Information Service Providers (Internet, cable, telephone)	Traffic Information Providers	AZ Office of Tourism	Visitor Centers	Tourist Industry (AAA, other)	Tourist Attractions	Associations of Governments	Local Governments (municipal, county, tribal)	Municipal Planning Organizations (MPO)	ADOT/FHWA	Railway Companies	Trucking Companies	Transit (bus, tour bus and shuttle companies)	Department of Public Safety (DPS)	Dept. of Environmental Quality (DEQ)	National Park Service (NPS)	National Weather Svc. (NWS)	U.S. Forest Service (USFS)	HAZMAT Teams	EMS/911 Operator	ITS Equipment Vendors	Vehicle Manufacturers	Private Security Companies	Cellular Industry	Towing Industry	Adjoining States
S	Broadcast Traveler Information				X	X	X	X		X	X	X		X		X			X	X		X	X				X	X		X		X
S	CVO Fleet Maintenance																	X	X								X					
S	Electronic Clearance				X											X		X									X					X
S	Emergency Response	X	X	X	X	X							X	X		X				X		X		X	X	X	X		X	X	X	X
S	Emissions and Environmental Hazards Sensing												X			X					X	X	X		X		X					X
S	Fleet Administration							X						X		X		X	X								X				X	
S	Freeway Control	X	X	X								X				X				X	X						X					X
S	Incident Management System	X	X	X		X		X				X	X	X		X	X			X		X	X		X	X	X		X	X	X	X
S	Interactive Traveler Information					X	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X			X	X	X	X		X
S	International Border Electronic Clearance			X	X											X		X									X					X
S	ITS Planning	X	X	X				X					X	X	X	X					X	X										X
S	Network Surveillance							X						X		X		X	X	X							X					X
S	Surface Street Control							X						X		X					X						X					X
S	Traffic Information Dissemination				X	X	X	X		X		X	X	X		X			X	X		X					X	X		X		X
S	Transit Maintenance												X	X					X								X					
S	Weigh-In-Motion															X											X					
M	CV Administrative Processes															X		X	X	X												X
M	Dynamic Toll/Parking Fee Management										X	X		X		X			X			X					X	X				
M	Emergency Routing	X	X	X			X	X		X			X	X		X				X		X		X	X	X	X	X	X	X	X	X
M	HAZMAT Management					X	X	X					X			X	X	X		X	X	X			X	X	X	X	X	X		X
M	ISP Based Route Guidance					X	X	X			X																X	X		X		X
M	Lateral Safety Warning																		X								X	X				
M	Longitudinal Safety Warning	X	X	X															X								X	X				
M	Mayday Support				X	X	X	X					X	X		X				X		X			X	X	X	X	X	X	X	X
M	On-board CVO Safety																	X	X								X	X				
M	Roadside CVO Safety															X		X		X							X	X				X
M	Standard Railroad Grade Crossing													X		X	X										X					
M	Transit Security					X								X		X	X		X	X		X		X		X	X	X	X			X
M	Transit Vehicle Tracking																		X			X					X	X				X
M	Yellow Pages and Reservation					X	X		X	X	X	X		X					X			X					X			X		X
L	Advanced Vehicle Lateral Control																	X	X								X	X				
L	Advanced Veh. Longitudinal Control																	X	X								X	X				
L	Autonomous Route Guidance																	X									X	X				
L	Driver Visibility Improvement																	X	X								X	X				
L	Dynamic Route Guidance				X		X	X								X		X									X	X				
L	In Vehicle Signing							X								X		X	X								X	X				
L	Integrated Transportation Management/Route Guidance				X	X	X	X					X	X		X						X					X					X
L	Intersection Safety Warning															X			X			X					X					
L	Pre-Crash Restraint Deployment																	X	X								X	X				
L	Regional Traffic Control												X	X		X					X	X					X					X
L	Transit Fixed-Route Operations												X	X		X			X			X					X					X
L	Vehicle Safety Monitoring															X		X	X								X	X	X			
L	Virtual TMC and Smart Probe Data	X	X	X									X			X		X	X	X							X	X				X

S: Short-term
M: Mid-term
L: Long-term

6.5 PLANNING ESTIMATES OF DEPLOYMENT CAPITAL, OPERATIONS, AND MAINTENANCE COSTS

Using the data in the "*ADOT Statewide Plan: Intelligent Transportation Infrastructure*," February 1997, and input from the stakeholders, the goal of this study has been to produce an updated listing of projects to be implemented throughout the state in the short-, mid-, and long-terms.

The planning-level estimate of the total public cost of deploying Intelligent Transportation Systems in rural Arizona indicates the need for funding in the next 15 years in amounts shown in **Table 6.5-1**. These estimates are presented in current-year dollars. While inflation would contribute to the price increases for materials and services required to implement the ITS elements listed in **Table 6.5-2**, it can be assumed that funds for these projects would also be subject to growth at a reasonable interest rate, thus offsetting the effects of inflation.

Table 6.5-1
Cost Estimate Summary
of ITS Deployment for Public Sector

Item	**Projected Funding Required**
ITS Communications 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**

Table 6.5-2 presents a more detailed planning estimate and serves as a budgetary estimate of the public capital expenditure that would be required to provide basic communications and ITS infrastructure for the system outlined in Technical Memorandum 4 and in this *Strategic Plan*.

Costs are based on leased lines (initially) and fiber-optic (in the future, through use of shared communications infrastructure of private providers) linkage between TMCs. The cost of the leased lines is based on the bid tabs from recent RWIS construction projects in rural areas in Arizona and is estimated per telephone drop (for each field device). The cost associated with field communications interfaces (e.g. modems, optical transceivers, etc.) is assumed to be included in the total cost of each device (cost "in-place").

In addition to the cost of communications equipment, field devices, and other hardware and software, this cost estimate includes the recommended amount of "seed" funds for other types of projects related to ITS deployment in Arizona. These projects include various studies or activities (such as Mayday corridor studies, technology evaluations, cellular coverage gaps, etc.) that are expected to be necessary throughout the deployment process. The design and construction costs are conservatively estimated at 40% of the projected capital budget, while operations and maintenance is estimated at five percent of the capital budget per year, for 15 years.

Table 6.5 -2
15-Year Deployment Estimate for Basic Intelligent Transportation Infrastructure in Rural Arizona

Item	Qty	Unit Price	Estimated Statewide Cost	Electronic Clearance	Emergency Response	Emiss. & Env. Hazards Sensing	Incident Management System	Int'l Border Electronic Clearance	Longitudinal Safety Warning	Network Surveillance	Surface Street Control	Traffic Information Dissemination	Weight-In-Motion
Communications Infrastructure													
Short-term Communications: leased telephone lines (cost estimated per telephone drop)	365	$10,000	$3,650,000										
Testing and Integration	365	$1,000	$365,000										
COMMUNICATIONS SUBTOTAL			**$4,015,000**										
Field Hardware/ Software				**MARKET PACKAGE**									
Variable Message Signs	143	$200,000	$28,600,000				**X**					**X**	
Video Cameras	73	$35,000	$2,555,000		**X**	**X**		**X**		**X**		**X**	
PrePass at Ports-of-Entry	17	$200,000	$3,400,000	**X**									
Other Weigh-in-Motion	61	$50,000	$3,050,000	**X**									**X**
Road Weather Information System	56	$50,000	$2,800,000			**X**							
Elk Crossing Signs	10	$30,000	$300,000						**X**				
Traffic Signal Coordination	19	$250,000	$4,750,000								**X**		
Flash Flood Sensors	5	$ 30,000	$150,000			**X**							
Blowing dust/visibility sensors	2	$20,000	$40,000			**X**							
Non-POE Enforcement Locations	4	$60,000	$240,000										**X**
Vehicle Detection Systems (non-POE)	11	$5,000	$55,000							**X**			
HW/SW SUBTOTAL			**$45,940,000**										
Other deployment efforts (e.g. MAYDAY corridor studies, technology evaluations, cellular coverage gaps studies, etc.)	1	$500,000	$500,000										
SUBTOTAL ITI CAPITAL COSTS			**$50,455,000**										
Design, Contingency, Construction Engineering	@ 40% of capital costs		**$20,182,000**										
Operations and Maintenance	@ 5% of capital costs per year for 15 years		**$37,841,000**										
TOTAL ITS Estimate			**$108,478,000**										

This cost estimate considers only the public portion of the Intelligent Transportation Infrastructure in the state. Private industry is expected to provide a significant portion of ITS services and equipment, both within and outside of public-private partnerships. Estimates are not available at this time for the cost of cellular or digital communications service (DCS) phone coverage.

Although no definitive studies have been made to suggest the level of private funding anticipated specifically in rural areas, estimates up to 2.5 times the public investment have been made for overall private ITS technology deployment. For example, the "Intelligent Transportation Systems National Investment and Market Analysis" study by Apogee Research, Inc. and Wilbur Smith Associates (ITS America, 1997) predicts that private ITS markets are expected to exceed $340 billion over the next 20 years, with public infrastructure-driven markets in the U.S. metropolitan areas projected to exceed $80 billion over the same period. This study is already being used to set the national agenda for ITS in the United States.

Using a conservative multiplier of 2.15, it might be assumed that the prorated private investment in ITS in Arizona could total $233 million over the next 15 years.

7. EVALUATION OF DEPLOYED ITS TECHNOLOGIES

7.1 INTRODUCTION

This chapter describes the long-term plan for evaluating the effectiveness of ITS technologies deployed in rural Arizona. This evaluation plan will be carried out during the coming years as ITS technologies are deployed.

There are numerous compelling reasons for and benefits of conducting an evaluation. An evaluation will:

- Assess or quantify improvements in transportation service and performance. These demonstrated benefits will promote future public and private sector investment in ITS projects in Arizona. Demonstrating these benefits will be important to maintaining support among the public sector partners, private sector partners, and the general public. Each of these groups will be seeking assurance that their investment in ITS projects is well spent;

- Identify which ITS projects have been more productive in improving transportation service and performance. This information will assist in targeting future investments in ITS projects, both in terms of individual projects and in geographic coverage;

- Identify possible enhancements to ITS systems deployed in the state. Additional capabilities would serve additional needs or reduce costs; and

- Recommend geographic expansion of individual projects and systems in future years.

Several principles guided development of the evaluation plan. The principles are described as follows:

- The evaluation plan must focus on the ITS projects that have been recommended for implementation. The plan must be designed to assess how well these projects are meeting statewide needs;

- The evaluation plan must use performance measures that are readily available and easily and relatively inexpensively measured. It will be most convenient, when possible, to select data that are already being collected. This will minimize the resources that must be devoted to evaluation;

- Baseline data (data representing conditions before the implementation of ITS projects) must be currently available or collected before deployment of the ITS projects;

- An “evaluation program” budget and schedule should be established so that resources can be allocated to the evaluation task; and

- An organization which will be responsible for evaluation should be identified, and should accept responsibility for evaluation to assure that the evaluation task is not overlooked or forgotten.

Evaluation must be a continuing and ongoing effort because projects will be deployed in the short-, medium-, and long-term. The geographic coverage of individual services is likely to expand with the passage of time, and implementation of ITS technologies will likely change from the current plan due to changes in technology, changes in needs, and in response to the results of evaluation in the early years of deployment. It will be important to know the impacts of ITS projects and services at each step in time so that better decisions can be made about deployment of ITS projects for future phases.

The evaluation plan developed now will be designed to assess the initially-recommended ITS projects. As projects and services to be deployed in later time periods become more clearly defined, the evaluation plan will need to be updated.

The evaluation results must be shared with the Technical Advisory Committee members and the key stakeholders on each project. Results demonstrating positive benefits will be important in maintaining support among the public sector partners, private sector partners, key stakeholders, and the general public.

7.2 EVALUATION PLAN ITEMS

The key items of an evaluation plan are listed below. Items 2 through 7 are addressed in detail in the following sections.

1. Identify the organization that will be responsible for the evaluation. This may require a contract by ADOT with another agency or organization.

2. Summarize projects recommended for deployment (Section 7.3).

3. Summarize system objectives and performance measures (Section 7.4).

4. Specify measures for assessing effectiveness (Section 7.5).

5. Identify data to be collected and design of data collection (Section 7.6).

6. Plan collection of baseline data (Section 7.6.1).

7. Plan for analysis and interpretation of data (Section 7.6.2).

8. Plan for sharing evaluation results with participants.

The remainder of this chapter is organized around these key items, as they apply to the statewide ITS deployment in Arizona.

7.3 PROJECTS RECOMMENDED FOR DEPLOYMENT

Chapter 6 recommended a number of ITS projects for statewide deployment. Section 6.3 provides a listing of those recommended projects. The projects are grouped by deployment timeframe and market package.

7.4 SYSTEM OBJECTIVES AND PERFORMANCE MEASURES

Chapter 4 provided a review of the needs in rural Arizona and defined system objectives and performance measures.

Each performance measure was evaluated based on the following considerations:

- Ability to describe system performance in a meaningful way and to identify system deficiencies;
- Measurability;
- Ease of data collection;
- General use or understanding of the measure among transportation professionals;
- Sensitivity of the measure to system expansion or enhancement;
- Applicability to statewide-level assessment; and
- Ease of computation/estimate.

7.5 MEASURES FOR ASSESSING EFFECTIVENESS

7.5.1 Candidate Measures

Chapter 4 identified 36 performance measures. Those 36 performance measures were further reviewed in this task.

In addition to the performance measures identified previously, additional quantitative measures that are recommended to be considered include:

- Number of trucks stopped at the ports-of-entry;
- Number of trucks by-passing the POE, due to lack of capacity;
- Number of trucks by-passed because of prior clearance;
- Mayday performance;
- Mayday system coverage on rural highways;
- Coverage of driver early warning systems;
- Emergency service call-outs;
- Number of "hits" for traveler information web pages (such as the www.azfms.com web site); and
- Number of calls to the 1-888-411-ROAD number.

Final selection of measures for assessing effectiveness was guided by the following considerations:

- Performance measures should be used that are associated with a large number of needs rather than just one or two;
- Performance measures should be used that provide the best chance of detecting a change;
- Performance measure information must be readily available and easily measured; and
- Performance measures with existing available data are preferable.

The evaluation plan has been designed to use the following selection of performance measures; additional details are provided in Section 7.6 of this report.

Quantitative measures

- Accident rate;
- Availability of traveler information (quantifiable aspect);
- Coverage of driver early warning systems;
- Emergency service call-outs;
- Mayday performance;
- Mayday system coverage on rural highways;
- Number of fatal accidents;
- Number of visitors;
- Timelines and traveler data; and
- Tow truck service calls.

Qualitative measures

- Availability of traveler information (perceptions);
- Conformance/response to messages;
- Customer survey data; and
- Level of service (LOS).

7.5.2 Challenges in Using Performance Measures

One of the challenges in evaluation is determining whether changes in performance measures over a period of time are the result of ITS projects or can be attributed to other factors. In other words, can it be proven that the ITS project is reason for the improvement? Another challenge relates to multiple, simultaneous project deployments. When multiple ITS projects are deployed, a performance measure may be affected negatively by one project and, at the same time, positively by another.

7.6 PROCESS FOR DATA COLLECTION AND ANALYSIS

7.6.1 Data Collection

Baseline data will serve as the frame of reference by which changes in performance will be measured. At present, very little ITS technology is deployed in rural Arizona; however, it is anticipated that improvements to the existing technologies will continue to be made and that additional ITS projects will be deployed within the coming year. Therefore, baseline data should be collected now. The following baseline data should be collected in 1999.

Quantitative Measures

- Accident rate.
  - Total number of accidents (by year) on state highways and interstates within Arizona in 1996, 1997, and 1998.
  - Number of accidents involving trucks (by year) on state highways and interstates in 1996, 1997, and 1998.
  - Number of accidents involving wet or icy pavement (by year) on state highways and interstates in 1996, 1997, and 1998.
  - Total traffic count / vehicle miles traveled data (by year) for state highways and interstates in 1996, 1997, and 1998.
  - Truck traffic count / VMT data (by year) for state highways and interstates in 1996, 1997, and 1998.
  - Starting and ending mileposts for segments of state highways and interstates with steep grades.
  - Starting and ending mileposts for segments of state highways and interstates subject to congestion.
- Availability of traveler information.
  - Number of traveler information kiosks currently deployed in rural parts of the state.
  - Amount of traveler information available in kiosks (number of pages, quantity of information).

  - Traveler information currently available on web pages (including hypertext link status/number of valid links, number of pages).

  - Usage of current sources of traveler information (number of “hits”).

  - Number of “hits” for traveler information web pages.

  - Number of calls to the 1-888-411-ROAD number.

- Coverage of driver early detection and warning systems.

  - Number of strategically placed variable message signs.

  - Geographic coverage of the Road Weather Information System (data collection stations).

  - Geographic coverage of the installed visibility sensors (data collection stations).

  - Geographic coverage of flash flood sensors.

  - Geographic coverage of FM Traveler Advisory Radio (coverage of participating radio stations).

- Emergency service call-outs.

  - Agencies and private providers of emergency services in Arizona.

  - Number of emergency service call-outs in 1998 for roadway-related emergencies on state highways and interstates and occurring outside of urban areas.

- Mayday system performance.

  - Incident detection time.

  - Incident location accuracy.

  - Incident notification time.

  - Incident response time.

- Mayday system coverage on rural highways.

  - Cellular coverage along rural corridors.

  - E911 rural coverage.

  - Number of coordinated Mayday systems in place for rural areas.

- Number of fatal accidents.
  - Number of fatal accidents (by year) on state highways and interstates 1996, 1997, and 1998.
- Number of visitors.
  - Number of visitors at visitor information centers in 1998 (estimates could use number of information searches performed using a kiosk).
  - Number of visitors to selected visitor attractions in 1996, 1997 and 1998.
- Timelines and traveler data.
  - Using kiosks in rural areas as a baseline.
- Tow truck service calls.
  - Private providers and government agencies that provide tow truck service on state highways and interstates.
  - Number of tow truck service calls in 1998 on state highways and interstates and occurring outside of urban areas.

Qualitative Measures

- Customer survey data.
  - Understanding of ITS.
  - Utilization of ITS.
  - Availability of traveler information (perception of users).
  - Satisfaction with technologies.
  - Conformance / response to messages.
  - Satisfaction with available communications channels (survey agency personnel).
- Level of Service (LOS)
  - LOS at selected rural locations (selection based on known current congestion levels).

Subsequent data should be collected after initial ITS projects have been deployed and operational for at least a few months. Since some performance measures are based upon annual counts of information, complete impacts may not be obvious until one year following implementation. Continuing evaluation can be done at annual intervals. Data collected each year can be compared with prior years to assess changes in performance.

7.6.2 Analysis and Interpretation of Data

Analysis and interpretation of the data can help to identify possible enhancements to the statewide ITS, suggest geographic expansions of the deployed technology, and identify additional systems for deployment.

7.6.3 Sharing Evaluation Results with Stakeholders

Sharing of evaluation results with rural residents and travelers on the state highway network, both public and private, is important to the continuing success of ITS in rural Arizona. Evaluation results represents feedback on the effectiveness of the participants' commitment of resources to ITS projects in the state. The feedback is vital for their continued interest and participation.

It is recommended that a report documenting the baseline data be distributed to the participants within three months following collection of baseline data. In future years, the results of annual evaluation analyses should also be distributed to the participants in the form of a written report.

7.6.4 Responsibility for Evaluation

An organization must be designated to have responsibility for executing the evaluation plan. This will assure that the evaluation task is not overlooked or forgotten. The responsible organization could be one of the following:

- Arizona Department of Transportation;
- A non-profit entity interested in promoting ITS deployment in Arizona;
- A state university;
- A coalition of Councils of Governments; or
- A consultant.

The options should be considered as part of an evaluation to be conducted by ADOT in-house staff (if staff resources are available) or by an independent organization hired under contract. In order to use available resources in a manner that would allow expediting contracting arrangements, a contract with a university is recommended, if appropriate faculty and staff resources are available and interested.

An evaluation budget should be established so that resources can be allocated to the evaluation task. It is estimated that the budget to collect the baseline data would be about $1,000,000 (20 projects over 15 years at $50,000 each). A full 12 months of data should be collected as part of setting the baseline. After a particular project is implemented, a 12-month period of data collection should follow.