Greater Yellowstone Rural ITS Priority Corridor Project

Task 11

Define Regional Architecture

Prepared for:

Montana Department of Transportation

and

U.S. Department of Transportation,

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In Cooperation with:

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Wyoming Department of Transportation,

and

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IMPLEMENTATION STATEMENT

This study is sponsored by the Montana Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. The major objective of this report is to develop and define the Greater Yellowstone Rural ITS (GYRITS) Priority Corridor Regional Architecture. The development of this regional architecture will enable effective implementation of ITS solutions within the Greater Yellowstone region.

DISCLAIMER

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Chapter

1

INTRODUCTION

The Greater Yellowstone Regional Architecture

The purpose of this chapter is to introduce the Greater Yellowstone Regional Architecture, establish its potential benefits, and describe the systematic approach that was used to develop it.

The Greater Yellowstone Rural Intelligent Transportation System (GYRITS) Priority Corridor, shown in Figure 1, is a nationally significant rural corridor connecting Idaho Falls, Idaho and Bozeman, Montana. A vast region encompassing 20,000 square miles covering portions of Montana, Idaho, and Wyoming and two National Parks (Yellowstone and Grand Teton), long travel distances, rugged terrain, sparsely populated areas, tourism, and severe weather combine to pose unique transportation challenges in the region.

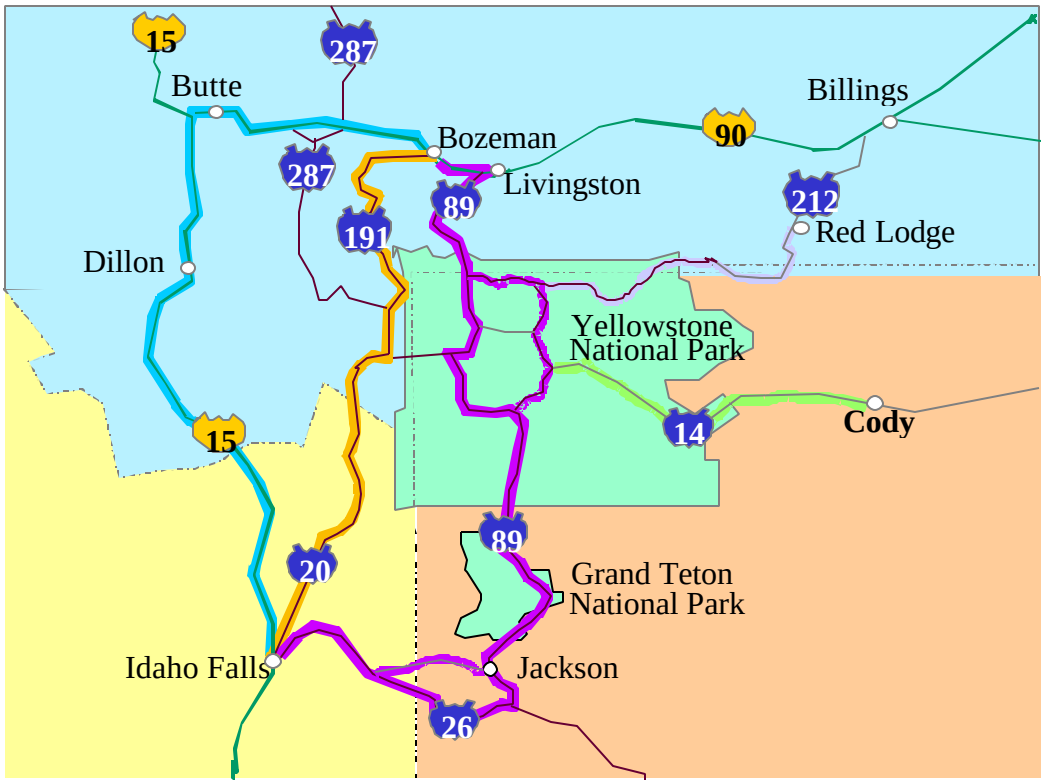


Figure 1: The Greater Yellowstone Region

This report defines an architecture for the Greater Yellowstone region that is a master blueprint for an integrated, multimodal Intelligent Transportation System that addresses these challenges. It clarifies how organizations, both public and private, can work together to deliver better safety, efficiency, and convenience to the rural traveler through deployment of ITS improvements.

This report describes the regional architecture in a manner that is consistent with both the National ITS Architecture and the transportation needs of the Greater Yellowstone region. In addition to the regional architecture, this report documents the process by which the architecture was developed, suggests rural extensions to the National ITS Architecture that were necessary to support Greater Yellowstone regional architecture, and offers specific project implementation guidance for the early winner projects that have been identified for the region.

PURPOSE

A regional architecture for the Greater Yellowstone Rural ITS Priority Corridor can guide ITS deployments in the region in a manner that is compatible with national efforts including the National ITS Architecture and ITS standards. Benefits of a regional architecture that demonstrates conformance with the National ITS Architecture include:

- Section 5206(e) of the Transportation Equity Act for the 21st Century (TEA-21) requires that ITS projects using funds from the Highway Trust Fund conform to the National ITS Architecture and standards. The GYRITS regional architecture presented in this report meets or exceeds the interim policy guidance for architecture conformity from US DOT. It is anticipated that this report will also support the final conformity policy that will be published later in 1999.

- A regional architecture facilitates regional integration. It helps agencies and other stakeholders to identify and plan for the many integration and information sharing opportunities which ITS offers.

- A regional architecture that conforms with the National ITS Architecture and identifies ITS standards enables other ITS systems that will be developed for use throughout the U.S. to operate in the Yellowstone region. The regional architecture and project implementation

guidance provided in this report addresses this national interoperability objective.

- Transportation improvements in the region will be made one project at a time. A regional architecture provides guidance for how these projects should fit together, improving interoperability between the projects, making efficient use of scarce resources, and facilitating future ITS expansion in the region.

These benefits will only be realized if the regional architecture is used in planning projects for the corridor and adapted as requirements change in the future. The initial architecture development is the first step in the sustained planning and integration effort that underlies most of the cited benefits. So that the architecture can easily be adapted as requirements change, a Microsoft Access database was delivered along with this report. The Access database allows many different views and focused reports from the regional architecture to be generated which should facilitate its use and maintenance in the future.

APPROACH

The Greater Yellowstone regional architecture is based on the results of several preceding tasks, including:

- The ITS stakeholders and systems in the region as identified by Task 3.
- The market packages that apply to the region as identified in Tasks 6, 7, and 8.
- The early winner projects for the region as defined in Task 9.

These products are each applied in turn to generate the regional and early winner project architectures as depicted in Figure 2. This report is structured so that separate chapters are devoted to each of the process steps identified in the figure.

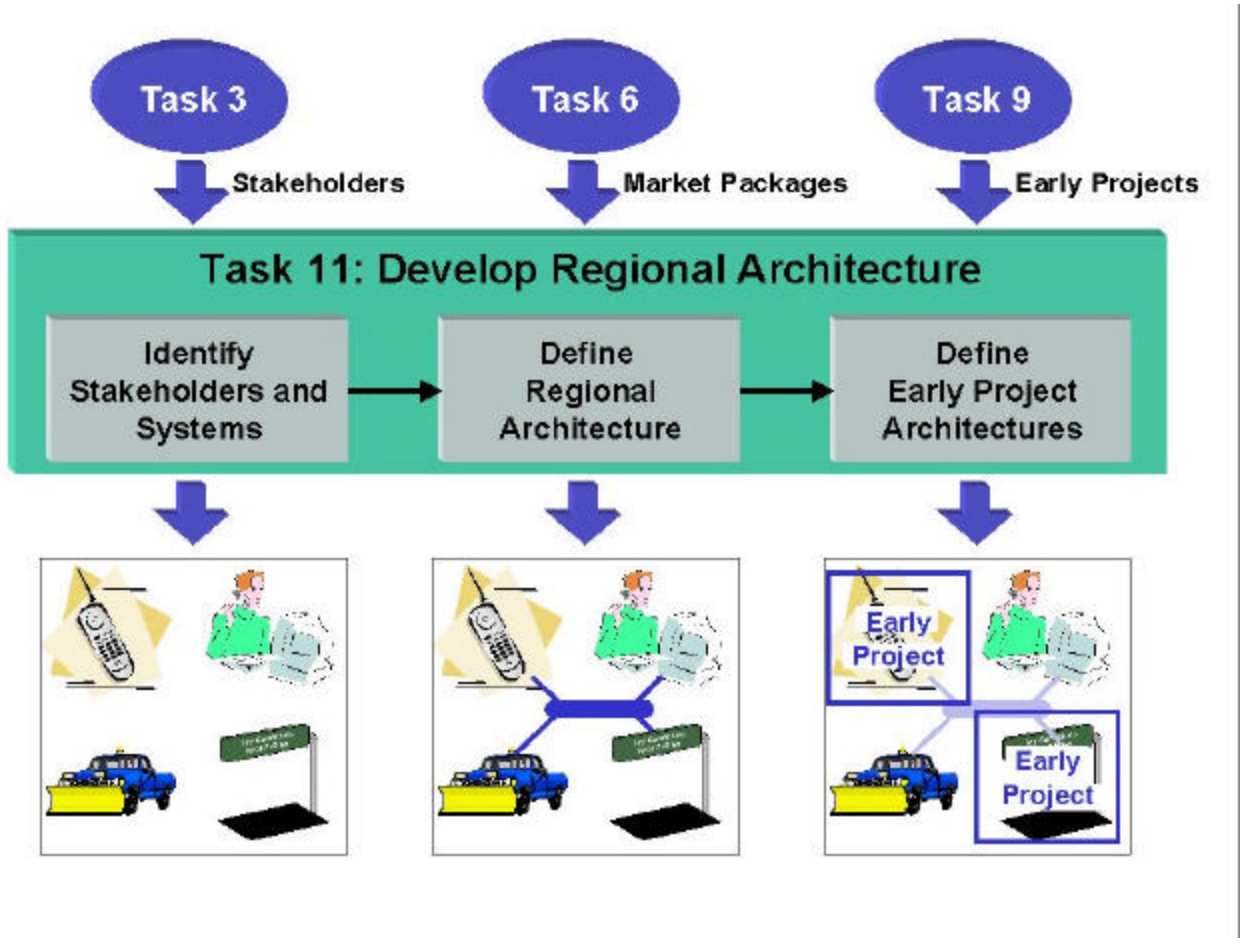


Figure 2: Developing the GYRITS Regional Architecture and Early Project Definitions

- **Chapter 2** provides an overview of the systems and stakeholders who support the Greater Yellowstone Rural ITS Priority Corridor. These regional systems are classified and presented in terms of the National ITS Architecture.

- **Chapter 3** assesses the priority market packages identified for the region in Tasks 6, 7, and 8. These market packages are further defined, with special emphasis on those market packages that are beyond the scope of the National ITS Architecture. This chapter also includes market package graphics for each of the new GYRITS rural market packages.

- **Chapter 4** presents the Greater Yellowstone regional architecture, building on the stakeholders identified in chapter 2 and the market packages identified in chapter 3. Several different depictions of the regional architecture are presented to suit different audiences and users.

- **Chapter 5** defines the portions of the regional architecture that support the early winner projects identified in Task 9. The relevant pieces of the regional architecture are identified and additional architectural detail is provided to support these projects. This detailed information includes the architecture flows that will be implemented by the early projects, the associated ITS standards that will facilitate interoperability in the region, and a brief survey of communications technologies and their potential application to the early projects.

Although the National ITS Architecture provides a general structure that is applied in the GYRITS regional architecture, the scope and structure of the GYRITS regional architecture is ultimately determined more by the regional architecture elements and requirements defined for GYRITS. Figure 3 shows the overlap between the scope of the National ITS Architecture and the scope of the Greater Yellowstone regional architecture. As shown, the Greater Yellowstone Regional Architecture substantially extends the National ITS Architecture to support various rural ITS services that are not explicitly covered by the National ITS Architecture. One of the significant challenges in developing the regional architecture was development of these elements that are not supported by the current National ITS Architecture.

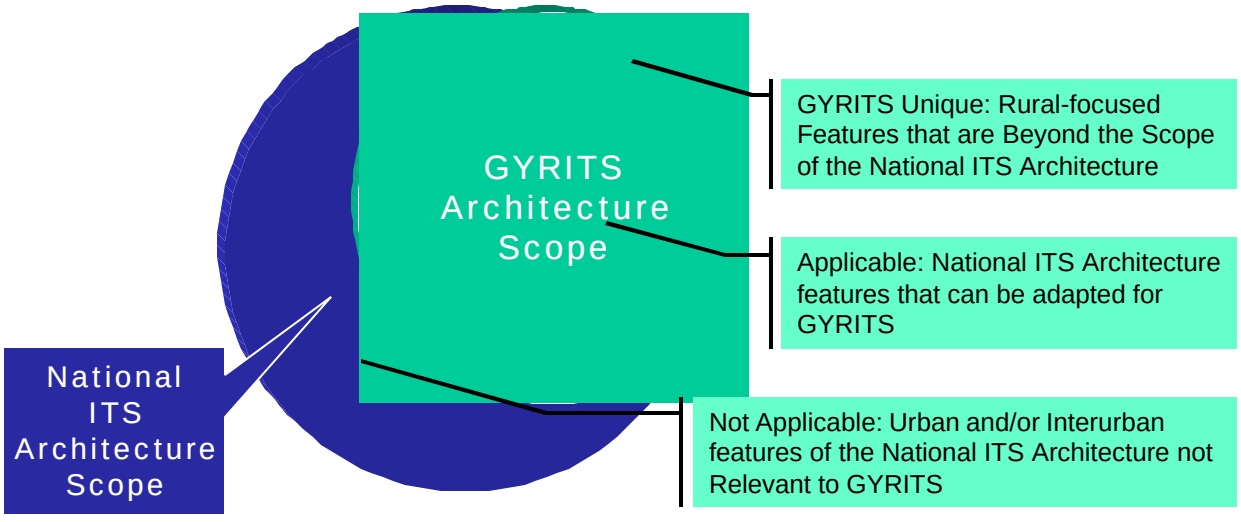


Figure 3: The GYRITS Architecture Expands on the National ITS Architecture

Several different depictions of the GYRITS architecture are developed in the course of this report, ranging from very high level "sausage diagram" renderings of the architecture to a

architecture flow level presentation that defines hundreds of information flows and specific interfaces that will be present in the high-end state regional transportation system. The different levels of presentation are each suited to different audiences and applications. It should be emphasized that the most detailed architecture flow-level depictions of the architecture have not been coordinated with the Priority Corridor Steering Committee and should be considered draft versions pending review and comment by the committee membership.

The GYRITS regional architecture is defined and maintained in a Microsoft Access database that was delivered with this report. This database links to the National ITS Architecture databases and extends and customizes the National ITS Architecture definition for application in the greater Yellowstone region. The Access database can be adapted in the future as regional requirements evolve. Appendix B provides a technical overview of the GYRITS Regional Architecture Microsoft Access database.

Chapter

2

GYRITS SYSTEM INVENTORY

Key Systems and Stakeholders in the Greater Yellowstone Region

The purpose of this chapter is to identify the stakeholders and systems that will participate in the Greater Yellowstone Regional Architecture. The existing and future systems in the region are identified along with the public agencies and private interests that will be responsible for each system's operation and maintenance. These identified systems and stakeholders are mapped to the National ITS Architecture.

By definition, the Greater Yellowstone Regional Architecture will be based on the systems that exist in the region today. Building on this established base, the regional architecture defines how these existing systems can be integrated with each other and with future systems.

Since the regional architecture is so dependent on the inventory of what exists and what is planned for the region, the definition of a regional architecture begins with an inventory of the existing and future systems that will be deployed. These systems together will provide the advanced transportation services that will be offered in the Greater Yellowstone region. These systems, and the stakeholders who are responsible for their operation and maintenance, are the heart of the regional architecture. They are the "boxes" in the regional architecture diagrams that are presented in chapter 4.

The inventory presented in this chapter is largely a product of the stakeholder workshops, extensive data collection efforts, and analysis that was performed under Task 3: "ITS-Related Inventory: Regional Needs Assessment".

GREATER YELLOWSTONE STAKEHOLDERS AND SYSTEMS

A high-level stakeholder list and a system inventory by major ITS stakeholder area is presented in the following paragraphs. Accompanying each inventory is a brief review of the transportation challenges relevant to that stakeholder area and a brief discussion of the mapping between the agencies and systems in the Greater Yellowstone region and the National ITS Architecture.

Where possible, the mapping is maintained at a high level, mapping general categories of agencies (e.g., State Departments of Transportation) to corresponding elements in the National Architecture. This level of abstraction allows the regional architecture to be more easily maintained and understood. It also highlights the common interfaces and requirements that are shared by stakeholders in the region. In general, it is better to define a few general interfaces that accommodate the range of regional implementations rather than specifying a unique architecture connection for each physical interface that may be implemented. The objective is to identify the major classes of systems and system interfaces in the region.

TRAFFIC MANAGEMENT IN THE REGION

Traffic operations and maintenance in the Greater Yellowstone region is provided by the Departments of Transportation for Idaho, Montana, and Wyoming, the National Parks, the County Road Departments, and the larger cities in the corridor. Each of these agencies is responsible for traffic management within its own jurisdictional boundary. The State DOT operations, comprised of Headquarters, District Offices, and Maintenance Offices, are a focal point for the traffic management portion of the regional architecture

Information on roadway geometry, maintenance facilities, and operational centers managed by the state departments of transportation were collected in a Task 3 survey as were the locations of existing highway advisory radio (HAR), variable message signs (VMS), environmental sensor stations (ESS), and weigh-in-motion (WIM) systems. Despite the rural setting, there are significant traffic management challenges in the region. Congestion is a seasonal problem at the entrances to Yellowstone National Park; nearly 3 million vehicles enter the park each year through one of the three entry gates, causing substantial delays at peak times. Large road construction projects are common in the region, causing periodic detours and delays. The agencies that manage traffic in the corridor are identified in Figure 4 along with their mapping to the National ITS Architecture.

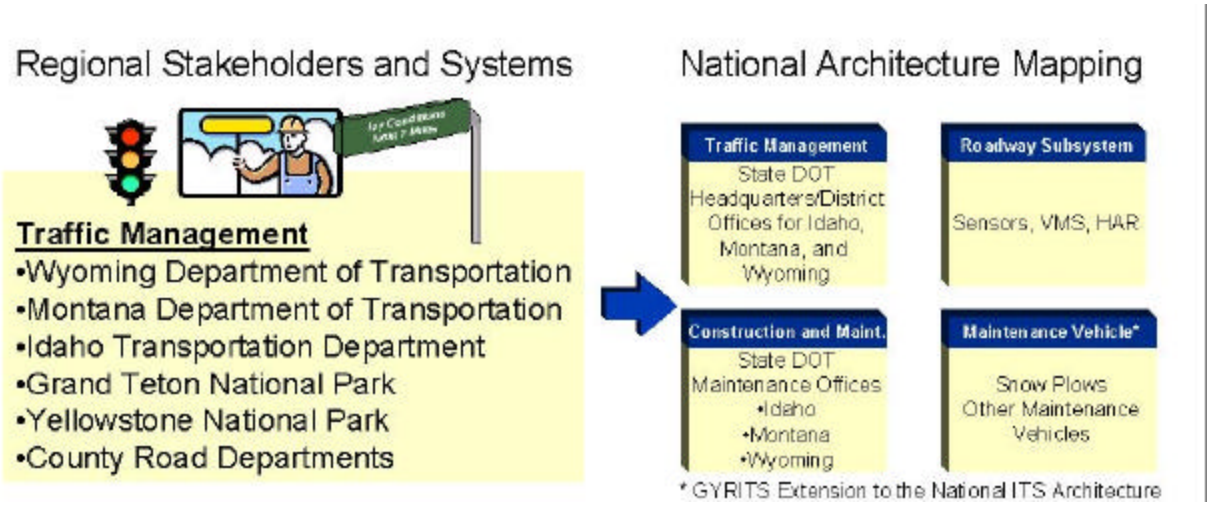


Figure 4: Traffic Management in the Regional Architecture

EMERGENCY MANAGEMENT IN THE REGION

Public safety agencies in the region include the state police, county sheriffs, local police, fire departments with varying levels of Hazardous Materials Capabilities, and many Emergency Medical Service providers. The county operated Public Safety Answering Points provide the 9-1-1 call-taking function for the region. In addition to the agencies and facilities identified in the Task 3 survey, detailed safety-related data on crashes, emergency response times, and hazardous materials incidents were also collected to determine where safety-related improvements were warranted. For example, statistics from the US Department of Transportation - Office of Hazardous Materials identifies 22 hazardous material spills within the corridor between 1994 and 1996. Since many of the roads are lightly traveled and travel distances are great, both notification and response times can be substantial. The public safety agencies in the region are summarized in Figure 5.

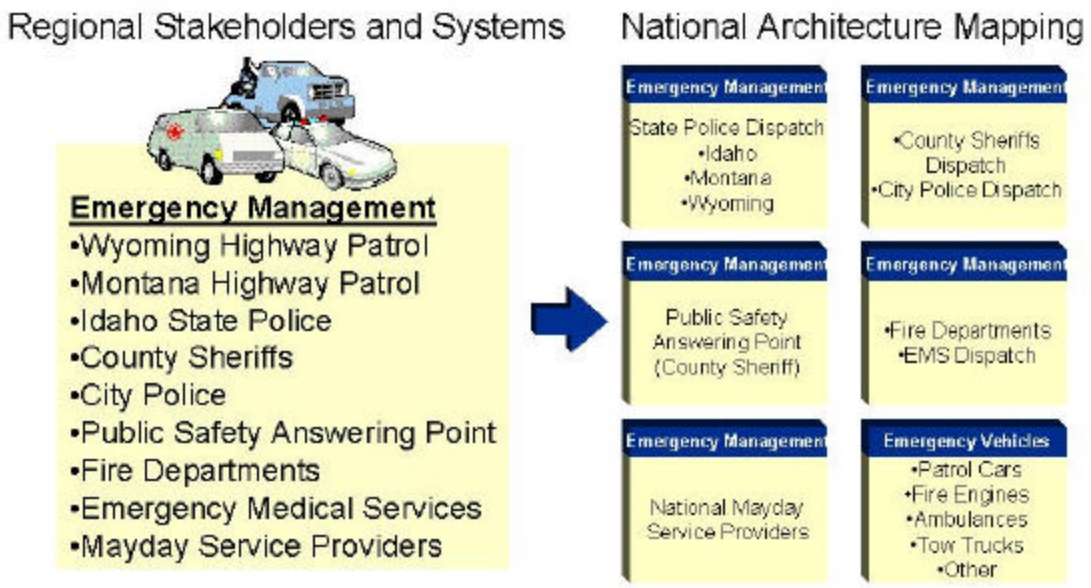


Figure 5: Public Safety in the Regional Architecture

TRANSIT MANAGEMENT IN THE REGION

Transit services in the region include Greyhound and chartered city to city bus service as well as paratransit and fixed route services in the larger cities (Bozeman, Butte, Livingston, Jackson, Idaho Falls). TW Recreation Services offers limited shuttle services in Yellowstone National Park. Transit services into Yellowstone National Park could be expanded in the future to add new routes (e.g., from the West Yellowstone Gate into the park) and offer enhanced services. A portion of the region's residents maybe dependent on transit including the elderly (10.4% of the population is over 65), residents with mobility limitations (3% of the population), and residents living below poverty level. Figure 6 summarizes the transit services offered in the region and shows the National ITS Architecture mapping that was selected for the regional architecture. The emphasis in the architecture mapping is on local transit services and future shuttle services that could be offered in the parks. The city-to-city bus services offered by Greyhound and Rimrock Trailways are also defined in the most detailed views of the architecture.

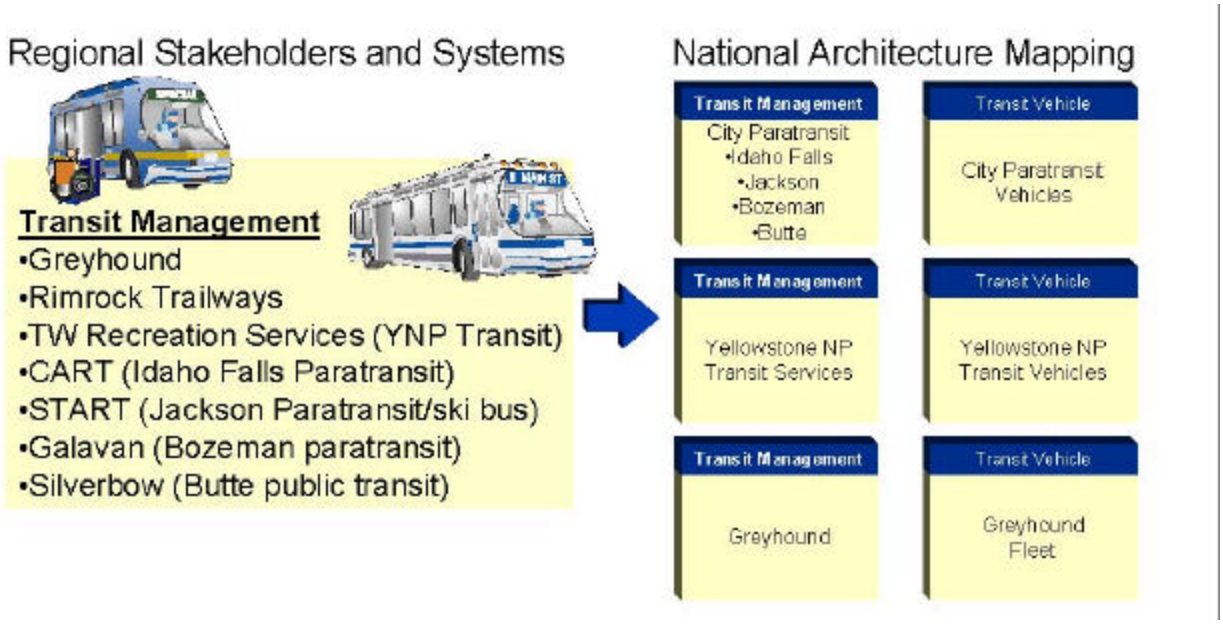


Figure 6: Transit Management in the Regional Architecture

INFORMATION SERVICE PROVIDERS IN THE REGION

Traveler information improvements are consistently identified as an area of emphasis for the Greater Yellowstone region. The kiosks that have been deployed by Travel Montana provide an excellent basis for traveler information system expansion. The kiosk network will be expanded and new features will be added in one of the early projects. In addition to traditional media (e.g., local cable channel providers), the architecture will accommodate other information service providers who wish to deploy their systems in the region in the future. Many of these service providers may specialize in a particular media (e.g., FM Subcarrier or the Internet). More traditional sources of traveler information are also identified for the region. The city chambers of commerce are a focal point for detailed traveler service information that will be a key component of the available information services. The departments of tourism for the three states provide broader traveler information bringing travelers to the region and orienting them once they arrive. Figure 7 shows the information service provider support planned for the Greater Yellowstone region and the National ITS Architecture mapping for these systems.

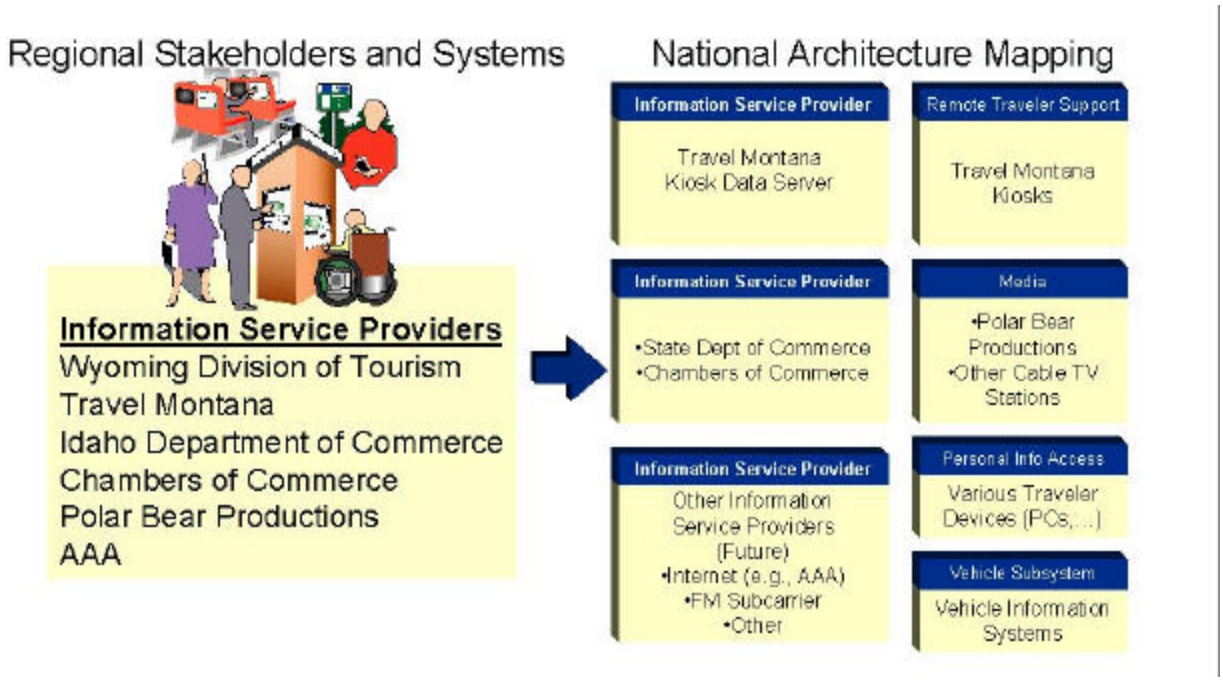


Figure 7: Information Service Providers in the Regional Architecture

In addition to Information Service Providers that serve the traveler, an Information Service Provider can also provide an important integration function for operating agencies in the region. A Regional Server has been proposed for the Yellowstone Region that would support information sharing between operating agencies. Figure 8 contrasts the complexity of a "stove piped" architecture for the region which relies on extensive point-to-point communications that could evolve with a topology that connects all participating agencies to one or more regional servers that provide a shared information resource for all agencies in the region. A standard interface can be defined, based on emerging national ITS standards, for the regional server that provides a standard mechanism for accessing ITS data in the region. The connection would provide all relevant transportation information for the region commensurate with the client agency's needs. The regional server could be centralized and provide a single shared transportation information repository or it could be virtual in the sense that it actually would consist of a smart local interface that transparently routes information requests to the appropriate information server, selecting from many different servers for the region. Using a regional server could facilitate future expansion and simplify participation by many allied agencies serving the transportation and public safety needs in the Greater Yellowstone region.

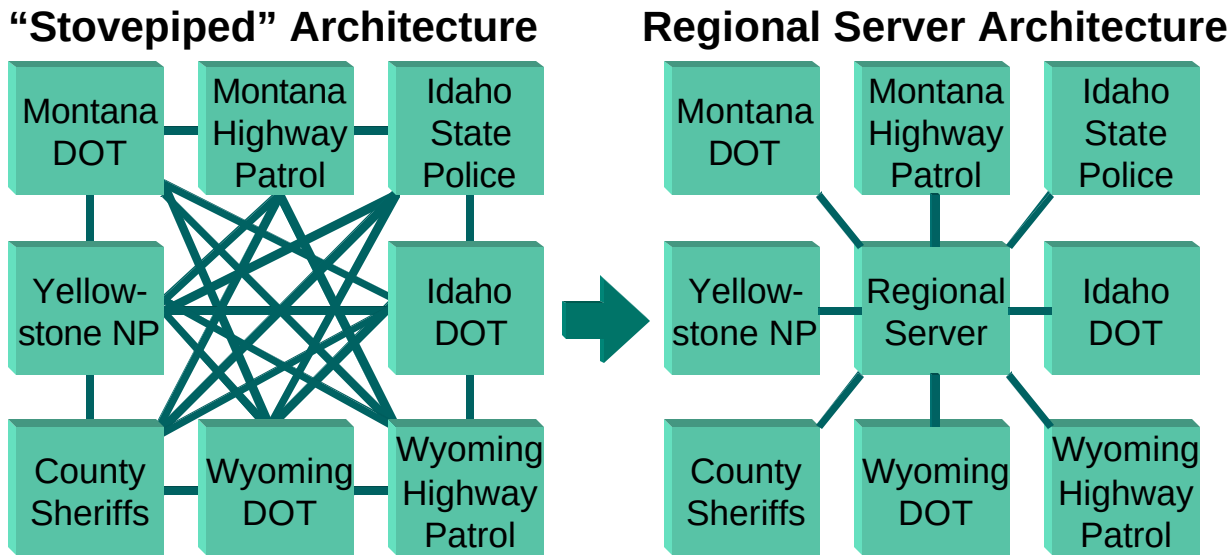


Figure 8: Contrasting a "Stovepiped" Architecture with One Built Around Regional Server(s).

TRAVELER SERVICES IN THE REGION

Tourist and traveler information is a key ingredient of the regional architecture. Major travel destinations in the region include the two National Parks, national forests, state parks, museums, ski resorts, historical sites, and reservoirs; these destinations receive over 6 million visitors annually. Traveler accommodations, restaurants, and shopping opportunities for the traveler are provided near many of the travel destinations and at the cities within the region. These stakeholders, and the systems they will be deploying are a key traveler information resource for the region. Figure 9 provides an overview of these services and shows the high-level mapping that is available in the National ITS Architecture. The various traveler services are grouped in the regional architecture to keep the architecture manageable. An architecture that enumerated all the various traveler services in the region would be overly complex and be very difficult to maintain as the available traveler services in the region changes. It is anticipated that tourism/traveler services treatment in the National ITS Architecture may be enhanced in future revisions to address the rural ITS emphasis on tourism.

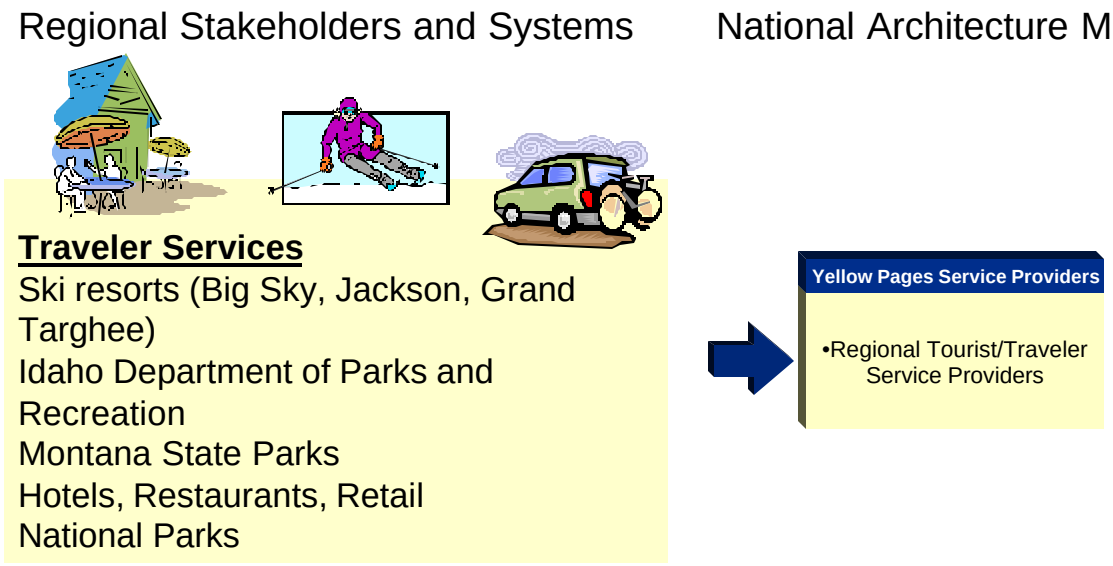


Figure 9: Tourist/Traveler Services in the Regional Architecture

FLEET AND FREIGHT MANAGEMENT IN THE REGION

Approximately 450,000 commercial vehicle miles are traveled per day in the corridor. Heavy commercial vehicle traffic uses Interstates 90 and 15 to travel between markets in the upper Midwest and the Intermountain and Southwest markets. Carriers located both within and outside the region use these routes and require permits and credentials from the three participating states. Six staffed weigh stations in the region monitor the commercial vehicle traffic at ports of entry along the three state boundaries. There are existing plans to implement the HELP, Incorporated Prepass system at several of these weigh stations. HELP, Incorporated Prepass equipment is operational at the Lima Weigh Station on Interstate 15. SummitNet is Montana's dedicated statewide communications network that links all the state's weigh station sites with a central Department of Transportation system in Helena. In all three states, the State DOTs provide this central commercial vehicle administration function.

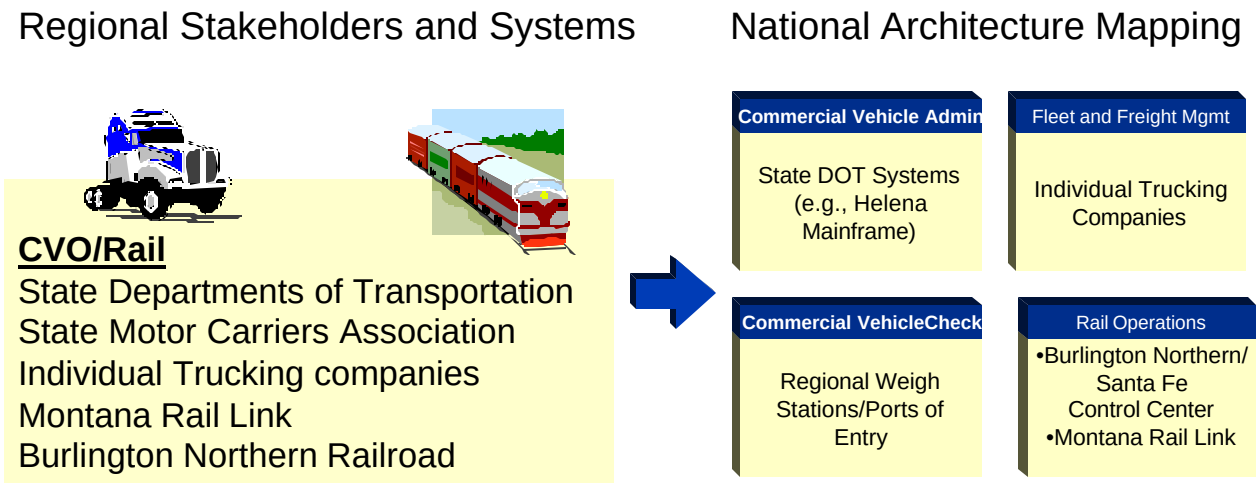


Figure 10: Commercial Vehicle/Rail Operations in the Regional Architecture

SUMMARY OUTPUT FROM THE ACCESS DATABASE

Table 1 is a summary output from the Greater Yellowstone Regional Architecture Access Database that shows the exact mapping between regional systems and National ITS Architecture entities that is included in this database. This table essentially aggregates the inventory from each of the preceding paragraphs and does a best-fit mapping to the National ITS Architecture entities. The "Abbreviation" field is used for regional architecture diagrams and other applications where more concise notation is appropriate.

Table 1: System Inventory and Architecture Mapping for GYRITS

Stakeholder	Abbreviation	System	Architecture Entity
Burlington Northern Santa Fe	BNSF/Montana Rail	Rail Operations Centers	Rail Operations
Cable Television Stations	Cable TV	Cable Television	Media
Chambers of Commerce	Chambers of Commerce	Visitor Information Services	Information Service Provider
City Paratransit Operators	Transit Operators	Paratransit Dispatch Systems	Transit Management
City Paratransit Operators	Transit Operators	Paratransit Vehicle Systems	Transit Vehicle Subsystem
County Sheriff	Sheriff	Public Safety Answering Point	Emergency Management
Individual Trucking Companies	Trucking Companies	Commercial Vehicle Systems	Commercial Vehicle Subsystem
Individual Trucking Companies	Trucking Companies	Fleet Dispatch/Operations Systems	Fleet and Freight Management
Mayday Service Providers	Mayday Service Providers	Mayday Answering Points	Emergency Management
Mayday Service Subscribers	Subscribers	Vehicle Mayday Systems	Vehicle
Montana Rail Link	BNSF/Montana Rail	Rail Operations Centers	Rail Operations
National Emergency Number Association	NENA	E-9-1-1 Telecommunications	Emergency Telecommunications System
National Weather Service	NWS	Weather Service	Weather Service
Other Traveler Information Providers	Private Providers	Traveler Information Systems	Information Service Provider
Police, Fire, EMS	Public Safety	Emergency Vehicle Systems	Emergency Vehicle Subsystem
Police, Fire, EMS	Public Safety	Incident Command/Dispatch Systems	Emergency Management
Regional Host (TBD)	TBD	Regional Server	Information Service Provider
State Dept. of Transportation	State DOTs	Animal-Vehicle Warning Systems	Roadway Subsystem
State Dept. of Transportation	State DOTs	Automated Gates	Roadway Subsystem
State Dept. of Transportation	State DOTs	CCTV RoadCams	Roadway Subsystem

Table 1: System Inventory and Architecture Mapping for GYRITS

Stakeholder	Abbreviation	System	Architecture Entity
State Dept. of Transportation	State DOTs	Dynamic Warning VMS	Roadway Subsystem
State Dept. of Transportation	State DOTs	Environmental Sensor Stations	Roadway Subsystem
State Dept. of Transportation	State DOTs	Headquarters/District Offices	Traffic Management
State Dept. of Transportation	State DOTs	Highway Advisory Radios	Roadway Subsystem
State Dept. of Transportation	State DOTs	Intersection Warning Systems	Roadway Subsystem
State Dept. of Transportation	State DOTs	Maintenance Offices	Construction and Maintenance
State Dept. of Transportation	State DOTs	Maintenance Vehicle Systems	Construction and Maintenance
State Dept. of Transportation	State DOTs	State Commercial Vehicle Admin	Commercial Vehicle Administration
State Dept. of Transportation	State DOTs	Variable Message Signs	Roadway Subsystem
State Police	State Police	Weigh Station Systems	Commercial Vehicle Check
Transit Users/Employees/Local Residents	Tag Owners	YNP Electronic Tags	Vehicle
Travel Montana (Lead)	Travel Montana	Kiosk Data Server	Information Service Provider
Travel Montana (Lead)	Travel Montana	Regional Kiosks	Remote Traveler Support
Traveler Service Providers (Lodging, Restaurants, Shopping, Destinations)	Service Owners	Traveler Service Providers	Yellow Pages Service Providers
Travelers/Tourists	Travelers	Traveler Information Devices	Personal Information Access
Travelers/Tourists	Travelers	Vehicle Information Systems	Vehicle
Yellowstone National Park	Yellowstone NP	Entrance Gate AVI Systems	Toll Collection
Yellowstone National Park	Yellowstone NP	National Park Parking Systems	Parking Management
Yellowstone National Park	Yellowstone NP	Park Entrance Fee Administration	Toll Administration
Yellowstone National Park	Yellowstone NP	Transit Operations Centers	Transit Management
Yellowstone National Park	Yellowstone NP	Transit Vehicle Systems	Transit Vehicle Subsystem

Chapter
3

GYRITS MARKET PACKAGES

Addressing the GYRITS Corridor Transportation Challenges

The purpose of this chapter is to identify the market packages that address the GYRITS Corridor challenges, building on outputs from Tasks 6, 7, and 8. National ITS Architecture market packages are identified and adapted and new market packages that extend the National ITS Architecture are defined. The objective is to identify the ITS services that will be required to address the transportation challenges in the Greater Yellowstone Region.

Background on Market Packages

The National ITS Architecture defines 60 market packages that represent a range of potential ITS implementations that address specific transportation challenges. "Broadcast Traveler Information", "Road Weather Information Systems", and "Transit Vehicle Tracking" are examples of the market packages that have been defined. The market packages combine this service-oriented view of ITS with a detailed identification of the pieces of the National ITS Architecture that are required to implement these services. For instance, the "Broadcast Traveler Information" market package identifies the pieces of the architecture that collect the traveler information, broadcast this information, and the devices used by the travelers to receive these broadcasts.

This combination of service-oriented and architecture-oriented views make the market packages a useful entry point to the National ITS Architecture definition. They provide an accessible, service-oriented view of the potential for ITS that can be used to build consensus on what needs to be done in a region. This service oriented view is easily converted into a more technical architecture view because of the connectivity between market packages and architecture definition. The market packages are used in this chapter as a convenient way to define the transportation services that the Greater Yellowstone Regional Architecture will provide.

A brief definition of all 60 market packages defined by the National ITS Architecture is included in Appendix A.

GYRITS Priority Market Packages

A set of priority market packages that best address the Greater Yellowstone regional challenges were identified from the National ITS Architecture market packages in Tasks 6, 7, and 8 "GYRITS Regional Architecture Development". In addition, a number of new rural market packages were identified that are not included in the National ITS Architecture, but represent important potential ITS implementations for the Greater Yellowstone Region. Table 2, based on a similar table from the Task 6, 7, and 8 report, summarizes the priority market packages and relates them to corridor challenges and the rural critical program areas. Market Packages that were defined specifically for GYRITS are designated with an asterisk (*) in the table.

Table 2 differs from the original table included in the Task 6, 7, and 8 report in several ways. Subsequent to publication of the Task 6, 7 ,and 8 report, version 2.0 (and more recently Version 2.1) of the National ITS Architecture was released. The version 2.0 architecture included several new market packages that are relevant to the Greater Yellowstone Region, most significantly a new Road Weather Information System (RWIS) market package. This new market package was added to the list of priority GYRITS market packages. Several of the market packages identified in the original report provided overlapping capabilities and were combined (e.g., Safe Speed Advisory Systems and Dynamic Warning Systems). The updated market package table provides a starting point for the market package analysis in this chapter.

Table 2: Summary of GYRITS Priority Market Packages (from Task 6, 7, and 8)

Critical Program Areas	Traveler Safety and Security	Emergency Services	Tourism and Travel Information Services	Public Traveler Services/Public Mobility Services	Commercial Vehicle Operations	Infrastructure Operations and Maintenance	Fleet Operations and Maintenance
INCLEMENT WEATHER CHALLENGE							
Broadcast Traveler Information			√			√	
Interactive Traveler Information			√				
Network Surveillance	√					√	
Probe Surveillance						√	
Dynamic Warning System	√				√		
Traffic Information Dissemination	√		√			√	
Automated Road Closure Management *	√	√				√	
Road/Weather Information System	√	√	√			√	
UNSAFE SPEED CHALLENGE							
Dynamic Warning System	√						
Mobile Traffic Management/Enforcement *	√						
COMMERCIAL VEHICLE SAFETY CHALLENGE							
CVO Fleet Maintenance					√		√
Driver Safety Monitoring	√				√		√
Mobile Traffic Management/Enforcement *	√						
On-board CVO Safety					√		√
Roadside CVO Safety					√	√	√
Weigh-in-motion					√	√	
HAZARDOUS MATERIALS CHALLENGE							
HAZMAT Management					√	√	√
Incident Management System	√					√	
Mobile Traffic Management/Enforcement *	√						
EMERGENCY RESPONSE TIME CHALLENGE							
Emergency Response	√	√					
Emergency Routing		√					
Emergency Vehicle Maintenance *		√					
Incident Management System	√					√	

GYRITS-Unique Market Packages are identified with an asterisk (*).

Table 2. Summary of GYRITS Priority Market Packages (Continued)

Critical Program Areas	Traveler Safety and Security	Emergency Services	Tourism and Travel Information Services	Public Traveler Services/Public Mobility Services	Commercial Vehicle Operations	Infrastructure Operations and Maintenance	Fleet Operations and Maintenance
EMERGENCY RESPONSE TIME CHALLENGE (Continued)							
Mayday Support	√	√					
Virtual TMC and Smart Probe Data		√				√	
TRAVELER/TOURIST INFORMATION CHALLENGE							
Broadcast Traveler Information			√			√	
Interactive Traveler Information			√				
Network Surveillance	√					√	
Probe Surveillance						√	
Virtual TMC and Smart Probe Data		√				√	
Yellow Pages and Reservation			√				
FAILURE TO YIELD RIGHT-OF-WAY/DISREGARD FOR TRAFFIC CONTROL CHALLENGE							
Intersection Collision Avoidance	√						
Mobile Traffic Management/Enforcement *	√						
REAR-END COLLISION CHALLENGE							
Driver Visibility Improvement	√				√		
Intersection Collision Avoidance	√						
Intersection Safety Warning	√						
Pre-Crash Restraint Deployment	√						
ANIMAL ENCROACHMENT ON THE ROADWAY CHALLENGE							
Animal-vehicle Collision Countermeasures *	√						
Lateral Safety Warning	√				√		
Longitudinal Safety Warning	√				√		
SNOWMOBILE CRASH CHALLENGE							
Dynamic Warning System *	√						
Intersection Collision Avoidance	√						
Lateral Safety Warning	√				√		
Longitudinal Safety Warning	√				√		

GYRITS-Unique Market Packages are identified with an asterisk (*).

Table 2. Summary of GYRITS Priority Market Packages (Continued)

Critical Program Areas	Traveler Safety and Security	Emergency Services	Tourism and Travel Information Services	Public Traveler Services/Public Mobility Services	Commercial Vehicle Operations	Infrastructure Operations and Maintenance	Fleet Operations and Maintenance
COMMERCIAL VEHICLE EFFICIENCY CHALLENGE							
CVO Fleet Maintenance					√		√
Electronic Clearance					√	√	√
Electronic Clearance Enrollment	√				√		√
Fleet Administration					√		√
Freight Administration					√		√
Vehicle Tracking and Dispatch					√		√
Weigh-in-motion					√	√	
TRAVELER MOBILITY CHALLENGE							
Demand Responsive Transit Operations				√			
Dynamic Ridesharing			√	√			
Multimodal Coordination							√
Traffic Information Dissemination	√		√			√	
Transit Fixed-Route Operations				√			√
Transit Passenger and Fare Management				√			√
Transit Vehicle Tracking							√
Vehicle Tracking and Dispatch							√
YELLOWSTONE NATIONAL PARK ENTRANCE CONGESTION CHALLENGE							
Facility Use/ Admittance Management *			√				
Mobile Traffic Management/Enforcement *	√						
Traffic Information Dissemination	√		√			√	
Transit Fixed-Route Operations							√
CONSTRUCTION ZONE CONGESTION CHALLENGE							
Mobile Traffic Management/Enforcement *	√						
Traffic Information Dissemination	√		√			√	
TOURISM AND ECONOMIC DEVELOPMENT CHALLENGE							
Facility Use/ Admittance Management *			√				
Transit Passenger and Fare Management							√

GYRITS-Unique Market Packages are identified with an asterisk (*).

Several new market packages are identified in Table 2 that are beyond the scope of the current National ITS Architecture. These new market packages are:

- Animal-Vehicle Collision Counter Measures
- Emergency Vehicle Maintenance
- Dynamic Warning Systems
- Facility Use/Admittance Management
- Automated Road Closure Management
- Mobile Traffic Management/Enforcement

A brief description and high-level graphic that is modeled after the National ITS Architecture definitions for the 60 existing market packages is provided for each of these new market packages in the following paragraphs. These definitions support the GYRITS regional architecture definition and may also provide a useful input to the National ITS Architecture team when rural enhancements are considered. Every effort was made to adapt and use existing National ITS Architecture elements for the new market packages wherever possible.

Animal-Vehicle Collision Counter Measures

Encroachment of animals on the roadway is a significant problem in the Greater Yellowstone region and in other rural areas in the United States. The Animal-Vehicle Collision Counter Measures Market Package combines sensors that detect animals with a dynamic warning system that warns drivers of the animal's presence on or near the roadway. While early implementations are likely to operate autonomously, future implementations may allow remote status reporting and calibration of the system to facilitate fault detection and maintenance of these potentially remote systems. Figure 11 identifies the architecture elements associated with this market package.

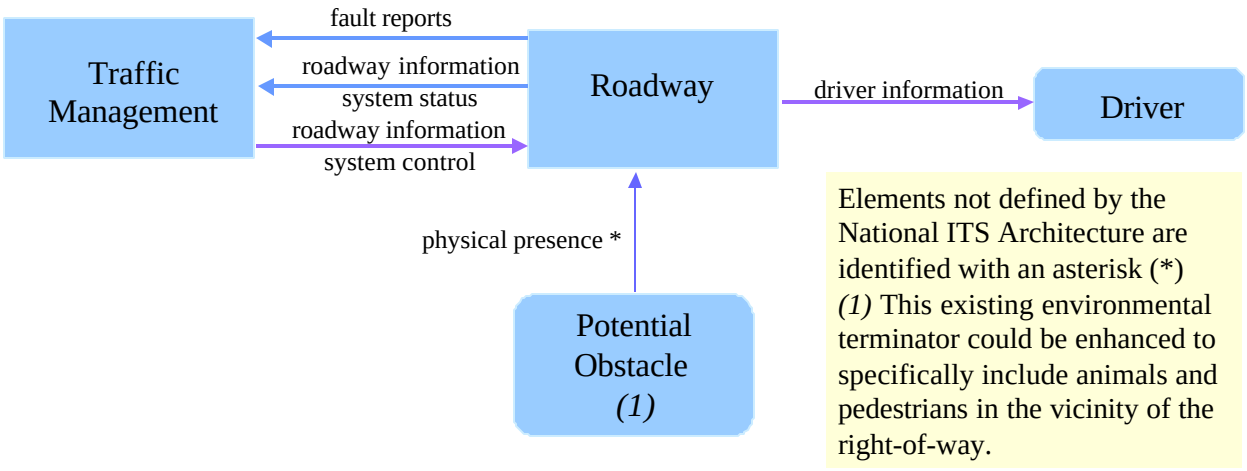


Figure 11: Animal-Vehicle Collision Counter Measures Market Package

Emergency Vehicle Maintenance

Large patrol areas and relatively small numbers of emergency vehicles that are in service at any given time place additional emphasis on emergency vehicle maintenance in the Greater Yellowstone region. This market package supports advanced monitoring of vehicle systems status and provides automatic maintenance scheduling and monitoring. On-board condition sensors monitor critical system status and provide this critical status information back to the Emergency Management Subsystem. Hardware and software in the Emergency Management Subsystem processes this data and schedules preventative maintenance activities.

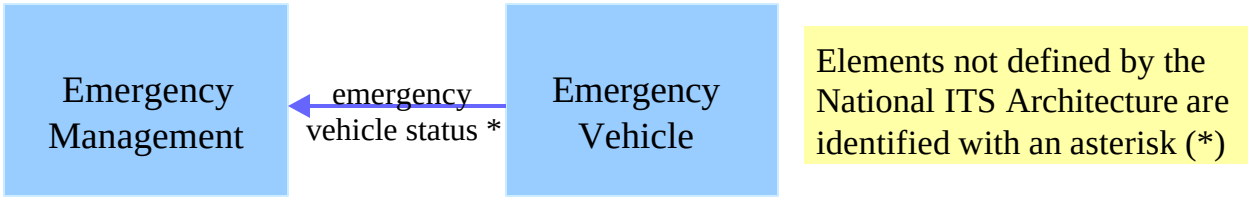


Figure 12: Emergency Vehicle Maintenance

Dynamic Warning Systems

A dynamic warning system monitors vehicle speeds and provides warnings to vehicles that are traveling at unsafe speeds. These systems can be deployed at spot locations where excessive speed is a problem such as locations in advance of curves and downgrades. Various levels of sophistication are possible including systems that simply measure vehicle speeds (safe speed advisory systems), systems that combine this speed information with real-time measures of road conditions, and systems that also classify approaching vehicles by weight and size so that increasingly selective warnings can be given to drivers that are exceeding the safe performance levels of either their vehicles and/or current conditions. Systems that operate autonomously and systems that communicate with and provide remote access to an operating center may be implemented.

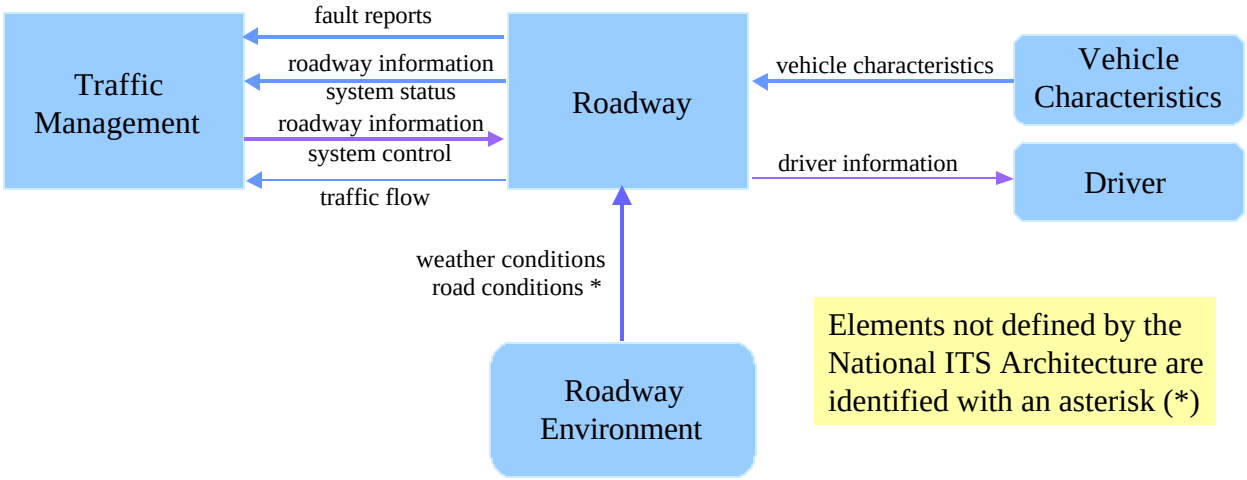


Figure 13: Dynamic Warning System Market Package

Facility Use/Admittance Management

This market package provides electronic fee collection at travel destinations, thereby providing traveler convenience and reducing delays and staffing requirements at facility entrances. Using the same tag/beacon systems that are used for electronic toll collection, this market package extends these systems to collect admittance and usage fees at various tourist destinations. In the Greater Yellowstone Region, early deployment of this market package will be at entrances to the National Parks, but the same techniques and systems could be used at any gated facility that

charges user fees. Special verification requirements may be included for these systems to prevent sharing or other misuse of the electronic pass "tag". In addition to the subsystems and architecture flows that support the admission fee transaction, this market package includes a connection to the information service provider so that information about the service can be made available to the traveling public.

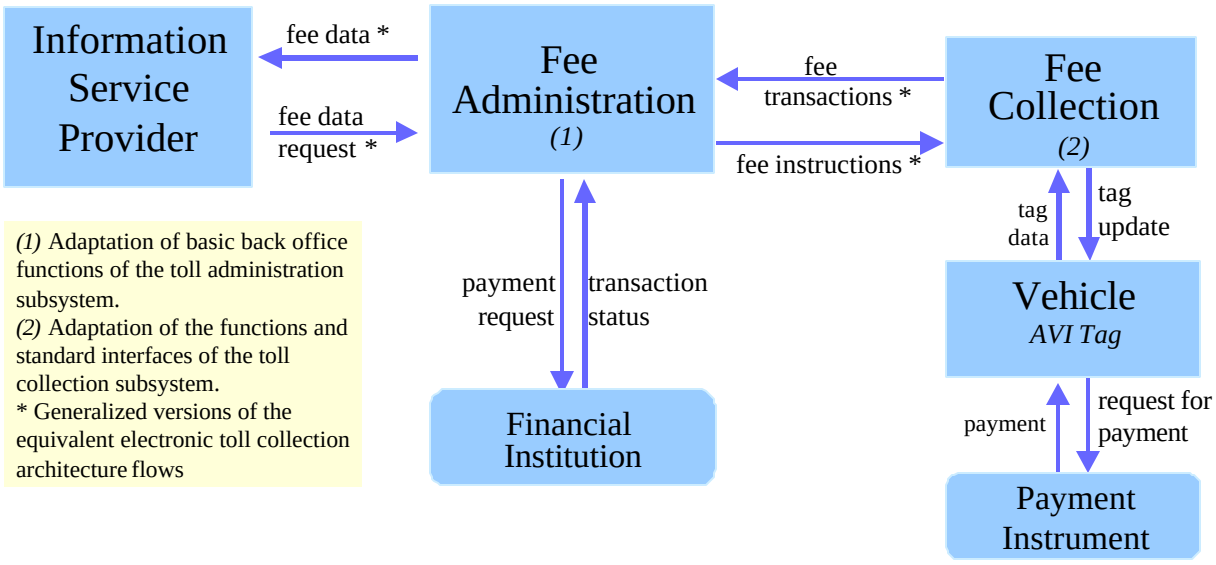


Figure 14: Facility Use/Admittance Fee Management

Automated Road Closure Management

This market package provides decision support for road closures, providing real time information on road conditions and allowing coordination between different agencies that may be impacted by, or otherwise involved in, the decision to close a road. Once the closure decision is made, automated gate closure systems are provided that allow the gates to be remotely closed, either from a patrol vehicle within line of site of the gate or remotely from an operating center. To improve the safety of remote operation, CCTV cameras can provide remote surveillance in the vicinity of the gate area and dynamic warning signs can provide closure warnings to drivers approaching the gates.

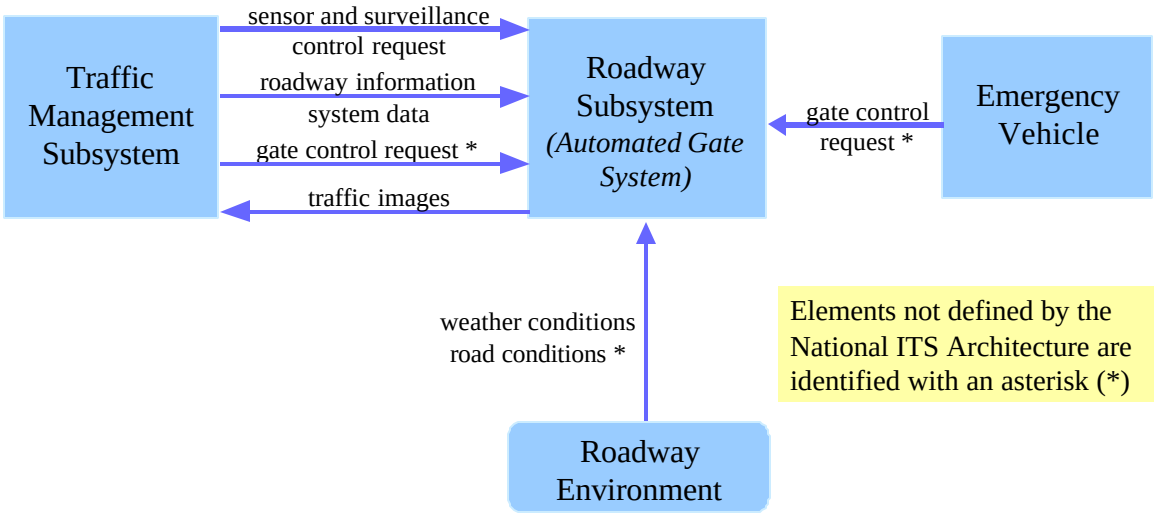


Figure 15: Road Closure Management Market Package

Mobile Traffic Management/Enforcement

The Mobile Traffic Management/Enforcement market package includes portable traffic control and enforcement equipment to be dynamically positioned in work zones and other locations where excessive speed is an issue. These systems use dynamic message signs to provide pertinent regulatory information to drivers at targeted locations. Optionally, sensors can be included to monitor the traffic stream and video imaging and recording systems can be added to support automatic detection and recording of infractions for enforcement applications.

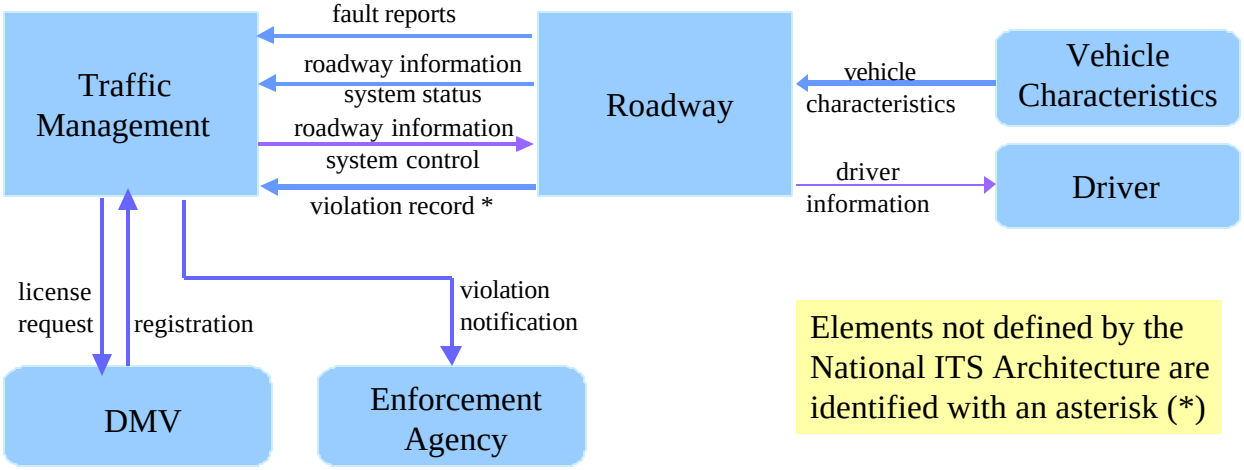


Figure 16: Mobile Traffic Management/Enforcement

Chapter
4

THE GYRITS REGIONAL ARCHITECTURE

Defining the Regional Architecture for GYRITS

The purpose of this chapter is to present the Greater Yellowstone Regional Architecture in a top-down manner, beginning with a high-level "sausage diagram" that is approachable and familiar, particularly for those with some previous exposure to the National ITS Architecture. As the chapter progresses, additional detail is added to this general framework to provide a more detailed description of the systems in the region and a framework for integrating these systems together into a cohesive, scalable network that will cost-effectively meet the needs of the region.

The Greater Yellowstone Regional Architecture is a master blueprint for an integrated, multimodal Intelligent Transportation System. The architecture identifies the major systems in the region and defines the interfaces between these systems. It clarifies how organizations, both public and private, can work together to deliver better safety, efficiency, and convenience to the rural traveler through deployment of ITS improvements.

The regional architecture was developed with participation from the transportation, tourism, and public safety agencies and myriad private interests that operate and use the transportation systems in the region. These regional partners, through the Greater Yellowstone Project Steering Committee, have identified the central requirements for the regional architecture. This collaborative effort will continue as the regional architecture is reviewed, refined, and adapted to meet changing needs and evolving preferences in the future.

The Greater Yellowstone Regional Architecture:

- **Does** focus its definition on the major system and institutional boundaries in the region. This emphasis is because optimal system performance can only be achieved when the overall system works as well at the jurisdictional boundaries as it does everywhere else.

- **Does** demonstrate conformance with the National ITS Architecture. The regional architecture is defined to the architecture flow level which should meet or exceed the level of detail required to satisfy federal policy for conformance with the National ITS Architecture.

- **Does** provide a long-term view that can guide ITS planning and project development in the region. The majority of the systems and the interfaces that are identified in the regional architecture have not yet been implemented.

- **Does Not** define the internal architecture or design for individual systems in the region. The regional architecture is silent on internal design decisions since these decisions are better left to the implementing agencies and their contractors.

- **Does Not** alter the existing institutional arrangements or the authority of participating agencies. A fundamental requirement of the regional architecture is to operate within the existing institutional framework in the region.

- **Does Not** mandate specific technology choices in the region. The steering committee may consider technology agreements, but these extend the fundamentally technology-independent framework defined by the regional architecture.

A Greater Yellowstone Regional Architecture "Sausage Diagram"

As an initial introduction to the Greater Yellowstone Regional Architecture, the systems in the region can be recast into a "sausage diagram" based on the mapping between regional systems and the National ITS Architecture that was developed in Chapter 2. The familiar sausage diagram is a mainstay of National ITS Architecture presentations and has been widely adopted as a useful way to present major systems and communications interconnects at the highest level. Figure 17 highlights the elements of the National ITS Architecture sausage diagram that are applicable to the Greater Yellowstone Region. As can be seen, all elements of the architecture are, or will be, relevant to the region except for the vehicle to vehicle communications interconnect.

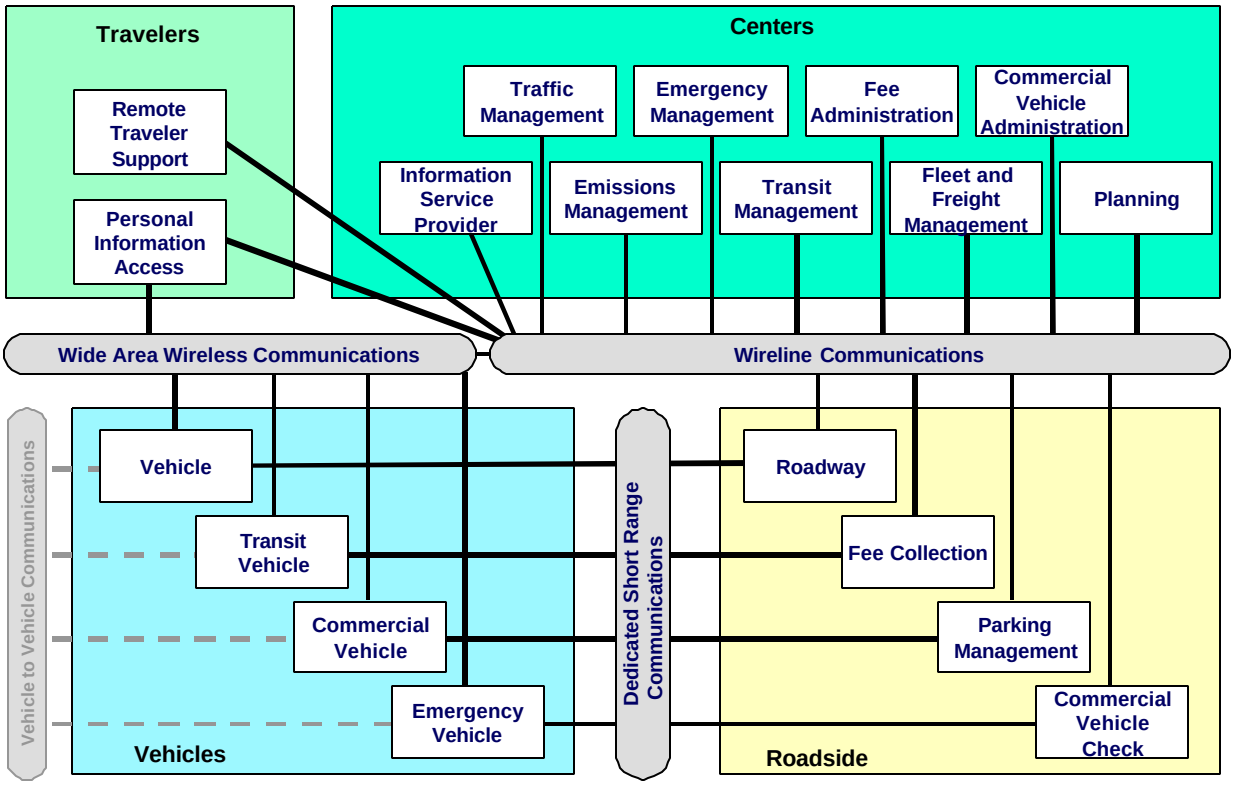


Figure 17: Subsystems and Interconnects Applicable to the Greater Yellowstone Region

The figure shows that all the subsystems and the majority of the communications interconnects defined in the National ITS Architecture have application in the Greater Yellowstone region. Two subsystems have been renamed to reflect the broader role they play in the Greater Yellowstone Region. The subsystem names that differ from the National ITS Architecture are the "Fee Administration Subsystem" and the "Fee Collection Subsystem". These subsystems are adaptations of the Toll Administration Subsystem and Toll Collection Subsystem that support more general fee collection services (e.g., National Park entrance fee collection).

All of these subsystems are included in the current detailed regional architecture definition for the Greater Yellowstone region except for the Planning Subsystem and the Emissions Management Subsystem. The Planning Subsystem is currently being extensively revised as part of the Archived Data User Service Addition to the National ITS Architecture. In this update, the Planning Subsystem will be replaced by a new Archived Data Management Subsystem. When this version of the architecture is available (Fall 1999), the new subsystem and interfaces should be mapped into the Greater Yellowstone Region. The general air-quality management features

of the emissions management subsystem are anticipated to be of interest to the National Parks. Once these potential systems are discussed with the National Park stakeholders, these systems can also be reflected into the detailed regional architecture definition.

The Greater Yellowstone Regional Architecture "Centers"

Figure 18 focuses on the "Centers" that are identified in the Greater Yellowstone Regional Architecture and identifies the agencies and systems that are associated with these center subsystems. Several items are worth noting:

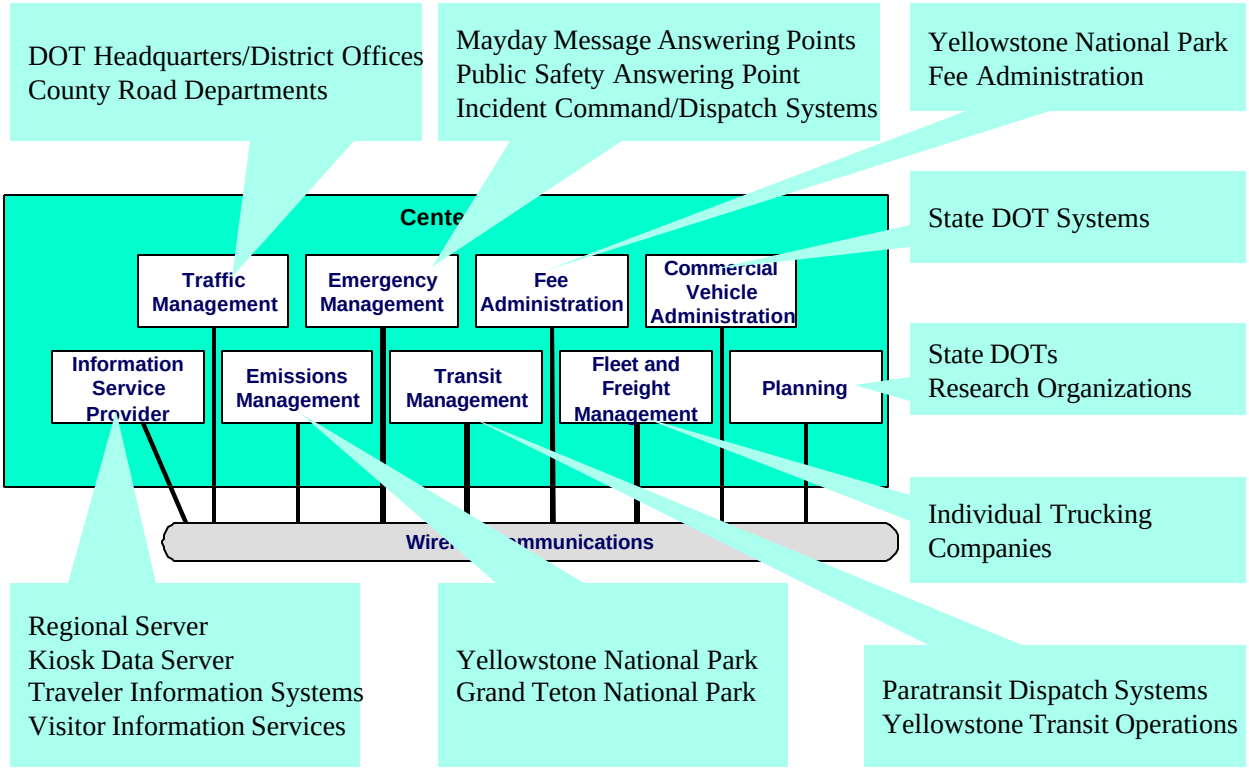


Figure 18: Greater Yellowstone Regional Center Systems

1) A single State DOT "Headquarters/District Offices" Center is depicted in the regional architecture. This does not imply that a single traffic management center is envisioned for the region. In fact, there will be several operational centers for each State DOT. By grouping each of these potential physical centers together into a single "box", the regional architecture indicates that each State DOT should connect into the larger regional system in a consistent way, using the same ITS standards.

2) Similarly, a single "Incident Command/Dispatch Systems" Center is shown in the regional architecture. Of course, there are many dispatch systems that are operated by many different public safety agencies in the region. By modeling these systems as a single "box", the regional architecture indicates that these dispatch systems should connect into the larger regional system in a consistent way. Internally, these dispatch systems may all be different, but the regional architecture suggests that a common interface should be defined, based on ITS standards, to cost-effectively address the ITS integration requirements of the public safety agencies in the region.

3) Several different types of Information Service Providers are identified in the architecture, each providing distinct information services for the region. The "Regional Server" will play an operational role in the region, enabling real-time transportation information sharing between the various agencies in the region. In addition to this operational role, the Regional Server is intended to provide a gateway to various traveler information providers. This gateway service provides a scalable, real-time information service to traveler information systems in the region, effectively shielding the operational systems that manage the regional transportation systems from those that provide traveler information services. Potentially valuable information that may be included on the Regional Server include construction and maintenance schedules, road closures, planned events and incidents, hazardous material movement, incident management plans, interagency agreements, and contact information for the various stakeholder agencies throughout the region.

4) Another Information Service Provider, the "kiosk data server" is intended to serve traveler kiosks with current traveler information. The current server relies heavily on manual data inputs, however, future upgrades will facilitate the transfer of accurate and timely information to the Kiosks without any manual data entry. "Traveler Information Systems" is a general class of information service provider that serves the traveling public and other transportation system "end users". Myriad different traveler information systems may be deployed in the region, each providing unique value-added content over different communications delivery mechanisms (e.g., FM Subcarrier vs. Cellular Services vs. …). The regional architecture specifies that each of these systems will access real-time traveler information in a consistent way, based on ITS standards. The fourth class of information

service provider, the "Visitor Information System" is focused on tourist information services that are a natural evolution of the information services provided by the state departments of tourism and local chambers of commerce. These systems provide both end-user services and up-to-date visitor information to other service providers to increase the availability of tourist information for the region.

Virtual Centers

The numerous "Centers" in the Greater Yellowstone Regional Architecture are not envisioned to be expensive, fully staffed ITS centers like those found in San Antonio, Los Angeles, and other large metropolitan areas. While selected centers in the region (e.g., the Public Safety Answering Points) may be traditional, large-scale operations centers with dedicated staffs, many regional centers will be more limited in scope. These smaller scale centers are identified as "virtual centers" in the National ITS Architecture documentation and other recent literature on this topic.

Virtual centers have several defining attributes:

- A virtual center does not collocate staff from different agencies in a single location. Coordination and information sharing between agencies is supported by the communications network rather than by collocating personnel.

- A virtual center may be implemented with one or more inexpensive computer systems that use existing communications systems to connect with other virtual centers and/or the Regional Server. Essentially, the idea is to scale down the system requirements for the center to suite agency needs and staffing levels. In some cases, a "Center" may be a personal computer that connects to the regional network and meets the needs of a single operations person on the agency staff.

As an example of a virtual center, the "Regional Server" Center could be an Internet website with an associated ftp site. This would allow password protection for data updating and uniform web administration duties to incorporate information from all the various stakeholder agencies. This would ensure uniform and consistent presentation of information to the end users while coordinating multiple sources of data and information. The Internet format will also allow the server to be in any location, as the electronic administration does not necessarily have to be housed in any one agency

- Virtual centers are typically not staffed around the clock and may be distributed so that the system operators who often have other responsibilities can monitor and manage system operation from different locations, for instance in the office, at home, and in the field.

Whatever the scale of each center, the important constraint imposed by the regional architecture is that these centers connect to the broader regional network in a consistent way, using ITS and other industry standards as a basis for these connections.

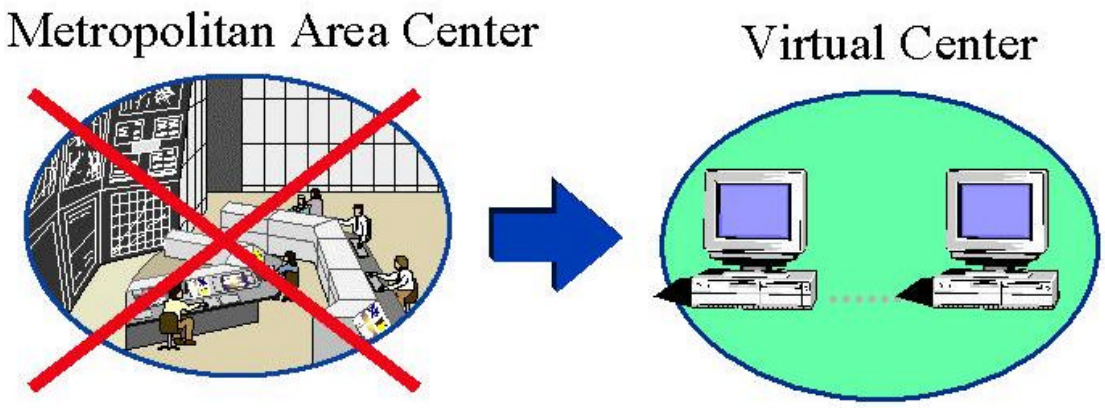


Figure 19: “Virtual” Centers can serve many of the needs of the Greater Yellowstone Region

A More Detailed Look at Regional Systems and Interconnects

The standard National ITS Architecture sausage diagram has several limitations that are addressed in this section.

- The standard sausage diagram only shows the 19 subsystems; it omits the 56 terminators, some of which are very important to the Greater Yellowstone Regional Architecture.

- The sausage diagram also shows a deceptively simple, fully networked communications system that connects every subsystem with every other on a single region-wide backbone. The Greater Yellowstone Regional Architecture does not require such complete connectivity between systems; in fact, a partitioned network which limits access to various systems and assets is important from a practical standpoint.

To address these issues, this section provides a more detailed view of how the systems in the region can be integrated together. The general connection strategy is a structure of several subnetworks that are interconnected through defined gateways to improve information sharing across the region without sacrificing the performance, reliability, and security of the most safety-critical portions of the network. Figure 20 is the high-level interconnect diagram for the region. This figure offers a more complete view of the types of systems in the region and the potential connectivity between these systems.

GYRITS Regional Architecture Interconnects

Figure 20 includes a number of interconnects that are more specific than the four basic interconnects (Wireline, Wide Area Wireless, DSRC, and Vehicle to Vehicle) defined by the National ITS Architecture. For example, several different "wireline" interconnects are defined to segregate the different applications for fixed point to fixed point communications in the region. This separation is important because the different wireline applications have different reliability, security, and performance constraints. Each of the interconnects in the graphic are described in more detail in Table 3.

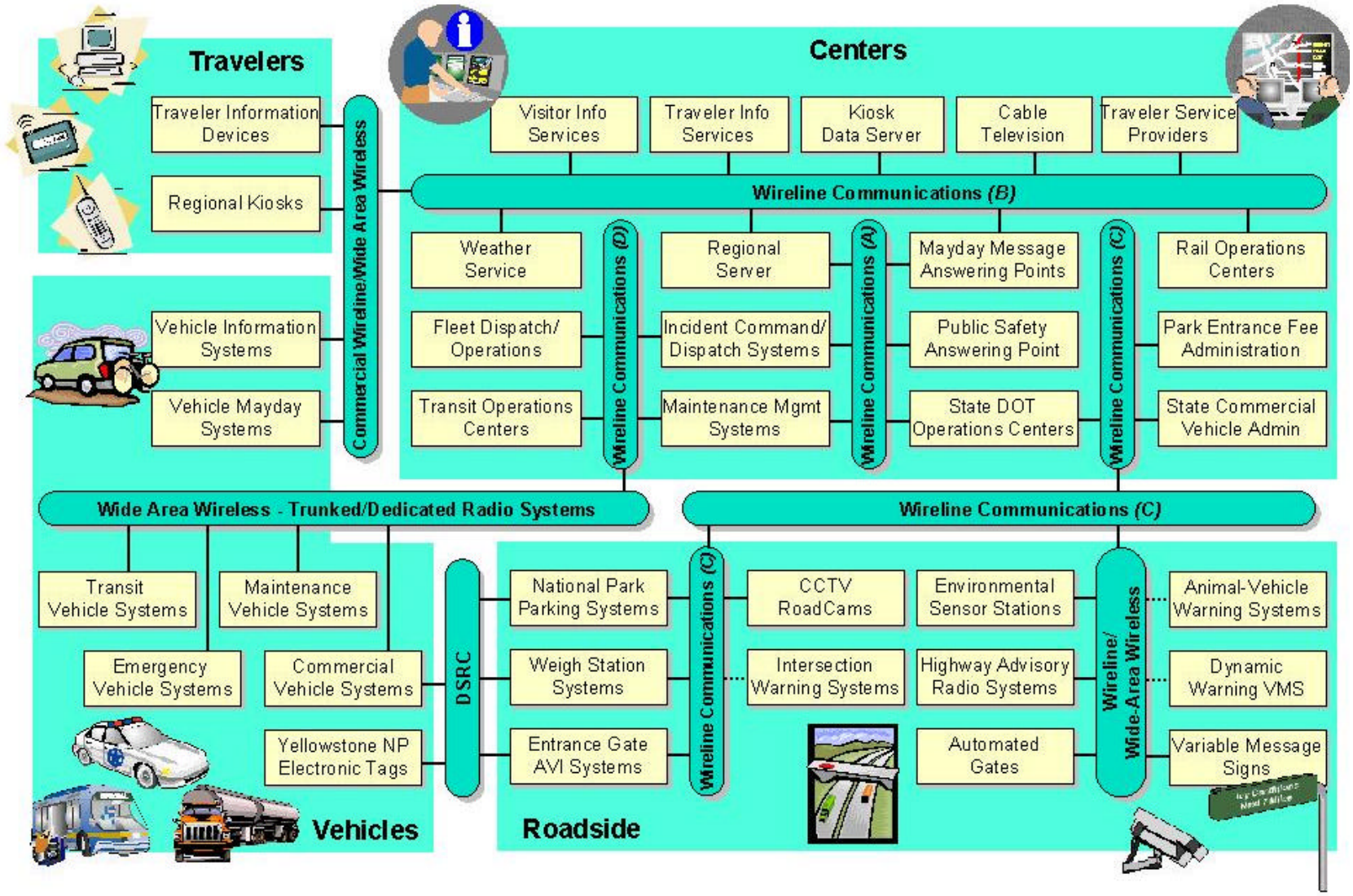


Figure 20: Greater Yellowstone Regional Architecture Systems and Interconnects

Table 3: GYRITS Regional Architecture Interconnect Definitions

Interconnect	Definition
Commercial Wireline/Wireless Networks	This interconnect represents the communications channels that connect information providers with their customers. A variety of commercial wireline and wireless communications systems can provide these connections today; on-going technical innovation in this dynamic, market driven area suggest that new communications options will be offered in the future. Beyond accommodating the information services and delivery mechanisms that develop as marketable products for the region and a general endorsement of those services that are supported by open standards, the regional architecture is not prescriptive for this interconnect since it is strongly influenced by larger market forces. The objective is not to constrain the number of systems that are deployed in the region, but to encourage private sector participation by making public domain information available to information service providers and developing clear policies that encourage broad participation in the region (reference recent work related to ATIS Business Plans sponsored by ITS America). Wireline communications systems that are available in the region include the traditional circuit switched telephone system (analog today with increasing numbers of higher-speed digital options for the consumer in the future) and cable systems in the larger cities. Perhaps the most relevant wireless media for the region are FM Subcarrier and Cellular communications in the near term and Satellite communications when increasing competition makes this option more affordable.
DSRC	Dedicated Short Range Communications (DSRC) is a short-range airlink used for close-proximity (less than 50-100 feet) transmissions between a mobile user and a base station. This type of interconnect has many applications in ITS wherever location-specific communication with a vehicle is required. The applications for DSRC that are envisioned in the Greater Yellowstone region are fee collection at entrance gates to the National Parks and mainline screening of commercial vehicles at weigh stations. As depicted, the same communications technologies could also be applied to parking management and probe data collection in the future. The regional architecture suggests that the emerging ITS standards for these interconnects be adopted and applied in the region.
Wide-Area Wireless – Trunked/Dedicated Radio Systems	This wireless infrastructure includes the 800 Mhz radio systems, Specialized Mobile Radio systems, and other wide area wireless infrastructure that enables vehicle fleet communications for public safety, maintenance, commercial vehicle, and transit fleets in the region. While primarily thought of as voice communications systems today, data applications will increasingly be supported by these systems in the future. The regional architecture suggests use of industry standards for these communications where they are available. Emerging TCIP standards should be reviewed for use in the transit fleet communications deployments. Although ITS standards work has not yet been initiated for emergency vehicle fleets, interagency agreements and implementations may be considered to facilitate incident command systems and resource sharing for large incidents which require the involvement of many agencies.

Table 3: GYRITS Regional Architecture Interconnect Definitions

Interconnect	Definition
Wireline/Wide-Area Wireless	Often, wireline communications infrastructure are simply not available at likely deployment locations for roadside ITS infrastructure like variable message signs, highway advisory radio, and environmental sensor stations. The cost-effective alternative for these relatively low-bandwidth applications is to use wireless communications to support this field equipment. This interconnect represents the radio systems and cellular infrastructure that will cost-effectively support limited bandwidth communications with remote field equipment.
Wireline Communications *(A)*	Safety-critical incident management communications between public safety, transportation, and other allied agencies is supported by this access-restricted network. Since regional agencies rely on this interconnect to coordinate incident management, this communications system should be reliable, secure, and offer deterministic performance. The regional architecture uses the Regional Server to shield this network from direct traveler information requests and serve as a filter which preserves privacy and security of the communications on the network. To support communications with command posts, staging areas, and other remote command centers that may be established for larger incidents under unified command systems, wireless as well as traditional wireline communications links will be used for this interconnect. The IEEE Incident Management, ITE Traffic Management Data Dictionary and External TMC Communications standards are among the key standards that apply to this interconnect that are recommended by the Regional Architecture.
Wireline Communications *(B)*	This wireline infrastructure makes current transportation information available to information service providers and other stakeholders who desire real-time transportation information, but do not have the direct operations role that would give them access to Wireline Communications *(A)*. While adequate performance and reliability that is scalable to meet future needs is important here, it is less imperative than with Wireline Communications *(A)*. Only data that has been cleansed to support data privacy principles is made available on this network. In the regional architecture, the "Regional Server" is a key source for this traveler information that has been sanitized from the operations version of the same information where necessary. In addition to incident data and other real-time information, this interconnect also makes available more static visitor and traveler information as a resource to information service providers in the region. This interface can be implemented using one or more of the many alternative existing public or private networks that may physically include wireless (e.g. microwave) as well as wireline infrastructure. This interconnect is supported primarily by the SAE ATIS Data Dictionary and Message Set standards.

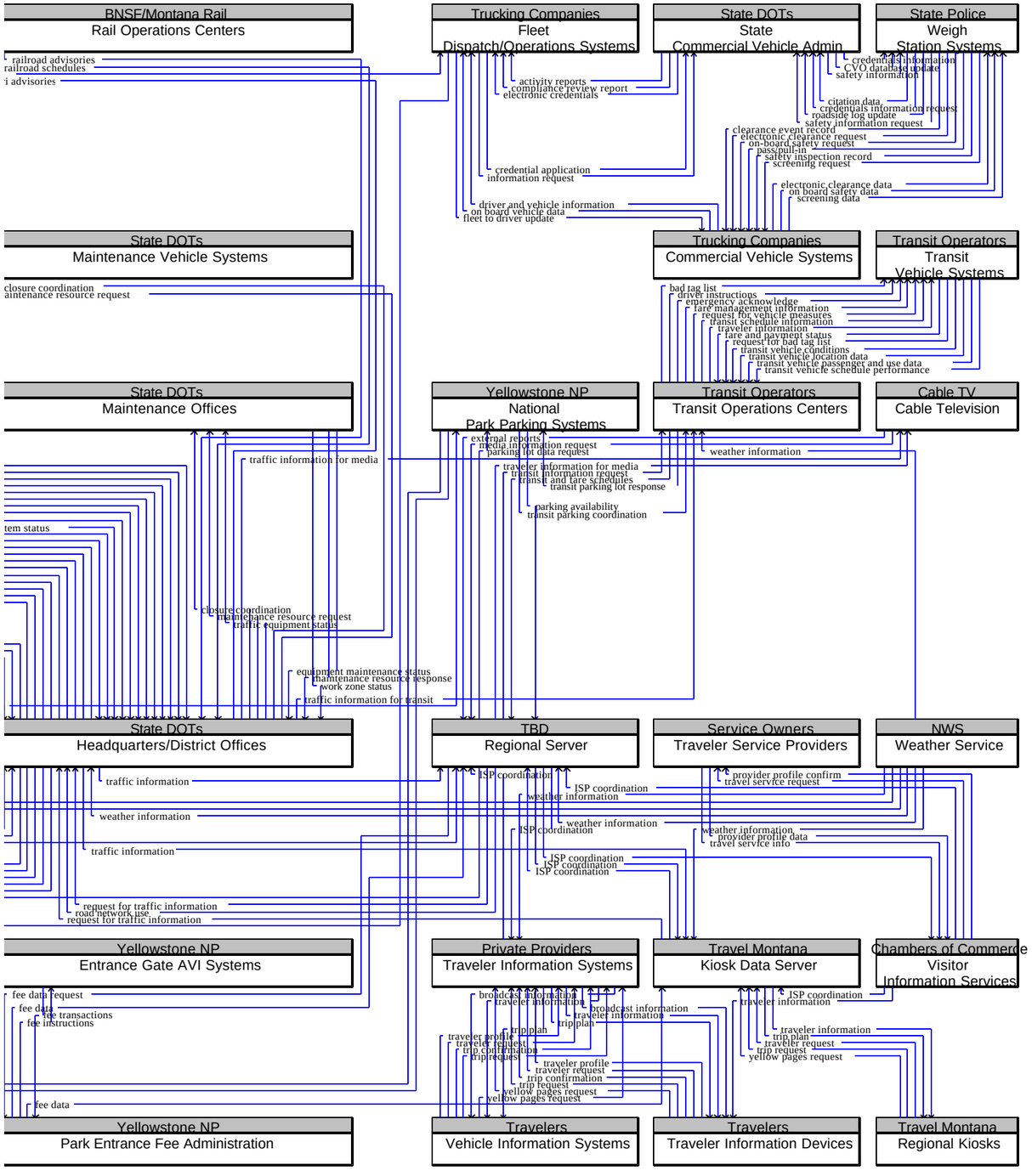
Table 3: GYRITS Regional Architecture Interconnect Definitions

Interconnect	Definition
Wireline Communications *(C)*	This wireline infrastructure connects centers with distributed field equipment that is monitored and controlled by the center. Since this interface enables the monitoring and control of field equipment, access to this interface must be restricted to those authorized to control the field equipment. In the Greater Yellowstone region, this interconnect allows the remote monitoring and control of roadside devices including variable message signs, highway advisory radio, automated road closure gates, dynamic warning systems, CCTV "RoadCam" cameras, etc. The same class of communications interconnect integrates commercial vehicle administration centers (e.g., SummitNET) with weigh stations and connects the fee collection systems (tag readers) at entrance gates with a back office center that manages the overall fee collection system. This interface can be implemented using any of the alternative existing public or private networks that may physically include wireless (e.g. microwave) as well as wireline infrastructure. Where relatively inexpensive low-bandwidth wireless communications alternatives are an option, the regional architecture explicitly shows a connection from "Wireline Communications *(C)*" to "Wireline/Wide Area Wireless". This reflects the likely scenario where wireline communications is used to carry message traffic between the Center and the transceiver which often is remotely located to achieve the best line of sight and coverage. The NTCIP standards activities have already published a number of standards that address the interface to traffic management field equipment. The regional architecture suggests that these standards be used for future implementations in the region to avoid proprietary alternatives and ultimately achieve economies of scale by using standards in the region that are being broadly adopted across the United States.
Wireline Communications *(D)*	This wireline infrastructure connects the fleet dispatcher operating at a fixed point with the trunked and/or dedicated radio systems that provide the wireless connection to the vehicle fleet. This may represent a fairly short run to a building-top antenna or more extensive use of public or private wireline networks for access to remotely located transceivers or trunked radio services. The regional architecture levies no specific requirements for these "dispatcher to antenna" links.

Additional Regional Architecture Details

The complete breadth and depth of the GYRITS regional architecture as defined to date is presented in Figure 21. This figure shows all systems and all architecture flows that have been defined for the regional architecture thus far. It is a product of the most detailed analysis that has been done to date and includes architecture flows that are included in the National ITS Architecture as well as those extended flows that were defined in Chapter 3 to support the GYRITS-unique market packages. The data at this level of detail has not been reviewed by the

steering committee. It is presented at this time as general information pending review and comment by the committee.


BNSF/Montana Rail
Rail Operations Centers
railroad advisories
railroad schedules
i advisories
Trucking Companies
Fleet
Dispatch/Operations Systems
activity reports
compliance review report
electronic credentials
credential application
information request
driver and vehicle information
on board vehicle data
fleet to driver update
State DOTs
State
Commercial Vehicle Admin
credentials information
CVO database update
safety information
citation data
credentials information request
roadside log update
safety information request
clearance event record
electronic clearance request
on-board safety request
pass/pull-in
safety inspection record
screening request
electronic clearance data
on board safety data
screening data
State Police
Weigh
Station Systems
State DOTs
Maintenance Vehicle Systems
closure coordination
aintenance resource request
Trucking Companies
Commercial Vehicle Systems
bad tag list
driver instructions
emergency acknowledge
fare management information
request for vehicle measures
transit schedule information
traveler information
fare and payment status
request for bad tag list
transit vehicle conditions
transit vehicle location data
transit vehicle passenger and use data
transit vehicle schedule performance
Transit Operators
Transit
Vehicle Systems
State DOTs
Maintenance Offices
Yellowstone NP
National
Park Parking Systems
external reports
media information request
parking lot data request
traffic information for media
traveler information for media
transit information request
transit and fare schedules
transit parking lot response
parking availability
transit parking coordination
Transit Operators
Transit Operations Centers
weather information
Cable TV
Cable Television
tem status
closure coordination
maintenance resource request
traffic equipment status
equipment maintenance status
maintenance resource response
work zone status
traffic information for transit
State DOTs
Headquarters/District Offices
TBD
Regional Server
Service Owners
Traveler Service Providers
NWS
Weather Service
traffic information
weather information
traffic information
request for traffic information
road network use
request for traffic information
ISP coordination
ISP coordination
weather information
ISP coordination
weather information
ISP coordination
ISP coordination
ISP coordination
provider profile confirm
travel service request
weather information
provider profile data
travel service info
Yellowstone NP
Entrance Gate AVI Systems
Private Providers
Traveler Information Systems
Travel Montana
Kiosk Data Server
Chambers of Commerce
Visitor
Information Services
fee data request
fee data
fee transactions
fee instructions
fee data
broadcast information
traveler information
broadcast information
traveler information
trip plan
trip plan
traveler profile
traveler request
trip confirmation
trip request
traveler profile
traveler request
trip confirmation
trip request
yellow pages request
yellow pages request
ISP coordination
traveler information
traveler information
trip plan
traveler request
trip request
yellow pages request
Yellowstone NP
Park Entrance Fee Administration
Travelers
Vehicle Information Systems
Travelers
Traveler Information Devices
Travel Montana
Regional Kiosks

Chapter

5

EARLY PROJECT DEFINITION

Early Project Architecture and Implementation Guidance

The purpose of this chapter is to identify the portions of the Regional Architecture that will be implemented by the early projects defined by Task 9. The basic architecture definition for these projects is extended to identify specific architecture flows that will be implemented and ITS standards that may be relevant to these projects.

PRIORITIZED PROJECT SUMMARIES

Five early winner projects have been selected for implementation by the Greater Yellowstone Project Steering Committee.

1. Interactive Touch Screen Kiosks
2. Cellular Incident Hotline Reporting Signing
3. Dynamic Warning Variable Message Signs
4. Incident Management Plan and Hazardous Material Tracking
5. AVI/Smart Card at Park Entrances

A complete description of the project selection process and the projects themselves is presented in the Task 9 report: "Task 9. Preliminary Project Identification and Evaluation". This section provides a summary description for each project and a high-level project architecture that relates the project to the regional architecture defined in chapter 4. Each project architecture definition concludes with a table that identifies standards that are potentially relevant to the project.

INTERACTIVE TOUCH SCREEN KIOSKS

Touch screen interactive kiosks will be placed at strategic locations where travelers stop in the GYRITS area. These kiosks will have a video "grabber" screen to entice travelers to use the system to access information on events, points of interest, services, and real-time road and weather conditions. Kiosks will initially be installed at locations in Montana and in Yellowstone and Grand Teton National Parks, with future locations in communities in Idaho and Wyoming.

1.1.2 Project Architecture

Figure 22 shows the subset of the regional architecture that is relevant to the Kiosks project. It identifies the features and integration options that may be implemented in a high-end state Kiosk project architecture. Elements that are included in the initial project scope are highlighted; the remaining flows are potential options for the initial project or will be considered as future expansion options.

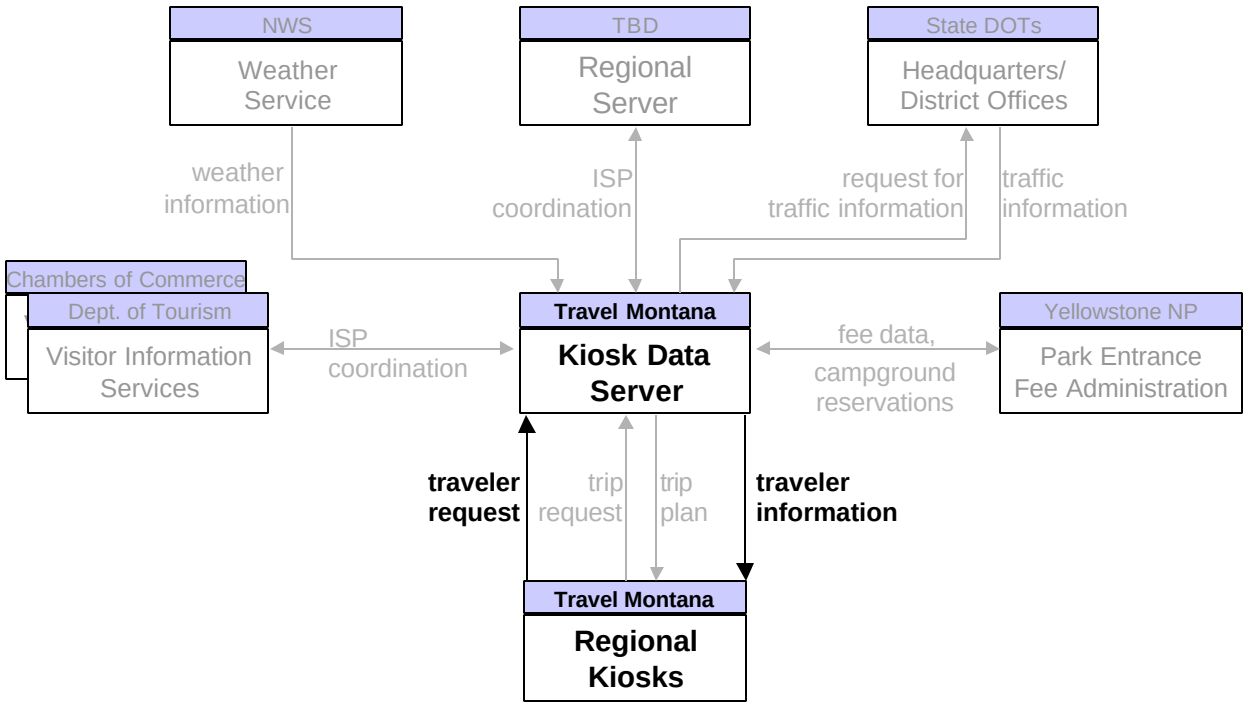


Figure 22: Interactive Touch Screen Kiosks Project Architecture

Note that the Kiosk project architecture shows connections to both the regional server and various direct data sources (i.e., the Weather Service, State DOTs, Yellowstone National Park, various other information service providers). If the regional server is available, then this system will provide a consolidated set of regional traveler information that will obviate the need for direct connections to the other information sources. In the event that the regional server is not implemented, the Kiosk Data Server can collect the information it needs directly from the data sources. Table 4 provides a brief definition of each architecture flow in the figure and an indication of how this flow will be used and when it could be implemented in the Greater Yellowstone region.

The Initial Project: The initial project will include the kiosks, a simple database entry system (identified as a Kiosk Data Server in the regional architecture) that allows updated traveler information to be entered into the system, and a dedicated phone line that supports the transfer of information to the kiosks (the "traveler information" architecture flow). The remaining integration options that are shown will be considered as part of the initial project or in future upgrades to the project. These potential interfaces will be considered in the initial project to the extent that the system can be cost-effectively designed to support these systems.

Expansion Options: As area agencies develop the capability to share real-time information in the region, real-time traveler and tourist information will be available in the region. By accessing this information, the initial Database Entry system will evolve into a true Kiosk Data Server that will be less reliant on manual entry and automatically make real-time traveler information available to the kiosks. The regional architecture also shows future expansion to provide enhanced traveler information services at the kiosks. These new features and enhanced services include:

- Real-time traffic, road, and weather conditions and other real-time information can be collected from operational centers and presented to travelers. Two means of collecting this information are identified: 1) If a Regional Server is implemented in the region, this Server would be the source for all required real-time traveler information and would be the logical point of access for the Kiosk Data Server, or 2) If the Regional Server is not implemented, then a direct data feed from Headquarters/ District Offices and other agency systems to the Kiosk Data Server could be provided. While the first implementation option is preferable

since it provides all required information through a single standard interface, the second option is available if the Regional Server is not developed or its development trails the enhancement to the Kiosk System. The Regional Server would also provide access to transit information, tourist information, the National Park AVI system information, and other information resources over the same interface to the Kiosk Data Server.

- Enhanced tailored information services can be provided to the kiosk user. These services include reservations and trip planning services that can only be provided with two-way real-time interaction between the data server and the kiosks.

Table 4: Regional Architecture Flows Related to Interactive Touchscreen Kiosk Project

Source	Destination	Flow	Definition	GYRITS Application
Kiosk Data Server	Regional Kiosks	traveler information	Traveler information comprised of traffic status, advisories, incidents, responses to traveler requests (e.g., traveler routing, yellow pages), payment information and many other travel-related data updates and confirmations.	**Included in the initial project.** Initially, the interface will provide current tourist information, traffic advisories, incidents, maintenance activities, and weather information. Later enhancements may add more advanced interactive services that are included in the broader National ITS Architecture definition.
Kiosk Data Server	Regional Kiosks	trip plan	A sequence of links and special instructions comprising a trip plan indicating efficient routes for navigating the links. Normally coordinated with traffic conditions, other incidents, preemption and prioritization plans.	A future flow that provides customized travel itineraries and route guidance that can be added depending on the success of the initial project and funding availability.
Kiosk Data Server	Headquarters/ District Offices	request for traffic information	Request for traffic information that specifies the region/route of interest, the desired effective time period, and other parameters that allow preparation of a tailored response. The request can be a subscription that initiates as-needed information updates as well as a one-time request for information.	This direct connection to the State DOT Headquarters/District Offices is a fall back position in case a Regional Server is not implemented in a timely fashion. In that event, the Kiosk Data Server could access real-time information directly from the various operations centers in the region.
Park Entrance Fee Administration	Kiosk Data Server	fee data/campground reservations	Current fee schedules for different types of vehicles as well as advanced fee payment information.	An extended flow that also includes campground reservations and other National Park reservations in addition to information on the new National Park Electronic Pass (AVI) system. This information would only be provided once the system is operational and beginning to be made available to tourists at some point in the future. This information would also be available through the Regional Server.
Regional Kiosks	Kiosk Data Server	traveler request	Request by a traveler to summon assistance, request information, make a reservation, or initiate any other traveler service.	**Related flow included in the initial project.** Note that the initial implementation may include minimal fault reporting information and kiosk status back from the kiosk to the data server. This initial implementation will store traveler services information on the kiosk, which will obviate the need for many of the interactive information features of this flow. Additional interactive traveler services could be implemented using the same communications interconnect and may be implemented in the future based on the success of the initial project.

Table 4: Regional Architecture Flows Related to Interactive Touchscreen Kiosk Project

Source	Destination	Flow	Definition	GYRITS Application
Regional Kiosks	Kiosk Data Server	trip request	Request by a driver/traveler for special routing.	This interactive trip planning service may be implemented in the future based on the success of the initial project.
Regional Server	Kiosk Data Server	ISP coordination	Coordination and exchange of transportation information between centers. This flow allows a broad range of transportation information collected by one ISP to be redistributed to many other ISPs and their clients.	This flow will be the primary source of real-time travel information once a Regional Server is operational. The Regional Server will serve as a gateway, collecting real-time travel information from operating centers and making it generally available to other systems (like the Kiosk Data Server) in the region.
Headquarters/ District Offices	Kiosk Data Server	traffic information	Current and predicted traffic information, road and weather conditions, incident information, and pricing data. Either raw data, processed data, or some combination of both may be provided by this architecture flow.	This flow would allow collection of real time traffic, road, and weather conditions from the state DOTs and other operating agencies in the event that a Regional Server is not implemented.
Visitor Information Services	Kiosk Data Server	ISP coordination	Coordination and exchange of transportation information between centers. This flow allows a broad range of transportation information collected by one ISP to be redistributed to many other ISPs and their clients.	Systems operated by the State Departments of Tourism and the Chambers of Commerce could directly provide current tourist information to the Kiosk Data Server in the future, obviating the need for manual entry of this information specifically to support the kiosk system.
Weather Service	Kiosk Data Server	weather information	Accumulated predicted and current weather data (e.g., temperature, pressure, wind speed, wind direction, humidity, precipitation, visibility, light conditions, etc.).	A third party provider, state meteorologist, or some other source that creates weather information products could actually provide this flow. This direct connection between weather provider and the Kiosk Data Server would only be required in the event that the Regional Server is not implemented or weather products available on the Regional Server are not suited to presentation on the Kiosks.

1.1.3 Related ITS Standards

The standards that may be relevant to the Interactive Touchscreen Kiosks project are identified in the Table 5. Each row in the table identifies a standard and the interface (in terms of source and destination) where that standard may be applicable. Standards that are applicable to multiple interfaces are repeated more than once in the table. The last three columns in the table indicate whether the standard establishes communications protocol ("C"), data dictionary ("D"), or message set ("M") standards for ITS. All three types of standards may be required to fully define an interoperable interface. This comprehensive standards list was generated based on the relationships between the project architecture, the national ITS architecture, and the standards activities. These lists should be reviewed and refined to identify the subset of these standards that should actually be considered for use in project implementation.

Table 5: ITS Standards Relevant to the Interactive Touchscreen Kiosk Project

SDO	Standard Title	Source	Destination	C	D	M
AASHTO	NTCIP - Class E Profile for Center to Center Communications	Kiosk Data Server	Headquarters/ District Offices	C		
AASHTO	NTCIP - Class E Profile for Center to Center Communications	Regional Server	Kiosk Data Server	C		
AASHTO	NTCIP - Class E Profile for Center to Center Communications	Headquarters/ District Offices	Kiosk Data Server	C		
AASHTO	NTCIP - Class E Profile for Center to Center Communications	Visitor Information Services	Kiosk Data Server	C		
ITE	ATMS Data Dictionary (TMDD) - Section 1 (Links/Nodes)	Kiosk Data Server	Headquarters/ District Offices		D	
ITE	ATMS Data Dictionary (TMDD) - Section 1 (Links/Nodes)	Headquarters/ District Offices	Kiosk Data Server		D	
ITE	ATMS Data Dictionary (TMDD) - Section 2 (Incidents)	Kiosk Data Server	Headquarters/ District Offices		D	
ITE	ATMS Data Dictionary (TMDD) - Section 2 (Incidents)	Headquarters/ District Offices	Kiosk Data Server		D	
ITE	External TMC Communications Scoping and Requirements Study	Kiosk Data Server	Headquarters/ District Offices			M
ITE	External TMC Communications Scoping and Requirements Study	Headquarters/ District Offices	Kiosk Data Server			M
ITE	Message Set for External TMC Communication (MS/ETMCC) - Bundle A	Kiosk Data Server	Headquarters/ District Offices			M
ITE	Message Set for External TMC Communication (MS/ETMCC) - Bundle A	Headquarters/ District Offices	Kiosk Data Server			M
ITE	Message Set for External TMC Communication (MS/ETMCC) - Bundle B	Kiosk Data Server	Headquarters/ District Offices			M
ITE	Message Set for External TMC Communication (MS/ETMCC) - Bundle B	Headquarters/ District Offices	Kiosk Data Server			M

Table 5: ITS Standards Relevant to the Interactive Touchscreen Kiosk Project

SDO	Standard Title	Source	Destination	C	D	M
SAE	Advanced Traveler Information System (ATIS) Data Dictionary	Kiosk Data Server	Regional Kiosks		D	
SAE	Advanced Traveler Information System (ATIS) Data Dictionary	Regional Kiosks	Kiosk Data Server		D	
SAE	Advanced Traveler Information System (ATIS) Data Dictionary	Regional Server	Kiosk Data Server		D	
SAE	Advanced Traveler Information System (ATIS) Data Dictionary	Headquarters/ District Offices	Kiosk Data Server		D	
SAE	Advanced Traveler Information System (ATIS) Data Dictionary	Visitor Information Services	Kiosk Data Server		D	
SAE	Advanced Traveler Information System (ATIS) Data Dictionary	Weather Service	Kiosk Data Server		D	
SAE	Advanced Traveler Information System (ATIS) Message Set	Kiosk Data Server	Regional Kiosks			M
SAE	Advanced Traveler Information System (ATIS) Message Set	Regional Kiosks	Kiosk Data Server			M
SAE	Advanced Traveler Information System (ATIS) Message Set	Regional Server	Kiosk Data Server			M
SAE	Advanced Traveler Information System (ATIS) Message Set	Visitor Information Services	Kiosk Data Server			M
SAE	Advanced Traveler Information System (ATIS) Message Set	Weather Service	Kiosk Data Server			M

INCIDENT REPORTING HOTLINE SIGNING

Static signs will be placed at strategic locations in advance of areas where there are relatively high emergency response times and where cellular telephone coverage exists. These static signs will display information on existing phone numbers for reporting incidents such as 911, *ISP, #HELP, 1-800-525-5555.

1.1.4 Project Architecture

Static sign installations are not identified in an ITS Architecture since they do not require a data interface. Note that the call-taker function that receives 9-1-1 calls is modeled in the regional architecture since it is a primary incident reporting interface and an important early source of incident information for ITS. The systems that support 9-1-1 in the regional architecture are the Public Safety Answering Point and the E-9-1-1 Telecommunications system where standards are generally established through the National Emergency Number Association (NENA).

DYNAMIC WARNING VARIABLE MESSAGE SIGNS

Dynamic Warning Variable Message Signs (VMS) will utilize real-time information collected by sensors in order to give immediate warnings to drivers at spot locations. For the early winner projects, the advisory will consist of warning of safe speeds in advance of curves and downgrades. This technology may or may not utilize pavement sensors and weigh-in-motion to assist in determining safe speed advisories.

1.1.5 Project Architecture

Figure 23 shows the subset of the regional architecture that is relevant to the Dynamic Warning VMS project. In addition to the roadside and operations center systems that are included in the regional architecture, the figure shows the other environmental and human interfaces that the Dynamic Warning VMS may implement. Elements that are included in the initial project scope are highlighted; the remaining flows are potential options for the initial project or will be considered for future installations or upgrades to existing installations. Table 6 provides a brief definition of each architecture flow in the figure and an indication of how the flow will be used and when it could be implemented in the Greater Yellowstone region.

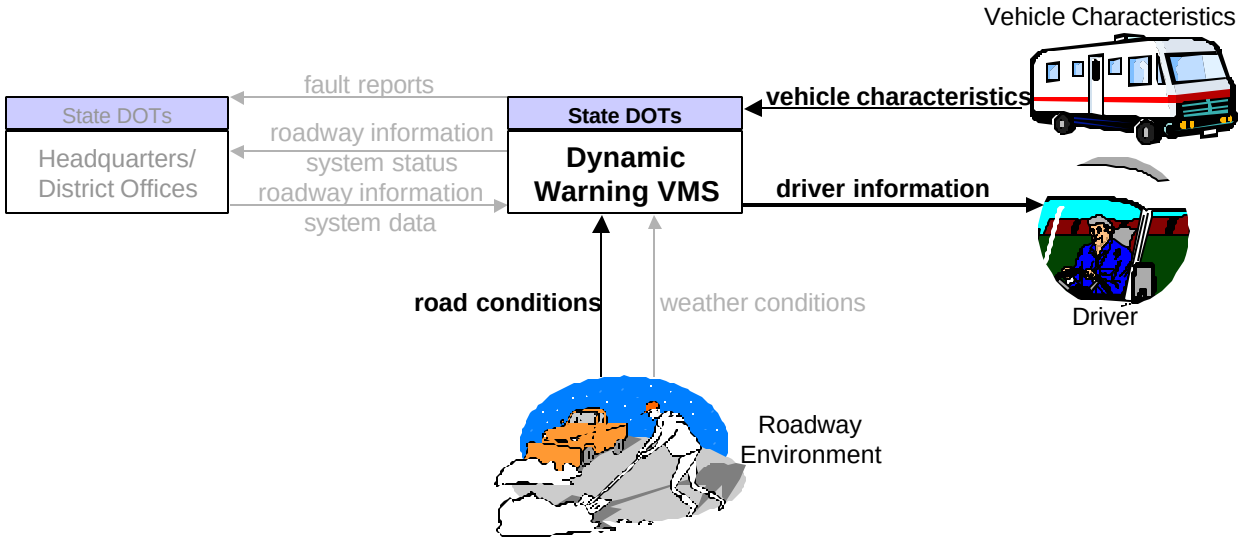


Figure 23: Dynamic Warning VMS Project Architecture

Table 6: Regional Architecture Flows Related to Dynamic Warning VMS Project

Source	Destination	Flow	Definition	GYRITS Application
Dynamic Warning VMS	Driver	Driver information	General advisory and traffic control information provided to the driver while en-route.	**Included in the initial project architecture.** This is the interface between the sign display and the driver's eyes which is subject to uniformity standards (e.g., MUTCD) but as a human interface, is not the focus of the regional architecture.
Dynamic Warning VMS	Headquarters/ District Offices	Fault reports	Reports from field equipment (sensors, signals, signs, controllers, etc.) which indicate current operational status.	Preliminary project descriptions indicate the first DWS installations will be autonomous. Two-way communications would allow fault reports to be generated by the DWS to notify traffic operations or maintenance personnel of potential device failures.
Dynamic Warning VMS	Headquarters/ District Offices	Roadway information system status	Current operating status of dynamic message signs, highway advisory radios, beacon systems, or other configurable field equipment that provides dynamic information to the driver.	Preliminary project descriptions indicate the first DWS installations will be autonomous. Two-way communications would allow system operation (and vehicle behavior) to be remotely monitored and collected.
Roadway Environment	Dynamic Warning VMS	Road conditions	Road surface conditions that can be detected and measured by environmental sensors on and about the road surface.	**Included in the initial project architecture.** Real-time measures of road surface conditions can be measured and factored into the safe speed warnings that are displayed. These sensors will be deployed as part of the project.
Roadway Environment	Dynamic Warning VMS	Weather conditions	Collected weather condition data from sensors.	Real-time measures of local weather conditions (e.g., visibility, and ambient light) can be factored into the safe speed warnings that are displayed. These sensors will not be part of the initial DWS project.

Table 6: Regional Architecture Flows Related to Dynamic Warning VMS Project

Source	Destination	Flow	Definition	GYRITS Application
Headquarters/ District Offices	Dynamic Warning VMS	Roadway information system data	Information used to initialize, configure, and control roadside systems that provide driver information (e.g., dynamic message signs, highway advisory radio, beacon systems). This flow can provide message content and delivery attributes, local message store maintenance requests, control mode commands, status queries, and all other commands and associated parameters that support remote management of these systems.	Preliminary project descriptions indicate the first DWS installations will be autonomous. Two way communications would allow the Dynamic Warning Signs to be remotely controlled. For example, a special message could be downloaded in the event of an emergency or other operating parameters could be adjusted manually without visiting the site.
Vehicle Characteristics	Dynamic Warning VMS	Vehicle characteristics	The physical or visible characteristics of an individual vehicle that can be measured to classify a vehicle and imaged to uniquely identify a vehicle.	**Partially implemented in the initial project.** For the initial DWS project, only vehicle speed will be measured. In addition to providing the key input to the DWS, vehicle speed data will be an important evaluation measure for the project. Future implementations will also measure vehicle weight and size so that more accurate advisories can be provided to the driver. Although it is not planned at this time, the DWS could also be adapted in the future to be a speed enforcement system by adding surveillance equipment/sensors that can record images of the vehicle and occupants.

Initial Project: The initial Dynamic Warning VMS project will include an advanced controller, variable message sign, custom software, and sensors that measure vehicle speed and road conditions. This equipment will be configured to operate autonomously in the initial implementation.

Expansion Options: Two major avenues for Dynamic Warning VMS enhancement are available: 1) The addition of two way communications and software that allow remote control and monitoring of the equipment, and 2) Deployment of additional sensors so that more accurate warnings are generated that take into account vehicle size and weight and additional road and weather conditions information. These more advanced features could be included in the initial project design or left as expansion options to be addressed in future upgrades.

1.1.6 Related ITS Standards

The standards that are related to the Dynamic Warning System project are identified in the following table. Each row in the table identifies a standard and the interface (in terms of source and destination) where that standard may be applicable. Standards that are applicable to multiple interfaces are repeated more than once in the table. The last three columns in the table indicate whether the standard establishes communications protocol ("C"), data dictionary ("D"), or message set ("M") standards for ITS. All three types of standards may be required to fully define an interoperable interface. This comprehensive standards list was generated based on the relationships between the project architecture, the national ITS architecture, and the standards activities. These lists should be reviewed and refined to identify the subset of these standards that should actually be considered for use in project implementation.

Table 7: ITS Standards Relevant to the Dynamic Warning VMS Project

SDO	Standard Title	Source	Destination	C	D	M
AASHTO	NTCIP - Class B Profile	Dynamic Warning VMS	Headquarters/ District Offices	C		
AASHTO	NTCIP - Object Definitions for Data Collection and Monitoring Devices	Dynamic Warning VMS	Headquarters/ District Offices		D	M
AASHTO	NTCIP - Object Definitions for Dynamic Message Signs	Dynamic Warning VMS	Headquarters/ District Offices		D	M
AASHTO	NTCIP - Object Definitions for Dynamic Message Signs	Headquarters/ District Offices	Dynamic Warning VMS		D	M
AASHTO	NTCIP - Object Definitions for Environmental Sensor Systems	Dynamic Warning VMS	Headquarters/ District Offices		D	M

Table 7: ITS Standards Relevant to the Dynamic Warning VMS Project

SDO	Standard Title	Source	Destination	C	D	M
AASHTO	NTCIP - Object Definitions for Transportation Sensor Systems	Dynamic Warning VMS	Headquarters/ District Offices		D	M
ITE	ATMS Data Dictionary (TMDD) - Section 1 (Links/Nodes)	Dynamic Warning VMS	Headquarters/ District Offices		D	
ITE	ATMS Data Dictionary (TMDD) - Section 1 (Links/Nodes)	Headquarters/ District Offices	Dynamic Warning VMS		D	
ITE	ATMS Data Dictionary (TMDD) - Section 3 (traffic control)	Dynamic Warning VMS	Headquarters/ District Offices		D	
ITE	ATMS Data Dictionary (TMDD) - Section 3 (traffic control)	Headquarters/ District Offices	Dynamic Warning VMS		D	
ITE	ATMS Data Dictionary (TMDD) - Section 4 (DMS/Video/etc)	Dynamic Warning VMS	Headquarters/ District Offices		D	
ITE	ATMS Data Dictionary (TMDD) - Section 4 (DMS/Video/etc)	Headquarters/ District Offices	Dynamic Warning VMS		D	

INCIDENT MANAGEMENT PLAN

This project will develop an incident management plan and/or hazardous materials tracking plan for the entire corridor or regional areas of the corridor. The goal of the incident management plan would be to provide a coordinated response to incidents, thus reducing the negative impacts of those incidents.

1.1.7 Project Architecture

Since this project is a paper study, a “project architecture” really doesn’t apply here. It is important, however, that the incident mananagement/hazardous material tracking plan and the regional architecture complement one another. The regional architecture must accurately represent the incident command systems and coordinated response that are central to many incident management plans. This implies that: 1) the plan developers should take the regional architecture into account so that each of the different integration options identified in the architecture is considered, and 2) the final plan should be analyzed and the regional architecture updated so that the plan and architecture are consistent.

AUTOMATED VEHICLE IDENTIFICATION ENTRANCE GATE SYSTEM

An AVI system will be installed at two of the Yellowstone National Park entrance gates (Cooke City and Gardiner) for transit users, employees, concessionaires, and local residents who are impacted by tourist congestion. Future phases may include additional Yellowstone National Park gates and gates in Grand Teton National Park at Moran and Moose. The objective is to create an electronic pass that will be a prototype in Yellowstone National Park and then expanded to other parks.

1.1.8 Project Architecture

Figure 24 shows the subset of the regional architecture that is relevant to the AVI system. Elements that are included in the initial project scope are highlighted; the remaining flows are potential options for the initial project or will be considered for future installations or upgrades to existing installations. Table 10 provides a brief definition of each architecture flow in the figure.

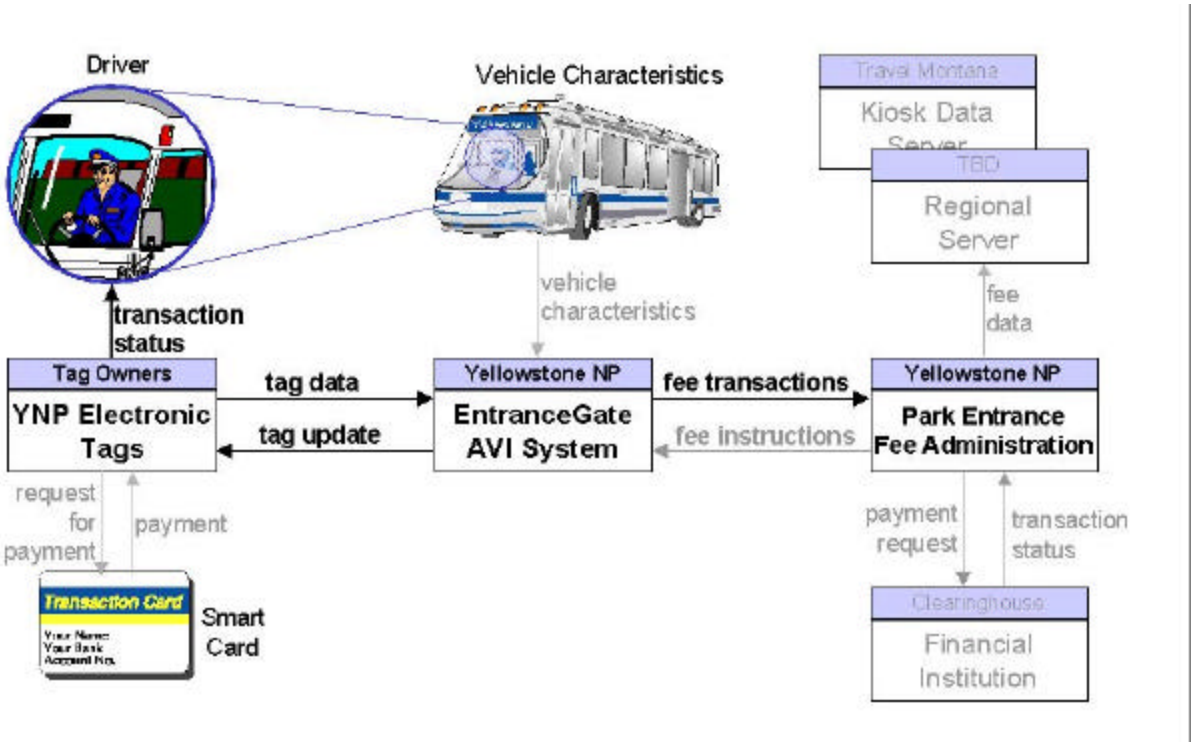


Figure 24: Entry Gate AVI System Project Architecture

Table 8: Regional Architecture Flows for the Entry Gate AVI System

Source	Destination	Architecture Flow	Definition	GYRITS Application
Entrance Gate AVI Systems	Park Entrance Fee Administration	fee transactions	Detailed list of transactions from a fee station.	**Included in initial project architecture.** This flow provides a record of all AVI transactions.
Entrance Gate AVI Systems	YNP Electronic Tags	tag update	Update data held in tag which can be read at another screening.	**Included in initial project architecture.** Update to the stored value on the tag.
Financial Institution	Park Entrance Fee Administration	transaction status	Response to transaction request. Normally dealing with a request for payment.	The interface between the back office system and the financial infrastructure. Since the initial project may only provide tags to annual passholders, there will initially be no pay-for-use financial transaction required.
National Park Parking Systems	YNP Electronic Tags	request tag data	Request for tag information including credit identity, stored value card cash, etc.	Similar electronic fee collection systems could be installed at major parking areas, state parks, ski resorts, and other travel destinations in the future.
National Park Parking Systems	YNP Electronic Tags	tag update	Update data held in tag which can be read at another screening.	Similar electronic fee collection systems could be installed at major parking areas, state parks, ski resorts, and other travel destinations in the future.
Park Entrance Fee Administration	Entrance Gate AVI Systems	fee instructions	Demand management fee pricing information based on current congestion.	Potential future flow supporting dynamic pricing intended to change behavior and reduce peak period congestion at the entry gates.
Park Entrance Fee Administration	Financial Institution	payment request	Request for payment from financial institution.	The interface between the back office system and the financial infrastructure. Since the initial project may only provide tags to annual passholders, there will initially be no pay-for-use financial transaction required.
Park Entrance Fee Administration	Kiosk Data Server	fee data	Current fee schedules for different types of vehicles as well as advanced fee payment information.	Potential integration into traveler information services once the AVI system is more broadly accepted and begins to be used by tourists. At that point, a broad range of information about the system could be made available to information service providers such as the kiosk data server.

Table 8: Regional Architecture Flows for the Entry Gate AVI System

Source	Destination	Architecture Flow	Definition	GYRITS Application
Park Entrance Fee Administration	Regional Server	fee data	Current fee schedules for different types of vehicles as well as advanced fee payment information.	Potential integration into traveler information services once the AVI system is more broadly accepted and begins to be used by tourists. At that point, a broad range of information about the system could be made available to information service providers. The most efficient mechanism for making this information broadly available will be to provide it to the Regional Server where it can be posted to all information providers serving the region.
Park Entrance Fee Administration	Toll Service Provider	toll revenues and summary reports	Summary of toll revenues and toll-related reports to toll service provider.	This general interface for reporting and archiving the electronic transactions is likely to be useful whether the fee collection is managed by a third party or managed directly by the park.
Payment Instrument	YNP Electronic Tags	payment	Payment of some kind (e.g., fee, parking, fare) by traveler which in most cases can be related to a credit account.	Smart cards can be plugged into the vehicle tag and used to support fee collection in future tag implementations.
Regional Server	Park Entrance Fee Administration	fee data request	Request made to obtain fee schedule information or pay a fee in advance. The request can be a subscription that initiates as-needed information updates as well as a one-time request for information.	Potential integration into traveler information services once the AVI system is more broadly accepted and begins to be used by tourists. At that point, a broad range of information about the system could be made available to information service providers. The most efficient mechanism for making this information broadly available will be to provide it to the Regional Server where it can be posted to all information providers serving the region.
Vehicle Characteristics	Toll Collection	vehicle characteristics	The physical or visible characteristics of an individual vehicle that can be measured to classify a vehicle and imaged to uniquely identify a vehicle.	If fees charged are dependent on vehicle type, vehicle classification would have to be determined at the entry gate so that the appropriate fee can be assessed. It is assumed that this feature will not be implemented in the initial project.
YNP Electronic Tags	Driver	transaction status	Response to transaction request. Normally dealing with a request for payment.	**Included in initial project architecture.** Status information displayed to the driver as the transaction is completed.

Table 8: Regional Architecture Flows for the Entry Gate AVI System

Source	Destination	Architecture Flow	Definition	GYRITS Application
YNP Electronic Tags	Payment Instrument	request for payment	Request to deduct cost of service from user's payment account.	Smart cards can be plugged into the vehicle tag and used to support fee collection in future tag implementations.
YNP Electronic Tags	Entrance Gate AVI Systems	tag data	Unique tag ID and related vehicle information for the purposes of payment for services.	**Included in initial project architecture.** Data read from the YNP Electronic Tag.
YNP Electronic Tags	National Park Parking Systems	tag data	Unique tag ID and related vehicle information for the purposes of payment for services.	Similar electronic fee collection systems could be installed at major parking areas, state parks, ski resorts, and other travel destinations in the future.

1.1.9 Related ITS Standards

The standards that may be relevant to the Entry Gate AVI project are identified in the following table. Each row in the table identifies a standard and the interface (in terms of source and destination) where that standard may be applicable. Standards that are applicable to multiple interfaces are repeated more than once in the table. The last three columns in the table indicate whether the standard establishes communications protocol ("C"), data dictionary ("D"), or message set ("M") standards for ITS. All three types of standards may be required to fully define an interoperable interface. This comprehensive standards list was generated based on the relationships between the project architecture, the national ITS architecture, and the standards activities. These lists should be reviewed and refined to identify the subset of these standards that should actually be considered for use in project implementation.

Table 9: ITS Standards Relevant to the Entry Gate AVI Project

SDO	Standard Title	Source	Destination	C	D	M
ASTM	DSRC Data Link Layer	Entrance Gate AVI Systems	YNP Electronic Tags	C		
ASTM	DSRC Data Link Layer	National Park Parking Systems	YNP Electronic Tags	C		
ASTM	DSRC Data Link Layer	YNP Electronic Tags	Entrance Gate AVI Systems	C		
ASTM	DSRC Data Link Layer	YNP Electronic Tags	National Park Parking Systems	C		
ASTM	DSRC Physical Layer - 902-928 MHz	Entrance Gate AVI Systems	YNP Electronic Tags	C		
ASTM	DSRC Physical Layer - 902-928 MHz	National Park Parking Systems	YNP Electronic Tags	C		
ASTM	DSRC Physical Layer - 902-928 MHz	YNP Electronic Tags	Entrance Gate AVI Systems	C		
ASTM	DSRC Physical Layer - 902-928 MHz	YNP Electronic Tags	National Park Parking Systems	C		
IEEE	Message Sets for DSRC ETTM & CVO	Entrance Gate AVI Systems	YNP Electronic Tags		D	M
IEEE	Message Sets for DSRC ETTM & CVO	National Park Parking Systems	YNP Electronic Tags		D	M
IEEE	Message Sets for DSRC ETTM & CVO	YNP Electronic Tags	Entrance Gate AVI Systems		D	M
IEEE	Message Sets for DSRC ETTM & CVO	YNP Electronic Tags	National Park Parking Systems		D	M
SAE	Advanced Traveler Information System (ATIS) Data Dictionary	Financial Institution	Park Entrance Fee Administration		D	
SAE	Advanced Traveler Information System (ATIS) Data Dictionary	Park Entrance Fee Administration	Financial Institution		D	
SAE	Advanced Traveler Information System (ATIS)	Financial Institution	Park Entrance Fee			M

Table 9: ITS Standards Relevant to the Entry Gate AVI Project

SDO	Standard Title	Source	Destination	C	D	M
	Message Set		Administration			
SAE	Advanced Traveler Information System (ATIS) Message Set	Park Entrance Fee Administration	Financial Institution			M
SAE	ITS In-Vehicle Message Priority	Vehicle	Driver			
SAE	Visual Demand Measurement	Vehicle	Driver			

VARIABLE MESSAGE SIGNS PROJECT

Two variable message signs will be installed in Wyoming. These signs will be located in advance of alternate routes or traveler facilities (e.g., lodging and food) and are designed to give advanced warning of weather conditions in order to modify travel behavior.

1.1.10 Project Architecture

Figure 25 shows the subset of the regional architecture that is relevant to the Variable Message Signs project. In addition to the roadside and operations center systems that are included in the regional architecture, the figure shows the human interface to the driver. Elements that are included in the initial project scope are highlighted; the remaining flows are potential options for the initial project or will be considered for future installations or upgrades to existing installations. Table 10 provides a brief definition of each architecture flow in the figure and an indication of how the flow will be used and when it will be implemented in the Greater Yellowstone region.

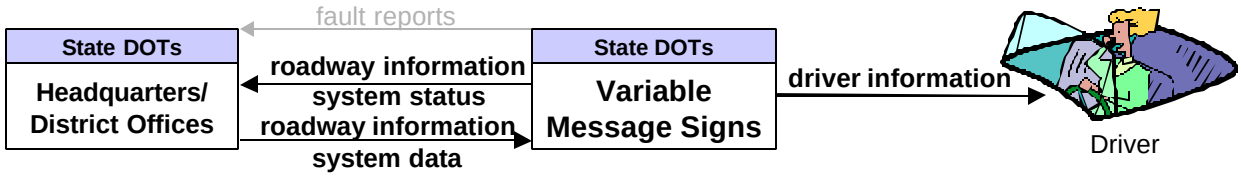


Figure 25: Variable Message Sign Project Architecture

From an architecture standpoint, the VMS project is a subset of the Dynamic Warning System project. The reader is invited to review the Dynamic Warning System standards lists to determine the range of standards that may be appropriate for this project.

Table 10: Regional Architecture Flows Related to Variable Message Sign Project

Source	Destination	Flow	Definition	GYRITS Application
Variable Message Signs	Driver	driver information	General advisory and traffic control information provided to the driver while en-route.	**Included in the initial project architecture.** This is the interface between the sign display and the driver's eyes which is subject to uniformity standards (e.g., MUTCD) but as a human interface, is not the focus of the regional architecture.
Variable Message Signs	Headquarters/ District Offices	fault reports	Reports from field equipment (sensors, signals, signs, controllers, etc.) which indicate current operational status.	It is assumed that the selected VMS will not provide automatic health check and fault reporting capabilities.
Variable Message Signs	Headquarters/ District Offices	roadway information system status	Current operating status of dynamic message signs, highway advisory radios, beacon systems, or other configurable field equipment that provides dynamic information to the driver.	**Included in the initial project architecture.** This flow provides positive feedback to the center indicating the variable message signs operational mode and current status.
Headquarters/ District Offices	Variable Message Signs	roadway information system data	Information used to initialize, configure, and control roadside systems that provide driver information (e.g., dynamic message signs, highway advisory radio, beacon systems). This flow can provide message content and delivery attributes, local message store maintenance requests, control mode commands, status queries, and all other commands and associated parameters that support remote management of these systems.	**Included in the initial project architecture.** As indicated in the National Architecture flow definition, this flow includes messages to be displayed and ancillary commands and status requests that can be remotely invoked on the VMS.

FOR MORE INFORMATION ON STANDARDS ACTIVITIES…

The laundry list of project-relevant standards activities that are identified in this chapter can be overwhelming. In general, every project interface can have three or more associated standards. This is because three general types of standards are being developed for ITS:

- Communications protocol standards (designated with a "C" in the standards lists),
- Data Dictionary Standards (designated with a "D" in the standards lists),
- Message Set Standards (designated with an "M" in the standards lists)

There are several excellent resources on the World Wide Web for those who want to learn more about ITS standards. The ITS America Standards Home Page provides access to standards information relating to all aspects of ITS. It also contains links to the organizations involved and, where possible, provides rapid access to published standards documents. The U.S. DOT Joint Program Office Standards site provides current status on the standards acceleration program.

In addition to these general sites, each Standards Development Organization also maintains a presence on the web. In many cases, the web sites and e-mail reflector sites together allow full monitoring and participation of standards committee activities with minimal travel and minimal time spent attending meetings. Since web addresses can change over time, only the top level addresses for the ITS America and US DOT sites are provided below. Each of these sites links to the individual SDO sites where you can get more detailed information.

- ITS America Web Site (Standards Page) – www.itsa.org/standards
- US DOT Standards Acceleration Program Page: - www.its.dot.gov/standards

Appendix

A

NATIONAL ITS ARCHITECTURE CONCEPTS

Background Information on the National ITS Architecture

This appendix provides background information on the National ITS Architecture concepts that are referenced in the body of this report. Other resources are available to the reader that would like to learn more about the National ITS Architecture. Comprehensive documentation and a complete list of references and contacts is available on the National ITS Architecture web site at http://www.odetics.com/itsarch.

Because of the extensive geographic and functional scope of the National ITS Architecture and the requirements which drove its development, it is structured somewhat differently and uses different terminology than is typically used today in the transportation community. It was developed to support ITS implementations over a 20-year time period in urban, interurban, and rural environments across the country. Accordingly, general names were given to the physical transportation system components in order to accommodate a variety of local design choices and changes in technology or institutional arrangements over time. This allows the general structure of the National ITS Architecture to remain stable while still allowing flexibility and tailoring at the local implementation level. This difference in language can be easily overcome with a better understanding of how the National ITS Architecture is organized and how it relates to familiar systems of today.

As background, this section explains the essential terminology and concepts needed to understand the National ITS Architecture components that were applied in the GYRITS regional architecture. The work that was done in this report focuses in particular on the physical architecture and the market packages from the National ITS Architecture.

THE PHYSICAL ARCHITECTURE

The physical architecture is a framework that defines what each major subsystem does and how they interact to provide services to the user. The physical architecture coordinates overall system operation by regulating interfaces between equipment packages which may be deployed by different procuring and operating sectors. This framework of subsystems and interfaces is specified in a manner that is implementation independent. This is to ensure maximum implementation flexibility. The physical architecture does not isolate the individual capabilities that may be purchased and deployed. It is deliberately maintained at a higher level to retain maximum flexibility so that a single specification may support project infrastructure that which will differ markedly across geographic regions and over time.

The physical architecture is comprised of two major *technical* layers, a Transportation Layer and a Communication Layer, which are constrained by and service an Institutional Layer. The Transportation Layer includes the various transportation-related processing centers, distributed roadside equipment, vehicle equipment, and equipment located with, and used by, the traveler to achieve ITS services. The Communication Layer provides for the transfer of information between the distributed entities within the Transportation Layer.

The Institutional Layer introduces the policies, funding incentives, working arrangements, and jurisdictional structure that support the technical Layers of the architecture. Figure A-1 illustrates the three layers that constitute the overall architecture.

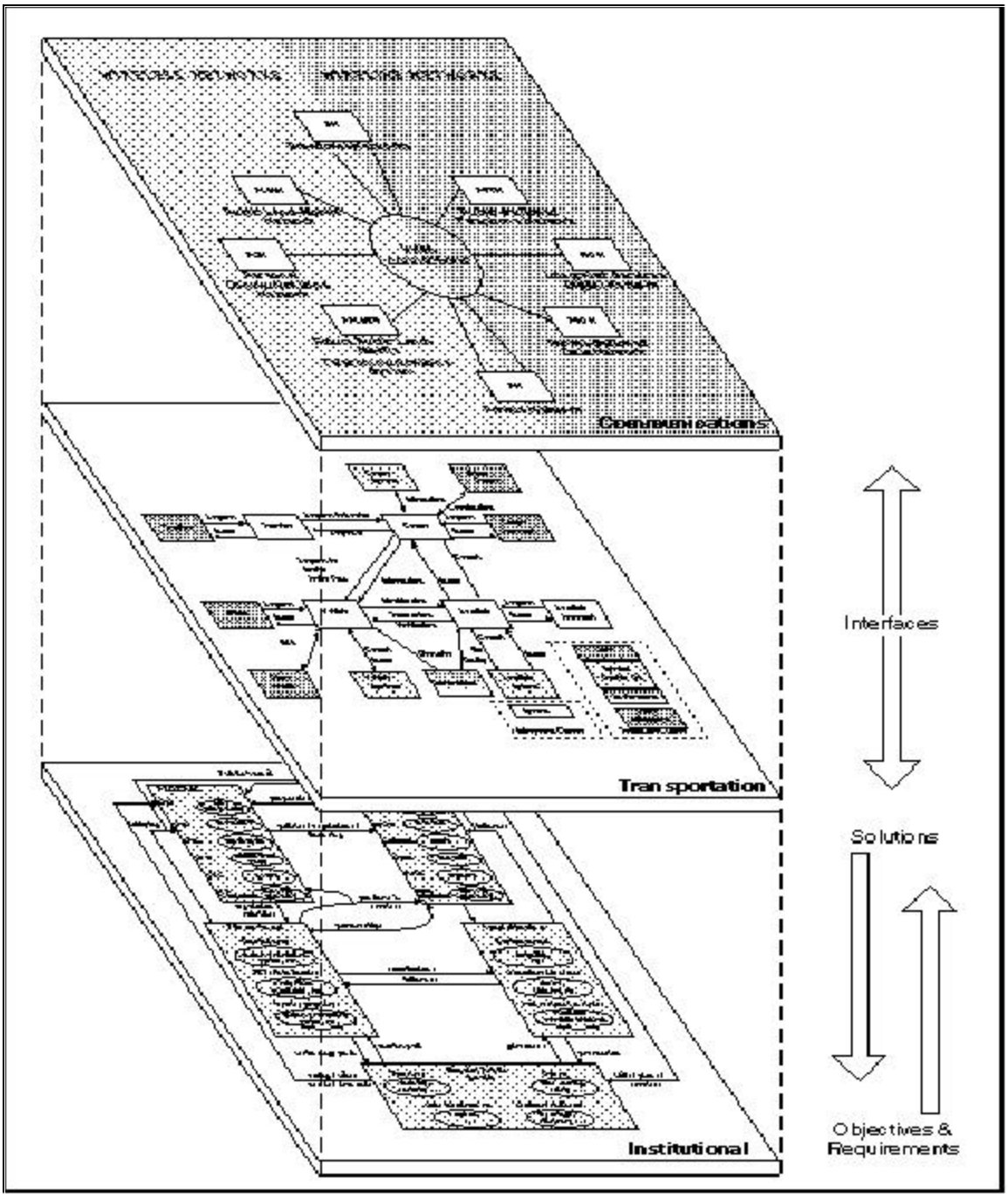


Figure A-1 - Architecture Layers

Transportation Layer

The Transportation Layer consists of the nineteen interconnected subsystems presented in Figure A-2. This diagram spans the transportation and communication layers of the architecture by depicting both the subsystems (transportation layer elements) and the major communications

interconnects (communication layer elements). As part of the transportation layer definition presented in this paragraph, each of the subsystems will be described.

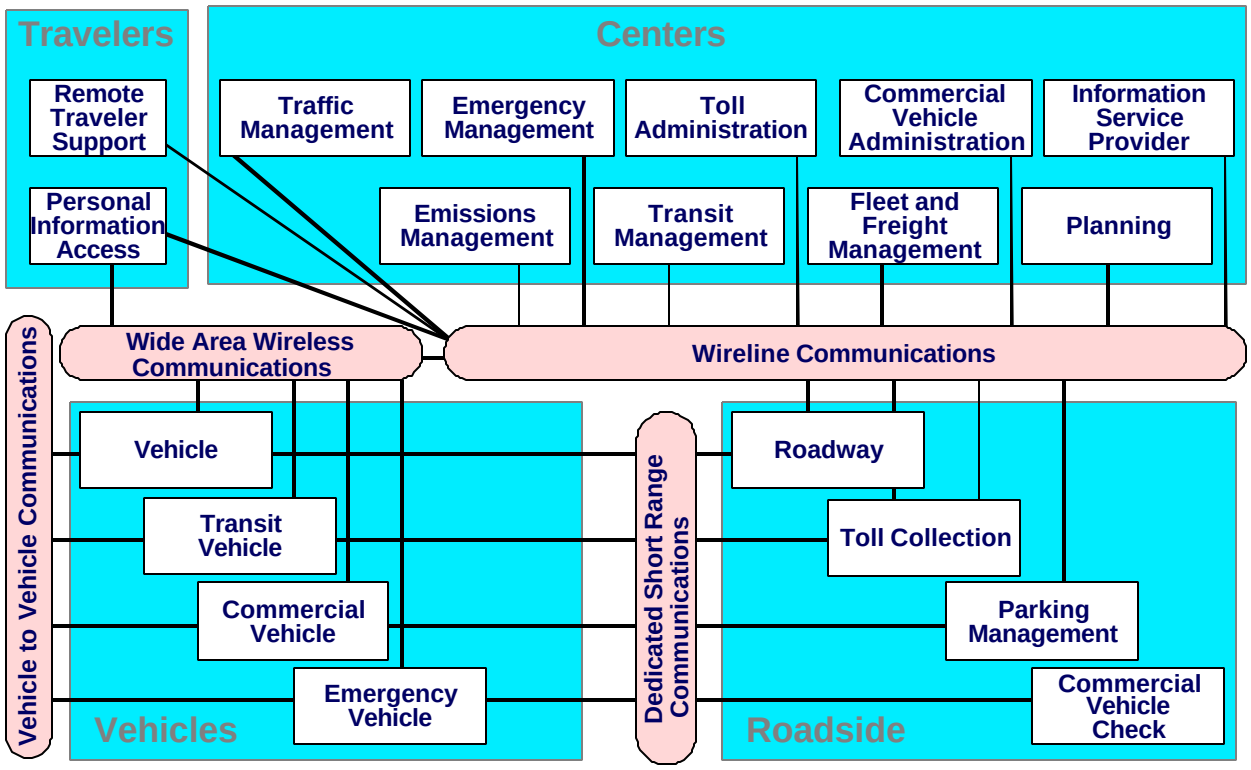


Figure A-2 - ITS Architecture Subsystems and Interconnects

The subsystems align closely with existing jurisdictional and physical boundaries that underscore the operation and maintenance of current transportation systems. By mirroring the current transportation environment with the identified subsystems, the subsystem boundaries identify the likely candidates for interface standardization. The architecture recognizes these boundaries to minimize the impact associated with adoption of the architecture. Maximum commonality between existing transportation system boundaries and architecture boundaries serves to minimize the number of artificial boundaries which are imposed (and constrained) by the architecture.

Subsystem Interfaces and Definition

The National ITS Architecture subsystems may be grouped into four distinct subsystem classes that share basic functional, deployment, and institutional characteristics. These classes (Center,

Roadside, Vehicle, and Traveler) are used to group top level descriptions for each of the subsystems in the following.

Center Subsystems

The center subsystems provide management, administration, and support functions for the transportation system. The center subsystems communicate with other centers to enable coordination between modes and across jurisdictions within a region. The center subsystems also communicate with roadside and vehicle subsystems to gather information and provide information and control that is coordinated by the center subsystems.

Commercial Vehicle Administration

The Commercial Vehicle Administration Subsystem performs administrative functions supporting credentials, tax, and safety regulations. Capabilities include issuance of credentials, fee and tax collection, and enforcement support of credential requirements. This subsystem communicates with the Freight and Fleet Management Subsystems associated with the motor carriers to process credentials applications and collect fuel taxes, weight/distance taxes, and other taxes and fees associated with commercial vehicle operations. The subsystem also receives applications for, and issues special Oversize/Overweight and HAZMAT permits in coordination with other cognizant authorities. The subsystem coordinates with other Commercial Vehicle Administration Subsystems (in other states/regions) to support nationwide access to credentials and safety information for administration and enforcement functions. This subsystem supports communications with Commercial Vehicle Check Subsystems operating at the roadside to enable credential checking and safety information collection. The collected safety information is processed, stored, and made available to qualified stakeholders to identify carriers and drivers that operate unsafely.

Emergency Management

The Emergency Management Subsystem operates in various emergency centers supporting public safety including police and fire stations, search and rescue special detachments, and HAZMAT response teams. This subsystem interfaces with other Emergency Management Subsystems to support coordinated emergency response involving multiple agencies. The

subsystem creates, stores, and utilizes emergency response plans to facilitate coordinated response. The subsystem tracks and manages emergency vehicle fleets using automated vehicle location technology and two-way communications with the vehicle fleet. Real-time traffic information received from the other center subsystems is used to further aide the emergency dispatcher in selecting the emergency vehicle(s) and routes that will provide the most timely response. Interface with the Traffic Management Subsystem allows strategic coordination in tailoring traffic control to support en-route emergency vehicles. Interface with the Transit Management Subsystem allows coordinated use of transit vehicles to facilitate response to major emergencies.

Emissions Management

This subsystem operates at a fixed location and may reside with a Traffic Management Subsystem or may operate in its own distinct location depending on regional preferences and priorities. This subsystem provides the capabilities for air quality managers to monitor and manage air quality. These capabilities include collecting emissions data from distributed emissions sensors within the roadway subsystem. These sensors monitor general air quality within each sector of the area and also monitor the emissions of individual vehicles on the roadway. The sector emissions measures are collected, processed, and used to identify sectors exceeding safe pollution levels. This information is provided to toll administration, traffic management, and transit management systems and used to implement strategies intended to reduce emissions in and around the problem areas. Emissions data associated with individual vehicles, supplied by the Roadway Subsystem, is also processed and monitored to identify vehicles that exceed standards. This subsystem provides any functions necessary to inform the violators and otherwise ensure timely compliance with the emissions standards.

Fleet and Freight Management

The Fleet and Freight Management Subsystem provides the capability for commercial drivers and dispatchers to receive real-time routing information and access databases containing vehicle and cargo locations as well as carrier, vehicle, cargo, and driver information. In addition, the capability to purchase credentials electronically shall be provided , with automated and efficient connections to financial clearinghouses and regulatory agencies, along with post-trip automated

mileage and fuel usage reporting. The Freight and Fleet Management Subsystem also provides the capability for Freight and Fleet Managers to monitor the safety of their commercial vehicle drivers and fleet.

Information Service Provider

This subsystem provides the capabilities to collect, process, store, and disseminate traveler information to subscribers and the public at large. Information provided includes basic advisories, real time traffic condition and transit schedule information, yellow pages information, ride matching information, and parking information. The subsystem also provides the capability to provide specific directions to travelers by receiving origin and destination requests from travelers, generating route plans, and returning the calculated plans to the users. Reservation services are also provided in advanced implementations. The information is provided to the traveler through the Personal Information Access Subsystem, Remote Traveler Support Subsystem, and various Vehicle Subsystems through available communications links. Both basic one-way (broadcast) and personalized two-way information provision is supported. The subsystem provides the capability for an informational infrastructure to connect providers and consumers, and gather that market information needed to assist in the planning of service improvements and in maintenance of operations.

Traffic Management

The Traffic Management Subsystem operates within a traffic management center or other fixed location. This subsystem communicates with the Roadway Subsystem to monitor and manage traffic flow. Incidents are detected and verified and incident information is provided to the Emergency Management Subsystem, travelers (through Roadway Subsystem Highway Advisory Radio and Variable Message Signs), and to third party providers. The subsystem supports HOV lane management and coordination, road pricing, and other demand management policies that can alleviate congestion and influence mode selection. The subsystem monitors and manages maintenance work and disseminates maintenance work schedules and road closures. The subsystem also manages reversible lane facilities, and processes probe vehicle information. The subsystem communicates with other Traffic Management Subsystems to coordinate traffic information and control strategies in neighboring jurisdictions. Finally, the Traffic Management

Subsystem provides the capabilities to exercise control over those devices utilized for AHS traffic and vehicle control.

Toll Administration

The Toll Administration Subsystem provides general payment administration capabilities to support electronic assessment of tolls and other transportation usage fees. This subsystem supports traveler enrollment and collection of both pre-payment and post-payment transportation fees in coordination with the existing, and evolving financial infrastructure supporting electronic payment transactions. The system sets up and administers escrow accounts to support pre-payment operations. It supports communications with the Toll Collection Subsystems (and Parking Management Subsystems and Transit Management Subsystems) to support fee collection operations. The electronic financial transactions in which this subsystem is an intermediary between the consumer and the financial infrastructure shall be cryptographically protected and authenticated to preserve privacy and ensure authenticity and auditability.

Transit Management

The Transit Management Subsystem provides the capability for determining accurate ridership levels and implementing corresponding fare structures. The fare system shall support travelers using a fare medium applicable for all surface transportation services. The subsystem also provides for optimized vehicle and driver assignments, and vehicle routing for fixed and flexibly routed transit services. Interface with the Traffic Management Subsystem control shall be integrated with traffic signal prioritization. This will allow for transit schedule adjustments and automated transit vehicle maintenance management with schedule tracking. The Transit Management Subsystem also provides the capability for automated planning and scheduling of public transit operations. The subsystem shall also provide the capability to furnish travelers with real-time travel information, continuously updated schedules, schedule adherence information, transfer options, and transit routes and fares. In addition, the capability for the monitoring of key transit locations with both video and audio systems shall be provided with automatic alerting of operators and police of potential incidents including support of traveler activated alarms.

Planning

The Planning Subsystem accepts data from every center subsystem and uses this data to plan new deployments and new ITS operations. This data also supports policy decision making, allocation of funding, allocation of resources and other planning activities.

Roadside Subsystems

These infrastructure subsystems provide the direct interface to vehicles traveling on the roadway network. Each of the roadway subsystems include functions that must be distributed to the roadside to support direct surveillance, information provision, and control plan execution. All roadside subsystems interface to one or more of the center subsystems which govern overall operation of the roadside subsystems. The roadside subsystems also generally include direct user interfaces to drivers and other travelers on the roadway network as well as short range interfaces to the Vehicle Subsystems.

Commercial Vehicle Check

The Commercial Vehicle Check Subsystem supports automated vehicle identification at mainline speeds for credential checking, roadside safety inspections, and weigh-in-motion using two-way data exchange. These capabilities include providing warnings to the commercial vehicle drivers, their freight and fleet managers, and proper authorities of any safety problems that have been identified, accessing and examining historical safety data, and automatically deciding whether to allow the vehicle to pass or require it to stop with operator manual override. The Commercial Vehicle Check Subsystem also provides supplemental inspection services to current capabilities by supporting expedited brake inspections, the use of operator hand-held devices, on-board safety database access, and the enrollment of vehicles and carriers in the pre-clearance program.

Parking Management

The Parking Management Subsystem provides the capability to provide parking availability and parking fee information, allow for parking payment without the use of cash with a multiple use medium, and support the detection, classification, and control of vehicles seeking parking.

Roadway

This subsystem includes the equipment distributed on and along the roadway which monitors and controls traffic. Equipment includes highway advisory radios, variable message signs, cellular call boxes, CCTV cameras and video image processing systems for incident detection and verification, vehicle loop detectors, signals, and freeway ramp metering systems. This subsystem also provides the capability for emissions and environmental condition monitoring. HOV lane management and reversible lane management functions are also available. In advanced implementations, this subsystem support automated vehicle safety systems by safely controlling access to and egress from an Automated Highway System through monitoring of, and communications with, AHS vehicles. Intersection collision avoidance functions are provided by determining the probability of a collision in the intersection and sending appropriate warnings and/or control actions to the approaching vehicles.

Toll Collection

The Toll Collection Subsystem provides the capability for vehicle operators to pay tolls without stopping their vehicles using pricing structures for locally determined needs and including the capability to implement various variable road pricing policies. Transactions to each customer shall be provided a confirmation and implemented to minimize fraud by supporting vehicle identification technologies and accommodating single billing to commercial carriers.

Vehicle Subsystems

These subsystems are all vehicle-based and share many general driver information, vehicle navigation, and advanced safety systems functions. The vehicle subsystems communicate with the roadside subsystems and center subsystems for provision of information to the driver. The Vehicle Subsystem includes general traveler information and vehicle safety functions that are also applicable to the three fleet vehicle subsystems (Commercial Vehicle Subsystem, Emergency Vehicle Subsystem, and Transit Vehicle Subsystem). The fleet vehicle subsystems all include vehicle location and two-way communications functions that support efficient fleet operations. Each of the three fleet vehicle subsystems also include functions that support their specific service area

Vehicle

This subsystem resides in an automobile and provides the sensory, processing, storage, and communications functions necessary to support efficient, safe, and convenient travel by personal automobile. Information services provide the driver with current travel conditions and the availability of services along the route and at the destination. Both one-way and two-way communications options support a spectrum of information services from low-cost broadcast services to advanced, pay for use personalized information services. Route guidance capabilities assist in formulation of an optimal route and step by step guidance along the travel route. Advanced sensors, processors, enhanced driver interfaces, and actuators complement the driver information services so that, in addition to making informed mode and route selections, the driver travels these routes in a safer and more consistent manner. Initial collision avoidance functions provide "vigilant co-pilot" driver warning capabilities. More advanced functions assume limited control of the vehicle to maintain safe headway. Ultimately, this subsystem supports completely automated vehicle operation through advanced communications with other vehicles in the vicinity and in coordination with supporting infrastructure subsystems. Pre-crash safety systems are deployed and emergency notification messages are issued when unavoidable collisions do occur.

Commercial Vehicle

This subsystem resides in a commercial vehicle and provides the sensory, processing, storage, and communications functions necessary to support safe and efficient freight movement. The Commercial Vehicle Subsystem provides two-way communications between the commercial vehicle drivers, their fleet managers, and roadside officials, and provides HAZMAT response teams with timely and accurate cargo contents information after a vehicle incident. This subsystem provides the capability to collect and process vehicle, cargo, and driver safety data and status and alert the driver whenever there is a potential safety problem. Basic identification and safety status data are supplied to inspection facilities at mainline speeds. In addition, the subsystem will automatically collect and record mileage, fuel usage, and border crossings.

Emergency Vehicle

This subsystem resides in an emergency vehicle and provides the sensory, processing, storage, and communications functions necessary to support safe and efficient emergency response. The

Emergency Vehicle Subsystem includes two-way communications to support coordinated response to emergencies in accordance with an associated Emergency Management Subsystem. Emergency vehicles are equipped with automated vehicle location capability for monitoring by vehicle tracking and fleet management functions in the Emergency Management Subsystem. Using these capabilities, the appropriate emergency vehicle to respond to each emergency is determined. Route guidance capabilities within the vehicle enable safe and efficient routing to the emergency. In addition, the emergency vehicle may be equipped to support signal preemption through communications with the roadside subsystem.

Transit Vehicle

This subsystem resides in a transit vehicle and provides the sensory, processing, storage, and communications functions necessary to support safe and efficient movement of passengers. The Transit Vehicle Subsystem collects accurate ridership levels and supports electronic fare collection. An optional traffic signal prioritization function communicates with the roadside subsystem to improve on-schedule performance. Automated vehicle location functions enhance the information available to the Transit Management Subsystem enabling more efficient operations. On-board sensors support transit vehicle maintenance. The Transit Vehicle Subsystem also furnishes travelers with real-time travel information, continuously updated schedules, transfer options, routes, and fares.

Traveler Subsystems

The traveler subsystems include the equipment that is used by the traveler to gather information and access other personal information services prior to a trip and while en-route. The class includes elements that are owned and operated by the traveler as well as elements that are owned by transportation providers and information providers. Though the equipment owned by the traveler (e.g., personal computer, personal digital assistant) is often general purpose and used for a variety of tasks, this equipment is specifically used for gaining access to traveler information within the scope of the ITS architecture. These subsystems interface to the information provider (one of the center subsystems, most commonly the Information Service Provider Subsystem) to access the traveler information. A range of service options and levels of equipment sophistication are supported.

Personal Information Access

This subsystem accesses traveler information at home, at work, and other locations frequented by the traveler using personal fixed and portable devices over multiple types of electronic media. Radio, television, personal computers, personal digital assistants, telephones, and any other communications-capable consumer products that can be used to supply information to the traveler are all encompassed by this subsystem definition. Sophistication ranges from simple receipt of broadcast advisories to advanced interactive capabilities which enables users to receive route plans and other real-time information tailored to their individual needs. Other available capabilities include Mayday and real-time reservation services.

Remote Traveler Support

This subsystem provides access to traveler information at transit stations, transit stops, other fixed sites along travel routes, and at major trip generation locations such as special event centers, hotels, office complexes, amusement parks, and theaters. Traveler information access points include kiosks and informational displays supporting varied levels of interaction and information access. At transit stops, simple displays provide schedule information and imminent arrival signals. This basic information may be extended to include multi-modal information including traffic conditions and transit schedules along with yellow pages information to support mode and route selection at major trip generation sites. Personalized route planning and route guidance information can also be provided based on criteria supplied by the traveler. In addition to traveler information provision, this subsystem also supports public safety monitoring using CCTV cameras or other surveillance equipment and emergency notification within public areas. Fare card maintenance, and other features which enhance traveler convenience may also be provided at the discretion of the deploying agency.

1.1.11 Communication Layer

The Communication Layer architecture for the ITS system has two components: 1) wireless and 2) wireline. One or both of these components will support all Transportation Layer entities requiring information transfer. In most cases, the wireless component merely provides a wireless user, usually one in a vehicle, with access to fixed (or wireline) network resources. The wireless

portion will be manifested in three different ways, all of which demand a nationally acceptable interface.

Each of the four identified interface types are defined as follows:

Wireline Communications

Wireline Communications addresses the information transfer between two fixed entities. Typically, this interface will be manifested using one of the many alternative existing public or private networks that may physically include wireless (e.g. microwave) as well as wireline infrastructure.

Wireless Communications

Wireless communications may be provided three ways:

- Wide area wireless communications are cell-based wireless infrastructures supporting wide-area information transfer of voice and data. The cell-based airlink from a mobile terminal to one of a set of base stations, provides connections between mobile users or between mobile and fixed network-connected users. It is typified by the current cellular telephone network, the larger cells of Specialized Mobile Radio, and PCs. This interface also includes one-way broadcast wireless communications systems used to provide basic traveler information across a wide area.

- Short range wireless communications defines a short-range airlink used for close proximity (less than 50 to 100 feet) transmissions between a mobile user and a base station. They are typified by transfers of vehicle identification numbers at toll booths.

- Vehicle to vehicle communications addresses the dedicated wireless system handling high data rate, low proximity of error, line of site, Automated Highway System (AHS) -related data flows, such as vehicle to vehicle transceiver radio systems.

Wide Area Wireless Communications

Wide Area Wireless Communications defines cell-based wireless infrastructures supporting wide-area information transfer (most data flows). The cell-based airlink, from a mobile terminal

to one of a set of base stations, provides connections between mobile users or between mobile and fixed network-connected users (e.g., those connected to the telephone network). It is typified by the current cellular telephone network, the larger cells of Specialized Mobile Radio, and PCS. This interface type also includes one-way broadcast wireless communications systems used to provide basic traveler information across a wide-area. Both voice and data communications are included. FM Subcarrier is a prime example of a data capable, broadcast communications technology that would be included.

Dedicated Short Range Communications

Short Range Wireless Communications defines the short-range airlink used for close-proximity (less than 50-100 feet) transmissions between a mobile user and a base station, typified by transfers of vehicle identification numbers at toll booths.

Vehicle to Vehicle Communications

Vehicle to Vehicle Communications addresses the dedicated wireless system handling high data rate, low probability of error, line of sight, AHS-related data flows, such as vehicle to vehicle transceiver radio systems.

1.1.12 Institutional Layer

The Institutional Layer represents policy makers, planners, and other users of the ITS services. Organization responsibilities and relationships are defined by policy, which in turn determines boundaries and barriers to implementation. Through development of institutional relationships and partnerships, successful implementation of ITS projects will be facilitated. While this is outside the realm of architecture, it is critical to the successful implementation of all ITS projects.

MARKET PACKAGES

The physical architecture definition presented in the previous section is intended to be extremely accommodating.

- It supports the complete range of ITS services from basic signal control improvements to Automated Highway Systems.

- It is scaleable so that implementations that are suitable for the nations largest population centers as well as the most remote rural areas are supported with equal aplomb.

- It is specified in a technology independent manner so that a range of current and future technologies can be supported by the framework.

All this flexibility is necessary since the architecture must accommodate the range of possible ITS implementations from coast to coast and over a twenty year timeframe. Unfortunately, this flexibility also makes it difficult to understand precisely what pieces of the architecture are applicable and how they can best be applied in solving a particular communities current transportation problems (see figure A-3).

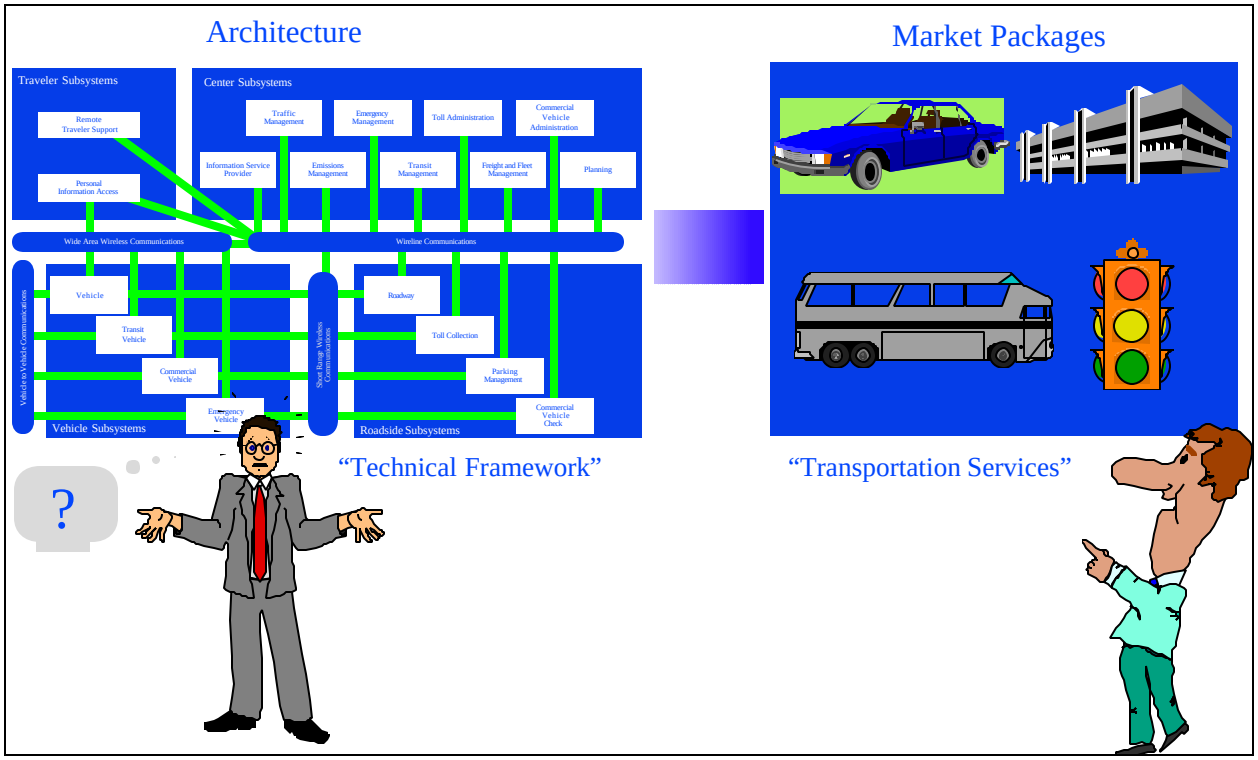


Figure A-3: Translating Architecture to Implementation Through Market Packages

To provide visibility into the service options that will be considered by the ITS implementor, a set of *market packages* have been defined. The market packages provide an accessible, deployment oriented perspective to the national architecture. They are tailored to fit - separately or in combination - real world transportation problems and needs. They address the specific service requirements of traffic managers, transit operators, travelers, and other ITS stakeholders. The market packages were defined with enough granularity to support specific benefits analysis with clear ties to transportation problems.

Several different market packages are defined in each major application area which provides a palette of service options at various costs. Market packages are also structured to segregate services that are likely to encounter technical or non-technical challenges from lower risk services. This approach identifies a subset of the market packages that are likely early deployments. At the other end of the spectrum, several of the market packages represent advanced products or services that will not be available for some time. Many of the market packages are also incremental so that more advanced packages can be efficiently implemented by building on common elements that were deployed earlier with more basic packages.

The complete set of market packages are identified in Table A-1. In order to more accurately specify market packages in tables, each is given an abbreviation indicating the general class of stakeholder and an index (e.g., ATMS1 is a market package primarily of interest to traffic managers).

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
APTS1	Transit Vehicle Tracking	This market package provides for an Automated Vehicle Location System to track the transit vehicle's real time schedule adherence and updates the transit system's schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A two-way wireless communication link with the Transit Management Subsystem is used for relaying vehicle position and control measures. Fixed route transit systems may also employ beacons along the route to enable position determination and facilitate communications with each vehicle at fixed intervals. The Transit Management Subsystem processes this information, updates the transit schedule and makes real-time schedule information available to the Information Service Provider Subsystem via a wireline link.
APTS2	Transit Fixed-Route	This market package performs automatic driver assignment and monitoring, as well as vehicle routing and scheduling for fixed-route services. This service

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
	Operations	uses the existing AVL database as a source for current schedule performance data, and is implemented through data processing and information display at the transit management subsystem. This data is exchanged using the existing wireline link to the information service provider where it is integrated with that from other transportation modes (e.g. rail, ferry, air) to provide the public with integrated and personalized dynamic schedules
APTS3	Demand Response Transit Operations	This market package performs automatic driver assignment and monitoring as well as vehicle routing and scheduling for demand response transit services. This package uses the existing AVL database to monitor current status of the transit fleet and supports allocation of these fleet resources to service incoming requests for transit service while also considering traffic conditions. The Transit Management Subsystem provides the necessary data processing and information display to assist the transit operator in making optimal use of the transit fleet. The Information Service Provider Subsystem may be either be operated by transit management center or be independently owned and operated by a separate service provider. In the first scenario, the traveler makes a direct request to a specific paratransit service. In the second scenario, a third party service provider determines the paratransit service is a viable means of satisfying a traveler request and uses wireline communications to make a reservation for the traveler.
APTS4	Transit Passenger and Fare Management	This market package allows for the management of passenger loading and fare payments on-board vehicles using electronic means. The payment instrument may be either a stored value or credit card. This package is implemented with sensors mounted on the vehicle to permit the driver and central operations to determine vehicle loads, and readers located either in the infrastructure or on-board the transit vehicle to allow fare payment. Data is processed, stored, and displayed on the transit vehicle and communicated as needed to the Transit Management Subsystem using existing wireless infrastructure.
APTS5	Transit Security	This market package provides for the physical security of transit passengers. An on-board security system is deployed to perform surveillance and warn of potentially hazardous situations. Public areas (e.g. stops, park and ride lots, stations) are also monitored. Information is communicated to the Transit Management Subsystem using the existing or emerging wireless (vehicle to center) or wireline (area to center) infrastructure. Security related information is also transmitted to the Emergency Management Subsystem when an emergency is identified that requires an external response. Incident information is communicated to the Information Service Provider.
APTS6	Transit Maintenance	This market package supports automatic maintenance scheduling and monitoring. On-board condition sensors monitor critical system status and transmit critical status information to the Transit Management Subsystem. Hardware and software in the Transit Management Subsystem processes this data and schedules maintenance activities.
APTS7	Multi-modal Coordination	This market package establishes two way communications between multiple transit and traffic agencies to improve service coordination. Intermodal coordination between transit agencies can increase traveler convenience at transfer points and also improve operating efficiency. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network. More limited local coordination between the transit vehicle and the individual intersection for signal priority is also supported by this package.
APTS8	Transit Traveler	This market package provides transit users at transit stops and on-board transit vehicles with ready access to transit information. The information services

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
	Information	include transit stop annunciation, imminent arrival signs, and real-time transit schedule displays that are of general interest to transit users. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this market package.
ATIS1	Broadcast Traveler Information	This market package provides the user with a basic set of ATIS services; its objective is early acceptance. It involves the collection of traffic conditions, advisories, general public transportation and parking information and the near real time dissemination of this information over a wide area through existing infrastructures and low cost user equipment (e.g., FM subcarrier, cellular data broadcast). Different from the market package ATMS6--Traffic Information Dissemination--which provides the more basic HAR and DMS information capabilities, ATIS1 provides the more sophisticated digital broadcast service. Successful deployment of this market package relies on availability of real-time transportation data from roadway instrumentation, probe vehicles or other means.
ATIS2	Interactive Traveler Information	This market package provides tailored information in response to a traveler request. Both real-time interactive request/response systems and information systems that "push" a tailored stream of information to the traveler based on a submitted profile are supported. The traveler can obtain current information regarding traffic conditions, transit services, traveler services, ride share/ride match, parking management, and pricing information. A range of two-way wide-area wireless and wireline communications systems may be used to support the required digital communications between traveler and the information service provider. A variety of interactive devices may be used by the traveler to access information prior to a trip or en-route to include phone, kiosk, Personal Digital Assistant, personal computer, and a variety of in-vehicle devices. Successful deployment of this market package relies on availability of real-time transportation data from roadway instrumentation, probe vehicles or other means.
ATIS3	Autonomous Route Guidance	This market package relies on in-vehicle sensory, location determination, computational, map database, and interactive driver interface equipment to enable route planning and detailed route guidance based on static, stored information. No communication with the infrastructure is assumed or required. Identical capabilities are available to the traveler outside the vehicle by integrating a similar suite of equipment into portable devices.
ATIS4	Dynamic Route Guidance	This market package offers the user advanced route planning and guidance which is responsive to current conditions. The package combines the autonomous route guidance user equipment with a digital receiver capable of receiving real-time traffic, transit, and road condition information which is considered by the user equipment in provision of route guidance.
ATIS5	ISP Based Route Guidance	This market package offers the user advanced route planning and guidance which is responsive to current conditions. Different than the Dynamic Route Guidance Market Package, this market package moves the route planning function from the user device to the information service provider. This approach simplifies the user equipment requirements and can provide the infrastructure better information on which to predict future traffic and appropriate control strategies to support basic route planning with minimal user equipment. The package includes two way data communications and optionally also equips the vehicle with the databases, location determination capability, and display technology to support turn by turn route guidance.
ATIS6	Integrated Transportatio n	This market package allows a traffic management center to continuously optimize the traffic control strategy based on near-real time information on intended routes for a proportion of the vehicles within their network while

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
	Management/ Route Guidance	offering the user advanced route planning and guidance which is responsive to current conditions . It would utilize the individual and ISP route planning information to optimize signal timing while at the same time providing updated signal timing information to allow optimized route plans. The use of predictive link times for this market package are possible through utilizing the market package ATMS9--Traffic Prediction and Demand Management--at the traffic management center.
ATIS7	Yellow Pages and Reservation	This market package enhances the Interactive Traveler Information package by adding infrastructure provided yellow pages and reservation capabilities to tailored requests for information regarding traffic conditions, transit services, traveler services, ride share/ride match, parking management, and pricing information. The same basic user equipment is included; service or advertising fees should allow recovery of the ISP investment. This market package provides multiple ways for accessing information either while en-route in a vehicle using wide-area wireless communications or pre-trip via wireline connections.
ATIS8	Dynamic Ridesharing	This market package enhances the Interactive Traveler Information package by adding infrastructure provided dynamic ridesharing capability to tailored requests for information regarding traffic conditions, transit services, traveler services, ride share/ride match, parking management, and pricing information. If this service is provided by a private ISP, service fees may be required to allow for recovery of the ISP investment. In terms of equipment requirements, ATIS8 is similar to ATIS7.
ATIS9	In Vehicle Signing	This market package supports distribution of traffic and travel advisory information to drivers through in-vehicle devices. It includes short range communications between roadside equipment and the vehicle and wireline connections to the Traffic Management Subsystem for coordination and control. This market package also informs the driver of both highway-highway and highway-rail intersection status.
ATMS01	Network Surveillance	This market package includes traffic detectors, environmental sensors, other surveillance equipment, the supporting field equipment, and wireline communications to transmit the collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g., when a CCTV system sends data back to the Traffic Management Subsystem). The data generated by this market package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Information Service Provider Subsystem.
ATMS02	Probe Surveillance	This market package provides an alternative approach for surveillance of the roadway network. Two general implementation paths are supported by this market package: 1) wide-area wireless communications between the vehicle and Information Service Provider is used to communicate current vehicle location and status, and 2) dedicated short range communications between the vehicle and roadside is used to provide equivalent information back to the Traffic Management Subsystem. The first approach leverages wide area communications equipment that may already be in the vehicle to support personal safety and advanced traveler information services. The second approach utilizes vehicle equipment that supports toll collection, in-vehicle signing, and other short range communications applications identified within the architecture. The market package enables traffic managers to monitor road conditions, identify incidents, analyze and reduce the collected data, and make

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
		it available to users and private information providers. It requires one of the communications options identified above, roadside beacons and wireline communications for the short range communications option, data reduction software, and utilizes wireline links between the Traffic Management Subsystem and Information Service Provider Subsystem to share the collected information. Both "Opt out" and "Opt in" strategies are available to ensure the user has the ability to turn off the probe functions to ensure individual privacy. Due to the large volume of data collected by probes, data reduction techniques are required in this market package which include the ability to identify and filter out-of-bounds or extreme data reports.
ATMS03	Surface Street Control	This market package provides the central control and monitoring equipment, communication links, and the signal control equipment that support local surface street control and/or arterial traffic management. A range of traffic signal control systems are represented by this market package ranging from static pre-timed control systems to fully traffic responsive systems that dynamically adjust control plans and strategies based on current traffic conditions and priority requests. Additionally, general advisory and traffic control information can be provided to the driver while en-route. This market package is generally an intra-jurisdictional package that does not rely on real-time communications between separate control systems to achieve area-wide traffic signal coordination. Systems that achieve coordination across jurisdictions by using a common time base or other strategies that do not require real time coordination would be represented by this package. This market package is consistent with typical urban traffic signal control systems.
ATMS04	Freeway Control	This market package provides the communications and roadside equipment to support ramp control, lane controls, and interchange control for freeways. Coordination and integration of ramp meters are included as part of this market package. This package is consistent with typical urban traffic freeway control systems. This package incorporates the instrumentation included in the Network Surveillance Market Package to support freeway monitoring and adaptive strategies as an option. This market package also includes the capability to utilize surveillance information for detection of incidents. Typically, the processing would be performed at a traffic management center; however, developments might allow for point detection with roadway equipment. For example, a CCTV might include the capability to detect an incident based upon image changes. Additionally, this market package allows general advisory and traffic control information to be provided to the driver while en-route.
ATMS05	HOV Lane Management	This market package manages HOV lanes by coordinating freeway ramp meters and connector signals with HOV lane usage signals. Preferential treatment is given to HOV lanes using special bypasses, reserved lanes, and exclusive rights-of-way that may vary by time of day. Vehicle occupancy detectors may be installed to verify HOV compliance and to notify enforcement agencies of violations.
ATMS06	Traffic Information Dissemination	This market package allows traffic information to be disseminated to drivers and vehicles using roadway equipment such as dynamic message signs or highway advisory radio. This package provides a tool that can be used to notify drivers of incidents; careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information. This package also covers the equipment and interfaces that provide traffic information from a traffic management center to the media (for instance via a direct tie-in between a

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
		traffic management center and radio or television station computer systems), transit management center, emergency management center, and information service provider.
ATMS07	Regional Traffic Control	This market package advances the Surface Street Control and Freeway Control Market Packages by adding the communications links and integrated control strategies that enable integrated interjurisdictional traffic control. This market package provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. This package relies principally on roadside instrumentation supported by the Surface Street Control and Freeway Control Market Packages and adds hardware, software, and wireline communications capabilities to implement traffic management strategies which are coordinated between allied traffic management centers. Several levels of coordination are supported from sharing of information through sharing of control between traffic management centers.
ATMS08	Incident Management System	This market package manages both predicted and unexpected incidents so that the impact to the transportation network and traveler safety is minimized. Requisite incident detection capabilities are included in the freeway control market package and through the regional coordination with other traffic management and emergency management centers, weather service entities, and event promoters supported by this market package. Information from these diverse sources are collected and correlated by this market package to detect and verify incidents and implement an appropriate response. This market package provides Traffic Management Subsystem equipment that supports traffic operations personnel in developing an appropriate response in coordination with emergency management and other incident response personnel to confirmed incidents. The response may include traffic control strategy modifications and presentation of information to affected travelers using the Traffic Information Dissemination market package. The same equipment assists the operator by monitoring incident status as the response unfolds. The coordination with emergency management might be through a CAD system or through other communication with emergency field personnel. The coordination can also extend to tow trucks and other field service personnel.
ATMS09	Traffic Prediction and Demand Management	This market package includes advanced algorithms, processing, and mass storage capabilities that support historical evaluation, real-time assessment, and forecast of the roadway network performance. This includes the prediction of travel demand patterns to support better link travel time forecasts. The source data would come from the Traffic Management Subsystem itself as well as other traffic management centers and predicted traffic loads derived from route plans supplied by the Information Service Provider Subsystem. In addition to short term forecasts, this market package provides longer range forecasts that can be used in transportation planning. This market package provides data that supports the implementation of TDM programs, and policies managing both traffic and the environment. Information on vehicle pollution levels, parking availability, usage levels, and vehicle occupancy are collected by monitoring sensors to support these functions. Demand management requests can also be made to Toll Administration, Transit Management, and Parking Management Subsystems.
ATMS10	Electronic Toll Collection	This market package provides toll operators with the ability to collect tolls electronically and detect and process violators. Variations in the fees that are collected enables implementation of demand management strategies.

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
		Dedicated short range communication between the roadway equipment and the vehicle is required as well as wireline interfaces between the toll collection equipment and transportation authorities and the financial infrastructure that supports fee collection. Vehicle tags of toll violators are read and electronically posted to vehicle owners. Standards, inter-agency coordination, and financial clearinghouse capabilities enable regional, and ultimately national interoperability for these services. The population of toll tags and roadside readers that these systems utilize can also be used to collect road use statistics for highway authorities. This data can be collected as a natural by-product of the toll collection process or collected by separate readers that are dedicated to probe data collection.
ATMS11	Emissions Monitoring and Management	This market package monitors individual vehicle emissions and provides general air quality monitoring using distributed sensors to collect the data. The collected information is transmitted to the emissions management subsystem for processing. Both individual detection and identification of vehicles that exceed emissions standards and general area-wide monitoring of air quality are supported by this market package. For area wide monitoring, this market package measures air quality, identifies sectors that are non-compliant with air quality standards, and collects, stores and reports supporting statistical data. For point emissions monitoring, this market package measures tail pipe emissions and identifies vehicles that exceed emissions standards. The gathered information can be used to implement environmentally sensitive TDM programs, policies, and regulations.
ATMS12	Virtual TMC and Smart Probe Data	This market package provides for special requirements of rural road systems. Instead of a central TMC, the traffic management is distributed over a very wide area (e.g., a whole state or collection of states). Each locality has the capability of accessing available information for assessment of road conditions. The package uses vehicles as smart probes that are capable of measuring road conditions and providing this information to the roadway for relay to the Traffic Management Subsystem and potentially direct relay to following vehicles (i.e., the automated road signing equipment is capable of autonomous operation). In-vehicle signing is used to inform drivers of detected road conditions.
ATMS13	Standard Railroad Grade Crossing	This market package manages highway traffic at highway-rail intersections (HRIs) where operational requirements do not dictate more advanced features (e.g., where rail operational speeds are less than 80 miles per hour). Both passive (e.g., the crossbuck sign) and active warning systems (e.g., flashing lights and gates) are supported. (Note that passive systems exercise only the single interface between the roadway subsystem and the driver in the architecture definition.) These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. Health monitoring of the HRI equipment and interfaces is performed; detected abnormalities are reported to both highway and railroad officials through wayside interfaces and interfaces to the traffic management subsystem. Similar interfaces and services are provided for other types of multimodal crossings (e.g., draw bridges).
ATMS14	Advanced Railroad Grade Crossing	This market package manages highway traffic at highway-rail intersections (HRIs) where operational requirements demand advanced features (e.g., where rail operational speeds are greater than 80 miles per hour). This market package includes all capabilities from the Standard Railroad Grade Crossing

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
		Market Package and augments these with additional safety features to mitigate the risks associated with higher rail speeds. The active warning systems supported by this market package include positive barrier systems which preclude entrance into the intersection when the barriers are activated. Like the Standard Package, the HRI equipment is activated on notification by wayside interface equipment which detects, or communicates with the approaching train. In this market package, additional information about the arriving train is also provided by the wayside interface equipment so that the train's direction of travel, its estimated time of arrival, and the estimated duration of closure may be derived. This enhanced information may be conveyed to the driver prior to, or in context with, warning system activation. This market package also includes additional detection capabilities which enable it to detect an entrapped or otherwise immobilized vehicle within the HRI and provide an immediate notification to highway and railroad officials.
ATMS15	Railroad Operations Coordination	This market package provides an additional level of strategic coordination between rail operations and traffic management centers. Rail operations provides train schedules, maintenance schedules, and any other forecast events which will result in highway-rail intersection (HRI) closures. This information is used to develop forecast HRI closure times and durations which may be used in advanced traffic control strategies or to enhance the quality of traveler information.
ATMS16	Parking Facility Management	This market package provides enhanced monitoring and management of a parking facility. The included equipment assists in the management of parking operations, coordinates with transportation authorities, and supports electronic collection of parking fees. This is performed by sensing and collecting current parking facility status, sharing the data with information service providers and traffic operations, and automatic fee collection using short range communications with the same in-vehicle equipment utilized for electronic toll collection.
ATMS17	Reversible Lane Management	This market package provides for the management of reversible lane facilities. In addition to standard surveillance capabilities, this market package includes sensory functions that detect wrong-way vehicles and other special surveillance capabilities that mitigate safety hazards associated with reversible lanes. The package includes the field equipment, physical lane access controls, and associated control electronics that manage and control these special lanes. This market package also includes the equipment used to electronically reconfigure intersections and manage right-of-way to address dynamic demand changes and special events.
ATMS18	Road Weather Information System	This market package monitors current and forecast road and weather conditions using a combination of weather service information and data collected from environmental sensors deployed on and about the roadway. The collected road weather information is monitored and analyzed to detect and forecast environmental hazards such as icy road conditions, dense fog, and approaching severe weather fronts. This information can be used to more effectively deploy road maintenance resources, issue general traveler advisories, and support location specific warnings to drivers using the Traffic Information Dissemination Market Package.
AVSS01	Vehicle Safety Monitoring	This market package will diagnose critical components of the vehicle and warn the driver of potential dangers. On-board sensors will determine the vehicle's condition and performance, determine on-board safety data and display information.
AVSS02	Driver Safety Monitoring	This market package will determine the driver's condition, and warn the driver of potential dangers. On-board sensors will determine the driver's condition

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
		and performance, determine on-board safety data and display information.
AVSS03	Longitudinal Safety Warning	This market package allows for longitudinal warning. It utilizes safety sensors and collision sensors. It requires on-board sensors to monitor the areas in front of and behind the vehicle and present warnings to the driver about potential hazards.
AVSS04	Lateral Safety Warning	This market package allows for lateral warning. It utilizes safety sensors and collision sensors. It requires on-board sensors to monitor the areas to the sides of the vehicle and present warnings to the driver about potential hazards.
AVSS05	Intersection Safety Warning	This market package will determine the probability of a collision in an equipped intersection (either highway-highway or highway-rail) and provide timely warnings to drivers in response to hazardous conditions. Monitors in the roadway infrastructure assess vehicle locations and speeds near an intersection. Using this information, a warning is determined and communicated to the approaching vehicle using a short range communications system. Information can be provided to the driver through the market package ATIS9--In-Vehicle Signing.
AVSS06	Pre-Crash Restraint Deployment	This market package provides in-vehicle sensors to monitor the vehicle's local environment, determine collision probability and deploy a pre-crash safety system. It will include on-board sensors to measure lateral and longitudinal gaps and together with weather and roadway conditions will determine lateral and longitudinal collision probability. It will have the mechanism to deploy a pre-crash safety system.
AVSS07	Driver Visibility Improvement	This market package will enhance driver visibility using an enhanced vision system. On-board display hardware is needed
AVSS08	Advanced Vehicle Longitudinal Control	This market package automates the speed and headway control functions on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to control the throttle and brakes. It requires on-board sensors to measure longitudinal gaps and a processor for controlling the vehicle speed.
AVSS09	Advanced Vehicle Lateral Control	This market package automates the steering control on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to control the steering. It requires on-board sensors to measure lane position and lateral deviations and a processor for controlling the vehicle steering.
AVSS10	Intersection Collision Avoidance	This market package will determine the probability of an intersection collision and provide timely warnings to approaching vehicles so that avoidance actions can be taken. This market package builds on the Intersection Collision Warning infrastructure and in-vehicle equipment and adds equipment in the vehicle that can take control of the vehicle in emergency situations. The same monitors in the roadway infrastructure are needed to assess vehicle locations and speeds near an intersection. This information is determined and communicated to the approaching vehicle using a short range communications system. The vehicle uses this information to develop control actions which alter the vehicle's speed and steering control and potentially activate its pre-crash safety system.
AVSS11	Automated Highway System	This market package enables "hands-off" operation of the vehicle on the automated portion of the highway system. Implementation requires lateral lane holding, vehicle speed and steering control, and Automated Highway System check-in and checkout. This market package currently supports a balance in intelligence allocation between infrastructure and the vehicle pending selection of a single operational concept by the AHS consortium.
CVO01	Fleet Administration	This market package keeps track of vehicle location, itineraries, and fuel usage at the Fleet and Freight Management Subsystem using a cell based or satellite

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
		data link and the pre-existing wireless infrastructure. The vehicle has a processor to interface to its sensor (e.g., fuel gauge) and to the cellular data link. The Fleet and Freight Management Subsystem can provide the vehicle with dispatch instructions, and can process and respond to requests for assistance and general information from the vehicle via the cellular data link. The market package also provides the Fleet Manager with connectivity to intermodal transportation providers using the existing wireline infrastructure.
CVO02	Freight Administration	This market package tracks cargo and the cargo condition. This information is communicated with the Fleet and Freight Management Subsystem via the existing wireless infrastructure. Interconnections are provided to intermodal shippers and intermodal freight depots for tracking the cargo from source to destination.
CVO03	Electronic Clearance	This market package provides for automated clearance at roadside check facilities. The roadside check facility communicates with the Commercial Vehicle Administration subsystem over wireline to retrieve infrastructure snapshots of critical carrier, vehicle, and driver data to be used to sort passing vehicles. This package allows a good driver/vehicle/carrier to pass roadside facilities at highway speeds using transponders and dedicated short range communications to the roadside. The roadside check facility may be equipped with AVI, weighing sensors, transponder read/write devices, computer workstation processing hardware, software, and databases.
CVO04	CV Administrative Processes	This market package provides for electronic application, processing, fee collection, issuance, and distribution of CVO credential and tax filing. Through this process, carriers, drivers, and vehicles may be enrolled in the electronic clearance program provided by a separate market package which allows commercial vehicles to be screened at mainline speeds at commercial vehicle check points. Through this enrollment process, current profile databases are maintained in the Commercial Vehicle Administration Subsystem and snapshots of this database are made available to the commercial vehicle check facilities at the roadside to support the electronic clearance process.
CVO05	International Border Electronic Clearance	This market package provides for automated clearance specific to international border crossings. This package augments the electronic clearance package by allowing interface with customs related functions and permitting NAFTA required entry and exit from the US to Canada and Mexico.
CVO06	Weigh-In-Motion	This market package provides for high speed weigh-in-motion with or without AVI attachment. Primarily this market package provides the roadside with additional equipment, either fixed or removable. If the equipment is fixed, then it is thought to be an addition to the electronic clearance and would work in conjunction with the AVI and AVC equipment in place.
CVO07	Roadside CVO Safety	This market package provides for automated roadside safety monitoring and reporting. It automates commercial vehicle safety inspections at the Commercial Vehicle Check roadside element. The capabilities for performing the safety inspection are shared between this market package and the On-Board CVO Safety Market Package which enables a variety of implementation options. The basic option, directly supported by this market package, facilitates safety inspection of vehicles that have been pulled in, perhaps as a result of the automated screening process provided by the Electronic Clearance Market Package. In this scenario, only basic identification data and status information is read from the electronic tag on the commercial vehicle. The identification data from the tag enables access to additional safety data maintained in the infrastructure which is used to support the safety inspection, and may also inform the pull-in decision if system timing requirements can be met. More advanced implementations, supported by the On-Board CVO Safety market

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
		package, utilize additional vehicle safety monitoring and reporting capabilities in the commercial vehicle to augment the roadside safety check.
CVO08	On-board CVO Safety	This market package provides for on-board commercial vehicle safety monitoring and reporting. It is an enhancement of the Roadside CVO Safety Market Package and includes roadside support for reading on-board safety data via tags. This market package uses the same communication links as the Roadside CVO Safety Market Package, and provides the commercial vehicle with a wireless link (data and possibly voice) to the Fleet and Freight Management and the Emergency Management Subsystems. Safety warnings are provided to the driver as a priority with secondary requirements to notify the Fleet and Freight Management and Commercial Vehicle Check roadside elements.
CVO09	CVO Fleet Maintenance	This market package supports maintenance of CVO fleet vehicles through close interface with on-board monitoring equipment and AVLS capabilities with in the Fleet and Freight Management Subsystem. Records of vehicle mileage, repairs, and safety violations are maintained to assure safe vehicles on the highway.
CVO10	HAZMAT Management	This market package integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of HAZMAT material and incidents. HAZMAT tracking is performed by the Fleet and Freight Management Subsystem. The Emergency Management subsystem is notified by the Commercial Vehicle if an incident occurs and coordinates the response. The response is tailored based on information that is provided as part of the original incident notification or derived from supplemental information provided by the Fleet and Freight Management Subsystem. The latter information can be provided prior to the beginning of the trip or gathered following the incident depending on the selected policy and implementation.
EM1	Emergency Response	This market package provides the computer-aided dispatch systems, emergency vehicle equipment, and wireless communications that enable safe and rapid deployment of appropriate resources to an emergency. Coordination between Emergency Management Subsystems supports emergency notification and coordinated response between agencies. Existing wide area wireless communications would be utilized between the Emergency Management Subsystem and an Emergency Vehicle to enable an incident command system to be established and supported at the emergency location. The Emergency Management Subsystem would include hardware and software for tracking the emergency vehicles. Public safety, traffic management, and many other allied agencies may each participate in the coordinated response managed by this package.
EM2	Emergency Routing	This market package supports dynamic routing of emergency vehicles and coordination with the Traffic Management Subsystem for special priority on the selected route(s). The Information Service Provider Subsystem supports routing for the emergency fleet based on real-time traffic conditions and the emergency routes assigned to other responding vehicles. In this market package, the Information Service Provider Subsystem would typically be integrated with the Emergency Management Subsystem in a public safety communications center. The Emergency Vehicle would also optionally be equipped with dedicated short range communications for local signal preemption.
EM3	Mayday Support	This package allows the user (driver or non-driver) to initiate a request for emergency assistance and enables the Emergency Management Subsystem to locate the user and determine the appropriate response. The Emergency

Table A-1: National ITS Architecture Market Packages

Market Package		Market Package Description
		Management Subsystem may be operated by the public sector or by a private sector provider. The request from the traveler needing assistance may be manually initiated or automated and linked to vehicle sensors. The data is sent to the Emergency Management subsystem using wide area wireless communications with voice as an option. Providing user location implies either a location technology within the user device or location determination within the communications infrastructure.
ITS1	ITS Planning	This market package supports ITS planning functions. It accepts data from every center subsystem and uses this data to plan new deployments. This data also supports policy decision making, allocation of funding, allocation of resources and other planning activities.

Appendix

B

THE GYRITS REGIONAL ARCHITECTURE DATABASE

A Technical Overview of the Microsoft Access Database Used in this Task

This appendix provides a brief technical overview of the Access Database that was used to define the GYRITS Regional ITS Architecture. A summary of the database design, data content, and the queries, reports, macros, and modules that are available to review, update, and report on the GYRITS architecture is presented.

Of necessity, this is a brief tutorial that only touches on the Access 97 database features. Anyone who wants to work extensively with the database should plan to spend some time learning Access in general and this particular National ITS Architecture application in particular. There are many good guides for Microsoft Access that are highly recommended. Books that I use are:

- "Using Microsoft Access 97" by Roger Jennings, Published by QUE. A comprehensive moderate user level guide.

- "Access 97 Developer's Handbook" by Litwin, Getz, and Gilbert, Published by Sybex. The best programmer's reference manual on Access 97.

Before we start, one more caveat is in order: The database is not a turn-key product that anyone can use. Many of the tools included in the database were generated "on-the-run" as I was generating the GYRITS architecture. This did not allow any time for some of the nice features that you've come to expect in software applications – like on-line help. You will be an Access database expert if you spend much time working with these databases…so let's roll up our sleeves and start.

INITIAL INSTALLATION

The GYRITS Architecture is defined in two Microsoft Access 97 databases: "gyrits architecture.mdb" and "physical99 gyrits.mdb". gyrits architecture.mdb includes the regional architecture definition and all five early project architecture definitions. It is built on the Exercise database that is distributed as part of the National ITS Architecture training course. This version of the database has been augmented to allow better regional tailoring of a regional architecture and improve the handling of "other *" terminators that are defined in the National

ITS Architecture. The "physical99 gyrits.mdb" database is an augmented version of the version 2.1 National ITS Architecture physical architecture database. In general, all regional architecture work is done in "gyrits architecture.mdb". The physical architecture database is transparent once you have it installed.

In order to use these databases, you must first load them both onto a writeable media (e.g., your hard disk) and then link the two databases together ("gyrits architecture.mdb" references and uses many of the tables in "physical99 gyrits.mdb"). Fortunately, there is a module that automates the table linking process that runs automatically on start-up. If the automatic process fails to relink all tables (because you have stored the two databases in different directories for instance), then you will have to manually relink the tables (see Tools – Add Ins – Linked Table Manager).

THE OPENING SCREEN

When you run Access 97 and open the gyrits architecture.mdb, your screen should look something like figure B-1.

The majority of this screen is the standard Access 97 interface which is well documented in the Access on-line help and in the previous reference books. I won't spend time trying to explain Access Tables, Queries, Macros, … here since they are much better explained in the cited works. The unique feature in figure B-1 that we will discuss is the "GYRITS Regional Architecture" form that includes a tab control with four different tabs: Inventory, Market Packages, Architecture, and Projects. This form gives you direct access to the GYRITS architecture that is defined in this document. Each of the tabs on this form includes a "Run" button that opens the indicated part of the architecture (Inventory, Market Packages, etc.) Let's talk a little bit more about each of these tabs and the forms that are opened when "Run" is selected.

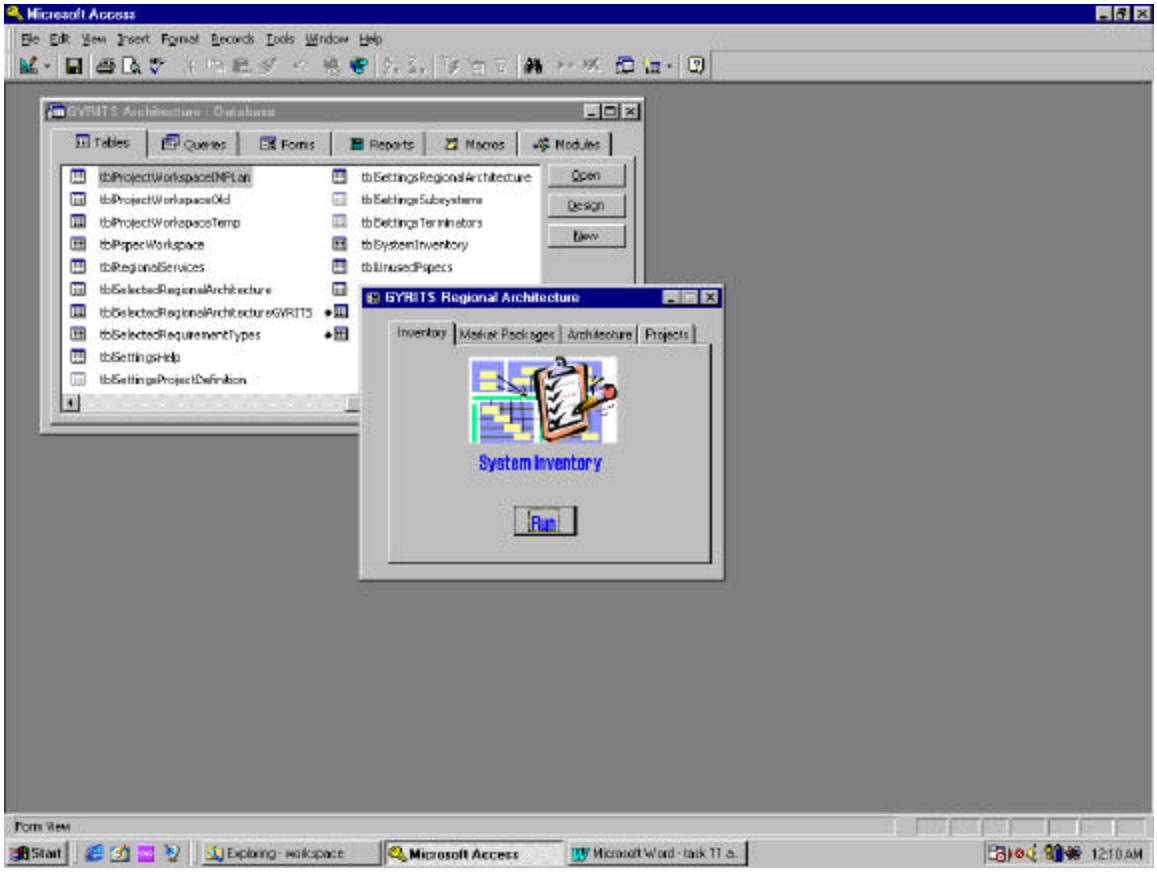


Figure B-1: We've just opened "gyrits architecture.mdb"

COMMON FEATURES SHARED BY ALL FOUR FORMS

Before we jump into each of the forms in detail, lets talk about the few features that all four forms share:

Forms include an "asterisk" row as the last row on the form. This is the "new row" where you can go to add new inventory items, market packages, etc. if required.

Forms are a pretty front for an ugly underlying relational database table or query. Knowing which tables are associated with which forms is sometimes important, so I will provide the form to table associations as we go.

Forms we have developed all include "Settings" and "Reports" buttons at the top. The settings button allows you to turn help off and on and to set filters so that you don't have to look at all the National ITS Architecture options if you don't want to. I've adjusted the settings so they should

work pretty well for you, all the help is turned on and the filters are set so that everything but environmental and human interfaces will be available in the National ITS Architecture mapping portion of regional architecture development. Feel free to play with them if you want to. Each of the forms has a unique set of associated reports which is touched on in the following form discussions.

SYSTEM INVENTORY

Selecting the Inventory Tab and selecting "Run" produces a form that was used to create the GYRITS system inventory that is discussed in Chapter 2. This form can be used to reviewed and/or edit the GYRITS inventory. A screen snapshot of the System Inventory form follows.

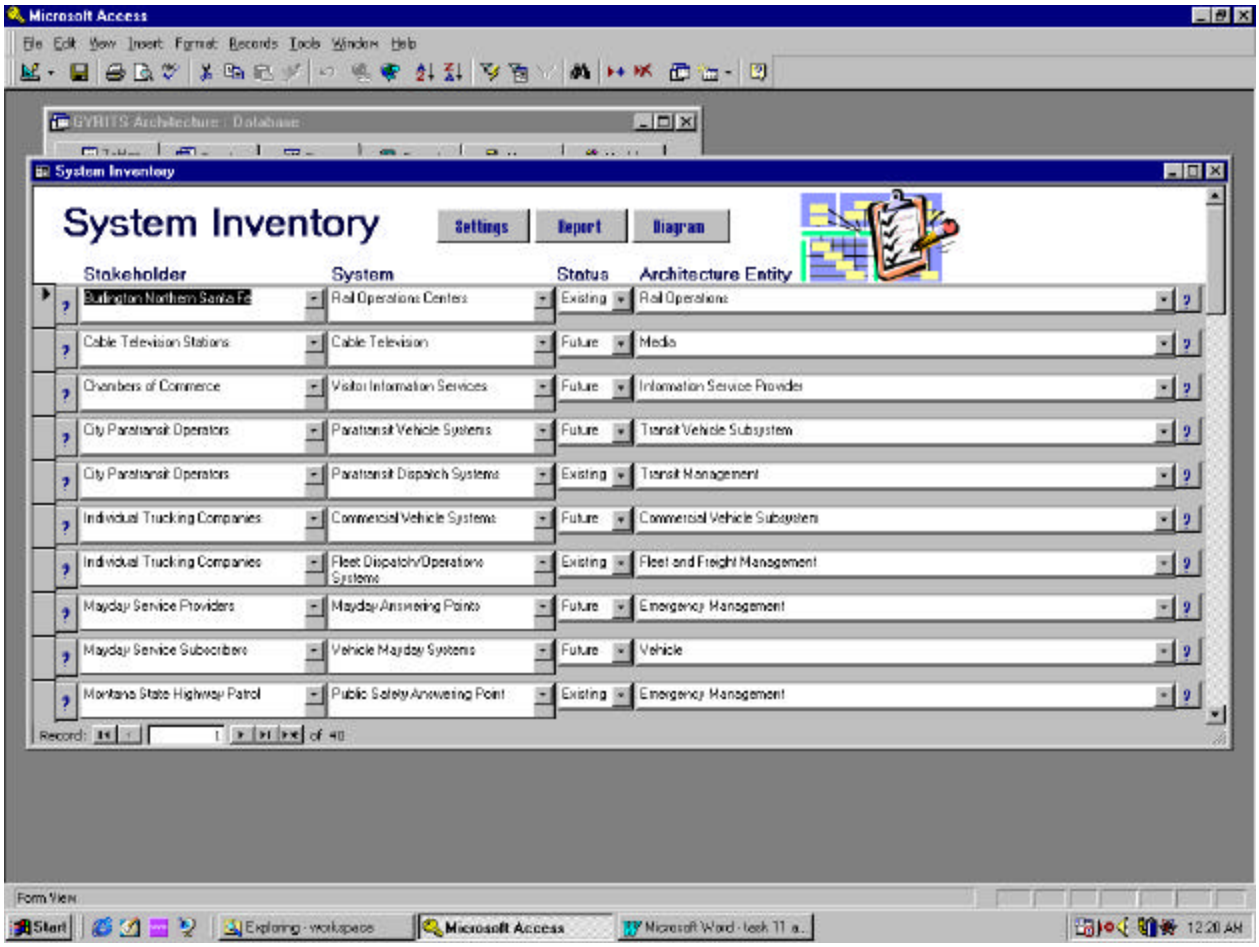


Figure B-2: The System Inventory Screen

The left-most columns on this form are the GYRITS stakeholders and systems. The right-most column is the National ITS Architecture subsystem or terminator that is mapped to the GYRITS system. Note that more than one architecture entity can be mapped to the same system by including more than one row in the report. The third column is pretty self-explanatory and was not a focal point of the GYRITS architecture definition. This column allows you to identify which parts of the inventory already exist and which parts are yet to be implemented (future). This is not of much consequence going forward; it does impact some of the report outputs. The inventory report is a National ITS Architecture sorted version of the inventory that has been entered. This sorting results in all traffic management systems to be sorted together, etc. Clicking the "Diagram" button generates a sausage diagram representation of the GYRITS inventory.

The System Inventory form is supported by the tblSystemInventory table that actually contains the entire GYRITS inventory. In general, any inventory update that can be made through the form can also be made by directly editing the table, either with a query or by manually editing the table in data sheet view.

MARKET PACKAGES

The Market Packages form is opened by selecting the second "market packages" tab on the opening form. This form, depicted in figure B-3, allows the assignment of National ITS Market Packages to regional projects or services that are desired for the region. The form as delivered, includes all market package selections that were made to generate the architecture defined in this document. In the case of the GYRITS architecture, several new market packages were added to the architecture to support this mapping. The new market packages were added to the Physical99 GYRITS database so that they would be available on this form. Based on the market packages identified on this form, architecture flows, subsystems, and terminators are selected from the National ITS Architecture. This list is compared with the system inventory in the first of the market packages reports. By reviewing this report, one can identify any market packages that are not supported by the inventory or identify elements of the inventory that are extraneous to the ITS services selected for the region.

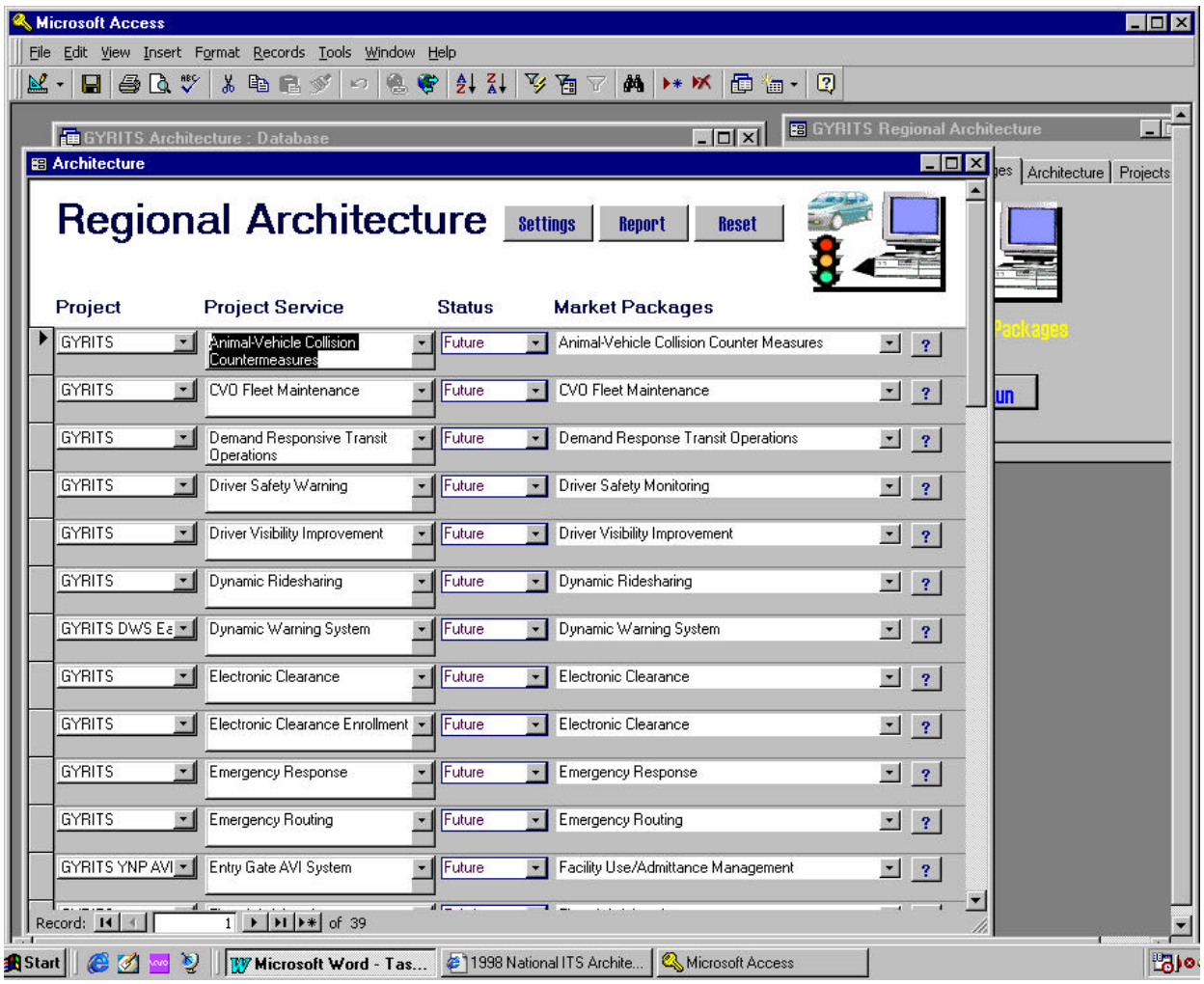


Figure B-3: Market Packages Selection Form

The “Reset” button on this form must be used with care. This button replaces the GYRITS architecture with a default architecture that is based only on the selected market packages and system inventory. The market packages form is based on table “tblSelectedRegionalArchitecture”. The “Reset” button copies this table into “tblSelectedRegionalArchitectureGYRITS” which is the table that is used to develop a tailored regional architecture. Since a lot of tailoring has already been done, it is recommended that the Reset button not be used unless it is decided that it is best to do a “clean start” on the regional architecture.

REGIONAL ARCHITECTURE FORM

The form shown in figure B-4 is opened by selecting the third tab “Architecture” on the main form and selecting “Run”. This form shows every possible architecture flow that might be relevant to GYRITS based on market package selections and the system inventory that were developed in the previous forms. Starting with this list of all possible architecture flows, the architecture is tailored by sleecting the architecture flows that should be included in the regional architecture using the check boxes in the far left hand column.

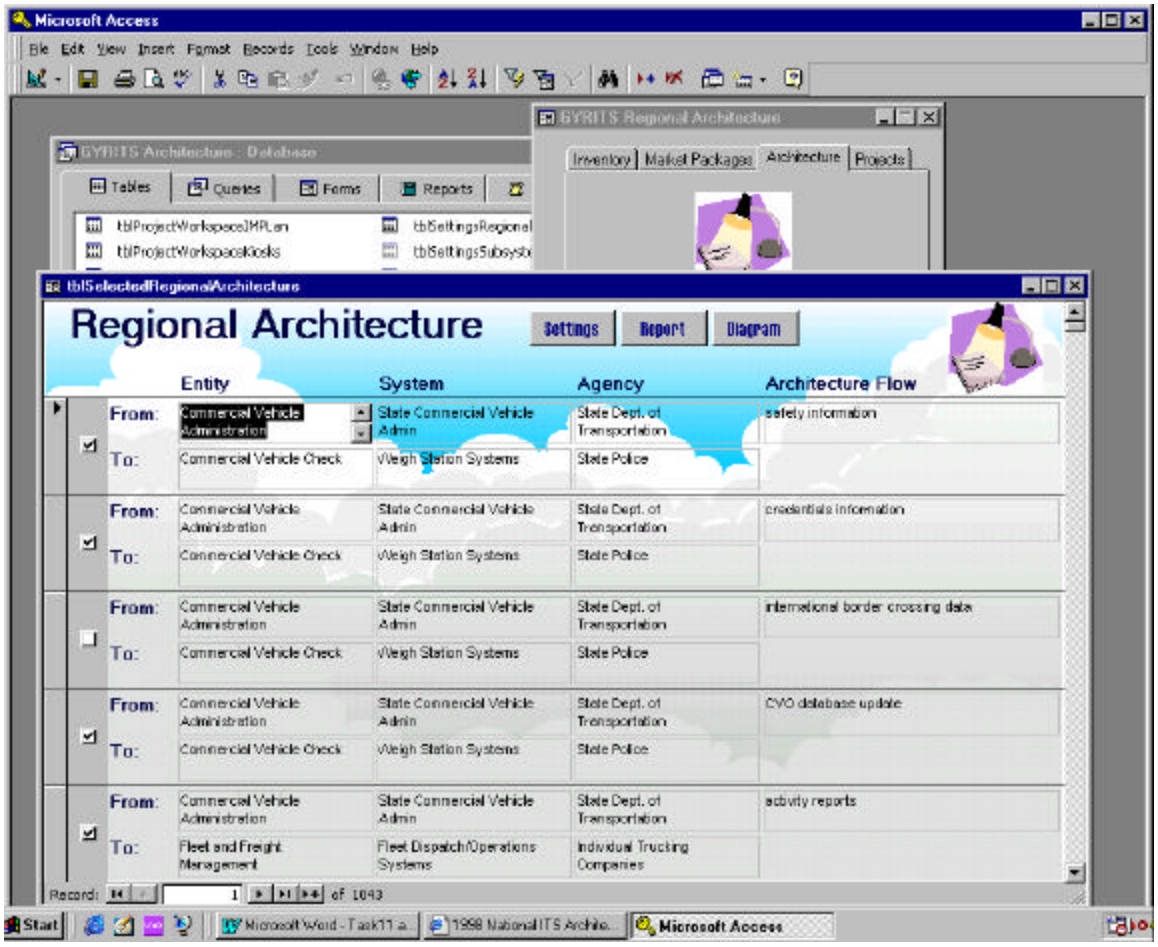


Figure B-4: The Regional Architecture form

Note that the form as delivered includes over 1000 rows of potential architecture flows of which only 172 were selected for this version of the GYRITS architecture. This substantial amount of tailoring took considerable time and has been refined on several additional passes through the flows To avoid doing the tailoring again, I would recommend that minor changes be made

directly to the "tblSelectedRegionalArchitectureGYRITS" table that underlies this form. It is relatively easy to write action queries to make consistent changes to the regional architecture (for instance, to change a system name or add a few additional architecture flows). This direct edit technique was used in several cases to avoid having to repeat the architecture tailoring step (which would have been required if I had went back to the System Inventory form, changed the name there, and regenerated the regional architecture table.) The report for this form shows all the architecture flows (the 172) that were selected for the GYRITS architecture. The "Diagram" button prints the complex architecture flow diagram that is included at the end of chapter 4. This diagram has been enhanced in several ways. One improvement of note is the customized organization of the diagram in which all roadside subsystems are grouped and systems that exchange a lot of data are collocated. This custom format is achieved with the "architecture plot positions" table which is used to specify where each system will be placed on the page. In addition to being displayed on the screen, a Windows Metafile (WMF) graphic file is created that contains the regional architecture diagram in file c:\alll.wmf. This file may be inserted into documents or presentations.

PROJECT ARCHITECTURE FORMS

By selecting the fourth project tab, and selecting "Run", the form shown in figure B-5 is displayed. This form allows any of the GYRITS projects (as entered into the Market Packages form) to be selected. Following project selection, the user is required to select a system in the second combo box, and then is allowed to open the project. By opening the project, the subset of the regional architecture flows that support the selected project and system are selected and placed in table tblProjectWorkspace.

This table is the working table behind the form that is displayed when the project is opened (see figure B-6). In order to save the four project architectures that were defined for chapter 5, four custom tables were created (all named tblProjectWorkspace* where * is a one word name/abbreviation of the project). These tables can either be reviewed directly, or they can be renamed individually to "tblProjectWorkspace" and viewed with the form. Relatively little tailoring was done on the default project definitions provided by the tool, so these project files could also be recreated from scratch in short order if required.

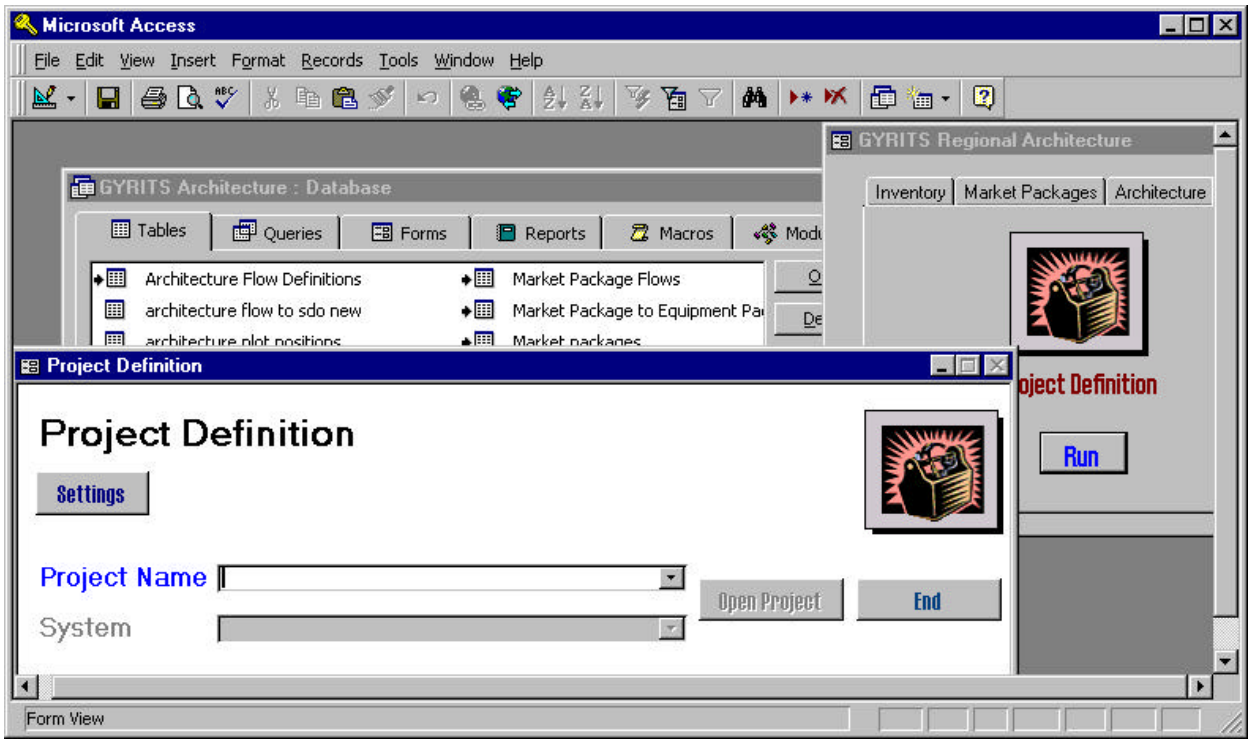


Figure B-5: Project Selection Form

The project tailoring form shown in Figure B-6 allows tailoring of the project architecture and allows several reports to be generated. Most notable of the reports is the related standards report that provides a list of all standards associated with the defined project. Rather than use these lengthy reports directly in the document, custom tables/queries were developed that generated the standards activities tables that were included in chapter 5.

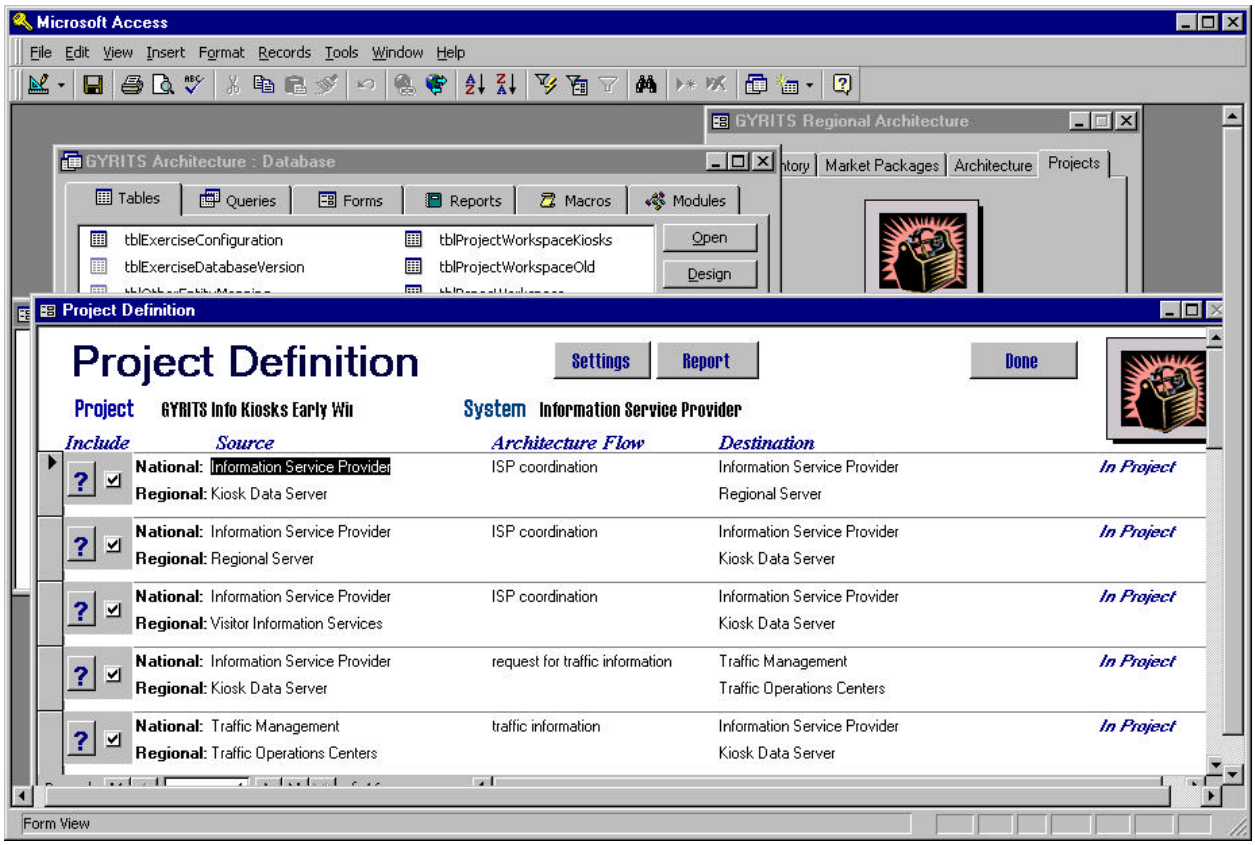


Figure B-6: Project Architecture Tailoring Form