ITS EARLY DEPLOYMENT PROGRAM

I-5 SEATTLE TO VANCOUVER, B.C.

Technical Memorandum 2

CORRIDOR ITS OPPORTUNITIES

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1 .O INTRODUCTION

1 .1 OVERVIEW

This Technical Memorandum has been prepared as part of the l-5 Seattle to Vancouver, B.C. & l-90 Seattle to Spokane Inter-City Urban/Rural Corridors ITS Early Deployment Project. This is the second technical memorandum for the ITS Early Deployment Plan for the l-5 corridor and is submitted in fulfillment of Work Element 2: Identify Corridor ITS Opportunities. Revisions based on the review of this draft document will be presented in Work Element 7: I-5 ITS Corridor Study - Final Report, which will be composed of subsequent memoranda in their final form from the other five work elements in this study. The summary Corridor Potential ITS Opportunities for the l-90 corridor is provided under a separate cover.

The scope of this Work Element is:

> The ITS user services benefits shall be mapped against the transportation needs in the corridor. The analysis shall reveal which ITS user services have the best potential to address corridor needs. The CONSULTANT shall focus on near term applications such as changeable message signs, variable speed limit signs, traveler information services, mayday systems, and commercial vehicle operations plus the other elements of ATMS, ATIS, ARTS, APTS, and CVO. This data shall be compiled in a matrix that lists ITS user services against their potential benefits categories such as safety, congestion, mobility, travel time, air quality, energy efficiency, and economic productivity.
>
> The ITS user services that best match corridor needs over time shall be packaged into solution sets in a table format based upon the segmentation of the corridor. The end result shall be the determination of ITS needs in the corridor.
>
> The results of the problem identification and potential ITS solutions shall be presented a a workshop, outlined in Work Element 6. This opportunity shall help to validate the assessment of corridor transportation and ITS needs. In addition, the CONSULTANT shall seek guidance from the participants on the relative priority of identified corridor needs.
>
> The results of the work element shall be documented in a technical memorandum for review by WSDOT.

1.2 ORGANIZATION OF THE TECHNICAL MEMORANDUM

The main body of this technical memorandum presents the findings of Work Element 2.7, Summary of Benefits and Costs of Potential ITS Solutions, and is divided into four sections. The first section introduces the memorandum, restates the scope of this task, and outlines the organization of the memorandum. The second section of the memorandum introduces the national ITS Architecture as defined by the Federal Highway Administration (FHWA), with discussion of FHWA User Services and Market Packages. The third section describes the National ITS Architecture Tool Packages which address specific corridor needs, and provides an estimate of costs and benefits. The final section of this memorandum will summarize

corridor-wide transportation needs and match them with appropriate ITS Tools (Market Packages).

Work from Tasks 2.1 through 2.6 are presented in the Technical Appendices. Work from these tasks were prepared specifically by members of the team to focus on specific ITS needs of the corridor as described below:

- **Appendix A** presents excerpts of the FHWA National ITS Architecture Implementation Strategy, which outlines ITS strategies and defines Market Packages.
- **Appendix B** presents the Weather Systems Technology Assessment as prepared under Work Element 2.1.
- **Appendix C** presents the Commercial Vehicle Operations Enhancement Opportunities as prepared under Work Element 2.2.
- **Appendix D** presents the Traveler/Tourist Information Opportunities Assessment as prepared under Work Element 2.3.
- **Appendix E** presents the Enforcement Enhancement Opportunities Assessment as prepared under Work Element 2.5.
- **Appendix F** presents the Additional User Services Potential as prepared under Work Element 2.6.
- **Appendix** G presents the Border Crossing Technologies Assessment as prepared under Work Element 2.4.

2.0 NATIONAL ITS ARCHITECTURE

The FHWA has organized emerging ITS technologies into a collection of interrelated user services and sample market packages in the development of the National ITS Architecture (NITSA). The NITSA provides a framework for the design of ITS systems and standards for interegional and national interoperability. Relevant excerpts from the NITSA Implementation Strategy document are provided in Appendix A in order to familiarize the reader with the work currently being done by FHWA. The reader is encouraged to read this section first in order to gain a thorough understanding of the NITSA. A brief recap of basic NITSA elements are provided here.

2.1 FHWA USER SERVICES

The primary objective of this memorandum is to map NITSA User Services against the corridor's transportation needs. The 29 NITSA User Services, as defined by FHWA, outline overall transportation service areas in which advanced technologies can be applied. They are broad categories of ITS-based transportation services, and do not specifically address corridor needs at the project level. It is therefore necessary to refine these 29 User Services to the project level in order to match corridor transportation needs with a specific ITS implementation strategy.

User Services are "bundled" by category. They are presented in the Table 1.

Table 1

User Services Bundles

Bundle	User Services
1.0 Travel and Transportation Management	1.1 Pre-Trip Travel Information 1.2 En-Route Driver Information 1.3 Route Guidance 1.4 Ride Matching and Reservation 1.5 Traveler Services Information 1.6 Traffic Control 1.7 incident Management 1.8 Demand Management and Operations 1.9 Emissions Testing and Mitigation
2.0 Public Transportation Operations	2.1 Public Transportation Management 2.2 En-Route Transit Information 2.3 Personalized Public Transit 2.4 Public Travel Security
3.0 Electronic Payment	3.1 Electronic Payment Services
4.0 Commercial Vehicle Operations	4.1 Commercial Vehicle Electronic Clearance 4.2 Automated Roadside Safety Inspection 4.3 On-board Safety Monitoring 4.4 Commercial Vehicle Administration Processes 4.5 Hazardous Materials Incident Response 4.6 Commercial Fleet Management
5.0 Emergency Management	5.1 Emergency Notification and Personal Security 5.2 Emergency Vehicle Management
6.0 Advanced Vehicle Control and Safety Systems	6.1 Longitudinal Collision Avoidance 6.2 Lateral Collision Avoidance 6.3 Intersection Collision Avoidance 6.4 Vision Enhancement for Collision Avoidance 6.5 Safety Readiness 6.6 Pre-Crash Restraint Deployment 6.7 Automated Highway System

Source: FHWA, National ITS Architecture, Executive Summary p. 2.

2.2 ITS MARKET PACKAGES

The Market Packages are functional descriptions of specific implementation projects that address the User Service goals through specific applications of ITS technology. FHWA has developed 53 sample Market Packages, each defining a particular set of deployment functionalities. These packages are each identified with the traditional ITS categories of Advanced Traffic Management Systems (ATMS), Advanced Public Transit Systems (APTS), Advanced Traveler Information Systems (ATIS), Advanced Vehicle Control and Safety Systems (AVSS), Commercial Vehicle Operations (CVO), Emergency Management (EM). Table 2 lists the 53 Market Packages by category.

Table 2

Market Packages

Traffic Management
- Network Surveillance
- Probe Surveillance
- Surface Street Control
- Freeway Control
- HOV and Reversible Lane Management
- Traffic Information Dissemination
- Regional Traffic Control
- Incident Management System
- Traffic Network Performance Evaluation
- Dynamic Toll/Parking Fee Management
- Emissions and Environmental Hazards Sensing
- Virtual TMC and Smart Probe

Emergency Management
- Emergency Response
- Emergency Routing
- Mayday Support

ITS Planning
- ITS Planning

Traveler Information
- Broadcast Traveler Information
- Interactive Traveler Information
- Autonomous Route Guidance
- Dynamic Route Guidance
- ISP Based Route Guidance
- Integrated Transportation Management/Route Guidance
- Yellow Pages aud Reservation
- Dynamic Rldesharing
- In Vehicle Signing

Commercial Vehicles
- Fleet Administration
- Freight Administration
- Electronic Clearance
- Electronic Clearance Enrollment
- International Border Electronic Clearance
- Weigh-In-Motion
- Roadside CVO Safety
- On-board CVO Safety
- CVO Fleet Maintenance
- HAZMAT Management

Transit Management
- Transit Vehicle Tracking
- Transit Fixed-Route Operations
- Demand Response Transit Operations
- Transit Passenger and Fare Management
- Transit Security
- Transit Maintenance
- Multi-modal Coordination

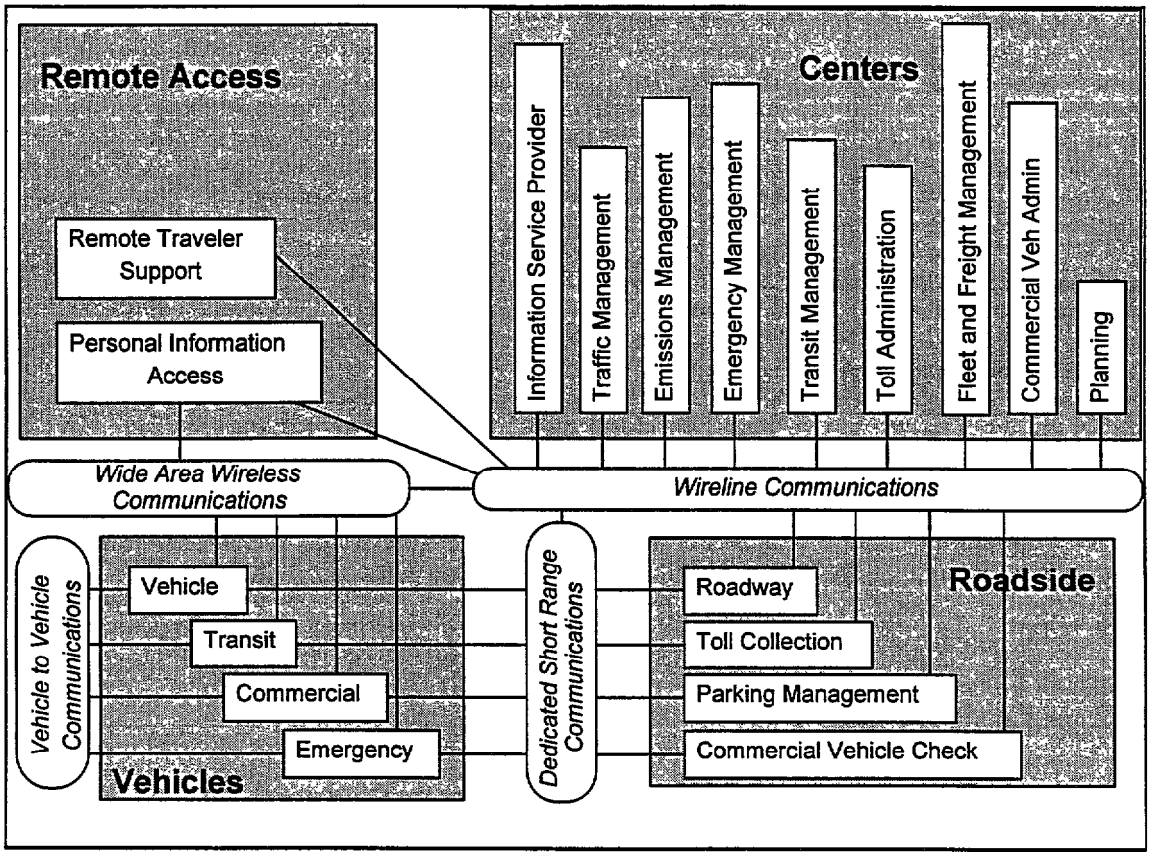
Advanced Vehicles
- Vehicle Safety Monitoring
- Driver Safety Monitoring
- Longitudinal Safety Warning
- Lateral Safety Warning
- Intersection Safety Warning
- Pre-Crash Restraint Deployment
- Driver Visibility Improvement
- Advanced Vehicle Longitudinal Control
- Advanced Vehicle Lateral Control
- Intersection Collision Avoidance
- Automated Highway System

Source: FHWA, National ITS Architecture. Implementation Strategy Executive Summary pp. 1-2.

The NITSA is comprised of two technical layers: a Transportation Layer and a Communications Layer. The Transportation Layer includes nineteen subsystems which have been categorized into four classes: Centers, Roadside, Vehicle, and Remote Access systems. Interface between these elements is achieved through the Communications Layer, which is broken down into the following four parts: Vehicle to Vehicle Communication, Wide Area Wireless Communication, Wireline Communication and Dedicated Short Range Communication. The four classes and nineteen subsystems of the Transportation Layer, and their linkages with the four parts of the Communications Layer, are illustrated in Figure 1and described in full in Appendix A.

NITSA Figure 1

Transportation Layer



Some:FHWA, National ITS Architecture, Implementation Strategy, p. 2-4.

Each Market Package serves the functional needs of a User Service and through the Communications Layer interacts and exchanges data with one or more of the above 19 subsystems of the Transportation Layer. Detailed descriptions of each sample Market Package are contained in Appendix A, and illustrate this relationship for each of these 53 market packages.

The Market Packages are directly traceable to the User Services. A Market Package often includes capabilities which span more than one User Service. A single User Service sometimes includes a range of incremental capabilities that are segregated into separate Market Packages so that they can be considered separately from a deployment perspective.

Table 3 illustrates the relationship between the User Services and Market Packages. For example, the User Service of Incident Management can be addressed by the Market Packages of Surface Street Control, Freeway Control, Incident Management System, Virtual TMC and Smart Probe Data, and HAZMAT Management.

Table 3

Market Package to User Service Relationships

	Market Packages	1.1 - Pre - Trip Travel Information	1.2 - En - Route Driver Information	1.3 - Route Guidance	1.4 - Ride Matching And Reservation	1.5 - Traveler Services Information	1.6 - Traffic Control	1.7 - Incident Management	1.8 - Travel Demand Management	1.9 - Emissions Testing And Mitigation	2.1 - Public Transportation Management	2.2 - En - Route Transit Information	2.3 - Personalized Public Transit	2.4 - Public Travel Security	3.1 - Electronic Payment Services	4.1 - Commercial Vehicle Electronic Clearance	4.2 - Automated Roadside Safety Inspection	4.3 - On - Board Safety Monitoring	4.4 - Commercial Vehicle Administrative Process	4.5 - Hazardous Material Incident Response	4.6 - Commercial Fleet Management	5.1 - Emergency Notification And Personal Security	5.2 - Emergency Vehicle Management	6.1 - Longitudinal Collision Avoidance	6.2 - Lateral Collision Avoidance	6.3 - Intersection Collision Avoidance	6.4 - Vision Enhancement For Crash Avoidance	6.5 - Safety Readiness	6.6 - Pre - Crash Restraint Deployment	6.7 - Automated Vehicle Operation
		User Services																												
ATMS	Network Surveillance						Ü																							
ATMS	Probe Surveillance						Ü																						Ü	
ATMS	Surface Street Control						Ü	Ü																						
ATMS	Freeway Control						Ü	Ü	Ü																					
ATMS	HOV and Reversible Lane Management						Ü		Ü																					
ATMS	Traffic Information Dissemination						Ü																							
ATMS	Regional Traffic Control						Ü																							
ATMS	Incident Management System							Ü																						
ATMS	Traffic Network Performance Evaluation						Ü		Ü																					
ATMS	Dynamic Toll/Parking Fee Management								Ü						Ü															
ATMS	Emissions and Environmental Hazards Sensing									Ü																				
ATMS	Virtual TMC and Smart Probe Data		Ü				Ü	Ü																						
APTS	Transit Vehicle Tracking										Ü	Ü	Ü	Ü																
APTS	Transit Fixed-Route Operations										Ü	Ü																		
APTS	Demand Response Transit Operations										Ü	Ü	Ü																	
APTS	Transit Passenger and Fare Management											Ü			Ü															
APTS	Transit Security										Ü			Ü																
APTS	Transit Maintenance										Ü																			
APTS	Multi-modal Coordination						Ü		Ü		Ü																			
ATIS	Broadcast Traveler Information	Ü	Ü									Ü																		
ATIS	Interactive Traveler Information	Ü	Ü									Ü	Ü		Ü															
ATIS	Autonomous Route Guidance		Ü	Ü																										
ATIS	Dynamic Route Guidance		Ü	Ü																										
ATIS	ISP Based Route Guidance	Ü	Ü	Ü											Ü															
ATIS	Integrated Transportation Mgmt/Route Guidance		Ü	Ü											Ü															
ATIS	Yellow Pages and Reservation	Ü	Ü			Ü									Ü															
ATIS	Dynamic Ridesharing	Ü	Ü		Ü							Ü	Ü		Ü															
ATIS	In Vehicle Signing		Ü				Ü																							
AVSS	Vehicle Safety Monitoring																												Ü	Ü
AVSS	Driver Safety Monitoring																												Ü	
AVSS	Longitudinal Safety Warning																							Ü					Ü	
AVSS	Lateral Safety Warning																								Ü				Ü	
AVSS	Intersection Safety Warning																									Ü			Ü	
AVSS	Pre-Crash Restraint Deployment																												Ü	Ü
AVSS	Driver Visibility Improvement																											Ü		
AVSS	Advanced Vehicle Longitudinal Control																							Ü						
AVSS	Advanced Vehicle Lateral Control																								Ü					
AVSS	Intersection Collision Avoidance																									Ü				
AVSS	Automated Highway System																													Ü
CVO	Fleet Administration																					Ü								
CVO	Freight Administration																				Ü									
CVO	Electronic Clearance															Ü			Ü											
CVO	Electronic Clearance Enrollment															Ü			Ü											
CVO	International Border Electronic Clearance															Ü			Ü											
CVO	Weigh-In-Motion															Ü														
CVO	Roadside CVO Safety																Ü													
CVO	On-board CVO Safety																	Ü												
CVO	CVO Fleet Maintenance																	Ü				Ü								
CVO	HAZMAT Managment							Ü												Ü	Ü									
EM	Emergency Response																						Ü							
EM	Emergency Routing																						Ü							
EM	Mayday Support																					Ü	Ü							
	ITS Planning										Ü																			

Source: FHWA, National ITS Architecture, Implementation Strategy, p. 2-28.

A Market Package is implemented with a combination of interrelated tools/equipment; these tools often reside in several different Transportation Layer subsystems within the NITSA framework, and may be operated by different stakeholders. Since equipment in different subsystems may be purchased and operated by different end-users, these subsystem-specific components may be deployed in stages or in increments for enhanced utility.'

The equipment available for ITS solutions and applications falls within several technological areas which are defined by the NITSA. These Technology Areas are grouped by function and listed in Table 4, cross-referenced with Market Packages. Black squares denote a basic core relationship between the Technology Area and the Market Packages; white squares denote a Technology Area that is desirable but not required for Market Package implementation. The Technology Areas are based on several basic functional areas including; Sensors, Location Determination Systems, Communications, Algorithms, Information Management, Payment Systems, User interface, and Control Systems. Devices and components of the ITS tool Kits used will fall under these basic categories. As an example, Traffic Sensors are represented by loop detectors, radar detectors, or infrared detectors. Table 2.5-2 in Appendix A describes these Technology Areas further.

1"Implementation Strategy," National ITS *Architecture,* FHWA, 1996, pg. 2-23.

Table 4

Market Package Requirements by Technology Area

	Market Packages	Technology Area																								
		Sensor										Comm								User I/F			Control		
		Traffic	Vehicle Status	Environment	Vehicle Monitoring	Driver Monitoring	Cargo Monitoring	Obstacle Ranging	Lane Tracking	Security	Location Determination	Cell-Based (U1)	Vehicle-Roadside (U2)	Vehicle-Vehicle (U3)	Broadcast (U1-B)	Fixed (W)	Algorithms	Information Mgmt	Payment	Driver	Traveler	Operator	Signals	Signs	Vehicle
ATMS	Network Surveillance	■		❑												■	❑	■				■			
	Probe Surveillance				■						■	■	❑			❑	■	■				■			
	Surface Street Control	■														■						■	■		
	Freeway Control	■														■						■	■	❑	
	HOV and Reversible Lane Mgmt	■	■								■	■				■	❑					■	■	■	
	Traffic Information Dissemination														■	■	❑	■				■		❑	
	Regional Traffic Control	■			■											■	■	■				■	■	■	
	Incident Management System	■			■						■	■				■	■	■				■	❑	❑	
	Traffic Network Performance Eval	■			■								■			❑	■	■				■			
	Dynamic Toll/Parking Fee Mgmt	■	■									❑	■		❑	■	■	■	■	■		■	❑	❑	
	Emissions and Enironmental Haz.		■	■	❑											■	■	■		❑		■		❑	
	Virtual TMC and Smart Probes				■						■	■	❑			❑	■	■				■			
APTS	Transit Vehicle Tracking				❑	❑					■	■	❑			❑		■			❑	■			
	Transit Fixed-Route Operations											❑	❑			❑		■		❑	❑	■			
	Demand Response Operations											■				❑	❑	■		■	❑	■			
	Transit Passenger and Fare Mgmt									❑	❑	❑				❑		■	■		■	■			
	Transit Security									■	❑	❑				❑		❑		■	■	■			
	Transit Maintenance				■	❑					❑	❑				❑		■		■		■			
	Multi-modal Coordination										■	■				■	❑	■	❑	■	❑	■			
ATIS	Broadcast Traveler Information	■		❑											■	■	■	❑		■	■	■			
	Interactive Traveler Information	■		❑							❑	■				■	■	❑		■	■	■			
	Autonomous Route Guidance										■						■	❑		■	■				
	Dynamic Route Guidance	■		❑							■	❑			■	■	■	❑		■	■				
	ISP-Based Route Guidance	■		❑							■	■				■	■	■	❑	■	■	■			
	Integrated Transportation Mgmt/RG	■		❑							■	■				■	■	■	❑	■	■	■			
	Yellow Pages & Reservation										❑	■				■	■	❑		■	■	■			
	Dynamic Ridesharing								■	❑		■				■				■	■	■			
	In Vehicle Signing		❑	❑	❑	❑	❑				■	❑	■			❑	❑	❑		■		❑			
AVSS	Vehicle Safety Monitoring				■												❑			■					
	Driver Safety Monitoring				■	■											■			■					
	Longitudinal Safety Warning				■	❑		■									■			■					
	Lateral Safety Warning				■	❑		■	■								■			■					
	Intersection Safety Warning		■	❑	■	❑		■	■			❑	■	❑		■	■	❑		■			❑	❑	
	Pre-Crash Restraint Deployment				■	❑		■									■								❑
	Driver Visibility Improvement					❑		■												■					
	Advanced Vehicle Longitudinal Ctrl				■	❑		■									■			■					■
	Advanced Vehicle Lateral Control				■	❑		■	■								■			■					■
	Intersection Collision Avoidance		■	❑	■	■		■	■			❑	■	❑		■	■	❑		■			❑	❑	■
	Automated Highway System	❑	■	❑	■	■		■	■	❑	■	■	■	■		■	■	■	❑	■		■	❑	❑	■

Table 4: Market Package Requirements by Technology Area (Continued)

	Market Packages	Technology Area																								
		Sensor										Comm								User I/F			Control			
		Traffic	Vehicle Status	Environment	Vehicle Monitoring	Driver Monitoring	Cargo Monitoring	Obstacle Ranging	Lane Tracking	Security	Location Determination	Cell-Based (U1)	Vehicle-Roadside (U2)	Vehicle-Vehicle (U3)	Broadcast (U1-B)	Fixed (W)	Algorithms	Information Mgmt	Payment	Driver	Traveler	Operator	Signals	Signs	Vehicle
CVO	Fleet Administration				■						■	■	❑			❑	❑	■		■		■			
CVO	Freight Administration						■				■	■	❑			■	❑	■		■		■			
CVO	Electronic Clearance												■					■		■		■	❑	❑	
CVO	Electronic Clearance Enrollment																								
CVO	International Border Clearance												■					■		■		■	❑	❑	
CVO	Weigh-In-Motion		■										❑				❑					■	❑	❑	
CVO	Roadside CVO Safety		■		❑		❑						■			■	❑					■	❑	❑	
CVO	On-board CVO Safety				■	■	■						❑				❑			■					
CVO	CVO Fleet Maintenance				■						■	■				❑	❑	■		■		■			
CVO	Hazmat Management						■				■	■	❑			■	❑	■		■		■			
	Emergency Response	❑								■	❑	❑				■	❑	■				■			
EM	Emergency Routing				❑	❑					■	■	❑			❑	❑	■		■		■			
EM	Mayday Support		❑								■	■				■		❑		■	■	■			
	ITS Planning													■		■		■				■			

Source: FHWA, National ITS Architecture, Implementation Strategy, pp. 2-42 through 2-43.

3.0 CORRIDOR ITS TOOLS

Development of corridor-specific ITS Tools is the first step in identifying potential ITS Project/Program Profiles that address individual corridor needs. Each ITS application is presented as a "Tool Kit". These ITS Tools were formulated using the basic NITSA structure as described earlier, and were developed to specifically address individual corridor needs. Following is a list of each of these tools, including a summary of the problem statement, project description, system components, implementation plan, potential benefits and drawbacks, potential application sites, and a preliminary cost estimate.

3.1 INTERNET PRE-TRIP TRAVELER INFORMATION

PROBLEM STATEMENT

There is a need to provide pre-trip information to travelers in the most convenient and cost effective manner possible. The burgeoning growth of personal computers for home and office, increased ease of access and use of the Internet, and new sophisticated World Wide Web browsers with the capability of displaying dynamic information make the Internet and ideal medium for disseminating pre-trip traveler information.

PROJECT DESCRIPTION

WSDOT currently operates an excellent World Wide Web home page that includes both static (transportation service schedules, construction schedules, etc.) and real-time (freeway conditions map and incident reports) travel information. It focuses primarily on Central Puget Sound, but does contain information on other regions in the state.

Work under this project would involve expanding pre-trip information availability in the corridors by establishing transportation home pages for the U.S./Canadian border crossing and the I-5 corridor. These home pages would also contain links to other sites such as the WSDOT main' home page, Metro, the Regional Transit Authority and other transit authorities, various school districts, community colleges, and universities. The web sites of government and tourism activities in Whatcom, and Snohomish Counties should also be linked. Directories such as the Emerald Web which is a list of Internet sites that are based in the Greater Seattle area should also be considered as a link.

Content of the home pages would depend upon available sources of data, but ultimately could include (in increasing order of data and management requirements):

1. Static information on local transportation services available.
2. Marine, rail and bus schedules.
3. Roadway construction information.
4. Incident reports, and/or unplanned road closures and diversions.
5. Current and forecast weather conditions (may be available through links to other sites).
6. Real-time traffic conditions.
7. Real-time transit vehicle locations.

Operation of these new home pages could be by the WSDOT Regional offices, the local convention and visitors bureaus, local governments, or a private sector service provider. Data sources would likely be from local and state transportation agencies.

This project type falls under the NITSA User Service of Pre-Trip Travel Information (1.1), En-Route Driver Information (1.2) Route Guidance (1.3) Ride Matching and Reservation (1.4), Traveler Services Information (1.5), Public Transportation Management (2.1) and En-Route Transit Information (2.2). This system falls under the NITSA Market Packages for Interactive Traveler Information (ATIS2), and could also include elements of Yellow Pages and Reservation (ATIS7).

SYSTEM COMPONENTS

- Web Servers - although new home pages could be established on an existing Web server(s), it is suggested that new servers be established specifically for providing traveler information.
- Internet Communications Access - the type of Internet connection will depend on overall data transfer requirements, but will likely require a dedicated T1 line.
- Electronic Data Interfaces - to allow automatic updating of both static and real-time information where electronic sources of that information are available.
- Manual Interfaces - to allow keyboard entry of incidents, construction updates, etc.
- Home Pages - setting up of transportation home page and hypertext links similar to the WSDOT main home page. More extensive use may be made of dynamic display capabilities and frames to utilize the capabilities of current browser software (Netscape 3 and Internet Explorer 3).

IMPLEMENTATION PLAN

There are opportunities to coordinate this effort with the development of data collection and aggregation systems, incident management systems, and other traveler information dissemination systems. The home pages could form the core means of disseminating information to broadcast radio stations and possibly kiosks.

USER BENEFITS

- Current static and real-time information can be provided to a wide audience at relatively low cost (uses existing Internet infrastructure).
- Access is easy for users with World Wide Web access.
- Hierarchical structure allows users to easily find information of direct relevance.
- For the operating agency, can form the core of a broader information dissemination system.

POTENTIAL DRAWBACKS

- Information sources in the corridors may be limited.
- Web sites must be maintained and kept current thus requiring funding.
- Only a subset of travelers have Internet access.

POTENTIAL APPLICATION SITES

Sites should be established for urban areas as monitoring infrastructure is installed.

PRELIMINARY COST ESTIMATE

Web site enhancement	$10,000
Construction/Enhanced or New Interfaces	$100,000
Annual O&M	$10,000

3.2 BROADCAST RADIO DISSEMINATION SYSTEM

PROBLEM STATEMENT

For most travelers, the most easily accessible source of en-route information is local radio broadcasts received through their in-vehicle radio. Outside of the major urban areas, it is difficult for local radio stations to obtain current, real-time information on traffic and travel conditions.

PROJECT DESCRIPTION

This project would primarily involve the implementation of a computer database and information system to aggregate route, weather, or other traveler information pertaining to the two corridors, and disseminate it to local broadcast radio stations. The computer database and information system would be developed and maintained by the WSDOT Northwest Region.

This project type falls under the ITS User Service of En-Route Driver Information (1.2). This project can be classified under the ITS User Service of Broadcast Traveler Information (ATIS1).

SYSTEM COMPONENTS

The Region would have a computer database and information system, comprised of the following primary components:

- Computer Processor - this would be a PC or similar computer with a relational database to store traveler information, and a graphical (map) user interface to display the location of incidents, road closures, weather conditions, special events, and other real-time traveler information pertinent to the route.

- TSMC Computer Interface - an interface would be required to electronically update the database where route conditions and other information is gathered by a TSMC or other computer.

- Manual Interface - information would be entered and updated manually through a computer keyboard where there is no TSMC computer, or for implementation in smaller WSDOT Regions.

- Broadcast Radio Station Communications Interface - For larger radio stations or those willing to invest in the purchase of a computer workstation with graphical display capabilities, a “dedicated” terminal could be provided and linked through the Internet or through a dial-up communications line with the WSDOT Regional database. For other radio stations, automatic fax generation by the WSDOT Regional database could be used to send fax messages (scheduled or on demand).

IMPLEMENTATION PLAN

The system would initially be developed and deployed by the WSDOT Northwest Region, and from there the software would be adapted and customized for the South Central and Eastern Regions. Each Region would be responsible for making arrangements with local radio stations to disseminate information.

USER BENEFITS

- Provides real-time traveler information that is accessible by most travelers in the corridors with no need for special in-vehicle devices.
- Provides "value added" to regular radio station broadcasts, and may have private sector participation opportunities.
- Through the relational database, information can be categorized by route, geographic area, or other criteria as desired by each radio station.
- Information dissemination is automatic.
- Dissemination to the radio stations can be scheduled or timed to coincide with regular news, traffic, or other broadcast for maximum timeliness.

POTENTIAL DRAWBACKS

- Information sources in the corridors may be limited.
- WSDOT Regions would need to maintain the database, and coordinate with local broadcast stations.
- Broadcast stations have ultimate control over what information is sent to travelers and when.
- Cost

POTENTIAL APPLICATION SITES

Any broadcast radio stations located in or near the corridors. Potential for corridor-wide coverage.

PRELIMINARY COST ESTIMATE

Design	$300,000
Construction	$1,500,000
Annual O&M	$100,000
Annual Private Participation	($25,000)

3.3 REST AREA TRAVELER INFORMATION KIOSKS

PROBLEM STATEMENT

There is a need to provide travelers with updated route and destination information while en-route, and provide local service information at stops along the way.

PROJECT DESCRIPTION

This project will involve the installation of computer information kiosks at freeway rest areas to interactively provide travelers with:

- Static information on local (in the vicinity of the rest stop) attractions, emergency and tourist services.
- Static information on other destinations along the route.
- Maps showing route alternatives.
- Dynamic information on current traffic, weather and other travel conditions along the route.

Travelers will be able to interact with the kiosk to obtain specific information of interest. If implemented as a public-private partnership, the kiosk may also contain advertising and/or other commercial information. The kiosk could be implemented as a stand-alone device, periodically receiving updated information, or could provide more dynamic information through a continuous connection to a TSMC or other traveler information service. A variation on the latter option could be an Internet connection to display information from one or more World Wide Web sites. This is the approach currently used by the RiderLink kiosks installed in the Seattle area.

This project is classified under the NITSA User Services entitled En-Route Driver Information (1.2) and Traveler Services Information (1.5). It primarily addresses the NITSA Market Package of Interactive Traveler Information (ATIS2), and may also support the Yellow Pages and Reservation Market Package (ATIS7) depending on the level of private sector involvement.

SYSTEM COMPONENTS

Each kiosk would have the following major components:

- Central Processor - an environmentally hardened PC or similar computer processor that would store static and dynamic traveler information, operate the user interface and other ancillary devices, and provide remote communications capability to upload new information.
- User Interface and Multi-media Audio/Visual Display - capable of simultaneous display of audio, text, graphics and photo-quality images. Travelers would request route or location-specific information by interacting with the kiosk via a touch screen or push button system.

- Communications Interface - this could be a dial-up telephone line (if information is updated only on a periodic basis), or could be a dedicated on-line connection (if information is updated continuously or if Internet access is provided).
- Enhancements - such as a thermal printer to provide a printed copy of information requested, or the capability of displaying MPEG or QuickTime computer "movies".

A central computer information system would also be required to update information sent to/displayed on the kiosks. This could be an existing system such as a TSMC central computer, an Internet server, or a private party information computer system.

IMPLEMENTATION PLAN

The first step would be to deploy a prototype kiosk to identify operational issues, problems and solutions, and solicit user feedback on information content and presentation, and kiosk operation. This information would be used to finalize kiosk functionality and operation, and allow deployment at other locations in the corridors.

USER BENEFITS

- Provides current, real-time information while en-route without the need for special in-vehicle devices.
- Provides route, destination or service information specific to a travelers trip or information needs.
- Includes opportunities for private sector sponsorship and value added involvement.
- Promotes local tourism and services.
- Provides greater information content than feasible with VMS, HAR or other en-route information systems.

POTENTIAL DRAWBACKS

- System must be "ruggedized" to withstand outdoor environments.
- May be subject to vandalism. Particularly problematic if a touch-screen video display terminal is used.
- Reliable power and communications is required.
- System must be able to autonomously re-boot and/or establish communications.
- Potential difficulty in self-financing

POTENTIAL APPLICATION SITES

Traveler information kiosks could be deployed at all rest areas within the corridors as listed below. Unless otherwise noted, there are two rest areas (one in each direction) at each location.

- Silver Lake Rest Area (southbound only) MP 188
- Smokey Point Rest Area - Arlington MP 208
- Bow Hill Rest Area - Burlington MP 238
- Custer Rest Area - Birch Bay (+ tourist ctr.) MP 268

PRELIMINARY COST ESTIMATE

Based on a per site basis:	
Design	$100,000
Construction	$500,000
Annual O&M	$75,000
Potential Annual Revenue	$100,000

3.4 BORDER CROSSING SYSTEM

ITS border crossing applications to be incorporated into technical memorandum 4.

3.5 PORTABLE LICENSE PLATE OPTICAL READER

PROBLEM STATEMENT

There is a need by enforcement agencies for additional aid in the identification of vehicles that have been stolen, are owned by repeat commercial vehicle violators, are being driven by fugitives, are actively being pursued, or that may be involved in other crimes. Due to minimal personnel resources of WSP as related to the geographic coverage area, a method to improve the efficiency of the State Patrol's operations is needed.

PROJECT DESCRIPTION

A portable automated license plate reader would allow license plates to be digitally read via a video camera using optical character recognition. This portable optical reader device would be operated by a laptop computer and would be connected to a national database via wide area wireless communications system. The license plate reader software will be programmable to search for pre-defined records of interest. Upon receiving a positive match the system would immediately notify response personnel through an audible alarm system, a direct paging feature or other means. Appropriate action would then be taken by an enforcement agency.

Automatic license plate readers also have multiple CVO applications and could be deployed to weigh stations. As an example, Wisconsin and Minnesota have combined efforts on a License Plate Reader (LPR) system used in conjunction with their commercial vehicle enforcement program. An LPR system is connected with a data base containing records of inspections and violations. The data base is kept up to date through the on-line entry of information at each of 20 Wisconsin scales. Minnesota information is entered from paper inspection forms. Wisconsin also has a portable reader mounted on a tripod for use on scale by-pass routes and secondary routes which works off a laptop.

Another system application could include origin destination surveys by planning agencies. WSDOT or other planning agencies could use two or more of these LPRs placed at strategic points along the corridor. The data could be collected over a selected period of time, resulting in a data file of date stamped license plate records. These could then be analyzed for origin destination information. To ensure privacy for this application, the license plate number could be encrypted. Similarly, travel time studies or traffic diversions studies could be conducted with this technology.

This project type falls under the ITS User Services of Emergency Notification and Personal Security (5.1) and has several CVO applications including Commercial Vehicle Electronic Clearance (4.1) and Commercial Vehicle Administrative Process (4.4). This system is under the ITS Market Packages for Emergency Response (EM1). Elements of the Market Packages for Probe Surveillance (ATMS2) and Virtual TMC and Smart Probe Data (ATMS12) could be addressed if License Plate information is used as a method to track travel time for use as traffic flow data.

SYSTEM COMPONENTS

- Automatic License Plate Reader: A portable device that can be placed to scan for license plates using optical character recognition techniques.
- Laptop Computer: The system will be driven via a laptop computer.
- System Integration/Software: Device drivers, algorithms and communication interface for license plate readers to link to the national database server.

IMPLEMENTATION PLAN

A single unit should be purchased or leased to determine system effectiveness.

USER BENEFITS

- Improved enforcement opportunities
- Deterrent to violators
- CVO enforcement
- Possible use in traffic surveys

POTENTIAL DRAWBACKS

- "Big brother" /privacy concerns.
- Success rate for matching plates is adversely affected by weather conditions.
- Accuracy Levels at present are less than 90%

POTENTIAL APPLICATION SITES

Due to the system's portable nature, this system may be applied anywhere throughout the corridor. Typical application sites include freeway mainline segments, ramps, weigh stations and rest areas.

PRELIMINARY COST ESTIMATE

Cost per each system:	
Design/System Integration	$50,000
Construction/Equipment Procurement	$50,000
Annual O&M	$1,000

3.6 COMMERCIAL VEHICLE OPERATIONS

It was determined that Commercial Vehicle Operations (CVO) would not be specifically addressed at the corridor level due to statewide work being conducted under two supplemental work orders to this contract. JHK and Associates, under separate cover, will produce two separate development studies that will address the future CVO needs, "Washington State CVO Strategic Plan" and "Information Technology Feasibility Study for the Washington State CVISN Deployment Plan"

3.7 SPEED DETECTION/VMS WARNING SYSTEM

PROBLEM STATEMENT

There is a need for speed detection/VMS warning systems on long steep upgrades and downgrades due to rearend accidents and potential runaways. As an example, there are a high number of accidents along Bow Hill due to slow moving vehicles in the uphill direction and speeding in the downhill direction.

PROJECT DESCRIPTION

In order to promote traffic safety and reduce accidents, a speed detection/VMS warning system should be installed on steep grades which experience a higher-than-average accident frequency. For upgrades, this system should be capable of detecting slow moving vehicles ahead in the traffic stream, and respond by activation of a warning message via a VMS to the driver of the vehicle. For downgrades, the system would detect overspeed vehicles approaching a horizontal curve, and activate a downstream warning message. The speed detection for the downstream scenario could also include height detection and weigh-in motion capabilities to perform additional calculations regarding overturn potential of commercial vehicles. These systems may have integration potential with other proposed ITS projects such as pavement icing detection systems, TravelAid, and the Mount Vernon/Bellingham TMS.

This project type falls under the ITS User Services of En-Route Driver Information (1.2) and Traffic Control (1.6). This system is a hybrid of the ITS Market Packages for Freeway Control (ATMS04) and Traffic Information Dissemination (ATMS06).

SYSTEM COMPONENTS

- Speed Detector System: This would measure the speed of approaching vehicles, and may utilize a variety of technologies including induction loops, radar, or ultrasonic detection. The radar detection system has the added advantage of emitting a radar signal which could trigger in-vehicle radar warning systems, encouraging drivers to slow down.
- VMS: Variable Message Signs used to display the appropriate message to the motorist.
- System Integration: A system field controller would control the operation of the system and may be part of a larger system depending on location. Algorithms would be programmed in the controller to accommodate system inputs of road/weather sensors and height detectors as appropriate.

IMPLEMENTATION PLAN

A phased implementation plan could begin by using the VMS signs to display a repeated "Caution - Slow Traffic Ahead" message. Future enhancements could then include the addition of detection equipment and integration with the VMS. The speed detection/VMS warning systems could eventually be integrated into a corridor monitoring system and be controlled from a traffic operations center.

USER- BENEFITS

- Improved traffic safety.
- Reduced traffic accidents.
- Deterrence of speeding.
- Source of corridor speed data.

POTENTIAL DRAWBACKS

- "Big brother-"/privacy concerns.

POTENTIAL APPLICATION SITES

This system could be deployed at existing steep grades with high accident histories, such as Bow Hill, and in areas of recurrent speeding, such as Mount Vernon.

PRELIMINARY COST ESTIMATE

Cost based on a per site basis:	
Design	$50,000
Construction	$300,000
Annual O&M	$30,000

3.8 VARIABLE SPEED LIMIT SIGNING AND WEATHER WARNING SYSTEM

PROBLEM STATEMENT

An increased incidence of accidents has been noted along the corridor in certain areas due to inappropriate vehicle speed during bad weather. There is a need to monitor weather and pavement conditions, notify drivers of the changing roadway conditions, determine safe operating speeds, and provide enforceable speed zones.

PROJECT DESCRIPTION

A variable speed limit signing system will determine a safe speed based on current roadway and weather conditions, and notify drivers via VMSs. Variable speed limit signing will be placed in advance of the location and spaced at appropriate intervals throughout the area of concern. The system would have communication links between the roadway devices, traffic sensors, road weather information systems (RWIS) providing weather conditions and pavement temperature data, the Traffic Management Center (TMC) and the Emergency Response Center (ERC). Each of these system components are described below.

This project type falls under the NITSA User Services of Traffic Control (1.6) and En-Route Driver (1.2). This system falls under the NITSA Market Package categories of Freeway Control (ATMS4) and Traffic Information Dissemination (ATMS6).

SYSTEM COMPONENTS

The variable speed limit signing and weather warning system would use a predetermined algorithm to convert data from traffic sensors into a displayed speed limit. Specific types of severe weather including ice, snow, or other unsafe driving conditions on the road ahead would trigger both roadside variable speed limit signs and overhead VMSs capable of longer text messages. Specific system components would include:

- Pavement Sensors: Pavement sensors would provide real-time data on pavement conditions including temperature and moisture levels. These pavement sensors would be located at strategic locations within the project coverage area. Data from the sensors would be frequently updated and transmitted to the roadside remote processing unit (RPU).

- Road Weather Information Systems (RWIS): Weather and pavement sensors would provide real-time data on air temperatures, humidity, and precipitation at selected sites. Data could be obtained from either existing or newly constructed RWIS stations. This data would be updated frequently and transmitted to the RPU for processing.

- Traffic detection: These devices would provide real-time data on the speed, volume, and/or density of traffic as inputs to the speed limit determination algorithm.

- Variable Message Signs: The VMS system would be placed along the corridor and be made up of both variable speed signs and general purpose VMSs. The sign controller would be connected directly to the Weather System RPU, which would provide input to sign display; the system would be designed to be automatically controlled by direct input from the RPU. The VMS would also include a direct connection to the TMC and ERC for monitoring and remote manual operation.

- Remote Processing Unit (RPU): The RPU would be connected to the variable speed limit sign to provide speed, weather, and pavement data to the VMS system. The system is designed to provide a reduced speed limit in response to several system inputs including the type of severe weather being reported on the highway, roadway condition sensors, traffic conditions, and manual override.

- Communication Interface: A communications system would be needed to support traffic, weather, and pavement data transmission to the variable speed limit sign locations and/or the ERC. It is important that standard communications protocols be used in all these interfaces. This is a particularly important issue in weather technology, as major manufacturers of field devices have been slow to recognize the need for such standardization. In turn, changes in sign speed limits would have to be supported by automatic response to traffic and weather data changes, or from inputs provided by an operator at the ERC.

IMPLEMENTATION PLAN

A phased implementation plan could begin in the greater Everett and Bellingham areas.

POTENTIAL USER BENEFITS

- Improved public safety.
- Reduced accidents through lower speed limits.
- Better motorist selection of alternate routing.

POTENTIAL DRAWBACKS

- False triggers.
- Potential litigation issues.
- Maintenance and potential vandalism of roadside equipment.

POTENTIAL APPLICATION SITES

Application of variable speed limit sign and weather warning systems should be considered for placement in the vicinity of the Mount Vernon Hills.

PRELIMINARY COST ESTIMATE

Costs based on a per site basis:

Design	$400,000
Construction	$750,000
Annual O&M	$60,000

3.9 ICE DETECTION WEATHER WARNING SYSTEM

PROBLEM STATEMENT

There are several locations along the corridor which are subject to roadway icing conditions. These conditions occur during the winter season and typically begin on bridges, low lying areas, and along shaded areas. These problems are accentuated when they occur along with steep grades, horizontal curves, high vehicle speed, and lane change maneuvers. These conditions lead to unsafe driving conditions and high accident rates. Ice detection systems are desirable at strategic locations along the corridor in order to provide warnings of ice-covered roads.

PROJECT DESCRIPTION

Pavement temperature sensors incorporated as road weather information systems (RWIS) or as separate pavement sensors connected to traffic warning systems would provide the capability to detect an increased probability of icy conditions. This information could be shared with ATIS services through VMSs, roadside kiosks, and/or radio broadcasts providing travel forecasts for general distribution and to WSP personnel through a traffic control center for use in possible preventive action. Ice detection sensors would be located where icy roads have historically contributed to accidents.

This project type falls under the ITS User Services of Traveler Services Information (1.5) and Traffic Control (1.6). This project uses components of two ITS Market packages Freeway Control (ATMS4) and Traffic Information Dissemination (ATMS6).

SYSTEM COMPONENTS

- Pavement Sensors - Pavement temperature sensors tied to road weather information systems or traffic signaling systems will sense the temperature and general conditions of the highway (dry, wet, etc.) Pavement data would be updated every minute and relayed to a roadside remote processing unit (RPU). The RPU would be connected directly to a VMS and/or an Emergency Response Center (ERC) to provide warnings of road icing to motorists either directly via road signage and/or through incorporation into weather forecasts for motorists.

- Variable Message Sign - A VMS could display messages regarding potential road icing at sensor locations through direct links to the RPU pavement sensor (via algorithm to interpret pavement data) and/or by command of the EMC, which would control the VMS message after obtaining sensor data and a weather forecast for a specific location.

- Communications Interface - A communications system, preferably with open and standard protocols, would need to support the pavement data transmission to VMSs and the ERC. The system would have to support automatic response to changes in pavement conditions or from inputs provided by the ERC operator/controller.

IMPLEMENTATION PLAN

RWIS systems with pavement sensors currently exist at key locations of other interstate corridors which experience road icing. A similar application within the I-5 corridor would be an expansion of this technology.

POTENTIAL USER BENEFITS

- Improved motorist safety
- Reduced accidents through timely warnings of icy roadways
- Better motorist selection of alternate routing or time of travel through advance information

POTENTIAL DRAWBACKS

- False or untimely triggers
- Potential litigation issues for failure to identify icy conditions with 100% accuracy.
- Maintenance and potential vandalism of roadside equipment

POTENTIAL APPLICATION SITES

These systems could be deployed at various locations throughout the corridor.

PRELIMINARY COST ESTIMATE

Design	$100,000
Construction	$350,000
Annual O&M	$10,000

Note: Costs are per installation.

3.10 VISIBILITY (FOG) DETECTION WARNING SYSTEM

PROBLEM STATEMENT

There is a need to provide advance warning to motorists and to recommend safe speeds during low visibility conditions. Fog conditions are prevalent in the vicinity of Eastmont and are a contributing factor to accidents at this location.

PROJECT DESCRIPTION

This project includes the implementation of a visibility detection and warning system that monitors weather conditions and traffic operations in fog-prone areas. Should reduced visibility on the freeway restrict traffic operations and safety, the system would provide driver information or alternate route information via VMS and HAR. A variable speed limit system, including speed detection and variable speed limit signs, would also be installed to display appropriate speed limits. Road condition information could be shared with other ITS sub-systems, including roadside kiosks at rest areas, public radio broadcasts, and WSDOT/WSP websites. Visibility information could also be used for input into road weather information systems for more accurate weather forecasting.

A visibility detection warning system would include the installation of visual range sensors; speed/flow traffic detectors; fixed, changeable and variable message signs; HAR; supporting communications systems; controllers and other supporting system hardware and software; and necessary infrastructure such as normal and emergency power systems.

This project type falls under the NITSA User Services of En-Route Driver Information (1.2) Traffic Control (1.6) and Pre-Trip Travel Information (1.1). This system is a hybrid of the NITSA Market Packages for Information Dissemination (ATMS6), Freeway Control (ATMS4), and Broadcast Traveler Information (ATIS1). Elements of Interactive Traveler Information (ATIS2) could also be included with links to websites and informational kiosks.

SYSTEM COMPONENTS

- Visibility Sensors: Visibility sensors tied to road weather information system (RWIS) installations along the corridor would detect lowered visibility due to fog. This information would be updated every few minutes and relayed to an adjacent remote processing unit (RPU). The RPU could be connected directly to nearby VMSs and/or an area Traffic Management Center (TMC) to provide warnings via roadside signals and HAR broadcasts, the website, and weather forecasts with motorist warnings.

- Variable Message Signs: The VMS system would be placed along the highway and would be made up of both variable speed signs and general purpose VMSs displaying predetermined low visibility messages. The system would be designed to be automatically controlled by direct input from the Weather System RPU. The VMS could also include a direct connection to a TMC for monitoring and remote manual operation.

- Speed Detection: This would measure the speed of approaching vehicles, and may utilize a variety of technologies including induction loops, radar, or ultrasonic detection. Algorithms accessing a large disparity in speeds may also be used to trigger pre-determined warning messages. The radar detection system has the added advantage of emitting a radar signal which could trigger in-vehicle radar warning systems.

- Remote Processing Unit: The RPU would be connected to the variable speed limit sign to provide speed, weather, and pavement data to the VMS system. The system is designed to provide a reduced speed limit in response to several system inputs including the type of severe weather being reported on the highway, roadway condition sensors, traffic conditions, and manual override.

- Highway Advisory Radio: The HAR would be placed at strategic points along the corridor. HAR uses a low power radio transmitter that transmits traffic information directly to the motorist via radio.

- Communications/Systems Interface: A communications and systems interface would be needed to support the visibility sensor transmissions to the VMSs, TMC, website, and other systems as necessary. This system would have to support automatic response to changes in roadside visibility, or in response to input from the TMC.

IMPLEMENTATION PLAN

Visibility sensors can be easily incorporated into current and planned road weather information systems and other planned ITS systems as appropriate. The installation of this system should focus on locations throughout the corridor where accidents are caused by reduced visibility, and/or where visibility is frequently reduced to under one-half mile.

USER BENEFITS

- Improved motorist safety.
- Reduced accidents due to fog.
- Improved driver information for use in selection of alternate routing.
- Flexible speed limits during poor travel conditions.
- Improved road closure efficiency in extreme situations.

POTENTIAL DRAWBACKS

- False or untimely triggers.
- Potential liability issues.
- Maintenance of roadside equipment.

POTENTIAL APPLICATION SITES

Visibility sensors should be located in the vicinity of Eastmont(MP 208).

PRELIMINARY COST ESTIMATE,

Cost based on a per site basis, include visibility sensor, VMS and speed detectors:

Design	$200,000
Construction	$1,500,000
Annual O&M	$50,000

3.11 ROCK FALL WARNING SYSTEM

PROBLEM STATEMENT

There is a need for a warning system to indicate rock fall incidents that pose a hazard to vehicles along the corridor. The area in the vicinity of Chuckanut Drive (MP 244 - 249) is susceptible to rock falls.

PROJECT DESCRIPTION

In order to reduce accidents caused by rock falls, a warning system should be installed in the vicinity of Chuckanut Drive. This system would include features that would notify maintenance crews of the time, severity, **and** location of rock falls, and could also be tied into an advanced warning system for oncoming traffic.

Two detection technologies may be applied for this project. Existing rock fall technology used by the railroads consists of electrified horizontal wires which set off a signal if broken. The wires are broken easily, and the majority of the time indicate the fall of rocks which are too small to actually present a driving hazard. Although a proven technology, it is subject to high maintenance.

The use of active infrared imaging sensors could provide a more accurate alternative. This detection technology involves the use of lasers to detect and determine dimensions and speed of a moving object. This information would then be interpreted through a remote processing unit to determine the size and quantity of the detections and initiate an appropriate roadside warning signal or maintenance response. This system could eventually be integrated into traffic control, emergency management, and advanced traveler information systems.

This project type falls under several NITSA User Services, including Pre-Trip Travel Information (1.1) and En-route Driver Information (1.2). This system falls under the defined NITSA Market Packages for Traffic Information Dissemination (ATMS6).

SYSTEM COMPONENTS

- Rock fall Detection System - Active-Infrared Imaging Sensor and Laser: This sensor could be used to provide the dimension and speed of moving objects, including a real-time data tag. This data would then be relayed back to the remote processing unit for analysis.
- VMS/Roadside Advisory System: This could be comprised of either a VMS-based warning system, or a simpler fixed warning sign with actuated beacon.
- Remote Processing Unit: A central control system is required to process incoming data, and to signal an action response in the VMS, traveler information services, electronic paging, etc.

IMPLEMENTATION PLAN

A phased implementation plan could begin with the installation a rock fall warning system along a small area-that experiences a high degree of slope instability. Implementation could include automatic maintenance paging upon receipt of rock fall detection. The page sent to the maintenance unit could include coding of event type, severity reading, and location.

USER BENEFITS

- Improved safety.
- Reduced travel time (with ATIS integration).
- Improved response time.
- More efficient use of maintenance crews.

POTENTIAL DRAWBACKS

- Maintenance costs
- False alarms
- May be redundant to cellular reports of rock fall incidents

POTENTIAL APPLICATION SITES

This system could be deployed at critical point locations in the vicinity of Chuckanut Drive, or as determined by WSDOT maintenance.

PRELIMINARY COST ESTIMATE

Based on a per site basis:

Design	$100,000
Construction	$750,000
Annual O&M	$150,000

3.12 ANIMAL CROSSING WARNING SYSTEM

PROBLEM STATEMENT

Certain areas along the corridor experience a greater frequency of accidents that are attributed to the crossing of animals. Crossing of large non-domestic animals such as deer and elk pose a significant threat to the safety of the motorist. Although signs provide a degree of advance warning to the motorist, these are often disregarded, losing their effectiveness. There is therefore a need to provide real-time information to the motorist of the presence of large animals on or near the roadway, and/or to provide a deterrent to, or alternate route for, animal crossings.

PROJECT DESCRIPTION

In order to reduce animal-vehicular accidents, animal warning systems could be installed at strategic locations throughout the corridor. This system would include features that could serve as a deterrent to animals crossing the highway system, and/or provide an alternative route for such crossings. The system should also provide drivers with advance warning of potential or actual crossings. An overall approach to this problem is discussed here, including applications that do not fall under the standard ITS definition.

There are several deterrents to animal crossings currently available. One type of deterrence involves the use of prisms or reflectors along the side of the road in high animal-vehicular collision areas. The prisms are able to create an "optical fence" to approaching animals. Prisms and reflectors are also able to create a flashing effect which can help to break the 'caught in the headlights" paralysis which often accompanies nighttime crossings, increasing the potential for a safe crossing. Actual fence installations, with or without barbed wire or electrification, can also prevent animals from entering the roadway if installed at sufficient height and length.

A relatively new deterrent involves the use of artificial wolf urine. This concoction was originally produced in the form of a paste that washed away quickly with rain. It is currently being produced in a plastic capsule which is nailed to trees, gradually releasing the scent for periods of up to one year. Initial tests in Sweden have been very favorable; a test in Washington State is scheduled for this year.2

Wild animals have a natural fear of humans and vehicles. The fact that animals attempt highway crossings in spite of this natural aversion would suggest a need for the animal to reach the area on the other side of the highway, be it for food, water, shelter, mating, or some other compelling reason. The effectiveness of a deterrence-only approach to animal crossings may therefore be limited. Options which provide alternate routes for these animals, such as under- or over- passes with appropriate landscaping and vegetation, should therefore be investigated.

Animal collision avoidance through driver information systems involve both in-vehicle warning systems and roadside warning systems. In-vehicle warning systems involve ultrasonic, radar, infrared, or machine-vision obstacle detection, with an on-board visual or audio warning

2Phone conversation with Jody Carson, TRAC, September 5, 1996.

message to notify the driver of the presence of an obstacle or animal in the path of the vehicle. Similar technologies can also be utilized for fixed or portable roadside systems, mounted on a pole or trailer with an interface to a VMS warning system, or fixed signing with detection-actuated beacons or audio warning.

Some statistics concerning animal-vehicular collisions indicate that possible benefits might be realized by driver education. Between 69 and 85 percent of reported animal-vehicular collisions occur at night, with the greatest number occurring during October and November, prime mating season for deer.[3] Driver education and/or extra signage during those time periods could alert drivers to potential danger. Signage could also be tied into an integrated ITS system.

This project type falls under the ITS User Services of En-Route Driver Information (1.2) and Traffic Control (1.6). This project uses components of two ITS Market packages Freeway Control (ATMS4) and Traffic information Dissemination (ATMS6).

SYSTEM COMPONENTS

- Advanced Warning System - A system to disseminate information to the driver. Can be through in-vehicle displays or through roadside VMSs.
- Crossing Deterrent - Devices deployed along the road side to deter animals crossing the freeway. May utilize technologies such as artificial scents, reflectors to discourage animal crossing, or fences.
- Obstacle Detection System - An electronic system using technologies such as ultrasonic, radar, infrared, or machine-vision detection to alert the driver to the presence of an animal. May be installed on vehicles or located along the road side.
- Traffic Management Interface - A communication link established to a central TMC for review of status, manual override of VMS, and dissemination of information to an ATIS.

IMPLEMENTATION PLAN

A prototype early deployment of a portable road-side system should be installed in the vicinity of areas which experience high rates of animal collisions. This system should become a test bed for other strategic installations elsewhere along the corridor. Future enhancements could include dissemination of this travel information through integration with ATIS.

USER BENEFITS

- Reduced risk of animal/vehicle collisions through reduced exposure.
- Portable roadside system increases flexibility of use.
- Environmental benefits of preserving existing migration routes (with provision of alternate routes).

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3 Huges, Warren E., et al, "Vehicle-Animal Crashes: An Increasing Safety Problem," ITE Journal, August 1996, pp. 25-26.

POTENTIAL DRAWBACKS

- False calls of system reduce driver sensitivity.
- System maintenance costs.
- In-vehicle systems require additional research to extend performance/reliability to satisfy preemptive control applications and decrease cost to achieve private vehicle market share.
- Animal crossing deterrents may move problem further down the highway if alternate “safe” crossing routes are not provided.

POTENTIAL APPLICATION SITES

Currently there is little demand for this type of ITS application. However, as urban areas expand, the need for animal crossing warning systems may increase.

PRELIMINARY COST ESTIMATE

Cost estimate of the roadside system without TMC interface, includes two VMSs, 16 detectors, animal deterrents, and supporting hardware.

Design	$200,000
Construction	$1 ,000,000
Annual O&M	$150,000

3.13 OVER-HEIGHT DETECTION WARNING SYSTEM

PROBLEM STATEMENT

There is a need to provide advance warning regarding the existence of low bridges along the corridor to commercial vehicle operators and drivers of other high profile vehicles. There are several locations along this corridor where this condition exists and contributes to a greater incidence of accidents. Accidents related to hitting bridge overcrossings affect not only the vehicle involved in the primary collision, but may contribute to secondary accidents associated with the subsequent roadway debris. Possible damage to the bridge superstructure also has maintenance implications.

PROJECT DESCRIPTION

This project includes the implementation of a height detection and warning system that monitors vehicle height at low bridge clearance areas. Once a high profile vehicle is detected on the freeway approach to a low bridge, the system would provide driver information or alternate route information via VMS or fixed signing with flashing warning beacons. The existence of low bridges along a route could also be shared with other ATIS sub-systems, including roadside kiosks at rest areas, public radio broadcasts, and WSDOT/WSP websites so that appropriate pre-trip decisions can be made. Bridge height information should also be used for input into commercial vehicle operator on-board system databases.

A height detection warning system would include the installation of height detection sensors; fixed, changeable and variable message signs; supporting communications systems with links to pre-trip traveler information services; controllers and other supporting system hardware and software; and necessary infrastructure such as normal and emergency power systems.

This project type falls under the NITSA User Services of En-Route Driver Information (1.2), Traffic Control (1.6) and Pre-Trip Travel Information (1.1). This system is a hybrid of the NITSA Market Packages for Information Dissemination (ATMS6), Freeway Control (ATMS4), and Broadcast Traveler Information (ATIS1). Elements of Interactive Traveler Information (ATIS2) could also be included with links to websites and informational kiosks.

SYSTEM COMPONENTS

- Height Sensors: Height sensor installations along the corridor would detect the presence of an over-height vehicle in the traffic stream. This information would be relayed to the detection controller and appropriate information would be sent to nearby VMSs, fixed signs with flashing beacons, and/or an area Traffic Management Center (TMC).
- Warning Sign System: Warning signs would be placed far enough in advance to allow for alternate routing. The signing system would be made up of either VMSdisplaying predetermined warning messages or a system of fixed signs with flashing beacons.
- Communications/Systems Interface: A communications and systems interface would be needed to support the height sensor transmissions to the VMSs, TMC, website, and other

systems as necessary. This system would have to support input from the Traffic Management Center.

IMPLEMENTATION PLAN

Height sensors can be easily installed at low bridge locations. The installation of this system should be prioritized based on the frequency of accidents associated with over-height accidents. Locations where existing VMS signs could be easily incorporated should also be considered for early implementation.

USER BENEFITS

- Improved motorist safety.
- Reduced accidents due over-height vehicles.
- Improved driver information for use in selection of alternate routing.
- Lower maintenance for bridges.

POTENTIAL DRAWBACKS

- False or untimely triggers.
- Maintenance of roadside equipment.

POTENTIAL APPLICATION SITES

Height sensors should be installed prior to the bridge located at the southern approach to the city of Mount Vernon (MP 226).

PRELIMINARY COST ESTIMATE

Cost per installation:	
Design	$20,000
Construction	$150,000
Annual O&M	$10,000

3.14 PORTABLE TRAFFIC MANAGEMENT SYSTEM

PROBLEM STATEMENT

There is a need to provide the WSP and WSDOT with a means to conduct traffic control services on an ad hoc basis, be it during an incident, maintenance operations, scheduled construction, during implementation of priority treatments for HOVs, or during periodic major events. As an example, freeway congestion occurs in the area of Mount Vernon during the Tulip Festival. Although this is for a limited duration, it puts strain on the transportation system. It is therefore necessary to provide a traffic management system that is sophisticated enough to accommodate traffic operational needs through utilizing existing hardware and resources, yet flexible enough to be transported to local non-recurring traffic events on an as-need basis.

PROJECT DESCRIPTION

This project will create a portable Traffic Management System (TMS) that is capable of managing short term traffic problems. This portable TMS would be designed to be a seamless, modular-based system using readily available equipment and existing systems. The system would function independently, or function as a remote operator interface (ROI) of, a larger Traffic Management Center (TMC). The ROI would be driven through a lap top computer with the necessary device drivers. Existing access to selected TMC system roadside devices such as VMS, HAR, traffic signals, detector stations, paging systems, and video would be available to the remote laptop unit through a dial-up access. The ROI would also be configured to drive other devices such as portable VMS, HAR, temporary traffic signals, video cameras, and video image detectors which WSDOT Maintenance or WSP may have available to them.

This project type fits under the ITS User Services of Traffic Control (1.6) and En-route Driver information (1.2). The system is a hybrid of ITS Market Packages for Freeway Control (ATMS04), Incident Management System (ATMS08), and Traffic Information Dissemination (ATMS06).

SYSTEM COMPONENTS

- Remote Operator Interface: A lap top computer would provide the interface with permanent and portable devices and systems. For example, proposed VMS, speed detection loops, ice detection systems, and other proposed ITS projects within the corridor could be designed to be integrated into the Portable TMS. Interfaces to portable devices such as temporary traffic signals, CCTV, HAR, VMS, detector stations, paging systems, and video would also be an integral part of the system.

- Variable Message Signs: VMS signs would be used to advise motorists of the changing traffic conditions ahead. These signs could be permanently located as part of a larger system, or portable in nature.

- Portable Traffic Signal: A trailer-mounted traffic signal and controller for use at ramp terminals during events. The signal could also be manually operated as needed.

- Vehicle Detection: The type of detection for the operation of the VMS and/or traffic signal system would depend on how frequently and for how long the portable TMS was needed at a specific location. Either pavement loops or image-based loops (such as Autoscope) could be provided as a trailer-mounted device in construction areas. Autoscope loops are drawn on a video display using a lap top computer; they can be changed & moved by the operator without interfering with traffic and would be helpful in confirming operational conditions through visual surveillance.

IMPLEMENTATION PLAN

The initial deployment of this portable system could be on an experimental basis during the Tulip Festival. It would include portable video detection, communication links to the proposed ITS project, VMS, and device drivers to any other proposed ITS systems.

USER BENEFITS

- Increased safety and driver information.
- Reduced delays and fuel consumption.
- Increased traffic management capabilities at specific sites.
- Portable and readily available for incident management.
- Economical use of limited State resources.

POTENTIAL DRAWBACKS

- Training would be necessary for proper use of system.
- Potential system integration problems with a variety of devices given current level of NTCIP development and available equipment.

POTENTIAL APPLICATION SITES

This system would be deployed during the Tulip Festival in the Mount Vernon area. Other potential uses would include deployment at the border during the June Peace Arch celebration, near Marysville July 3rd - 4th during fireworks sales, at the Mercer Street ramps during Bumbershoot, and at bridges for emergency weight restriction.

PRELIMINARY COST ESTIMATE

Design	$500,000
Construction/Equipment procurement	$1,500,000
Annual O&M/Training	$200,000

3.15 NORTHWEST REGION TSMC ENHANCEMENT

PROBLEM STATEMENT

There is a need to enhance the Northwest Region's existing Surveillance, Control, & Driver Information (SC&DI) system, due to increasing traffic operational and enforcement needs caused by growth in the I-5 corridor. The SC&DI system is operated by the WSDOT's NW Region Traffic Systems Management Center (TSMC) in Shoreline. Tools currently used by the TSMC to manage traffic include ramp metering, closed circuit television (CCTV), variable message signs (VMS), highway advisory radio (HAR), traffic data stations, and a computer-generated traffic condition graphic display (Flow-map) which is available through the Internet.

PROJECT DESCRIPTION

In order to continue to support the traffic, operational, and enforcement needs of the I-5 corridor, WSDOT's Northwest Region TSMC must be enhanced to keep pace with the region's growth. Eventually the coverage may be extended all the way to the U.S./Canada border, and possibly beyond if the British Columbia Ministry of Transportation and Highways (MoTH) pursues a similar application.

Enhancements would include additional devices within the existing limits as the needs arise. For example, as traffic congestion increases in the urban areas of the corridor, enforcement of the HOV lanes may become more of an issue. If this occurs, surveillance systems could then be expanded to assist in this effort. Additional emphasis on HOV enforcement may also include the application of a HERO type program where facility users monitor HOV facilities and report violations. This system could be enhanced to include voice recognition, automated vehicle identification, and automated preparation of letters to the owners of violating vehicles.

This project is broad in scope and may fall under several NITSA User Services including Traffic Control (1.6), En-route Driver Information (1.2), or Incident Management (1.7). The system is comprised of system elements from the NITSA Market Packages of Freeway Control (ATMS4), Incident Management System (ATMS8), and Traffic Information Dissemination (ATMS6).

SYSTEM COMPONENTS

- CCTV System: Provides real-time video images of the corridor, including ramps. This will aid in supplying current traffic reports to drivers and allow for faster response to incidents.
- VMS : Variable Message Signs supply information to the motorist from the Traffic Operations Center. This interaction contributes to smoother traffic flows.
- Data Stations: Traffic controllers are used as data stations, using pavement loops to collect volume, occupancy, and speed data. This data is then transmitted to the TSMC.
- Ramp Meters: Control the flow of traffic onto the freeway by allowing vehicles on at regular intervals, with enough space in between vehicles to accommodate merging. This function is handled by a traffic controller. Can also provide HOV priority with a second ramp lane.
- HAR: The Highway Advisory System uses a low power radio transmitter to transmit traffic information directly to the motorist via radio.

IMPLEMENTATION PLAN

A phased implementation plan could result in infilling the existing TSMC coverage area with missing system components.

USER BENEFITS

- Improved motorist safety.
- Improved incident response.
- Increased fuel savings.
- Improved traffic flow.
- Enhanced enforcement opportunities.
- Increased driver information opportunities.
- HOV priority.

POTENTIAL DRAWBACKS

- None perceived at this time.

POTENTIAL APPLICATION SITES

This application would occur within the existing coverage area of the Northwest Region TSMC which extends north on l-5 to Marysville (MP 206).

PRELIMINARY COST ESTIMATE

Recommended annual budget for continued expansion:

Design	$200,000
Construction	$1 ,ooo,ooo
Annual O&M	$30,000

3.16 BELLINGHAM & MO-UNT VERNON TRAFFIC MANAGEMENT SYSTEM

PROBLEM STATEMENT

Due to increasing growth and resulting freeway congestion in the Bellingham and Mount Vernon areas, there is a need to improve traffic operations, optimizing the use of scarce resources in terms of physical highway infrastructure and agency personnel. Traffic operations in these areas would be enhanced through improvements to safety, enforcement, incident management, traffic control measures, and driver information services.

PROJECT DESCRIPTION

In order to improve traffic operations and safety, a Traffic Management System should be established in the Bellingham and Mount Vernon areas. These systems should include features that would enhance safety, maximize corridor traffic operations, decrease emergency response time (returning traffic flows to normal as soon as possible after an incident), provide real-time communication to motorists about traffic conditions, and promote efficient maintenance and enforcement efforts.

These traffic management systems could be comprised of a Traffic Operations Center (TOC) with communication channels to a variety of field subsystems. Alternatively, the function of the TOC could be accommodated at an existing WSDOT maintenance office with either a staffed or automated work station. Such a work station would have a fiber link to the Northwest Region TSMC.

The subsystems would have devices located strategically along the corridor, including closed circuit television (CCTV), variable message signs (VMSs), highway advisory radio (HAR), traffic data stations, and ramp metering. The TOC would communicate directly with these subsystems and would act as the regional hub for traffic information, facilitating regional traffic control strategies. A Graphical User Interface (GUI) could display compiled data input from various field devices, detect system faults and failures, detect incidents (based on predetermined traffic data thresholds), and monitor real-time operations. The system would support communication channels to third party information services including broadcast radio and Internet websites. The system would also be expandable to include additional ITS field devices such as weather and ice warning systems.

This project type falls under the ITS User Services of En-route Driver Information (1.2), Traffic Control (1.6), and Incident Management (1.7). This system will primarily include the ITS Market Packages of Freeway Control (ATMS4), Traffic Information Dissemination (ATMS6), and Incident Management System (ATMS8); Regional Traffic Control (ATMS7), Probe Surveillance (ATMS2), and Transit Vehicle Tracking (APTS1) could be easily integrated upon future expansion.

SYSTEM COMPONENTS

- SC&DI: Three levels of SC&DI are contemplated for the I-5 corridor:
  1. Seattle Urban Level, with fiber communication, full CCTV coverage, VMS, ramp metering, data stations at approximately half-mile intervals, and a large networked TSMC.
  2. Small Urban Level, with hardwire communication, CCTV and VMS at critical locations, a small TSMC, and data stations at approximately two mile intervals.
  3. Rural Level, with wireless communications, a PC-based management system in existing facilities, CCTV at critical locations, some VMS (with portable VMS and CCTV), and data stations at approximately five mile intervals.
- CCTV System: This system will provide real-time video images of the corridor, including ramps. This would aid in supplying real-time traffic reports to drivers, and assist operations personnel in the verification of incidents.
- VMS : A Variable Message Sign system would display information to the motorist based on input from the Traffic Operations Center.
- HAR: The Highway Advisory System would be placed at strategic locations throughout the corridor.
- Ramp Meters: Control the flow of traffic onto the freeway by allowing vehicles on at regular intervals, with enough space in between vehicles to accommodate merging. This function is handled by a traffic controller. Can also provide HOV priority with a second ramp lane.
- Traffic Detection: Traffic data stations would provide real-time data to the TOC for use in control algorithms. This data would also be available for historical documentation and could also be used to supplement data for state and local Metropolitan Planning Organization planning efforts. Traffic detection systems can be based on inductive loops, radar, video image detection, or other technologies.
- Traffic Operation Center: A Traffic Operations Center would be constructed or integrated into existing facilities. The TOC would house the central system hardware with a graphical user interface and communication interfaces with the field devices. External communication channels to third party information services would be provided. The TOC would be staffed 24 hours a day, seven days a week.

IMPLEMENTATION PLAN

Level 1, to Broadway (Everett) in the near-term, and to Marysville in the long-term.

Level 2, to Marysville in the near-term, and to Bellingham and Mount Vernon in the medium-term.

Level 3, to Bellingham and Mount Vernon in the short-term, and the entire corridor in the long-term.

USER BENEFITS

- Improved motorist safety.
- Improved incident response.
- Increased fuel savings.
- Improved traffic flow.

- Enhanced enforcement opportunities.
- Increased driver information opportunities.

POTENTIAL DRAWBACKS

- System maintenance costs
- Staff training Costs
- System integration problems

POTENTIAL APPLICATION SITES

The TMS should be installed in the Mount Vernon and Bellingham areas.

PRELIMINARY COST ESTIMATE

Recommended budget per TMS:	
Design	$1 ,000,000
Construction	$7,500,000
Annual O&M	$500,000

3.17 MAYDAY SUPPORT SYSTEM

PROBLEM STATEMENT

A Mayday Support System should be installed throughout the corridor. There are several interchanges throughout the corridor that currently have emergency telephones. However, there is a need for a comprehensive Mayday Support System to provide a dependable emergency communication link between motorists and Emergency Management. This would involve enhancing the existing cellular systems along the I-5 corridor between Seattle and the border, as the existing cellular network has areas of weak coverage.

PROJECT DESCRIPTION

This system would integrate the use of call boxes with existing cellular networks. By using the existing cellular technology and networks rather than creating "new technology," construction time could be minimized and development, construction, and startup costs could be kept to a minimum. The existing cellular systems are already in place and fully operational, providing emergency services through the 911 system which connect to the WSP or a central dispatch center. However, they lack Global Positioning System (GPS) technology and a Customer Service Center (CSC), which could provide a variety of services to assist motorists in addition to emergency-only service.

The proposed Mayday system should include the following features:

- Two-way voice communication between motorist and emergency/roadside services.
- Electronic location of the cellular caller through triangulation, GPS, or other means.
- Roadside call boxes in areas with poor cellular coverage.
- A CSC to provide a "one number" call format for motorist assistance.
- A dial *800 toll- and airtime-free phone number.
- Additional signage along corridor promoting the *800 emergency call program.

This project type falls under the NITSA User Service of Emergency Notification and Personal Security. This system is included in the NITSA Market Packages for Mayday Support (EM3).

SYSTEM COMPONENTS

- Call Boxes: Call boxes would be deployed in areas determined to be at high risk for motorist assistance, and in areas with poor existing cellular coverage. Several call box strategies could be deployed including:
  - Telephone-based call boxes, using standard telephone service connections.
  - Cellular call boxes, using cellular phone technology and powered by a standard electrical service drop.
  - Solar powered cellular call box, using cellular phone technology and solar powered with a battery backup.
- Communications Site: To receive and relay cellular calls. New sites are necessary to improve existing cellular coverage which is weak in parts the corridor. This may be conducted in the form of a public-private venture.

- Cellular Phones: Both existing and new phones to provide the "link" to the motorist.
- Highway Signing: Additional signs promoting the "800 number for emergency services.
- Customer Service Center (CSC): A facility to provide dispatch and response to the *800 motorist assistance requests needs to be established. This could be in the form of enhancements to Computer Aided Dispatch (CAD) where they exist, or creation of a separate facility.

IMPLEMENTATION PLAN

A phased implementation plan could begin with providing Mayday coverage in an area with existing cellular coverage, providing a CSC at two WSDOT/WSP facilities, and a "*800" roadside signage program along the corridor segment served by the program. The benefits of this program could then be documented and the Mayday System expanded into other regions, with expansion of existing cellular coverage where appropriate.

USER BENEFITS

- Improved traveler safety.
- A large number of motorists already have cellular phones - the necessary "link" - and could take immediate advantage of the system without the purchase of a new device.
- Users are familiar with the technology and would not have to learn something new.
- Improved response time to incident scenes.
- Existing equipment and technology would be used, thereby reducing cost.
- System could be implemented within a short time frame.

POTENTIAL DRAWBACKS

- Big Brother/privacy issues resulting from use of a cellular phone/GPS system.
- Motorists without a cellular phone would not benefit as directly.
- High staffing requirements to respond to multiple calls for a single incident

POTENTIAL APPLICATION SITES

This system should be deployed along the I-5 corridor.

PRELIMINARY COST ESTIMATE

Cost based on recommended budget for phased implementation:

Design	$300,000
Construction	$3,000,000
Annual O&M	$200,000

3.18 REST AREA SECURITY SYSTEM

PROBLEM STATEMENT

There is a need for enhanced security at rest areas due to the increased incidence of vandalism, assault and other illegal activities.

PROJECT DESCRIPTION

To promote safer rest areas and provide a deterrent to illegal activity, a rest area security system should be installed at various rest areas as noted below.

These systems should include features that would detect an incident through a manual alarm system as well as provide a surveillance component. The system should include surveillance, an emergency detection alarm system, enhanced illumination, supplemental warning signs, and a communication interface.

This project type falls under the NITSA User Service of Public Travel Security. The system is designed to provide remote travel support at rest areas through communication links from the project site to the Emergency Response Center. This system is a hybrid of the NITSA Market Packages for Emergency Response (EV1) and Mayday Support (EV3), providing similar functions of both system types.

SYSTEM COMPONENTS

- Video Surveillance - A CCTV system with cameras mounted on existing luminaire poles, building or other. Real-time video images would be transmitted back to the Emergency Response Center or recorded locally with a continues tape for review as evidence.
- Emergency Detection/Alarm System - Push Buttons, pull cords or similar devices could be installed at critical locations within the facility. These would be tied into the WSP for emergency dispatch as well as to a local alarm system consisting of a strobe light mounted on the building exterior and an audible warning device such as a siren.
- Illumination - Additional lighting may be required both as a deterrent and to improve the CCTV images.
- Warning/Information Signs - Installation of highly visible signs advising of the CCTV system and the other security features. It would be noted that the system is constantly monitored by WSP as a deterrent.
- Communication Interface - A communication system would need to support video transmission as well as two way communication between the call box and the emergency center.

IMPLEMENTATION PLAN

A phased implementation plan could begin with a self supporting alarm system with a dial 911 link. Future enhancements could then include CCTV with on-site video recording followed by

real-time video feed to the Emergency Response Center. Rest area security systems could eventually be integrated into corridor surveillance.

POTENTIAL USER BENEFITS

- Improved public safety
- Reduced vandalism and property damage
- Reduced emergency response time
- Deterrence of illegal activities
- Increased conviction rate

POTENTIAL DRAWBACKS

- False triggers
- "Big Brother"/privacy issues
- Maintenance and potential vandalism of surveillance

POTENTIAL APPLICATION SITES

This system could be deployed at the existing rest areas, including:

• Silver Lake Rest Area/WSP Detachment Office (southbound only)	MP 188
• Smokey Point Rest Area - Arlington	MP 208
• Bow Hill Rest Area - Burlington	MP 238
• Custer Rest Area - Birch Bay (+ tourist ctr.)	MP 268

PRELIMINARY COST ESTIMATE

Costs based on a per site basis:

Design	$100,000
Construction	$500,000
Annual O&M	$60,000

3.19 PUBLIC-PRIVATE INITIATIVE REST AREA

PROBLEM STATEMENT

Existing rest areas provide only minimal services such as rest rooms, telephone, and vending machines. Motorist needing fuel and other vehicle services or wishing to eat must leave the Interstate system in order to access these services at all times of the day and night. Motorists requiring rest should be encouraged to take a break in order to avoid the many run-off-the-road accidents that are experienced along this corridor. There is a need for "Full Service Rest Areas" that would supply most of the travelers' needs with 24 service hour, 7 days a week service.

PROJECT DESCRIPTION

This project would allow private sector enterprise to provide needed motorist services along the corridor through the shared use of WSDOT right-of-way. Existing rest area facilities could be upgraded through private and/or public investment and leased through competitive bid to interested service providers. The state would supply the land through a long term lease and the private sector would be responsible for site development, staffing, maintenance and operation. Oversight of service quality and service provider contract compliance would remain with the state. Service areas may provide a variety of amenities including:

- Food Service supplying either fast food or a more relaxed sit down restaurant.
- Vehicle Service including both gasoline & diesel fuels, towing, possibly a small repair facility.
- Tourist Information Kiosks would provide information on local recreational opportunities and accommodations.
- Rest rooms which are clean and safe
- Children's Play Area
- Convenience Store for minor purchases.
- Sanitary Dump for motor homes or travel trailers.
- Walking and Pet Area

This system is included in the ITS Market Packages for Emergency Notification and Personnel Security (5.1). This project would fall under the ITS Market Package of Mayday support in that it will provide vehicle services.

SYSTEM COMPONENTS

The components for this project are varied depending on the ultimate services provided at each site, however improvements due to the expanded use of the rest areas would include: building and site facilities, water and wastewater facilities, communications, and power.

IMPLEMENTATION PLAN

A phased implementation plan could begin with a demonstration project by remodeling one of the existing rest areas in the corridor. After a successful demonstration, additional rest areas could be upgraded.

USER BENEFITS

- Improved traveler safety
- Reliable availability of services in areas of limited services.
- Improved tourism through increased advertising opportunities
- Improved traveler and tourist goodwill through enhanced services.
- Provide private partnership, enhancing local economies.

POTENTIAL DRAWBACKS

- Conflicts with existing businesses due to competition.
- Private partnership lack of interest due to possible uncertainty of a customer base.

POTENTIAL APPLICATION SITES

The initiative could be deployed at the existing rest areas, including:

• Silver Lake Rest Area (southbound only)	MP 188
. Visitor Information Center	MP 201
• Smokey Point Rest Area - Arlington	MP 208
• Bow Hill Rest Area - Burlington	MP 238
• Custer Rest Area - Birch Bay (+ tourist ctr.)	MP 268

PRELIMINARY COST ESTIMATE

Based on the state's commitment for development of one rest area:

Design/permitting	$500,000
Misc. Construction to support improvements	$1 ,000,000
Annual O&M	$500,000

NOTE: Costs may vary considerably depending on the final services to be incorporated.

3.20 MAINTENANCE MANAGEMENT SYSTEM

ITS maintenance management applications to be incorporated into technical memorandum 4.

3.21 ADVANCED VEHICLE LATERAL CONTROL SYSTEM

Portions of the I-5 corridor are rural in nature. The most severe problems associated with rural freeways include run-off-the-road accidents due to inattention or falling asleep, whichoccasionally are severe head-on collisions. As described in Market Package AVSS9, Advanced Vehicle Lateral Control Systems will be vehicle technologies that will assist the motorist in maintaining lateral control through on-board sensors to measure lane positioning and processors for controlling vehicle steering. These technologies, although extremely worthwhile, are years away and will require a significant investment at the individual vehicle level.

4.0 SUMMARY OF CORRIDOR ITS OPPORTUNITIES

Figures 2 & 3 present a summary of the I-5 ITS needs based on each of the defined problem areas as determined in the I-5 Corridor Needs Assessment Memorandum . Each of the corridor needs is mapped against the ITS Tool Kit as described in the previous section. An estimate of expected benefits by type and overall costs to implement are provided. Implementation costs are exclusive of the communication costs, but will be included when the communication plan is completed. These costs depend on a variety of factors including the current state of the communication infrastructure necessary to support the individual ITS application.

Figure 2

I-5 ITS OPPORTUNITIES MATRIX

DESCRIPTION OF CORRIDOR NEED	CONTRIBUTING CAUSE	PROPOSED ITS SOLUTION
SAFETY AND ENFORCEMENT		
General		
Video Surveillance	No video available north of Everett area	12. NW Region TSMC Expansion - CCTV component
Vehicular Pursuits		16. Portable License Plate Optical Reader System
Everett and Vicinity		
Crime at Rest Areas		19. Rest Area Security System - video, panic buttons
Enforcement at Hewitt Trestle	Physical constraints	12. NW Region TSMC Expansion - CCTV component, licence plate recognition
Urban Accidents from 220th St. SW to SR 528	Speeding, Weather related incidents	12. NW Region TSMC Expansion - ramp metering, VMS
Rural Accidents, Smokey Point & SR 530	Speeding, Weather related incidents	12. NW Region TSMC Expansion - ramp metering, VMS
Motorist Assistance & Citations (Montlake Terrace to Marysville)	Vehicle breakdowns, speeding	
Mount Vernon and Vicinity		
Speeding		11. Var. Speed Limit Signing & Weather Warning
Urban Accidents SR 536	Speeding, Weather related incidents	13. Mt. Vernon & Bellingham TMS - ramp metering, VMS, HAR
Rural Accidents SR 11 & Cook Road Interchange	Speeding, Weather related incidents	13. Mt. Vernon & Bellingham TMS - ramp metering, VMS, HAR
Bellingham and Vicinity		
Cross-Over Accidents		13. Mt. Vernon & Bellingham TMS - ramp metering, VMS, HAR
Vertical Clearance at RR Bridges MP 255	Low bridges	8 Over-height Detection
Urban Accidents Vicinity of SR 539	Speeding, Weather related incidents	13. Mt. Vernon & Bellingham TMS - ramp metering, VMS, HAR
Rural Accidents from Samish Hwy. to SR 548	Speeding, Weather related incidents	4. Ice Detection Weather Warning System
TRAFFIC OPERATIONS, CONGESTION & TRAFFIC MANAGEMENT		
General		
Install Permanent Traffic Data Recorders	Lack of data collection program	12. NW Region TSMC Expansion - data stations
Address Low Bridges	Low bridges	8. Over-height Detection
Expand Region's Traffic Management Center	Improved efficiency	12. NW Region TSMC Expansion

I-5 ITS OPPORTUNITIES MATRIX

DESCRIPTION OF CORRIDOR NEED	CONTRIBUTING CAUSE	PROPOSED ITS SOLUTION
Everett and Vicinity		
Accommodate Forecast Growth of Up to 1.5%/Yr		12. NW Region TSMC Expansion - Ramp metering, VMS, HAR
Address Traffic Queuing at Rest Area at 128th	Vehicle storage areas	12. NW Region TSMC Expansion - VMS, HAR
Mount Vernon and Vicinity		
Address Heavy Morning Congestion (MP215) - Transit Route	Capacity	13. Mt. Vernon & Bellingham TMS - Ramp metering, VMS
Bellingham and Vicinity		
Accommodate Forecast Growth of Up to 3%/Yr		13. Mt. Vernon & Bellingham TMS - Ramp metering, VMS, HAR, data stations
U.S. - Canada Border		
Address Queuing	Peak travel demand	14. Border Crossing - smart cards and membership
Data Collection	Lack of data collection program	14. Border Crossing - data stations
TRAVELER INFORMATION NEEDS		
Everett and Vicinity		
VMS Near Eastmont Approaches & Visitor Center at 128th	Lack of traveler information	12. NW Region TSMC Expansion - VMS
Provide Travel Information Through Partnership	Lack of traveler information	2. Broadcast Radio Dissemination System
Mount Vernon and Vicinity		
Special Event Signing	Lack of traveler information	9. Portable TMS - VMS
Additional Advance Signing for Hwy. 20	Lack of traveler information	13. Mt. Vernon & Bellingham TMS
VMS for Incident Management		9. Portable TMS - VMS
Bellingham and Vicinity		
Additional Tourist Information Signing for Anacortes Ferry	Lack of traveler information	13. Mt. Vernon & Bellingham TMS - VMS, HAR
Advance Border Crossing Information	Lack of traveler information	14. Border Crossing - VMS
U.S. - Canada Border		
U.S.		
Additional Customer Service Agent	Greater demand	
Expand PACE Operations	Greater demand, processing efficiency	14. Border Crossing - smart card, membership
Complete Installation of License Plate Readers	Processing efficiency	14. Border Crossing
Implement Un-Staffed PACE Lane at Point Roberts	Manual processing procedures	14. Border Crossing
Traffic Data Collection	Lack of data collection program	14. Border Crossing

I-5 ITS OPPORTUNITIES MATRIX

DESCRIPTION OF CORRIDOR NEED	CONTRIBUTING CAUSE	PROPOSED ITS SOLUTION
Expedite the Processing of Bus Passengers	Passenger processing time	14. Border Crossing
CANADA		
Provide Additional Motorist Information	Lack of traveler information	14. Border Crossing
Consider Internet Application for Real Time Travel Data	Lack of traveler information	1. Internet Pre-Trip Traveler Information
Expedite the Processing of Bus Passengers	Peak demand	14. Border Crossing
Monitor & Address Traffic Diversion		14. Border Crossing
COMMERCIAL VEHICLE OPERATIONS		
Everett and Vicinity		
Address Queuing At Everett Truck Weigh Station	Capacity of ramp	
Consider Constructing a New Weigh Station	Increased demand	
Mount Vernon and Vicinity		
Address Low Overpass (MP 226)	Low bridges	8. Over-height Detection
Consider Weigh-in-Motion for Bow Hill	Processing time	17. Commercial Vehicle Operations
Bellingham and Vicinity		
Address Low Bridges (MP 254.26, 254.47, 263.05)	Low bridges	8. Over-height Detection
U.S. - Canada Border		
U.S.		
Consider Automated Manifest System	Processing time, peak demand	14. Border Crossing
Consider Electronic Pre-Clearance	Processing time , peak demand	14. Border Crossing
Consider Long-term Application of Transponders	Processing time, peak demand	14. Border Crossing
Consider Sharing Commercial Manifests with Canada	Processing time, peak demand	14. Border Crossing
Consider Full Container X-Ray	Processing time, peak demand	14. Border Crossing
Identify Special ITS Requirements for Truck Crossing		17. Commercial Vehicle Operations
Consider Long-term Upgrade at Lynden Crossing	Processing time, peak demand	14. Border Crossing
Address Inadequate Holding Areas & Signing	Increased demand	14. Border Crossing
Consider Exclusive Truck Crossing		17. Commercial Vehicle Operations
Reduce Border Crossing Delay for Trucks	Processing time, peak demand	17. Commercial Vehicle Operations
CANADA		
Advanced Information on Cargo (Line Release)	Processing time, peak demand	17. Commercial Vehicle Operations

I-5 ITS OPPORTUNITIES MATRIX

DESCRIPTION OF CORRIDOR NEED	CONTRIBUTING CAUSE	PROPOSED ITS SOLUTION
OTHER CORRIDOR NEEDS		
WEATHER		
Everett and Vicinity		
Address Fog at Eastmont (MP 208)	Fog	5. Visibility (Fog) Detection Warning System
Address Bridge Icing (I-5/SR 526 Interchange)	Low tempratures, bridge location	4. Ice Detection Weather Warning System
Mount Vernon and Vicinity		
Consider Temperature Activated Signs at Bridge Approaches		4. Ice Detection Weather Warning System
Address Ice Problems (MP 210)	Low tempratures	4. Ice Detection Weather Warning System
Address Ice Problems (MP 208-209)	Low tempratures	4. Ice Detection Weather Warning System
Address Problems at Anderson Road (MP 225)	Speeding	11. Var. Speed Limit Signing & Weather Warning
Bellingham and Vicinity		
Inform Motorists of Changes in Roadway Conditions	Lack of travelere information	11. Var. Speed Limit Signing & Weather Warning
Consider Expansion of CMA Test Area	Low tempratures	11. Var. Speed Limit Signing & Weather Warning
Address Ice Problems Near Lake Samish	Low tempratures	4. Ice Detection Weather Warning System
Address Ice Problems on Nooksack River Bridges	Low tempratures	4. Ice Detection Weather Warning System
COMMUNICATIONS		
General		
Communication Infrastructure		12. NW Region TSMC Expansion
Improve Information Flow		1. Internet Pre-Trip Traveler Information
Fully Utilize Internet		1. Internet Pre-Trip Traveler Information
Expand Use of Common Systems	Compatibility	12. NW Region TSMC Expansion
Enhance Surveillance and Communications		12. NW Region TSMC Expansion
Everett and Vicinity		
Consider Surveillance Cameras to Enhance WSP Center	Lack of video capabilities	12. NW Region TSMC Expansion
Consider CCTV From 164th SW to Broadway w/HOV Project	Lack of video capabilities	12. NW Region TSMC Expansion
Maintenance		
Consider Comprehensive Maintenance Program	Maintenance of transportation infrastructur	15. Maintenance Management System
Bellingham and Vicinity		
Address Rock-Fall Problems	Loose Rocks, Steep Slopes	6. Rock Fall Warning System

Figure 3

I-5 Corridor ITS Tools Summary

User Service		ITS Tool Kit	ITS User Service	Benefits: Safety	Congestion	Mobility	Travel Time	Air Quality	Energy Efficiency	Enforcement	Economic Productivity	Overall Benefits	Costs (x $1000)	Priority
Traveler Information	1	Internet Pre-Trip Traveler Information	1.1	◑	◑	○	◑	◑	◑	○	◑		110	
	2	Broadcast Radio Dissemination System	1.2	◑	◑	◑	◑	◑	◑	○	◑		1,800	
	3	Rest Area Traveler Information Kiosks	1.2, 1.5	●	◑	◑	◑	○	○	○	◑		600	
	4	Ice Detection Weather Warning System	1.5, 1.6	●	○	○	○	○	○	◑	○		450	
	5	Visibility (Fog) Detection Warning System	1.1, 1.2, 1.6	●	○	◑	◑	◔	○	◑	◑		1,700	
	6	Rock Fall Warning System	1.1, 1.2	●	○	○	○	○	○	○	○		850	
	7	Animal Crossing Warning System	1.2, 1.6	●	○	○	○	○	○	○	○		1,200	
	8	Over-Height Detection	1.2, 1.6	●	○	○	○	○	○	◔	◔		170	
Traffic Management	9	Portable Traffic Management System	1.2, 1.6	●	●	●	●	◑	◑	◑	◑		2,000	
	10	Speed Detection/VMS Warning System	1.2, 1.6	●	◑	◑	◑	○	○	◑	○		350	
	11	Var. Speed Limit Signing and Weather Warning System	1.2, 1.6	●	◑	◑	◑	○	○	◑	○		1,150	
	12	Northwest Region TSMC Geographic Expansion	1.2, 1.6, 1.7	●	●	●	●	●	●	●	●		1,200	
	13	Mt. Vernon & Bellingham Traffic Management Systems	1.2, 1.6, 1.7	●	●	●	●	●	●	●	●		8,500	
	14	Border Crossing	1 5, 1.6	○	●	◔	●	◔	◑	●	◑			
	15	Maintenance Management System												
CVO/Enforcement	16	Portable License Plate Optical Reader System	5.1	◑	○	○	○	○	○	●	○		100	
	17	Commercial Vehicle Operations	4.1 - 4.6											
Emergency Management	18	Mayday Support System	5.1	●	○	○	○	○	○	◑	○		3,300	
	19	Rest Area Security System	5.1	◑	○	○	○	○	○	◑	●		600	
	20	Public-Private Initiative Rest Area	5.1	◑	○	○	○	○	○	◑	●		1,500	
Advanced Vehicle	21	Advanced Vehicle Lateral Control System	6 2	●	◑	◑	◑	○	○	◑	◑			

APPENDICES

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APPENDIX A: EXCERPTS FROM NATIONAL ITS ARCHITECTURE, "IMPLEMENTATION STRATEGY"

This Appendix is provided as background to the National ITS Implementation Strategy as discussed in this technical Memorandum. Included here are Section 2 and Appendix A of the "Implementation Strategy" (FHWA 1996) which describes the National Architecture in terms of its functional areas and Market Packages.

These two sections define the NITSA and describe its relationship to ITS implementation and the Intelligent Transportation Infrastructure (ITI). Major technology and standards requirements that are associated with the range of potential ITS implementations are identified. Key early deployments and synergies that enable efficient incremental deployment of more advanced services are also defined. The Implementation Strategy is one of several volumes which make up the NITSA framework, and are available over the Internet. The reader is encouraged to review other volumes from the NITSA document at: http://www.itsa.org/fhomeold.html.

NITSA DOCUMENT, IMPLEMENTATION STRATEGY, CHAPTER 2: WHAT ARE THE POTENTIAL IMPLEMENTATIONS?

This section introduces the architecture defined by the National ITS Architecture Program and relates this definition to the range of ITS services and implementation options that will be considered by implementors. This relationship between architecture and implementation is presented using a defined set of *Market Packages.*

The technical implications of these implementation choices are then considered and used to identify promising early deployments. These likely candidates for early deployment are identified as *Key Market Packages.* Finally, the implementation choices are related to the Intelligent Transportation Infrastructure initiative. Figure 2-1 shows the general structure of the section and the relationships between each of the subparagraphs.

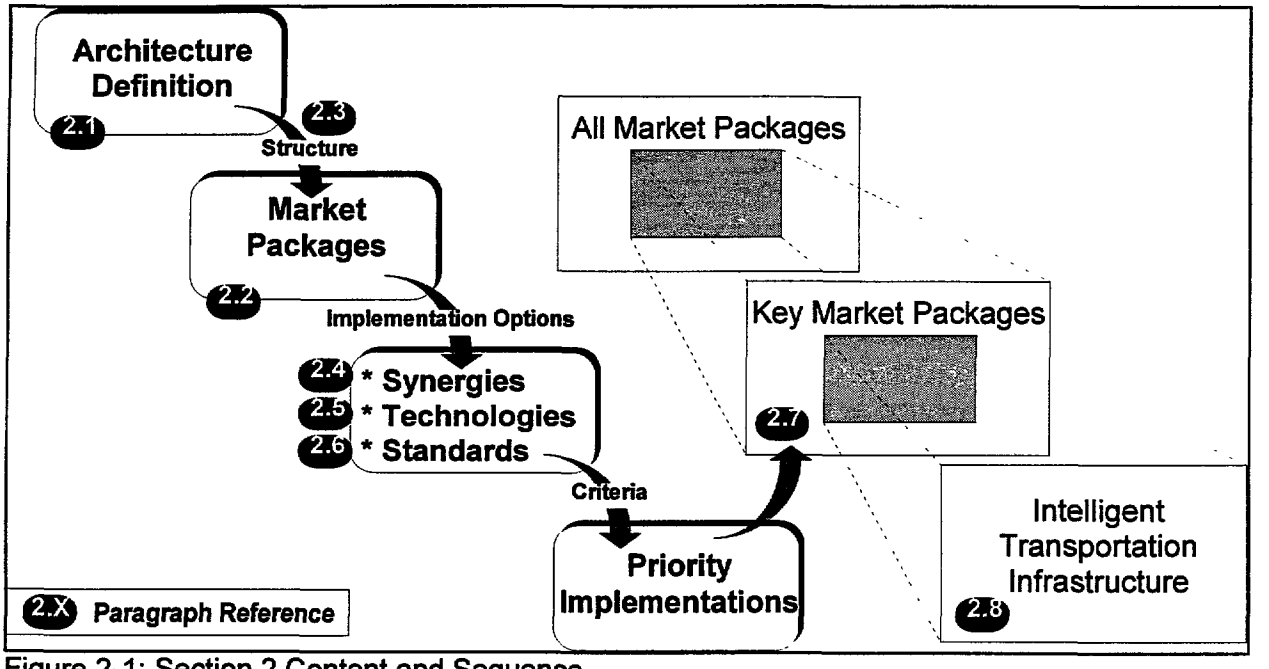


Figure 2-1: Section 2 Content and Sequence

2.1 Architecture Definition

The National Architecture is comprised of two technical layers, a Transportation Layer and a Communication Layer, which must operate in the context of an Institutional Layer. Figure 2.1-1 illustrates the three layers and their inter-relationships.

Figure 2.1-1: Architecture Layers

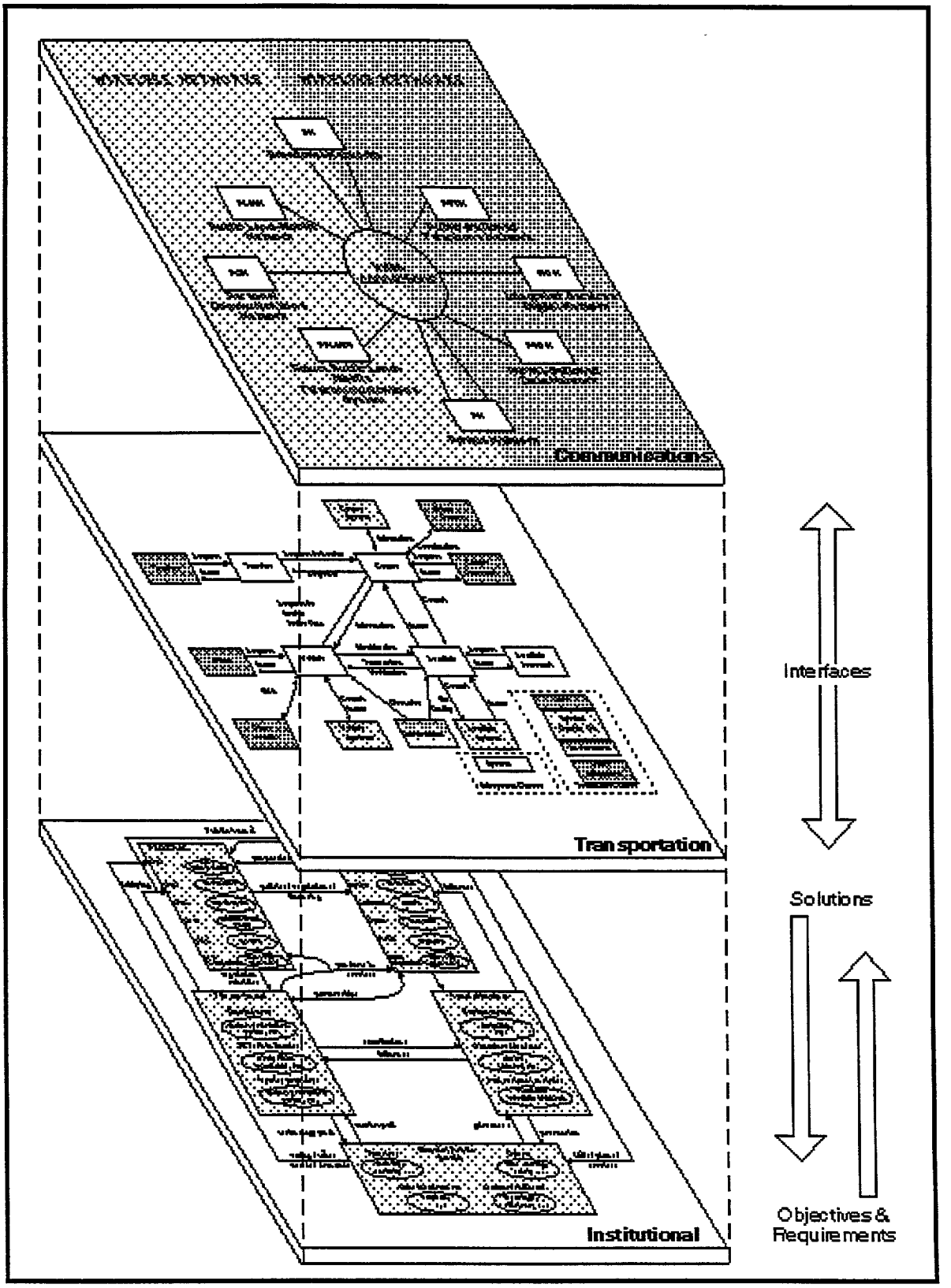


Figure 2.1-1: Architecture Layers

The Transportation Layer includes the various transportation-related processing centers, distributed roadside equipment, vehicle equipment, and other equipment used by the traveler to access ITS services. The Transportation Layer is fully documented in the separate Physical Architecture deliverable. The Communication Layer provides for the transfer of information between the distributed entities within the Transportation Layer. The technical details associated with the Communication Layer are presented in the Communications Analysis deliverable. The Transportation and Communication Layers together are the *architecture framework* that coordinates overall system operation by defining interfaces between equipment which may be deployed by different procuring and operating sectors. The Institutional Layer introduces the policies, funding incentives, working arrangements, and jurisdictional structure that support the technical layers of the architecture. The Institutional Layer is fully defined in section 3. This section provides an overview of the architecture framework by presenting the Transportation and Communication Layer definitions in more detail.

The architecture framework defines what each major transportation system element does and how they interact to provide all user services. This framework of subsystems and interfaces is specified in an implementation independent fashion to preserve maximum implementation flexibility.

The benefits of the architecture framework are the benefits of interoperability. For the private sector, interoperability and compatibility create larger markets for ITS products. For public sector and individual consumers of these products, the benefits are reduced costs and more efficient operations through economy of scale and increased competition. Coast to coast utility of ITS services and “mix and match” parts replacement are also primary benefits for the individual consumer. It is important to note that the architecture framework, by itself, will not achieve the desired national interoperability and compatibility goals. To achieve this end, the architecture framework requirements must be interpreted and developed into consensus standards by Standards Development Organizations such as ITE, SAE, and IEEE. This work is on-going.

Figure 2.1-1 provides a high-level view of the architecture framework. The figure includes both the transportation and communication layers of the architecture since it depicts both the subsystems (transportation layer elements) and the major communications interconnects (communication layer elements) required to support the user services.

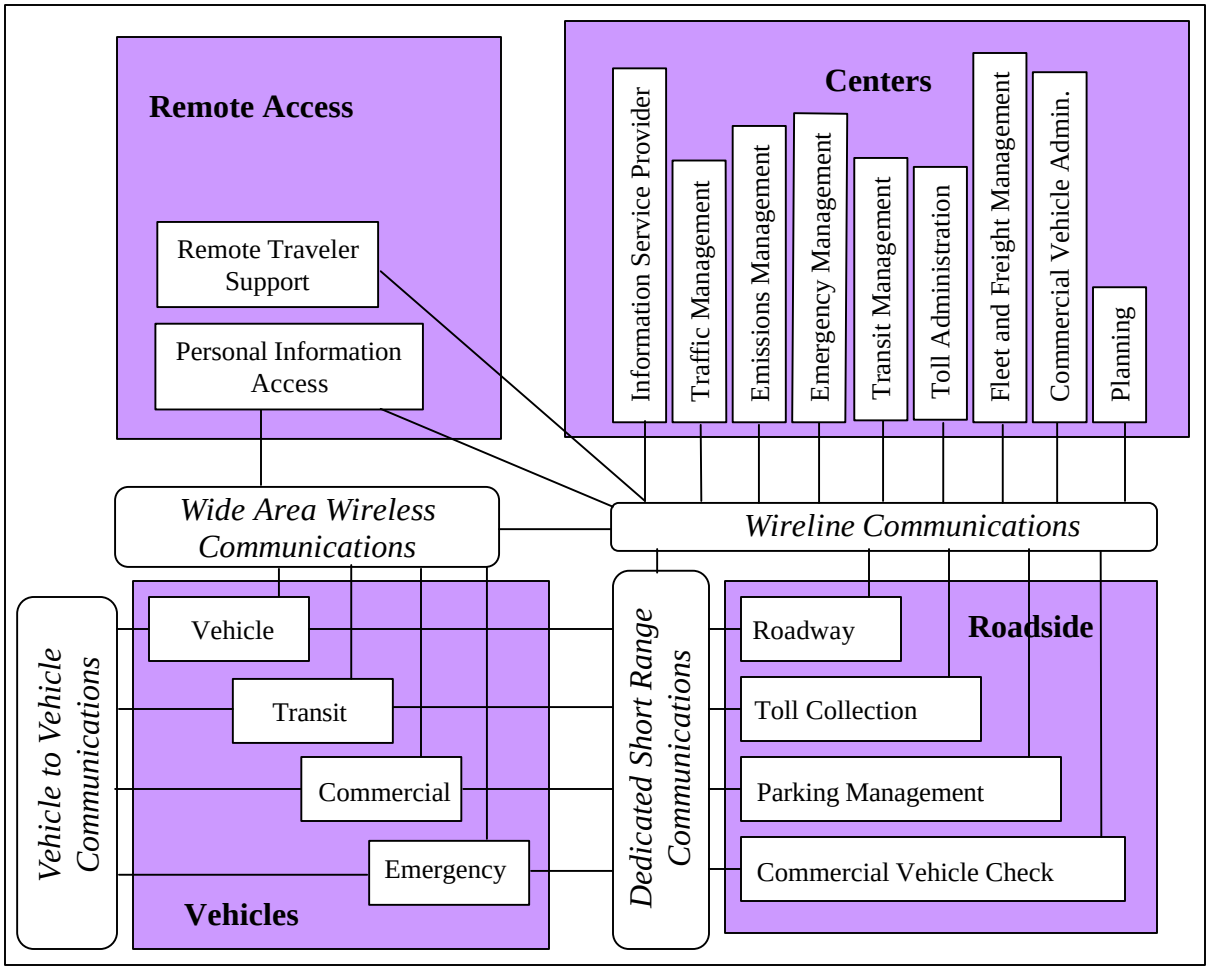


Figure 2.1-2: ITS Architecture Subsystems and Communications

2.1.1 TRANSPORTATION LAYER ARCHITECTURE

The Transportation Layer includes the nineteen interconnected subsystems identified in Figure 2.1-2. The selected 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.

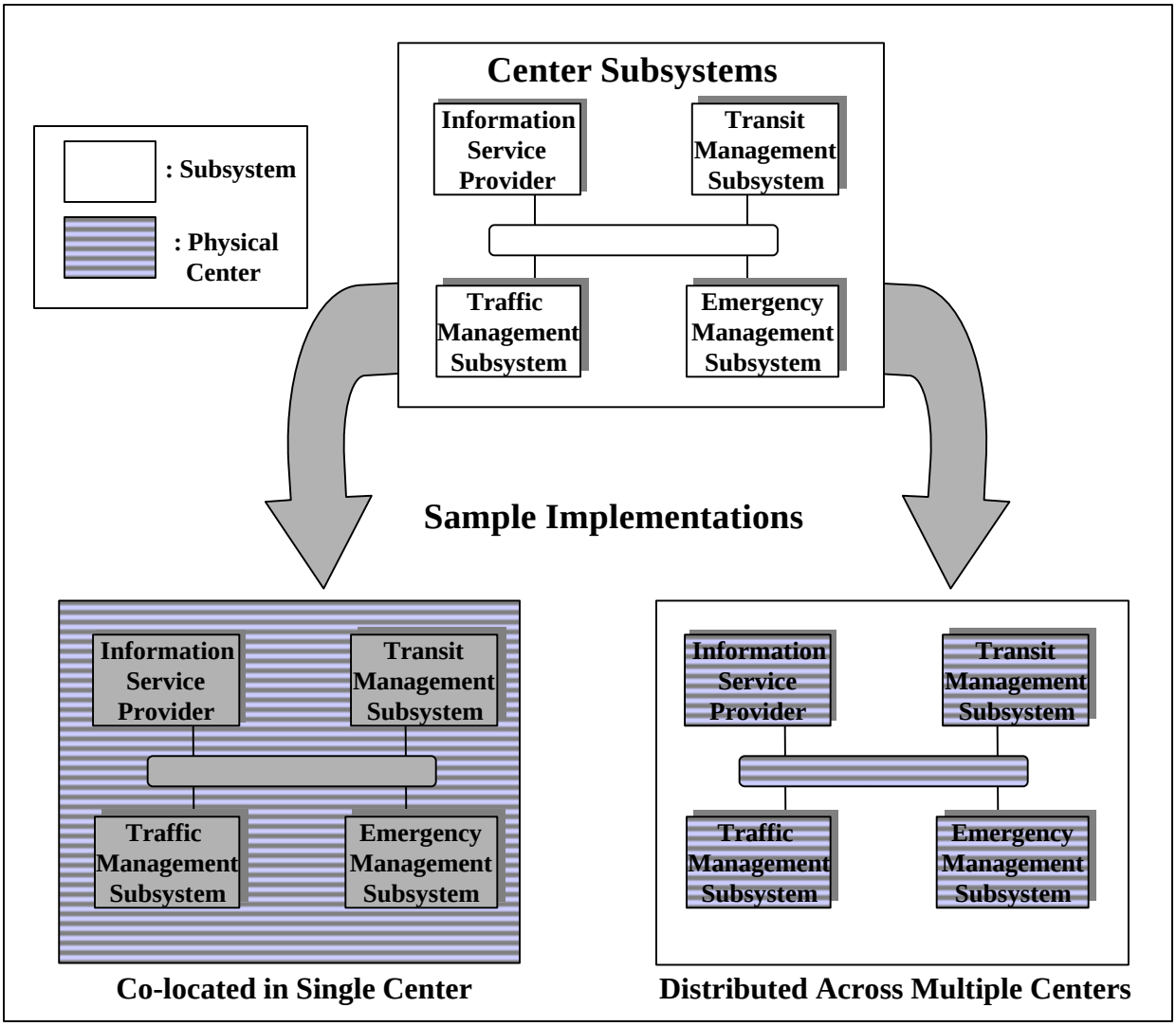
Reference the Physical Architecture document for complete subsystem definitions. Within the Physical Architecture, each subsystem is further decomposed into one or more equipment packages. Equipment packages are the basic elements that implementors will develop or buy; they represent the lowest level decomposition provided by the Physical Architecture.

As illustrated in Figure 2.1-2, the subsystems may be grouped into four distinct subsystem classes that share basic functional, deployment, and institutional characteristics. These classes (Center, Roadside, Vehicle, and Remote Access) are used to group top level descriptions for each of the subsystem in this section.

2.7.1.1 Center Subsystems

The center subsystems provide management, administration, and support functions for the transportation system. The center subsystems each 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.

Before describing the center subsystems in detail, an important distinction must be made between the "center" subsystems and the transportation management "centers" that are familiar to most transportation professionals. In simplest terms, the center subsystems are not "brick and mortar". Each subsystem is a cohesive set of functional definitions with required interfaces to other subsystems; subsystems are functionally defined, not physically defined. A regional implementation may include a single physical center that collocates the capabilities from several of the center subsystems. For instance, a single Transportation Management Center may include Traffic Management Subsystem, Transit Management Subsystem, Emergency Management Subsystem, and Information Service Provider subsystem capabilities. Conversely, a single subsystem may be replicated in many different physical centers in a complex metropolitan area system. For instance, the traffic management subsystem may be implemented in a traffic management center for freeway control in addition to several distinct city traffic management centers that cooperatively control the arterials. Figure 2.1-3 provides an indication of the range of ways that center subsystems may be implemented in physical centers.



Commercial Vehicle Administration Subsystem

The Commercial Vehicle Administration Subsystem will operate at one or more fixed locations within a region. This subsystem performs administrative functions supporting credentials, tax, and safety regulations. It issues credentials, collects fees and taxes, supports enforcement of credential requirements. This subsystem communicates to process credentials applications and collect fuel taxes, eight/distance taxes, and 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 (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 Subsystem

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 Subsystem

This subsystem operates at a fixed location and may co-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 Subsystem

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

Infonnation Service Provider Subsystem

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, ridematching 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 Subsystem

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 Subsystem

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 subsystem also sets and administers the pricing structures and includes the capability to implement road pricing policies in coordination with the Traffic Management Subsystem. 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 Subsystem

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 Subsystem

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.

2.7.1 .2 Roadside Subsystems

These distributed infrastructure subsystems provide the direct interface to vehicles traveling on the roadway network. Each of the roadside subsystems include functions that must be located on or near the roadway 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 Subsystem

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 Fleet and Freight 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 preclearance program.

Parking Management Subsystem

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 Subsystem

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 Subsystem

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.

2.7. 1.3 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. In the following descriptions, the Vehicle Subsystem description 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 Subsystem

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 Subsystem

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 Subsystem

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 Subsystem

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.

2.1.1.4 Remote Access Subsystems

The remote access 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 Subsystem

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 Subsystem

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.

2.1.2 COMMUNICATION LAYER ARCHITECTURE

The relationship between the Communication Layer and the Transportation Layer is presented in the generic communication hierarchical model in Figure 2.1-4. The ITS users in the figure are the Transportation Layer subsystems which share information. The Transportation Layer user is not concerned with the specifics of the information transfer performed by the Communication Layer. In fact, the Communication Layer can be viewed as plumbing that transparently carries information between users.

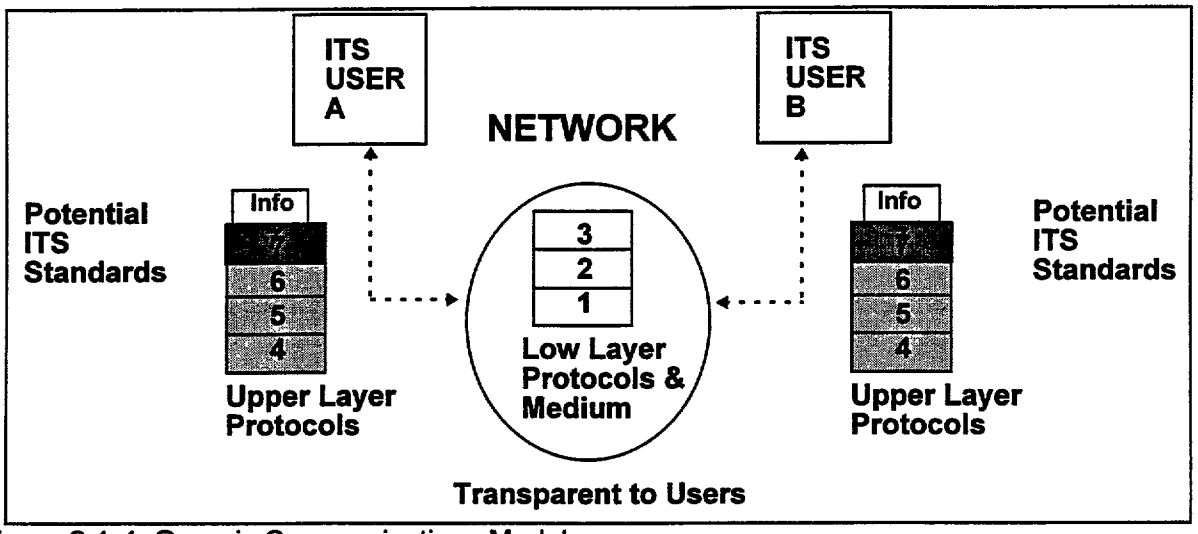


Figure 2.1-4: Generic Communications Model

The Communication Layer architecture for the ITS system has two components: one wireless and one wireline. All Transportation Layer entities requiring information transfer will be supported by one, or both, of these components. In most cases, the wireless component merely provides a tetherless 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 air link.

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

- **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.

- **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** 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.

- **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.

Figure 2.1-2, included at the beginning of this section, showed the allocation of these basic communications types to the interfaces between the transportation layer subsystems.

2.2 Market Packages

The 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 scalable 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 2.2-l).

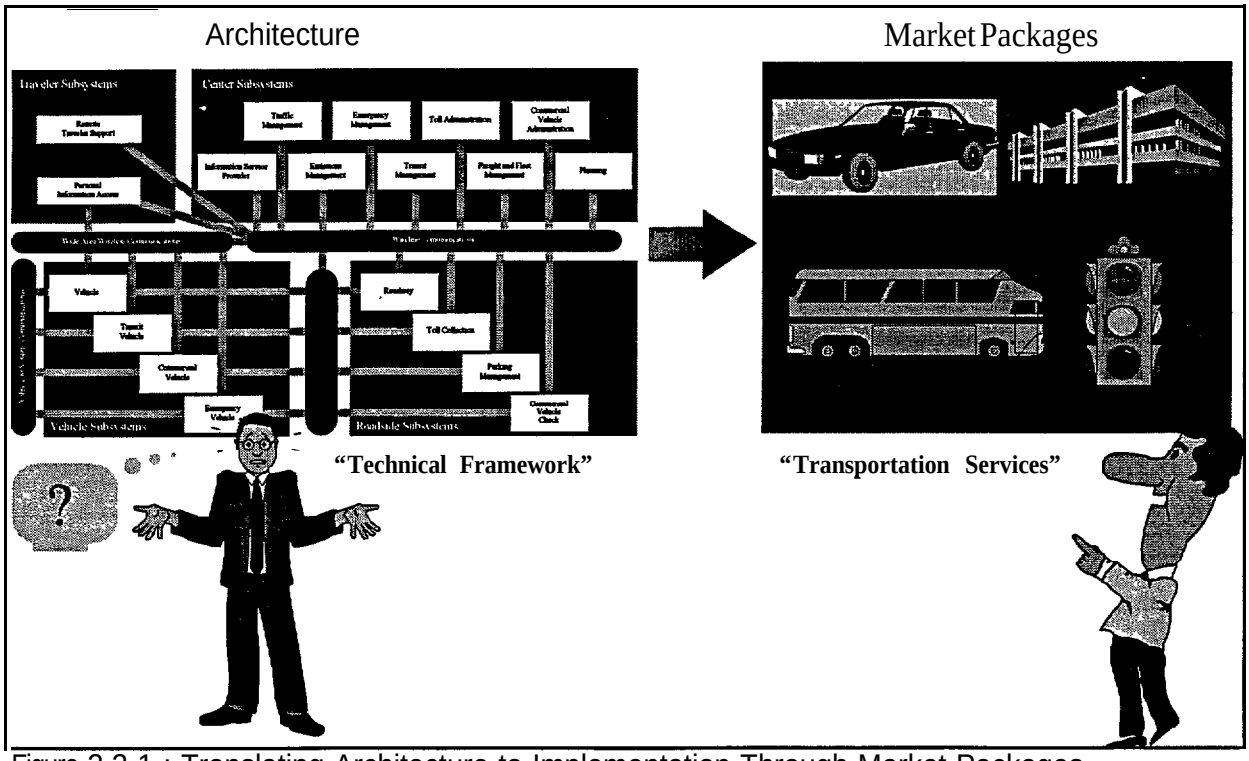


Figure 2.2-1 : Translating Architecture to Implementation Through Market Packages

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, service 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 yields a subset of the market packages that are likely early deployments. 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 2.2-l. 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 transportation managers).

Table 2.2-1. Market Package Summary

Table 2.2-1: Market Packages Summary

Market Package	Market Package Name
ATMS01	Network Surveillance
ATMS02	Probe Surveillance
ATMS03	Surface Street Control
ATMS04	Freeway Control
ATMS05	HOV and Reversible Lane Management
ATMS06	Traffic Information Dissemination
ATMS07	Regional Traffic Control
ATMS08	Incident Management System
ATMS09	Traffic Network Performance Evaluation
ATMS10	Dynamic Toll/Parking Fee Management
ATMS11	Emissions and Environmental Hazards Sensing
ATMS12	Virtual TMC and Smart Probe Data
APTS1	Transit Vehicle Tracking
APTS2	Transit Fixed-Route Operations
APTS3	Demand Response Transit Operations
APTS4	Transit Passenger and Fare Management
APTS5	Transit Security
APTS6	Transit Maintenance
APTS7	Multi-modal Coordination
ATIS1	Broadcast Traveler Information
ATIS2	Interactive Traveler Information
ATIS3	Autonomous Route Guidance
ATIS4	Dynamic Route Guidance
ATIS5	ISP Based Route Guidance
ATIS6	Integrated Transportation Management/Route Guidance
ATIS7	Yellow Pages and Reservation
ATIS8	Dynamic Ridesharing
ATIS9	In Vehicle Signing
AVSS01	Vehicle Safety Monitoring
AVSS02	Driver Safety Monitoring
AVSS03	Longitudinal Safety Warning
AVSS04	Lateral Safety Warning
AVSS05	Intersection Safety Warning
AVSS06	Pre-Crash Restraint Deployment
AVSS07	Driver Visibility Improvement
AVSS08	Advanced Vehicle Longitudinal Control
AVSS09	Advanced Vehicle Lateral Control
AVSS10	Intersection Collision Avoidance
AVSS11	Automated Highway System
CVO1	Fleet Administration
CVO2	Freight Administration
CVO3	Electronic Clearance
CVO3a	Electronic Clearance Enrollment
CVO4	International Border Electronic Clearance
CVO5	Weigh-In-Motion
CVO6	Roadside CVO Safety
CVO7	On-board CVO Safety
CVO8	CVO Fleet Maintenance
CVO9	HAZMAT Management
EM1	Emergency Response

Market Package	Market Package Name
EM2	Emergency Routing
EM3	Mayday Support
ITS1	ITS Planning

As will be seen in section 2.3, the service-oriented market packages are traceable to the interface-oriented architecture definition. Once a particular market package is selected for implementation, the required subsystems, equipment packages, and interface requirements may be identified through this traceability. This approach allows the implementor (and this document) to first consider service needs and later concentrate on those pieces of the architecture necessary to provide the selected service.

It is important to note that the market packages are illustrative rather than prescriptive. The actual implementation variations that are possible across the country are myriad and cannot be enumerated through a concise set of packages. The market packages are tools that allow this Implementation Strategy to discuss incremental deployment of ITS services in a manner that is relevant to the underlying architecture definition.

So that the reader develops a general feel for the market packages and how they relate to the architecture and to each other, several examples are presented in this section. Appendix A provides detailed definitions for each of the market packages.'

The example market packages that are presented in this section illustrate the range of route guidance implementations supported by the architecture. The four route guidance market packages incrementally build on one another to provide a progressive set of capabilities that can be incrementally deployed over time. Alternatively, the four market packages represent the varied levels of infrastructure support that a route guidance system may encounter as it travels across the country some time in the future.

The route guidance series of market packages begins with the Autonomous Route Guidance package which provides a self-contained route guidance service. Initial infrastructure support is provided by a second'incremental Dynamic Route Guidance market package which adds the capability to broadcast real-time updates from the infrastructure to the mobile route guidance equipment. The third market package, ISP-Based Route Guidance, supports direct provision of route plans from the infrastructure. This market package may potentially reduce the cost of in-vehicle equipment since it removes the requirement for route plan calculation from the vehicle. It also enables more explicit infrastructure control of the route selection process which has the potential to enhance network performance. Building on this latter potential, the most advanced route guidance market package tightly integrates the centralized route planning capability with area-wide traffic control for further enhancements in overall system performance.

The incremental nature of the market packages is readily seen through a comparison of the subsystems, equipment packages, and interfaces that support each. The following pages describe each of the four route guidance market packages in turn. In each example, a description of the service offered by each market package is coupled with a graphic that identifies how the architecture framework supports the market package. Where alternative implementation options are supported by the market package, these are also identified and differentiated in the descriptions.

Figure 2.2-2 provides a legend to assist in interpretation of the sample market package diagrams. Only the most salient elements from the architecture definition (e.g., directly involved subsystems, system terminators, an the highest level data flows) are depicted in each graphic to improve clarity.

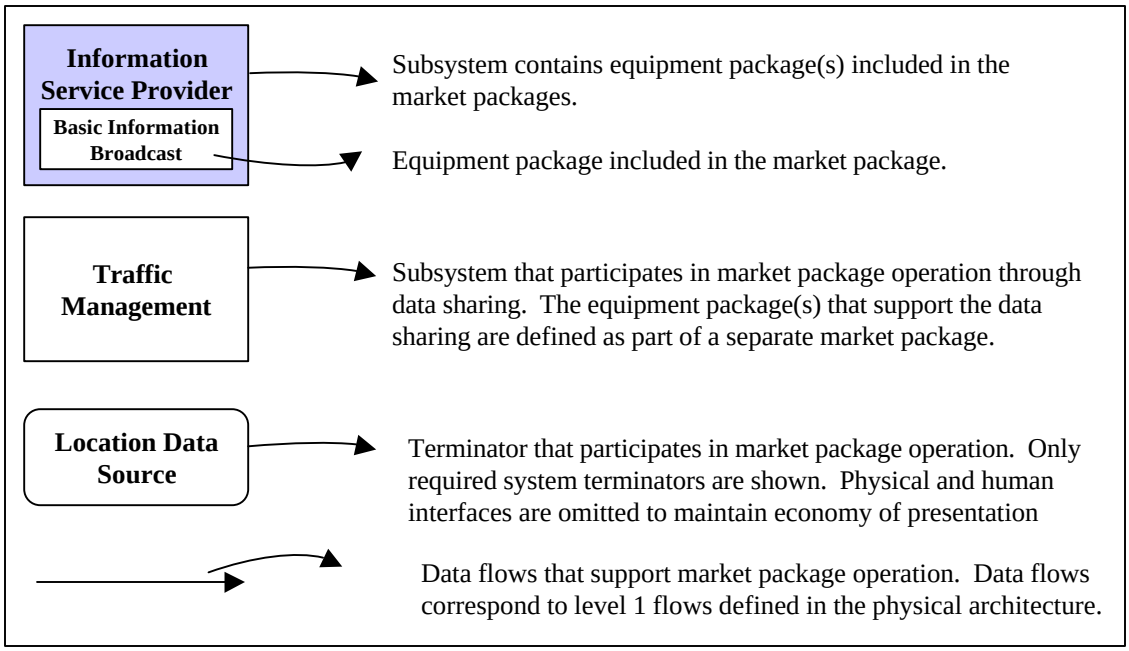
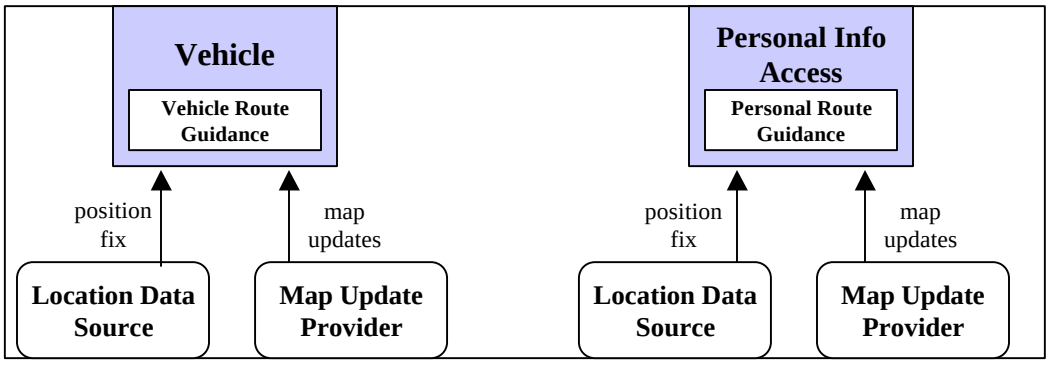


Figure 2.2-2: Market Package Diagram Elements

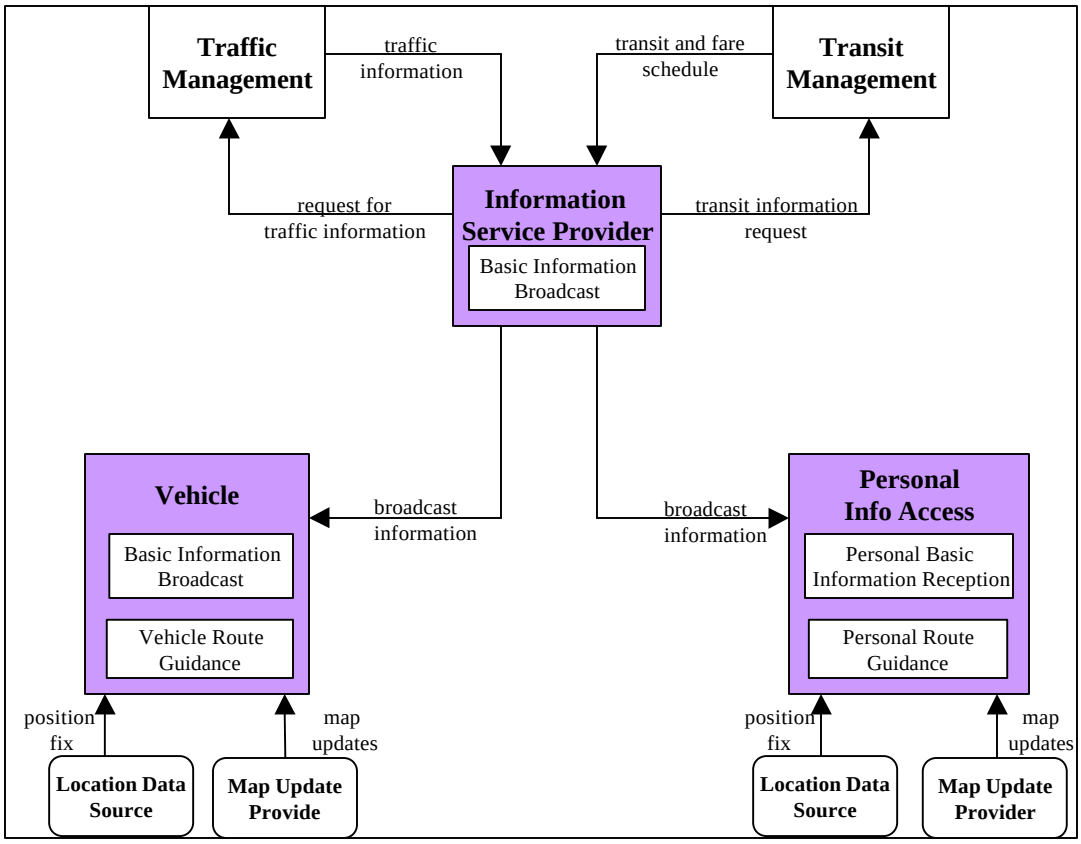
Autonomous Route Guidance (ATIS3)

This market package relies on in-vehicle sensory, location determination, computation, 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.



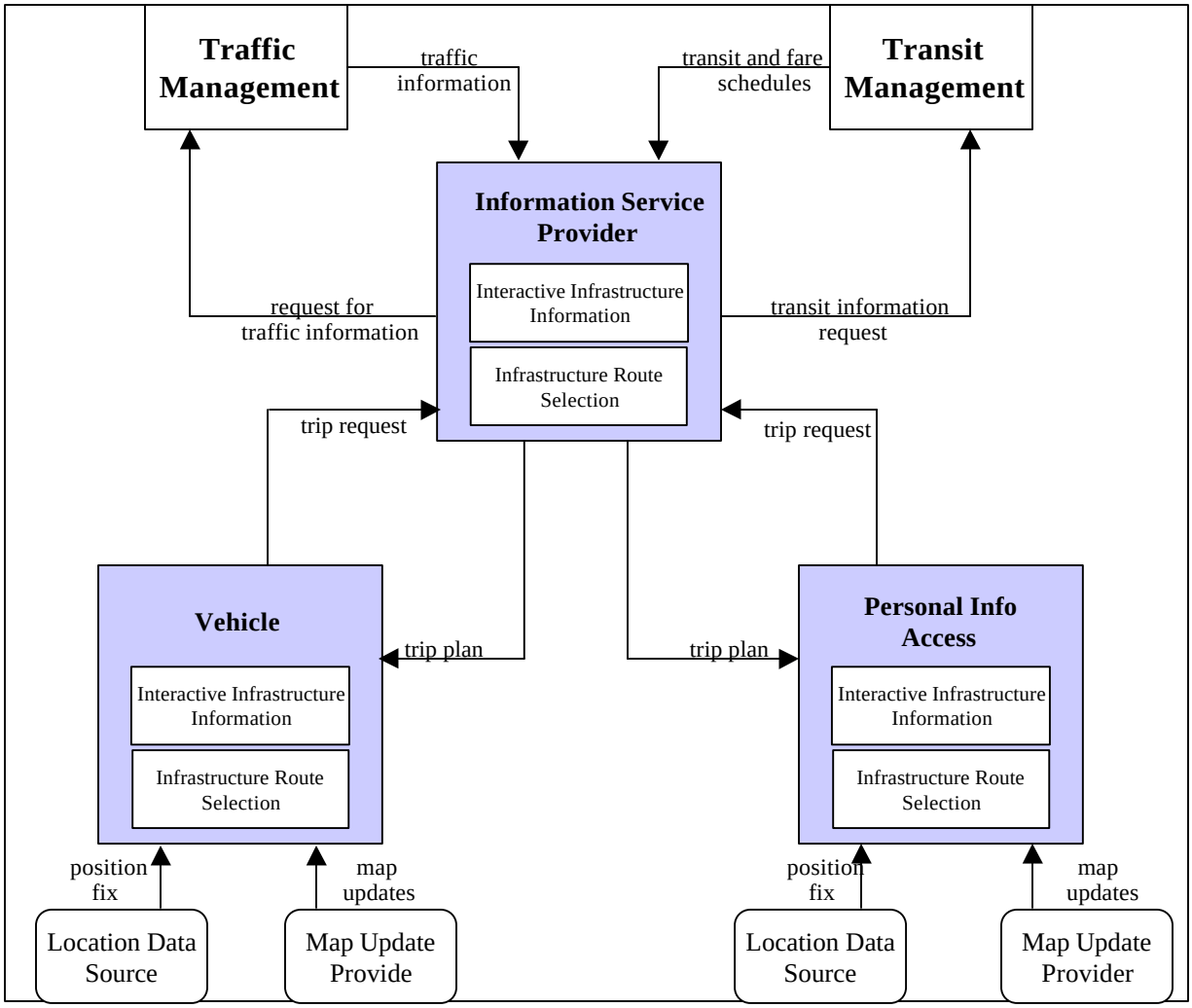
Dynamic Route Guidance (ATIS4)

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.



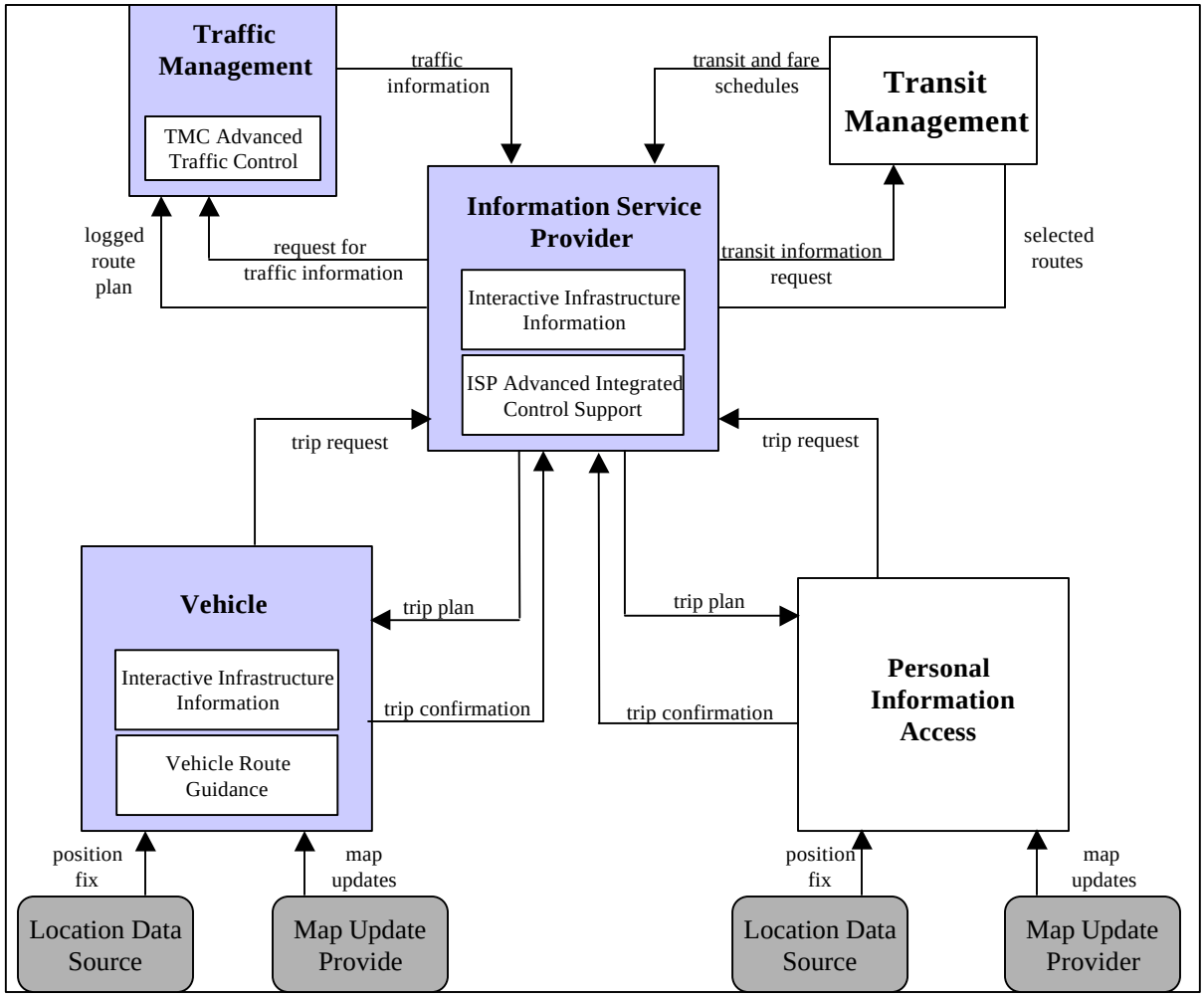
ISP-Based Route Guidance (ATIS5)

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. The package includes two way data communications and optionally also equips the user with the data bases, location determination capability, and display technology to support turn by turn route guidance



Integrated Transportation Management/Route Guidance (ATIS6)

This market package extends the level of coordination between the Information Service Provider and Traffic Management Subsystem. The additional coordination allows the traffic management subsystem 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. It would utilize this ISP-provided route planning information to optimize traffic management strategies while at the same time providing update signal timing information back to the ISP to allow optimized route plan.



In other cases, the market package elements are owned and operated by different stakeholders. Many of the ATIS market packages require equipment in the Information Service Provider Subsystem that is owned and operated by a public or private information provider and equipment that is acquired and operated by the consumer as part of the Vehicle Subsystem or Personal Information Access Subsystem. Since equipment in different subsystems may be purchased and operated by different end-users, these subsystem-specific components may encounter varied deployment.

To understand and analyze these potential deployment variations, the defined market packages must be decomposed to their constituent elements. The portion of the market package capabilities that are allocated to each subsystem are segregated and defined as equipment packages to support this additional resolution. An *equipment package* represents a set of equipment/capabilities which are likely to be purchased by an end-user to achieve a desired capability.

Since equipment packages are both the lowest level elements of the physical architecture and associated with specific market packages, there is clear traceability between the interface-oriented architecture framework and the service-oriented market packages. Figure 2.3-1 depicts the relationship between the user services, architecture elements, and market packages.

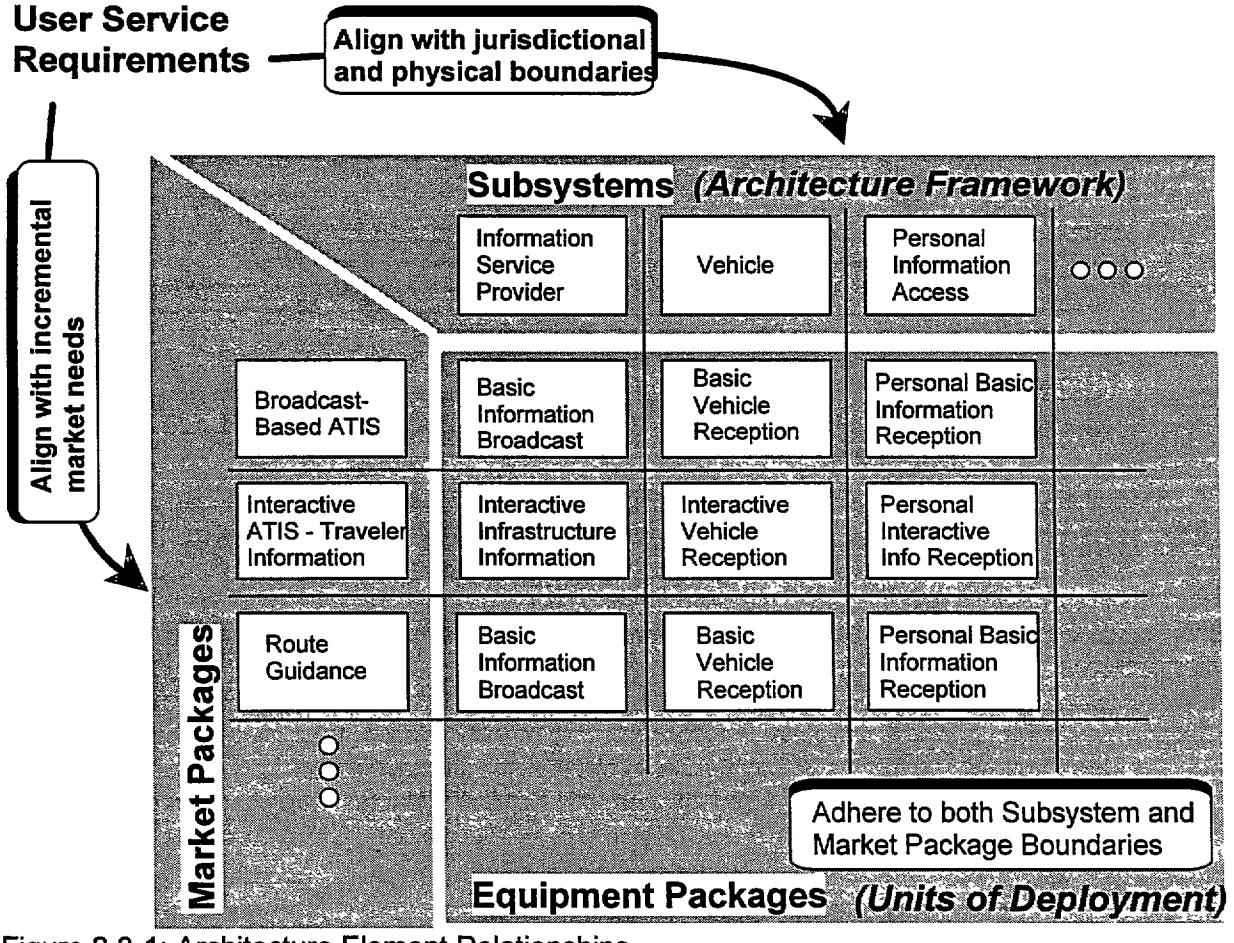


Figure 2.3-1: Architecture Element Relationships

Table 2.3-l provides a complete listing of the equipment packages for each valid market package/subsystem combination. (Note: Table not available.) In the table, the rows represent the defined market packages, the columns represent the subsystems, and the center section of the table identifies the associated equipment packages. Related market packages are grouped along the left side so the reader can see the total set of equipment packages which make up a particular market package deployment. The Physical Architecture deliverable provides detailed specifications for each of the equipment packages identified in the table.

The market packages are also directly traceable to the user services. A market package often includes capabilities which span more than one user service. A single user service sometimes includes a range of incremental capabilities that are segregated into separate market packages so that they can be considered separately from a deployment perspective. As a result, there is a many to many relationship between the market packages and the user services.

To illustrate these relationships with examples:

- The Traffic Control user service requires distinct surveillance, freeway and surface street traffic control, integrated area-wide traffic control, HOV lane control, and traffic information dissemination capabilities. Each of these capabilities may be deployed individually by a local jurisdiction and are allocated to distinct market packages. The market packages also distinguish between different traffic surveillance approaches: Roadside instrumentation (Network Surveillance Market Package) and vehicle probes (Probe Surveillance Market Package) are separated due to fundamentally different technical and institutional issues for the two approaches. In total, eleven separate market packages provide different mechanisms and levels of support for satisfying the Traffic Control user service requirements.

- The HOV and Reversible Lane Management Market Package supports both the traffic control and Travel Demand Management user services since both services require HOV lane management capabilities. This single deployable package satisfies portions of the requirements associated with both of these user services.

The association between user services and market packages is presented in Table 2.3-2. As shown in the table, the identified market packages support all required user services.

Table 2.3.2: Market Package to User Service Relationship

Table 2.3-2: Market Package to User Service Relationships

	Market Packages	1.1 - Pre - Trip Travel Information	1.2 - En - Route Driver Information	1.3 - Route Guidance	1.4 - Ride Matching And Reservation	1.5 - Traveler Services Information	1.6 - Traffic Control	1.7 - Incident Management	1.8 - Travel Demand Management	1.9 - Emissions Testing And Mitigation	2.1 - Public Transportation Management	2.2 - En - Route Transit Information	2.3 - Personalized Public Transit	2.4 - Public Travel Security	3.1 - Electronic Payment Services	4.1 - Electronic Vehicle Electronic Clearance	4.2 - Commercial Vehicle Inspection	4.3 - Automated Roadside Safety Monitoring	4.4 - On - Board Safety Monitoring	4.5 - Commercial Vehicle Administrative Process	4.6 - Hazardous Material Incident Response	5.1 - Commercial Fleet Management	5.2 - Emergency Notification And Personal Security	6.1 - Emergency Vehicle Management	6.2 - Longitudinal Collision Avoidance	6.3 - Lateral Collision Avoidance	6.4 - Intersection Collision Avoidance	6.5 - Vision Enhancement For Crash Avoidance	6.6 - Safety Readiness	6.7 - Pre - Crash Restraint Deployment	7.1 - Automated Vehicle Operation
ATMS	Network Surveillance						✓																								
	Probe Surveillance						✓	✓																							
	Surface Street Control						✓	✓	✓																						
	Freeway Control						✓	✓	✓																						
	HOV and Reversible Lane Management						✓	✓		✓																					
	Traffic Information Dissemination						✓	✓	✓																						
	Regional Traffic Control							✓		✓							✓														
	Incident Management System							✓		✓																					
	Traffic Network Performance Evaluation											✓																			
	Dynamic Toll/Parking Fee Management																✓														
	Emissions and Environmental Hazards				✓				✓	✓			✓	✓	✓	✓															
	Virtual TMC and Smart Probe Data												✓	✓																	
APTS	Transit Vehicle Tracking												✓	✓	✓	✓															
	Transit Fixed-Route Operations												✓	✓			✓														
	Demand Response Transit Operations												✓																		
	Transit Passenger and Fare Management								✓			✓	✓																		
	Transit Security														✓																
	Transit Maintenance														✓	✓			✓												
	Multi-modal Coordination	✓	✓																												
ATIS	Broadcast Traveler Information	✓	✓																												
	Interactive Traveler Information		✓	✓															✓												
	Autonomous Route Guidance		✓	✓															✓												
	Dynamic Route Guidance	✓	✓	✓															✓												
	ISP Based Route Guidance		✓	✓					✓								✓	✓	✓												
	Integrated Transportation Mgmt/Route	✓	✓					✓																							
	Yellow Pages and Reservation	✓	✓								✓																				
	Dynamic Ridesharing			✓																											
	In Vehicle Signing																														
AVSS	Vehicle Safety Monitoring																														
	Driver Safety Monitoring																														
	Longitudinal Safety Warning																														
	Lateral Safety Warning																														
	Intersection Safety Warning																														
	Pre-Crash Restraint Deployment																														
	Driver Visibility Improvement																														
	Advanced Vehicle Longitudinal Control																														
	Advanced Vehicle Lateral Control																														
	Intersection Collision Avoidance																														
	Automated Highway System																														
CVO	Fleet Administration																														
	Freight Administration																														
	Electronic Clearance																														
	Electronic Clearance Enrollment																														
	International Border Electronic Clearance																														
	Weigh-In-Motion																														
	Roadside CVO Safety																														
	On-board CVO Safety																														
	CVO Fleet Maintenance																														
	HAZMAT Managment																														
EM	Emergency Response																														
	Emergency Routing																														
	Mayday Support																														
	ITS Planning																														

2.4 Market Package Synergy

One of the unique attributes of the National Architecture Program is the breadth of ITS services that it covers. This scope allows each potential service to be considered in context with all other ITS services, identifying common features and shared functionality. Questions such as: “Once I implement electronic toll collection in my region, what other services can I implement by extending the beacon infrastructure?“, and “What sorts of efficiencies are possible when advanced traveler information and traffic management systems are implemented in the same region?” are readily answered through the National Architecture. These inter-relationships, or synergies, are presented for each of the defined market packages in this section.

Consideration for these market package synergies can result in more efficient deployment of ITS services over time. The architecture can only identify the potential synergies, it is up to the local implementor to develop a deployment strategy that capitalizes on these efficiencies.

Synergies have been identified and analyzed for each equipment package and then aggregated and presented in this section at the market package level. A large number of synergies can be derived from the Architecture Framework by examining the data flows that are shared between equipment packages. Only the most significant synergies are brought forward and discussed in this section.

Several different types of synergies have been identified, from most restrictive to least restrictive as follows.

Interdependent: Interdependent equipment packages are the most closely coupled. Two equipment packages are interdependent if both must be deployed to achieve a required ITS service. If interdependent equipment packages are not deployed at the same time in the same region, the resulting service will be marginal or non-existent. All interdependent equipment packages have been allocated to common market packages to reflect this required association.

Common Functions: Equipment packages which reside in the same subsystem can share common functions to more efficiently implement the required services. This type of synergy reflects the potential sharing of hardware and/or software to perform a function that is required by both equipment packages. The shared functions are included in only one of the equipment packages and synergy is noted between the equipment package which includes the common equipment and the remaining equipment package(s) which utilize it. Many equipment packages rely on equipment included in more basic equipment packages to support more advanced capabilities. Such “incremental” equipment packages allow efficient deployment over time by building on existing equipment capabilities. In other cases, equipment packages which share functionality are of the same relative sophistication. In such cases, the dependent equipment packages may be implemented in either order based on the needs (and preferences) of the end user. The common equipment is purchased with the first equipment package to be deployed.

Shared Information: Some equipment packages rely on information provided by a equipment package in a separate subsystem. In many cases, if the equipment package which supplies the information is not deployed, the equipment package which relies on

the information will still provide degraded capabilities but not satisfy all user service requirements allocated to it. Typically, this "Shared Information" synergy reflects information that is shared between an information collection/provider equipment package in the infrastructure and an information user equipment package which is part of a second infrastructure subsystem or a mobile subsystem.

Complementary: Even when equipment packages may be independently deployed and operated to achieve the required user services (i.e., the equipment packages are not part of the same market package, do not share equipment, and are not required to share information), there may still be synergy between the provided services which should be considered in an implementation strategy. Complementary equipment packages provide compatible services which, taken together, enhance net system performance. In most cases, this relationship reflects the sharing of optional information between equipment packages within the architecture definition. In such cases, the information generated by one equipment package, if available, enhances the service provided by a second equipment package. In contrast, a Shared Information dependency, if not satisfied, prevents the associated equipment packages from meeting all of the user service requirements.

A series of five diagrams and accompanying discussion describe the principal synergies identified for the market packages. In each diagram, the connections represent the synergies between the market packages. Tracing the diagrams along the flows provides various efficient deployment sequences that leverage the incremental nature of the market packages.

The connections are coded to represent the types of synergies between market packages. When market packages are related in more than one way, the most restrictive dependency type is shown. (e.g., If two market packages share common functions and share information, the flow connecting the two market packages would reflect a "Common Functions" synergy.). Note that the "Interdependent" relationship is not represented in the figure since this synergy exists only between equipment packages within the same market package.

Each of the diagrams illustrate the market package synergies for a particular stakeholder area (e.g., Traffic Management, Traveler Information, etc.) Often, synergies will cross stakeholder boundaries (e.g., Traveler Information market packages are often reliant on information from Traffic Management market packages). These synergies are documented by "off-page references" which indicate the stakeholder area in an oval along with the associated market package. The text accompanying each diagram briefly describes, and justifies, the major synergies.

Advanced Traffic Management Systems

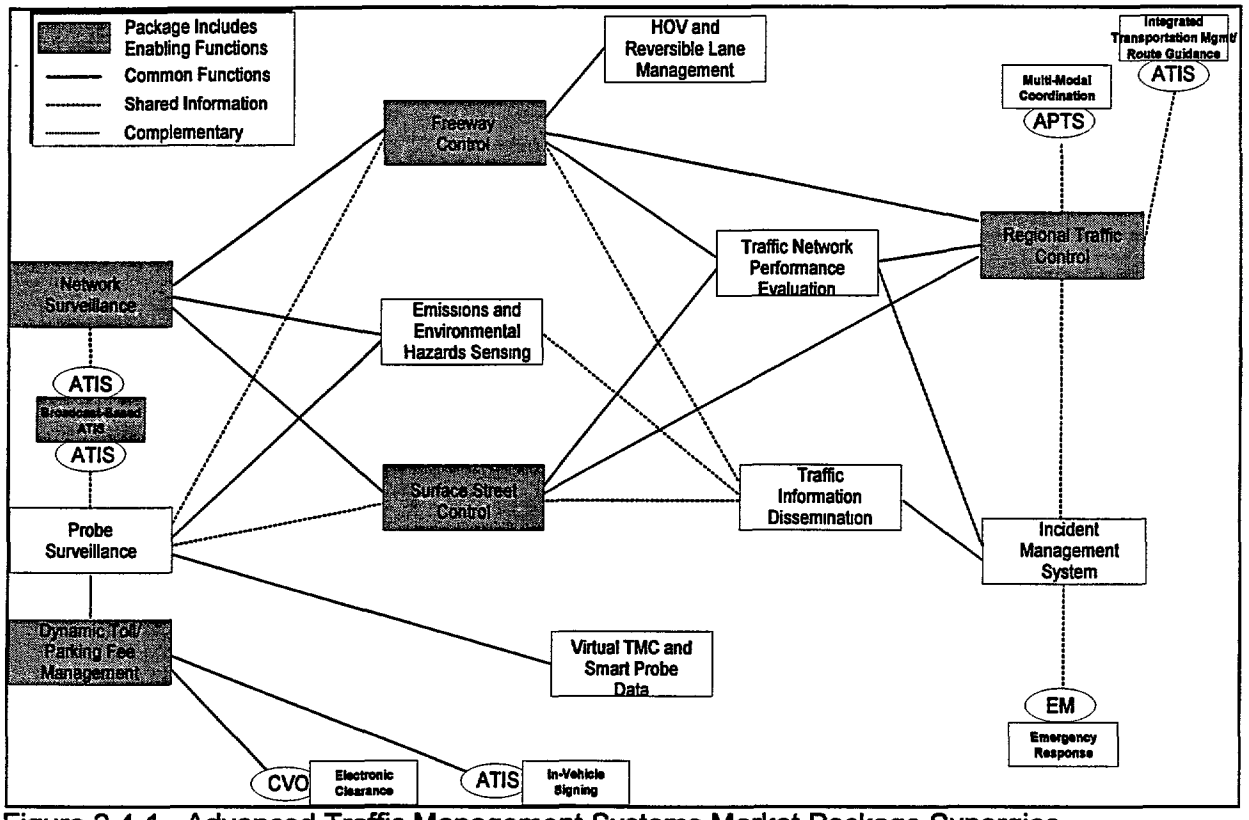


Figure 2.4-1. Advanced Traffic Management Systems Market Package Synergies.

The most significant common feature of the Traffic Management market packages is the shared need for traffic information. Each of these packages are supported by the basic surveillance infrastructure that is implemented through the two surveillance market packages. The information provided by this equipment (e.g., traffic counts and speeds) can be used for many purposes, including control and management of the traffic signals, incident management, emissions management, and traveler information. The surveillance data can also be saved as historical data for planning purposes or for evaluating the effectiveness of previous system enhancements. Each of the synergies that have been identified between the Traffic Management market packages are elaborated in the following descriptions.

Network Surveillance Market Package

This market package implements the basic roadside sensors, controllers, and communications infrastructure equipment which is leveraged by most of the other ATMS market packages. In addition to providing the information necessary to support more advanced traffic management implementations, this package also shares traffic information with the ATIS market packages.

Probe Surveillance Market Package

This market package provides an alternative approach to surveillance which provides many of the same fundamental benefits as the network surveillance market package.

The dependency to the Surface Street and Freeway control market packages is denoted as data sharing since this package does not require implementation of the extensive distributed roadside infrastructure that may be directly utilized by the other ATMS packages. Dedicated Short Range Communications and AVI technologies may be shared between this package and the Dynamic Toll/Parking Management package. The Virtual TMC and Smart Probe Data market package adds additional "smart probe" capabilities such as road condition monitoring to the basic probe capabilities offered by this package.

Dynamic Toll/Parking Fee Management Market Package

This market package shares common functionality with the Electronic Clearance, In-Vehicle Signing, and Probe Surveillance market packages. Each of these market packages are additional potential applications for the dedicated short range communications, AVI, and rudimentary driver interface capabilities offered by this Toll/Parking market package.

Freeway Control Market Package

The infrastructure implemented to support this market package facilitates implementation of the HOV and Reversible Lane Management market package. HOV management should be able to utilize much of the same wireline communications, surveillance, and control infrastructure provided by this market package. Several more advanced traffic management market packages build on the fundamental infrastructure and control strategies supported by this package by increasing the level of coordination and/or increasing the sophistication of the control strategies.

Surface Street Control Market Package

This market package provides a basic surface street control building block, analogous to the Freeway Control Market Package above.

Emissions and Environmental Hazards Sensing Market Package

This market package provides emissions and hazards information to the Traffic Information Dissemination market package. It may be interconnected with the basic surveillance infrastructure deployed at the roadside for cost-effective implementation.

Incident Management System Market Package

This market package utilizes the traffic information dissemination and traffic control capabilities deployed through other market packages to adapt traveler information and traffic control strategies to account for incidents. The communications infrastructure and working relationships established to support Incident Management can also be used to support the coordination required for the regional traffic control market package. This market package shares information with the Emergency Response market package to enable coordination between traffic management and emergency management subsystems in incidents and other emergencies impacting traffic management strategies.

Regional Traffic Control Market Package

This market package enhances the coordination between traffic management systems within a region. It directly leverages the existing traffic control systems (freeway and arterial) already implemented in the region through improved coordination between traffic management systems in the region.

Advanced Traveler Information Systems

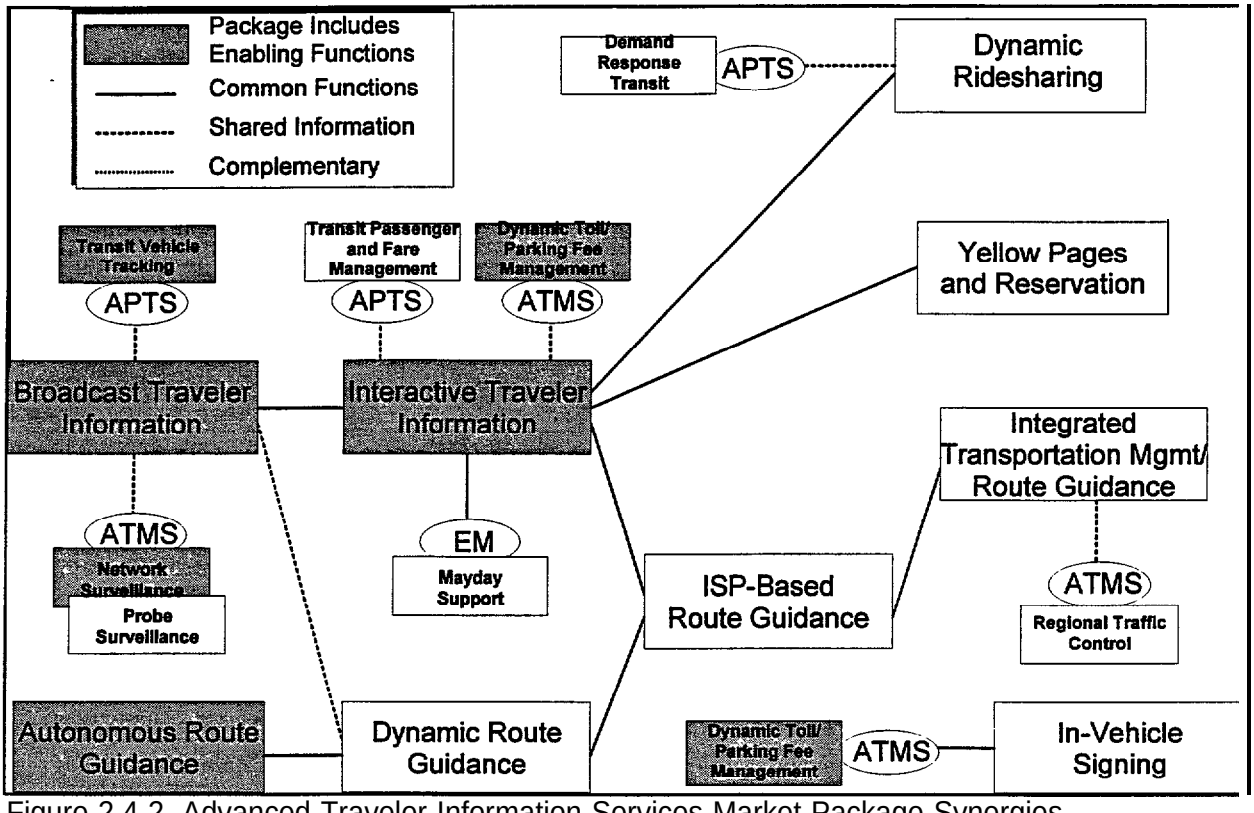


Figure 2.4-2. Advanced Traveler Information Services Market Package Synergies.

Broadcast Traveler Information Market Package

This market package shares many of the basic transportation data collection and management functions with more advanced interactive traveler information packages. This market package and its interactive counterparts each collect traffic, transit and other traveler information for processing and disseminating. In addition to providing advisories and other basic traffic information, this market package can be extended to provide real-time traffic information in a format supporting dynamic route guidance.

Interactive Traveler Information Market Package

This market package shares the basic traveler information collection and management and interactive communications capabilities with more advanced or specialized traveler information market packages. The basic interactive traveler information service can be extended to support centralized route planning services offered by the ISP-Based Route Guidance market package. The interactive capabilities of this market package allow it to

better use information provided by the Transit Passenger and Fare Management and the Dynamic Toll/Parking Fee Management market packages for transit, toll, and parking fees and transit schedules and parking occupancy and reservation.

Autonomous Route Guidance Market Package

This market package provides a rich set of in-vehicle functions that can be utilized by enhanced route guidance services that require interaction with the infrastructure. Each of the more advanced route guidance market packages provide successive enhancements to the infrastructures role in supporting the autonomous vehicle equipment included in this market package.

In-Vehicle Signing Market Package

This market package communicates with the roadside using the same dedicated short-range communications used by the Dynamic Toll/Parking Fee Management market package.

Advanced Public Transit Systems

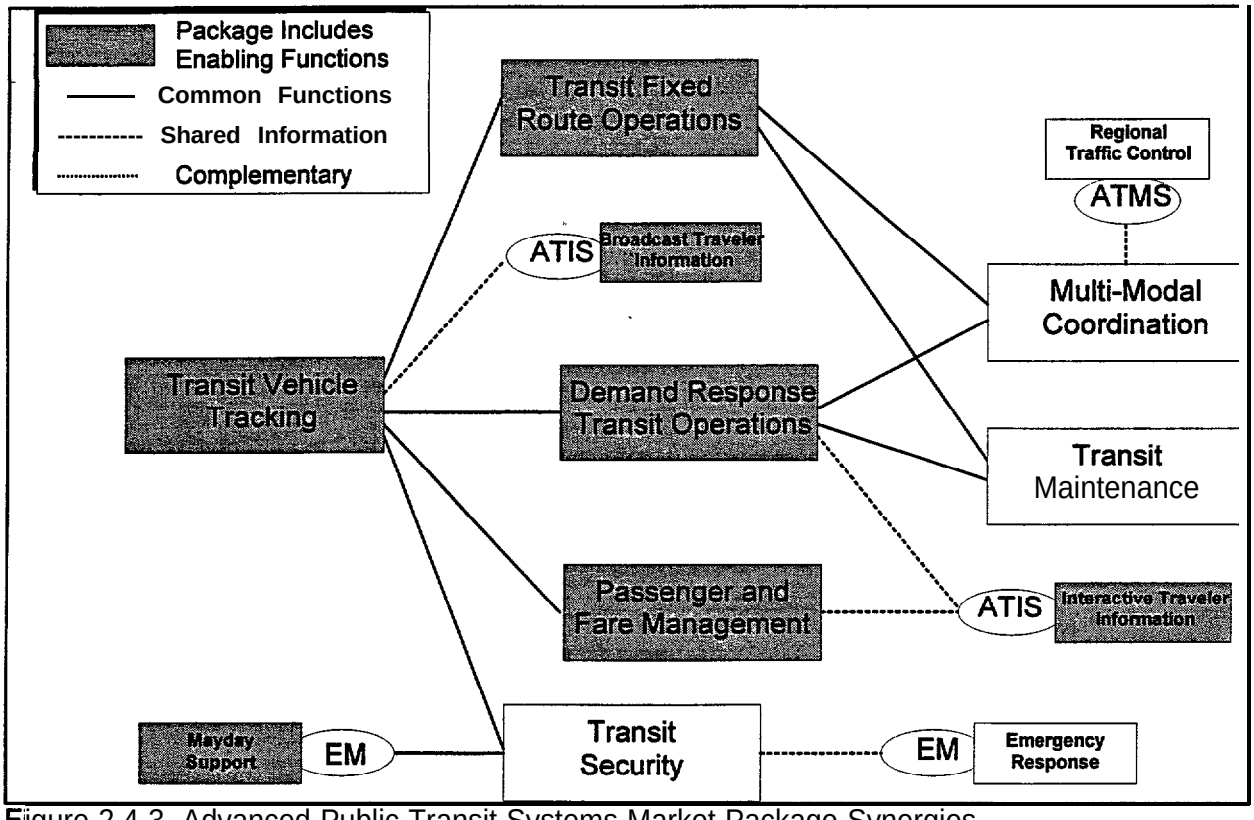


Figure 2.4-3. Advanced Public Transit Systems Market Package Synergies.

Transit Vehicle Tracking Market Package

This market package provides a fundamental vehicle location service that is required by many of the other APTS related market packages since accurate and current knowledge of transit vehicle position is key to many other services. The automated vehicle location and tracking capability provided by this market package is necessary to support the advanced operations packages, passenger and fare management, and transit security. Current transit schedule information, derived through this package, also supports the traveler information market packages.

Transit Fixed Route and Demand Response Transit Operations Market Packages

These two market packages support operations and dispatch and provide key database management functions which are utilized to support more specialized Transit Maintenance and Multi-Modal Coordination market packages. The Demand Response Transit service is only well supported by the more advanced interactive traveler information services which enable a convenient, real-time request/response interface to travelers seeking transit.

Transit Security Market Package

This market package shares emergency notification and status information with the Emergency Response market package. It provides many of the same safety features that are provided by the Mayday Support market package which is oriented towards individual subscribers rather than a transit provider.

Passenger and Fare Management Market Package

This market package shares information with the Interactive ATIS Driver and Traveler Information market package for providing real-time fare information to prospective transit passengers.

Multi-Modal Coordination Market Package

This market package shares transit signal request information with the Regional Traffic Control market package.

Commercial Vehicle Operations

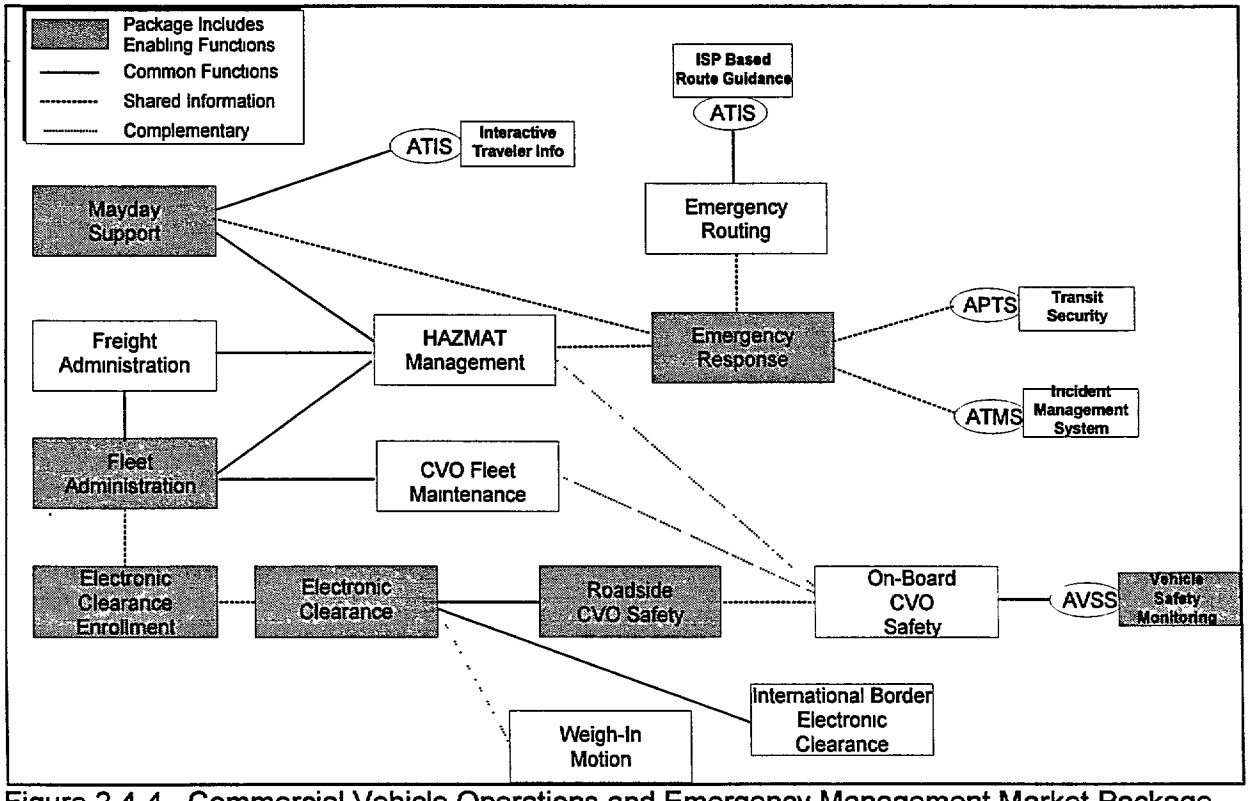


Figure 2.4-4. Commercial Vehicle Operations and Emergency Management Market Package Synergies.

Fleet Administration Market Package

This market package shares common tracking, management, and dispatch capabilities with the Freight Administration, CVO Fleet Maintenance, and HAZMAT Management market packages.

Freight Administration Market Package

This market package adds more specific freight monitoring capabilities to the basic tracking capabilities provided by fleet administration. These more advanced cargo tracking capabilities also support the HAZMAT Management market package.

Electronic Clearance Market Package

This market package is interdependent with the Electronic Clearance Enrollment market package since participants must both enroll (through the enrollment package) and be cleared electronically (using this market package) before a service is actually provided to participating carriers. The International Clearance market package extends the basic clearance functions provided by this package by adding an interface to customs and permitting to support entry and exit from Canada and Mexico. The Weigh-In-Motion market package provides a logical enhancement to the AVI and commercial vehicle screening capabilities offered by this package. The Roadside CVO Safety Market Package provides another potential enhancement that enlists the basic AVI functions established for Electronic Clearance.

Roadside and On-Board CVO Safety Market Packages

This On-Board CVO Safety market package provides advanced sensory and diagnostic capabilities on-board the vehicle that complements the services provided by the HAZMAT Management, CVO Fleet Maintenance, and Roadside CVO Safety market packages by making additional diagnostic data. The roadside checking and verification against database entries and safety standards provided by the Roadside market package will be enhanced by the on-board safety verification provided by the CVO On-Board Safety market package.

HAZMAT Management Market Package

This market package provides HAZMAT spill notification information to the Emergency Response market package.

Emergency Management

Mayday Support

The Mayday Support market package requires a portable traveler interface and interactive, wide area wireless communications between the traveler and the infrastructure. This same portable traveler interface and interactive communications capabilities can be leveraged to support other traveler information capabilities addressed by the Interactive Traveler Information market package. This progression reflects a likely scenario in which the consumer is motivated by the potential for enhanced safety, installs

the equipment, and then becomes part of a larger market for more advanced interactive information services.

Emergency Response Market Package

The Emergency Response market package enables a rapid response to the emergency notifications provided by the Mayday Support, Transit Security, and Incident Management System market packages. The Emergency Routing Market Package provides the basic dispatcher support capabilities which may be extended and integrated to support the required multi-agency coordination supported by the Emergency Response Market Package.

Emergency Routing Market Package

The emergency routing capabilities supported by this market package are a special application of similar route selection algorithms and processing capabilities provided by the traveler-oriented ISP Based Route Guidance Market Package.

Advanced Vehicle Safety Systems

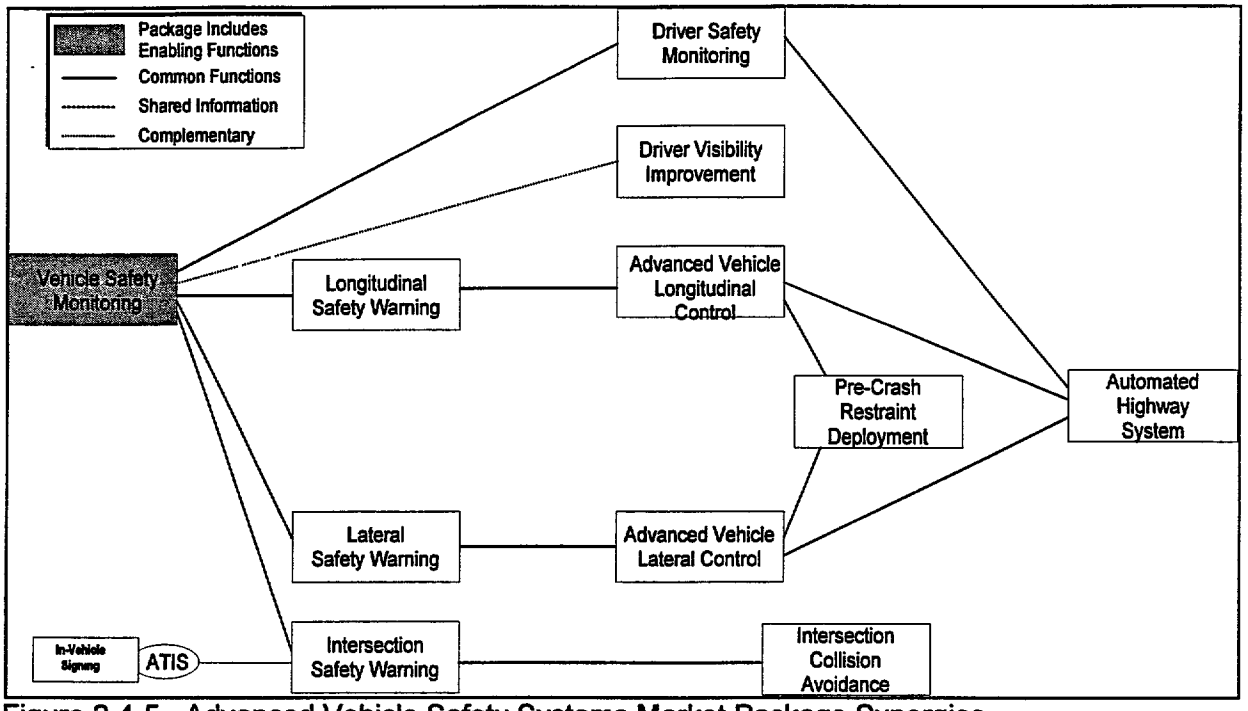


Figure 2.4-5. Advanced Vehicle Safety Systems Market Package Synergies.

Vehicle Safety Monitoring Market Package

This market package shares common functions with the Driver Safety Monitoring, Longitudinal Safety Warning, Lateral Safety Warning and Intersection Safety Warning market packages since each of these packages includes common sensory, processing, and driver interface capabilities. Each of these safety-related market packages may include separate sensing devices, however similar processing algorithms as well as the same or similar processors can be expected. The status and warning displays can be expected to be similar as well.

Longitudinal Safety Warning Market Package

This market package shares common sensory functions with the Advanced Vehicle Longitudinal Control market package. The sensing and detecting of obstacles in the longitudinal direction performed in this market package is directly applicable to the Advanced Vehicle Longitudinal Control market package.

Lateral Safety Warning Market Package

This market package shares common functions with the Advanced Vehicle Lateral Control market package. The proximity sensing and lane following functions performed in this market package may be applied to the Advanced Vehicle Lateral Control market package.

Intersection Safety Warning Market Package

This market package has common functions with the Intersection Collision Avoidance market package. The sensing and detecting of obstacles and conditions in the vicinity of an intersection and communicating this information to on-coming vehicles performed in this market package is directly applicable to its successor, the Intersection Collision Avoidance market package. The provision of basic intersection status to the vehicle supports intersection safety warning and is a logical extension of the in-vehicle signing function provided by a separate market package.

Advanced Vehicle Longitudinal and Lateral Control Market Packages

These two market packages share common functions with the Pre-Crash Restraint Deployment and Automated Highway System market packages. The capability to sense, detect, and act based upon longitudinal and lateral detection is a requirement for the Pre-Crash Restraint Deployment market package. This market package provides these functionalities that would be integral to the Pre-Crash Restraint Deployment market package. Complete automated control of the vehicle is an extension to these predecessor packages.

2.5 Technology Requirements

A range of technologies, each with unique performance, cost, and maturity characteristics can be applied to provide ITS services through the market packages. The majority of these technologies are commercially available and expose the ITS to little technical risk. The most problematic technology implications exist where a required ITS function is not supported by any cost-effective, commercially available technology.

In a few cases, required technologies may not exist or may be too costly and/or unreliable for commercial application. Market packages that are dependent on such technologies require further research and development to provide the enabling technology and integrate it into a commercially viable deployment package. This paragraph identifies the technologies associated with the market packages, defines and determines the maturity for each technology area, and postulates the potential impact to deployment for those critical technologies requiring additional research and development.

Table 2.5-l identifies functional groups of technologies and relates them to the market packages. Each column in the table represents a general technology area which is applied through one or more market packages to support ITS user services. The technology requirements for each market package are presented in the body of the table using the following icons:

■ : The opaque (black) squares denote a basic relationship between the market package and the technology area. This assignment indicates that the technology area is fundamental to the core services provided by the market package.

[] : The transparent (white or gray) squares denote a secondary relationship between the market package and the technology area. This assignment indicates that the technology would enhance the market package through provision of optional features or by playing a

supplementary role in supporting core services. Use of this technology area is desirable but not necessarily required for market package implementation.

The columns in Table 2.5-1 are highlighted for critical technology areas with potential impact to the deployment strategy. The rows in the table are highlighted where a market package requires at least one of the identified critical technology areas.

Table 2.5-1: Market Package Requirements by Technology Area

	Market Packages	Technology Area																						
		Sensor										Comm							User I/F			Control		
		Traffic	Vehicle Status	Environment	Vehicle Monitoring	Driver Monitoring	Cargo Monitoring	Obstacle Ranging	Lane Tracking	Security	Location Determination	Cell-Based (U1)	Vehicle-Roadside (U2)	Vehicle-Vehicle (U3)	Broadcast (U1-B)	Fixed (W)	Algorithms	Information Mgmt	Payment	Driver	Traveler	Operator	Signals	Signs	Vehicle
ATMS	Network Surveillance	■		☐												■	☐	■				■			
	Probe Surveillance				■						■	■	☐			☐	■	■				■			
	Surface Street Control	■														■						■	■		
	Freeway Control	■														■						■	■	☐	
	HOV and Reversible Lane Mgmt	■	■								■	■				■	☐					■	■	■	
	Traffic Information Dissemination														■	■	☐	■				■		☐	
	Regional Traffic Control	■			■											■	■	■				■	■	■	
	Incident Management System	■			■						■	■				■	■	■				■	☐	☐	
	Traffic Network Performance Eval	■			■								■			☐	■	■				■			
	Dynamic Toll/Parking Fee Mgmt	■	■									☐	■		☐	■	■	■	■	■		■	☐	☐	
	Emissions and Enironmental Haz.		■	■	☐											■	■	■		☐		■		☐	
	Virtual TMC and Smart Probes				■						■	■	☐			☐	■	■				■			
APTS	Transit Vehicle Tracking				☐	☐					■	■	☐			☐		■			☐	■			
	Transit Fixed-Route Operations											☐	☐			☐		■		☐	☐	■			
	Demand Response Operations											■				☐	☐	■		■	☐	■			
	Transit Passenger and Fare Mgmt									☐	☐	☐				☐		■	■		■	■			
	Transit Security									■	☐	☐				☐		☐		■	■	■			
	Transit Maintenance				■	☐					☐	☐				☐		■		■		■			
	Multi-modal Coordination										■	■				■	☐	■	☐	■	☐	■			
ATIS	Broadcast Traveler Information	■		☐											■	■	■	☐		■	■	■			
	Interactive Traveler Information	■		☐							☐	■				■	■	☐		■	■	■			
	Autonomous Route Guidance										■						■	☐		■	■				
	Dynamic Route Guidance	■		☐							■	☐			■	■	■	☐		■	■				
	ISP-Based Route Guidance	■		☐							■	■				■	■	■	☐	■	■	■			
	Integrated Transportation Mgmt/RG	■		☐							■	■				■	■	■	☐	■	■	■			
	Yellow Pages & Reservation										☐	■				■	■	☐		■	■	■			
	Dynamic Ridesharing									☐		■				■				■	■	■			
	In Vehicle Signing		☐	☐	☐	☐	☐				■	☐	■			☐	☐	☐		■		☐			
AVSS	Vehicle Safety Monitoring				■												☐			■					
	Driver Safety Monitoring				■	■											■			■					
	Longitudinal Safety Warning				■	☐		■									■			■					
	Lateral Safety Warning				■	☐		■	■								■			■					
	Intersection Safety Warning		■	☐	■	☐		■	■			☐	■	☐		■	■	☐		■			☐	☐	
	Pre-Crash Restraint Deployment				■	☐		■									■								☐
	Driver Visibility Improvement					☐		■												■					
	Advanced Vehicle Longitudinal Ctrl				■	☐		■									■			■					■
	Advanced Vehicle Lateral Control				■	☐		■	■								■			■					■
	Intersection Collision Avoidance		■	☐	■	■		■	■			☐	■	☐		■	■	☐		■			☐	☐	■
	Automated Highway System	☐	■	☐	■	■		■	■	☐	■	■	■	■		■	■	■	☐	■		■	☐	☐	■

Table 2.5-1: Market Package Requirements by Technology Area (Continued)

	Market Packages	Technology Area																								
		Sensor									Comm									User I/F			Control		
		Traffic	Vehicle Status	Environment	Vehicle Monitoring	Driver Monitoring	Cargo Monitoring	Obstacle Ranging	Lane Tracking	Security	Location Determination	Cell-Based (U1)	Vehicle-Roadside (U2)	Vehicle-Vehicle (U3)	Broadcast (U1-B)	Fixed (W)	Algorithms	Information Mgmt	Payment	Driver	Traveler	Operator	Signals	Signs	Vehicle
CVO	Fleet Administration				■						■	■	❑			❑	❑	■		■		■			
CVO	Freight Administration						■				■	■	❑			■	❑	■		■		■			
CVO	Electronic Clearance												■					■		■		■	❑	❑	
CVO	Electronic Clearance Enrollment																								
CVO	International Border Clearance												■					■		■		■	❑	❑	
CVO	Weigh-In-Motion		■										❑				❑					■	❑	❑	
CVO	Roadside CVO Safety		■		❑		❑						■			■	❑					■	❑	❑	
CVO	On-board CVO Safety				■	■	■						❑				❑			■					
CVO	CVO Fleet Maintenance				■						■	■				❑	❑	■		■		■			
CVO	Hazmat Management						■				■	■	❑			■	❑	■		■		■			
EM	Emergency Response	❑								■	❑	❑				■	❑	■				■			
EM	Emergency Routing				❑	❑					■	■	❑			❑	❑	■		■		■			
EM	Mayday Support		❑								■	■				■		❑		■	■	■			
EM	ITS Planning													■		■		■				■			

Table 2.5-2 defines the ITS-relevant technologies identified in Table 2.5-1 and highlights those areas which have been defined as critical. In the table, each basic technology area is defined and qualitatively assessed with regard to relative maturity. The maturity assignments used in the table are defined as follows:

- **Mature:** Current commercially available technology supports the identified ITS requirements in this area. Deployment of the ITS user services is not predicated on further research and development of these technologies.

- **Mature with rapid innovation:** Current commercially available technology supports the identified ITS requirements. The area is one of rapid technology growth which indicates that the basic support provided by current technologies will likely be superseded within the deployment period. While further research and development is not required to support ITS, future deployments may benefit from technology enhancements which should not be precluded by excessive rigidity in the architecture or deployment definitions.

- **Mixed:** This technology area satisfies a range of ITS requirements including some that are not supported by current technology. Useful services may be deployed using currently available technologies; however, satisfying all user service requirements will require additional research and development to bolster the identified deficiencies. Where this assignment is made, the associated description in Table 2.5-1 highlights the specific areas where technology advancement is required.

- **Immature:** Additional research and development is required before technologies in this area can be cost-effectively and reliably applied to support ITS services. In some cases,

potentially suitable technologies have been applied in defense or aerospace applications. Additional research and development is still required in these areas to address the unique producibility, safety, and cost issues associated with larger commercial markets.

Technology areas identified as "Mixed" or Immature" are highlighted in Table 2.5-2 and considered further as "pacing technologies" in this analysis.

Few absolute conclusions can be drawn from the technology maturity assessment alone. The identification of a technology area as immature is not the same as an absolute prediction that deployments will not occur without significant further research. There are numerous examples where relatively immature technologies have been applied in successful products, depending on the customer's needs and expectations. Voice recognition is an example of a technology that might be labeled as immature by this analysis and yet one already finds many workable voice recognition products on the market. Where the need is great enough, creative providers will find other approaches that can be used for interim deployments. For example, technologies which automate vehicle occupant sensing for purposes of determining compliance with HOV requirements are in their infancy. Special rules and manned surveillance stations with high speed cameras are being used in the Fast-Trac Tollway in Southern California to support vehicle occupant sensing today.

Although the relationship is not absolute, the deployment timing for the dependent market packages will be influenced by the timing of the required technology advancements. Unfortunately, accurately forecasting technology development timing is extremely difficult. This timing is dependent upon the current status of the required technology and the quantity and productivity of the research that will be performed in the area. Despite the difficulties, many forecasts of technology development timing have been made based on assessment of the best available information. Table 2.5-3 draws on the assessments contained in the National Program Plan, augmented by other sources, for each pacing technology area.

Table 2.5-2: ITS Technology Areas

Technology	Description	Maturity
Traffic Sensors	Sensor technology which monitors overall traffic conditions. Enables collection of basic aggregate measures such as occupancy, volume, and speed.	Mature
Vehicle Status Sensors	Sensors which determine individual characteristics of passing vehicles. Technologies which assess individual vehicle length, weight, number of axles, lane position, and speed are available. Enforcement application technologies that monitor emissions and passenger counts for specific vehicles are less mature.	Mixed
Environment Sensors	Sensor technology which monitors local climate (temperature, humidity, precipitation, wind, pollution) and road surface status (dry, wet, ice, snow).	Mature

Table 2.5.2- ITS Technology Areas (continued)

Table 2.5.2- ITS Technology Areas (continued)

Table 2.5-2: ITS Technology Areas (continued)

Vehicle Monitoring Sensors	The range of on-board sensor technologies which monitor vehicle condition (e.g. engine, brake, tire, and suspension status) and performance (current speed, acceleration, yaw, traction, current steering, throttle, braking, and transmission status).	Mature
Driver Monitoring Sensors	Technologies which monitor driver condition by monitoring driving characteristics and/or other psychophysiological symptoms associated with impaired performance.	Immature
Cargo Monitoring Sensors	Technologies which monitor various indicators of cargo status. Load distribution, temperature, acceleration, and pressure are among potential indicators that may be monitored depending on the nature of the cargo.	Mature
Obstacle Ranging Sensors	Technologies which detect and characterize potential obstacles (other vehicles, people, road debris) in a vehicle's vicinity. Supports family of applications with variable performance requirements. Advanced headway maintenance requires high frequency and precision. Driver warning systems may have reduced requirements due to human time scale. Vision enhancement sensors must support overall environment imaging.	Immature
Lane Tracking Sensors	Technologies on-board the vehicle which monitor the position of the vehicle with respect to the travel lane and optionally support interpretation of travel lane geometry ahead of the vehicle.	Immature
Security Sensors	Technologies which provide surveillance of, and restrict access to, secure public areas. Card readers which restrict access and closed circuit television cameras are examples.	Mature
Location Determination	Technologies which determine absolute position. Examples include GPS and other systems which apply trilateration to known locations, either terrestrial or space based. Augmenting these technologies are those which measure travel path and distance (e.g., odometer, compass, gyroscope) from a known location. Very high-precision systems associated with vehicle control applications are one remaining research area.	Mature w/ rapid innovation
Cell-Based Communication (U1)	Wide-area wireless communications, both one-way and two-way. Primary examples of mature systems for transmitting ITS information include circuit-switched cellular, Cellular Digital Packet Data (CDPD), and FM subcarrier. Future, emerging technologies include Personal Communications Services (PCS) and various mobile Satellite Networks.	Mature w/ rapid innovation

Table 2.5-2: ITS Technology Areas (continued)

Technology	Description	Maturity
Vehicle-Roadside Communication (U2)	Short range wireless communications between infrastructure and vehicle using active radio frequency, passive (backscatter) radio frequency, and/or infrared.	Mature w/ rapid innovation
Vehicle-Roadside Communication (U2)	Short range wireless communications between infrastructure and vehicle using active radio frequency, passive (backscatter) radio frequency, and/or infrared.	Mature w/ rapid innovation
Vehicle-Vehicle Communication (U3)	High data rate, short range, reliable two way digital communications between vehicles using RF, microwave or infrared spectrum. Favored technical approach has not been selected.	Immature
Fixed Communication (W)	Technologies used to carry information between fixed locations; technology choices are largely dependent on local service provider or local preference for private networks. Various networks (PSTN, ISDN, IP, PDN, private local network) support ITS requirements.	Mature w/ rapid innovation
Algorithms	Processing technology and advanced algorithms which enable advanced vehicle and traffic control applications. Overlap exists between this computational element and the other technology areas it supports.	Mixed
Information Management	Information storage, fusion, and retrieval systems supporting access to distributed heterogeneous data.	Mature w/ rapid innovation
Payment	Technologies which enable secure automated financial transactions in conjunction with information management and communications technologies above. Magnetic strip cards and Smart Card technologies are examples. Both contact and contactless technologies may be used.	Mature w/ rapid innovation
Driver Interface	Audio, visual, and tactile interface technologies appropriate for interaction with drivers during vehicle operation. Console displays (LED, LCD, etc.), heads-up displays and synthesized speech are primary examples of mature technologies. Technologies enabling voice input and non-distracting visual enhancement of the driver's view are less mature.	Mature w/ rapid innovation

Table 2.5-2: ITS Technology Areas (continued)

Traveler Interface	Same technologies as for driver interface with other, varied constraints. Extreme portability requirements restrict interface options for hand-held devices. Additional capabilities, including hard copy options, for fixed presentation devices.	Mature
Operator Interface	Same as for traveler interface.	Mature
Signals	Control signals, barriers, or other physical control devices and supporting electronics.	Mature
Signs	Variable message signs including those which include interface to vehicle-roadside communications technologies enabling complementary in-vehicle displays.	Mature
Vehicle Control	Vehicle control system actuators and supporting processing technology	Immature

Table 2.5-3: Pacing Technology Development Forecasts

Technology	Current Status	Research Projections	Delay
Vehicle Status Sensors -Emissions -Pass. Counts	Infrared technology commercially available to support remote sensing of CO and Hydrocarbons. On-going research in application to remote NOx sensing. Technologies which remotely count passengers without vehicle cooperation in infancy. Implementations which rely on vehicle reporting are more feasible in the near term but face similar institutional obstacles.	Uncertain market potential suggests research will primarily be funded by the public sector	Moderate - Long
Driver Monitoring Sensors	Research stage. Tests indicate marginal performance (75% detection rate with 3% false alarm rate cited in National Program Plan) for current implementations. New monitoring algorithms, monitoring of new symptoms, and combinational approaches are under research.	Uncertain market potential suggests research will primarily be funded by the public sector	Long Term

Obstacle Ranging Sensors	Preliminary commercial market initiatives. Ultrasonic, radar, and machine vision technologies have been developed and marketed in heavy vehicle proximity detection systems. Additional research required to extend performance/reliability to satisfy preemptive control app.'s and decrease cost to achieve private vehicle market price points.	Large market potential indicates continued robust private sector research initiatives, supplemented by federal research driven by safety benefits and AHS program.	Moderate
Lane Tracking Sensors	Research stage. Proof-of-concept systems using various infrastructure support concepts (e.g., magnetic nails, special paint/markers, active beacons) have been developed with promising results in controlled environments. Machine vision application to lane departure warning systems without special infrastructure support under study.	Potentially large market in the long term indicates continued private sector research initiatives, supplemented by federal research driven by safety benefits and AHS program.	Long Term
Vehicle-Vehicle Comm (U3)	Preliminary research stage. Academic research supported by isolated tests in US (PATH program), Japan (Toyota), and Europe (RACE Programme).	Near-term US research will continue on limited scale substantially augmented by AHS program in the near term.	Long Term
Algorithms	Varied status depending on application area (see other entries in this table). Traffic prediction algorithms (not covered elsewhere) are rudimentary since sufficient source data is not commonly available.	Level of research dependent on application area.	Moderate - Long
Vehicle Control	Academic research as well as proof-of-concept tests in US, Japan, and Europe funded by public sector and automotive industry. Sensory support and control algorithms are primary research areas.	Potentially large market suggests continued private sector research initiatives, supplemented by federal research driven by safety benefits and AHS program.	Moderate - Long

2.6 Standards Requirements

Appropriate standards are fundamental to the establishment of an open, ITS architecture. Standards will enable deployment of consistent, non-interfering, reliable systems on local, regional and national levels. Open standards will further benefit the consumer by enhancing competition for the range of products necessary to implement the ITS user services. Producers benefit from standards because they assure a wide market over which the product can be sold. As deployment occurs, diverse systems will be developed to address the special needs of urban, suburban and rural environments. Standards must ensure interoperability across these implementations without impeding innovation as technology advances and new approaches evolve.

A complete discussion of the standards requirements associated with the ITS Architecture is presented in the companion Standards Development Plan and Standards Requirements Document deliverables. This section provides an overview of this material as it applies to the implementation strategy developed in this deliverable.

2.6.1 IDENTIFYING STANDARDS REQUIREMENTS

The architecture is a framework that is intended to guide the establishment of standards which will enable nationwide ITS interoperability and compatibility. Table 2.6-1 provides interoperability assignments for each of the major system interfaces defined by the architecture. The first column in the table identifies each of the subsystems, and the second column identifies the associated interfaces (either to other subsystems or other interfaced systems as defined by the architecture). As presented in the table, several levels of interoperability ranging from no interoperability to national interoperability are suggested for each of the interfaces. In some cases, only a portion of the interface may need to be standardized, including only the particular set of messages or core data that is required to guarantee the successful delivery of an ITS service. To encourage early deployment and maximum utilization of existing infrastructure, standards requirements for the many internal interfaces within each subsystem (e.g., within a Traffic Management Subsystem) are not addressed by the Architecture.

Table 2.6-1: Major Subsystem Interface Interoperability Assignments

Subsystem	Interfacing Subsystem/System	Interoperability
Commercial Vehicle Administration	Commercial Vehicle Check	regional
Commercial Vehicle Administration	CVO Information Requestor	national
Commercial Vehicle Administration	DMV	national
Commercial Vehicle Administration	Enforcement Agency	regional
Commercial Vehicle Administration	Financial Institution	national
Commercial Vehicle Administration	Fleet and Freight Management	national
Commercial Vehicle Administration	Other CVAS	national
Commercial Vehicle Administration	Planning Subsystem	regional
Commercial Vehicle Check	Commercial Vehicle Administration	regional
Commercial Vehicle Check	Commercial Vehicle Subsystem	national
Commercial Vehicle Subsystem	Commercial Vehicle Check	national
Commercial Vehicle Subsystem	Fleet and Freight Management	none
Emergency Management	E911 or ETS	regional
Emergency Management	Emergency Vehicle Subsystem	regional
Emergency Management	Fleet and Freight Management	national
Emergency Management	Information Service Provider	regional
Emergency Management	Map Update Provider	national
Emergency Management	Other EM	regional
Emergency Management	Personal Information Access	national
Emergency Management	Planning Subsystem	regional
Emergency Management	Remote Traveler Support	national
Emergency Management	Traffic Management	regional
Emergency Management	Transit Management	regional
Emergency Management	Vehicle	national
Emergency Vehicle Subsystem	Emergency Management	regional
Emergency Vehicle Subsystem	Roadway Subsystem	regional
Emissions Management	Map Update Provider	national
Emissions Management	Planning Subsystem	regional
Emissions Management	Roadway Subsystem	product
Emissions Management	Traffic Management	product
Fleet and Freight Management	Commercial Vehicle Administration	national
Fleet and Freight Management	Commercial Vehicle Subsystem	none
Fleet and Freight Management	Emergency Management	national
Fleet and Freight Management	Information Service Provider	none

Table 2.6.1- Major Subsystem Interface Interoperability Assignments

Table 2.6-1: Major Subsystem Interface Interoperability Assignments

Subsystem	Interfacing Subsystem/System	Interoperability
Fleet and Freight Management	Intermodal Freight Depot	national
Fleet and Freight Management	Intermodal Freight Shipper	regional
Information Service Provider	Emergency Management	regional
Information Service Provider	Financial Institution	national
Information Service Provider	Fleet and Freight Management	none
Information Service Provider	Intermodal Transportation Service	regional
Information Service Provider	Map Update Provider	national
Information Service Provider	Media	product
Information Service Provider	Other ISP	national
Information Service Provider	Parking Management	regional
Information Service Provider	Personal Information Access	national
Information Service Provider	Planning Subsystem	regional
Information Service Provider	Remote Traveler Support	product
Information Service Provider	Toll Administration	regional
Information Service Provider	Traffic Management	regional
Information Service Provider	Transit Management	regional
Information Service Provider	Vehicle	national
Information Service Provider	Weather Service	regional
Parking Management	DMV	national
Parking Management	Enforcement Agency	regional
Parking Management	Financial Institution	national
Parking Management	Information Service Provider	regional
Parking Management	Parking Service Provider	product
Parking Management	Planning Subsystem	regional
Parking Management	Traffic Management	regional
Parking Management	Transit Management	regional
Parking Management	Vehicle	national
Personal Information Access	Emergency Management	national
Personal Information Access	Information Service Provider	national
Personal Information Access	Map Update Provider	national
Personal Information Access	Transit Management	national
Planning Subsystem	Map Update Provider	national
Planning Subsystem	Traffic Management	regional
Remote Traveler Support	Emergency Management	national
Remote Traveler Support	Information Service Provider	product
Remote Traveler Support	Map Update Provider	national
Remote Traveler Support	Transit Management	product
Roadway Subsystem	Emissions Management	product
Roadway Subsystem	Multimodal Crossings	national
Roadway Subsystem	Traffic Management	product
Roadway Subsystem	Vehicle	national
Toll Administration	DMV	national
Toll Administration	Enforcement Agency	regional
Toll Administration	Financial Institution	national
Toll Administration	Information Service Provider	regional
Toll Administration	Planning Subsystem	regional
Toll Administration	Planning Subsystem	regional
Toll Administration	Toll Collection	regional
Toll Administration	Traffic Management	regional
Toll Collection	Toll Administration	regional
Toll Collection	Vehicle	national
Traffic Management	DMV	national
Traffic Management	Emergency Management	regional
Traffic Management	Emissions Management	product
Traffic Management	Enforcement Agency	regional
Traffic Management	Information Service Provider	regional
Traffic Management	Map Update Provider	national
Traffic Management	Other TM	regional
Traffic Management	Parking Management	regional

Table 2.6-1: Major Subsystem Interface Interoperability Assignments

Subsystem	Interfacing Subsystem/System	Interoperability
Traffic Management	Planning Subsystem	regional
Traffic Management	Roadway Subsystem	product
Traffic Management	Toll Administration	regional
Traffic Management	Transit Management	regional
Traffic Management	Weather Service	regional
Transit Management	Emergency Management	regional
Transit Management	Enforcement Agency	regional
Transit Management	Financial Institution	national
Transit Management	Information Service Provider	regional
Transit Management	Intermodal Transportation Service	regional
Transit Management	Map Update Provider	national
Transit Management	Other TRM	regional
Transit Management	Parking Management	regional
Transit Management	Personal Information Access	national
Transit Management	Planning Subsystem	regional
Transit Management	Planning Subsystem	regional
Transit Management	Remote Traveler Support	product
Transit Management	Traffic Management	regional
Transit Management	Transit Vehicle Subsystem	product
Transit Vehicle Subsystem	Roadway Subsystem	regional
Transit Vehicle Subsystem	Roadway Subsystem	regional
Transit Vehicle Subsystem	Transit Management	product
Transit Vehicle Subsystem	Transit Vehicle	product
Vehicle	Emergency Management	national
Vehicle	Information Service Provider	national
Vehicle	Map Update Provider	national
Vehicle	Other Vehicle	national
Vehicle	Parking Management	national
Vehicle	Roadway Subsystem	national
Vehicle	Toll Collection	national

In general, the minimal level of standardization necessary to achieve the interoperability goals of the national architecture is suggested by the table. The following rules were used in making the standards assignments:

Interfaces between subsystems that are operated and maintained by a single stakeholder do not require standardization to achieve national interoperability. The data formats and communications mechanisms that are used for these interfaces are transparent to the remainder of the architecture. In some cases, national standards are still attainable and beneficial since they may consolidate a market to achieve economy of scale efficiencies (e.g. Traffic Management Subsystem to Roadway Subsystem). For these interfaces, "Product" interoperability is specified in the figure. Such standards also support an optional level of interoperability by enabling various cooperative control options to be implemented based on regional preference. In other cases, the sheer range of application-specific interfaces precludes efficient national standardization and no standard is specified.

Examples: Traffic Management Subsystem to Roadway Subsystem, Freight and Fleet Management Subsystem to Commercial Vehicle Subsystem.

Interfaces connecting subsystems that may be operated by different agencies (interfaces that can span jurisdictional and/or regional boundaries) should be standardized to facilitate the sharing of information between agencies. National standards mitigate issues that may arise as boundaries change and new requirements for information sharing develop over time. In the

diagram, “Regional” interoperability is specified where the underlying coordination issues are regional, rather than national, in scope. For instance, there is no real requirement for a Traffic Management Subsystem in California to be able to communicate and coordinate with a Traffic Management Subsystem in New York. Two different regional dialects for Traffic Management Subsystem communications could evolve in the two geographically isolated subsystems without significant impact to national interoperability goals.

Example: Traffic Management Subsystem to Transit Management Subsystem, Traffic Management Subsystem to Information Service Provider, Traffic Management Subsystem to Traffic Management Subsystem.

Interfaces to the mobile subsystems (Vehicle Subsystems, Personal Information Access Subsystems) are a major focus in the national architecture since the same mobile subsystem should be able to roam the nation and use the local infrastructure to support ITS services. “National” interoperability is specified for all interfaces to mobile subsystems except where both the mobile subsystem and interfacing infrastructure are owned and operated by the same user

Examples: Information Service Provider to Personal Information Access Subsystem, Toll Collection Subsystem to Personal Vehicle Subsystem, Commercial Vehicle Subsystem to Commercial Vehicle Check Subsystem.

As a minimum, the key application data that is communicated across each of the identified interfaces will be specified. This degree of specification preserves the choice of communications media/frequency and protocols for the implementing agencies. National standard interfaces to mobile subsystems must be more fully specified to ensure the mobile subsystem can communicate with the local ITS infrastructure or other mobile subsystems regardless of where in the nation it is.

Identification of standards requirements for each subsystem interface may lead to some redundancy; for example, general purpose message elements such as location reference and time measures should be defined once and be applicable across multiple interfaces. There are numerous groups that are already examining this type of issue. The Standards Development Organizations (SDOs) will seek coordination and commonality as a natural part of their process in developing the ITS-related standards. Also, some of the market packages have optional features that may be implemented as part of future upgrades to an initial basic implementation. Thus, the constraints levied by standards on initial market package deployments may be less than Table 2.6-I suggests.

2.6.2 ADDRESSING THE STANDARDS REQUIREMENTS

The standards requirements associated with ITS may be addressed in three general ways: (1) application of existing standards to ITS, (2) enhancing existing standards to more specifically accommodate ITS functions, and (3) development of new standards for emerging technologies and applications. It is anticipated that it will be possible to produce valid ITS implementations that almost exclusively utilize existing or emerging commercial communications technology and standards. Based on this expectation, emphasis will be placed on standardizing the data to be communicated and not on the communications media or protocols.

Based on the interoperability assignments highlighted in the previous section, the standardization needs associated with each of the market packages can be determined. This essentially aligns the standards with the deployments they are intended to support. This relationship between market packages and standards can then be used to prioritize standards relative to their importance to near-term deployment. Note that standards priorities will be somewhat independent from the "National", "Regional", "Product", and "None" assignments developed in this section. Both priority and non-priority "National" interfaces may be identified, for example. The distinction is that while both interfaces require standards, the priority interfaces are viewed as critical to the early rollout of ITS services. Non-priority standards may not be as urgent, may have dependencies on the definition of priority interface standards, or may be based on as yet undefined or immature technology. Similarly, a high priority standard may be identified for an interface where standardization is only "encouraged". This may occur where there is early and significant deployment activity for the related services and there is significant economic benefit forecast for early standardization. In all cases, it will be desirable to specify a phased set of compatible standards that can be implemented over time for each interface.

Standards dependencies are "soft" since the absence of published standards may be a deterrent to, but will not prevent, a product developer from pursuing new markets. Historically, standards have followed commercial markets rather than led; it is assumed that this general principle will be repeated for ITS deployments. Where there is clear benefit (e.g., existing market opportunity) to early deployment, it is understood that many market package deployments will occur before the related standards are available. Such early deployments will ultimately be at risk since any pre-existing equipment is likely to conflict with the standard which is finally adopted. The alternative, to somehow regulate entry to the market until the standards are complete is neither viable nor attractive. Early deployments are necessary to provide the SDOs an understanding of all the issues at hand; they provide valuable input to ensure the standards which are finally adopted are viable.

A complete treatment of the planned development of ITS standards and their relationship to the National Architecture effort is included in the Standards Development Plan deliverable. Additional recommendations on standards adoption, supporting legacy systems, and other issues which are related to standards development are identified in section 5.1 of this document.

2.7 Identifying Key Market Packages

The market packages presented in section 2.2 are inter-related and are also dependent on external factors such as technology advancement, policy change, and development of common interface standards as detailed in sections 2 and 3 of this document. Moreover, each market package provides different benefits, lends itself to different cost recovery mechanisms, and is subject to different levels of market influence. It is through the interplay of these influences that ITS deployments will occur over time.

Figure 2.7-I is a generalized view of the factors which influence deployment of each market package. Each of these factors is discussed in the Implementation Strategy in the indicated section. An efficient deployment strategy can reduce the need for the motivators presented on the left hand side of the figure (e.g., Strategic Investment) by recognizing the time-dependent nature of the impediments on the right hand side of the figure (e.g., Technology Constraints) in the deployment strategy.

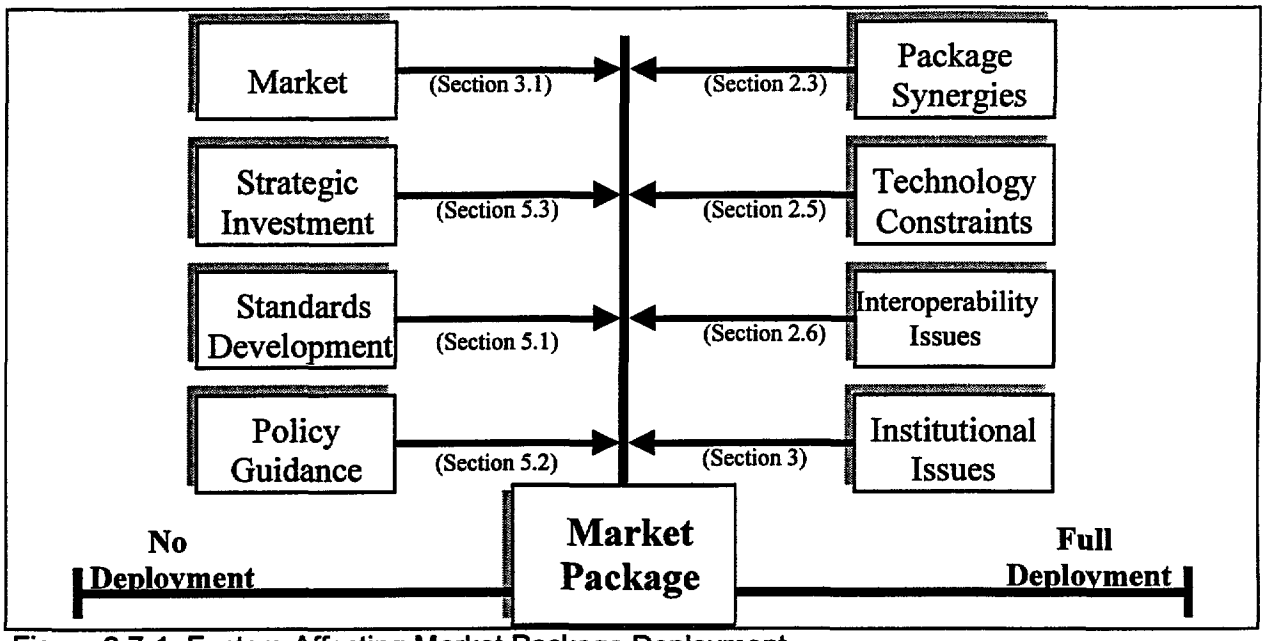


Figure 2.7-1: Factors Affecting Market Package Deployment

The deployment impediments identified in figure 2.7-1 are generally reduced over time. As ITS deployment is initiated and basic market packages are deployed, the deployment of more advanced market packages which build on the existing capabilities will be enabled. As technology advances, technical constraints for a market package should be reduced. As the required standards are developed and approved, interoperability issues are resolved. Thus, as a natural progression, market demand may overcome the challenges associated with an increasing number of market packages over time as the impediments are reduced. The implementation strategy then requires a forecast of this market driven deployment coupled with a plan for judicious application of additional motivators where this forecast natural progression is unsatisfactory.

By considering each of these factors, a subset of the market packages have been highlighted as important early deployments. Such market packages are identified as *key market packages* in this section. The evaluation leading to this market package prioritization is based on the supporting analysis in sections 2, 3 and 5 in this document as highlighted in figure 2.7-1. The key market packages are those packages that meet, or nearly meet, three general criteria:

- *Core function.* A key market package satisfies fundamental requirements that enable implementation of a range of more advanced packages that can be selectively implemented over time to meet local needs.

- *Feasible.* A key market package can be implemented with existing technologies, is not dependent on forthcoming national standards for basic implementations, and is also subject to limited non-technical risk since existing institutions and policy are also adequate to support basic implementations.

- *Established Benefit.* A key market package has already been implemented in several locations around the nation which is an indicator of potential demand for the package. Moreover, these preliminary deployments have demonstrated tangible benefits in an

operational setting. As such, a key market package is shrouded by fewer unknowns and is likely to subject the local implementor to limited risk. These criteria indicate that market influence is likely to be a significant near-term force in enabling early deployment for the identified packages.

In short, the key market packages appear to be early winners due to a promising combination of low risk implementation characteristics, developing public or private markets for the packages, and tangible system or user benefits.

Table 2.7-l evaluates the market packages against these attributes and identifies the key market packages. A summary of the source and approach for developing each dimension of the evaluation summarized in the table is described.

Core Function: Market packages that are checked (u) are highlighted in the market package synergy analysis in section 2.3 of this Implementation Strategy as providing critical early capabilities that will enable future deployments of more advanced services.

Technology Supports: The majority of the market packages require only relatively mature, commercially available technologies for implementation. Market packages that are checked (ii) are identified in section 2.5 of this Implementation Strategy as not reliant on an identified critical technology area. In interpreting the analysis from section 2.5, basic implementations were also considered. For instance, the HOV and Reversible Lane Management market package is identified in section 4.1 as reliant on a critical vehicle passenger occupancy verification technology. Since useful implementations of this market package can be achieved, even without this technology, this market package is still identified as technically feasible in Table 2.7-1.

Standards Exist: Market packages that are checked (ii) are not dependent on forthcoming national standards for basic implementations as analyzed in section 2.6. In reviewing the standard interface requirements associated with each of the market packages, interfaces that are fundamental to provision of a service were distinguished from optional interfaces. Also, it was recognized that even fundamental “national interoperability” requirements will often be met through multiple, competing product-specific “standards”. For instance, the Autonomous Route Guidance market package is identified as requiring a national interoperability interface to a Map Update Provider. Viable implementations can occur in the absence of a nationally prescribed standard using proprietary map databases that provide the required coverage. Emerging standards efforts such as the Spatial Data Transfer Standard and Open GIS may ultimately enable plug and play interoperability between different map databases. In the mean time, viable products can and will be developed based on the existing proprietary standards. These assumptions to some degree accurately reflect the interplay of market forces and standards and the evolution through proprietary interfaces to open standards as the products and market matures. All market packages which can be viably implemented without the associated standards are identified in the column.

Institutionally Feasible: Market packages that are subject to limited non-technical risk per the analysis included in section 3 of this Implementation Strategy are checked (ii). Market packages that were identified as having associated interjurisdictional issues, liability implications, antitrust issues, privacy issues, or regulatory constraints in section 3 are not checked in the column.

Established *Benefit:* Results from the separate "Performance and Benefits Study" deliverable were used as a basis for this column. Only market packages that were highlighted in the Performance and Benefits study deliverable as particularly beneficial are checked in this column. To further reduce the set of candidate market packages, only those market packages which have existing or currently emerging implementations were considered since the benefits associated with these market packages can be more reliably estimated.

The key market packages are those that best satisfy the combination of these criteria as identified in the last column of table 2.7-l. In some cases, a compelling benefit or significant market activity for a market package caused it to be identified as key even though there may be remaining standards or institutional issues associated with that package. The shaded boxes in the table identify where a market package designated as key is dependent on development of a standard or resolution of institutional issues; such activities are crucial near-term activities to support successful deployment of ITS.

Table 2.7-l: Identifying Key Market Packages

Market Package	Core Function	Technology Available	Standards not Reqd	Institutionally Feasible	Established Benefit	Key Package
Traffic Management						
Network Surveillance	✓	✓	✓	✓	✓	✓
Probe Surveillance	✓	✓				
Surface Street Control	✓	✓	✓		✓	✓
Freeway Control	✓	✓	✓		✓	✓
HOV and Reversible Lane Mgmt		✓	✓			
Traffic Information Dissemination		✓	✓	✓		✓
Regional Traffic Control	✓	✓			✓	✓
Incident Management System		✓	✓		✓	✓
Traffic Network Performance Eval		✓	✓			
Dynamic Toll/Parking Fee Mgmt	✓	✓			✓	✓
Emissions & Environ. Hazards Sensing					✓	
Virtual TMC and Smart Probe Data		✓				
Transit Management						
Transit Vehicle Tracking	✓	✓	✓	✓	✓	✓
Transit Fixed-Route Operations	✓	✓	✓	✓	✓	✓
Demand Response Transit Operations	✓	✓	✓	✓	✓	✓
Transit Passenger and Fare Mgmt	✓	✓		✓	✓	✓
Transit Security		✓			✓	✓
Transit Maintenance		✓	✓	✓		✓
Multi-modal Coordination		✓				
Traveler Information						
Broadcast Traveler Information	✓	✓		✓	✓	✓
Interactive Traveler Information	✓	✓	✓	✓	✓	✓
Autonomous Route Guidance	✓	✓	✓	✓	✓	✓
Dynamic Route Guidance		✓		✓	✓	
ISP Based Route Guidance		✓				
Integrated Transportation Mgmt/						
Yellow Pages and Reservation		✓		✓		
Dynamic Ridesharing		✓				
In Vehicle Signing		✓				
Advanced Vehicle Systems						
Vehicle Safety Monitoring	✓	✓	✓	✓	✓	✓

Market Package	Core Function	Technology Available	Standards not Reqd	Institutionally Feasible	Established Benefit	Key Package
Driver Safety Monitoring			✓			
Longitudinal Safety Warning			✓	✓		
Lateral Safety Warning			✓	✓		
Intersection Safety Warning						
Pre-Crash Restraint Deployment			✓	✓		
Driver Visibility Improvement			✓			
Advanced Vehicle Longitudinal Control			✓			
Advanced Vehicle Lateral Control			✓			
Intersection Collision Avoidance						
Automated Highway System						
Commercial Vehicle Operations						
Fleet Administration	✓	✓	✓	✓	✓	✓
Freight Administration		✓	✓	✓	✓	
Electronic Clearance	✓	✓		✓	✓	✓
Electronic Clearance Enrollment	✓	✓		✓	✓	✓
Intn'l. Border Electronic Clearance		✓			✓	
Weigh-In-Motion		✓	✓	✓	✓	
Roadside CVO Safety	✓	✓		✓	✓	✓
On-board CVO Safety						
CVO Fleet Maintenance		✓	✓	✓		
HAZMAT Management		✓			✓	✓
Emergency Management						
Emergency Response	✓	✓			✓	✓
Emergency Routing		✓	✓	✓	✓	✓
Mayday Support	✓	✓			✓	✓
ITS Planning	✓	✓			✓	✓

Notes: Check marks (✓) indicate the market package meets the criteria identified in the column heading.

Further rationale is provided for each of the key market packages in the following:

Traffic Management:

Network Surveillance. This market package provides the basic sensing elements for traffic management. It is the foundation upon which control and management systems can be implemented. It is also a vital source of information supporting real-time traveler information systems which makes it among the most crucial of the identified "core functions".

Surface Street Control. Benefits are well established for this market package and existing technologies and institutional arrangements support its deployment. Interjurisdictional issues which may be associated with broader implementations are also resolvable based on the success of existing wide area implementations. The imminent arrival of the NTCIP standard further facilitates advanced implementations.

Freeway Control. See surface street control.

Traffic Information Dissemination. The equitable distribution of basic traffic information through Variable Message Signs and Highway Advisory Radio implemented through this market package provides immediate benefit to the traveling public using established technologies and without the need for new standards or investment in new in-vehicle equipment. The

implementations represented by this market package have been, and will continue to be, judiciously deployed as the technical and non-technical challenges of more advanced en-route driver information systems are addressed.

Regional Traffic Control Traffic control strategies are increasingly regional in scope with emphasis on improving flow along major travel corridors. The potential benefits of integrated regional strategies have been clearly established through many trial implementations. Such implementations are also one of the focus areas within the Intelligent Transportation Infrastructure Initiative (see section 2.8). The peer-to-peer interjurisdictional arrangements and regional communications internetworking that enable regional control strategies facilitate implementation of many of the other traffic control and traveler information market packages.

Incident Management. Since incidents account for a significant percentage of congestion, this market package is a key early deployment which is actively being deployed in larger metropolitan areas. Preliminary implementations that achieve significant benefit are possible without new standards activity. Interjurisdictional issue resolution which is inherent in this market package has already successfully occurred in many areas.

Dynamic Toll Parking Fee Management. This market package provides tangible benefits to users when compared to manual systems and is generally well accepted and widely deployed. This market package is also naturally self sustaining through user fees. The market package provides core dedicated short range communications, basic driver interface, and AVI functions that can enable several other market packages.

Transit Management:

Transit Vehicle Tracking. This market package provides the communications between vehicles and transit centers and current vehicle location information that is required by other packages. The technology of Automatic Vehicle Location is proven and in use by many transit agencies. While insufficient data exists at this time to validate transit benefits, its usage in commercial transportation such as the trucking industry has shown it to be beneficial.

Transit Fixed Route Operations. This market package provides many of the operations and planning functions required in an automated transit management system. It is in place in many parts of the United States with many vendors providing automated transit management system software products.

Transit Demand Responsive Operations. As with the fixed route operations package, this market package provides many of the core operations and planning functions that would be required by the larger demand responsive fleet.

Transit Passenger and Fare Management. This market package provides immediate and tangible benefit to transit users who enjoy the convenience of an electronic fare medium. The benefits of more efficient, cashless operations also accrue to the implementing transit agencies. These deployments are possible in the interim while industry standards move towards the ultimate goal of a common fare medium that transcends transportation modes and regions and may be applied in other consumer transactions.

Transit Security. ITS applications which improve the security of transit users are one of the tools available to transit agencies. Current US DOT support for these systems is demonstrated by their inclusion within the Intelligent Transportation Infrastructure initiative. Potential privacy issues associated with this market package must be considered and implementations selected which strike an appropriate balance between individual privacy and personal safety.

Transit Maintenance. Advanced applications which enhance maintenance monitoring and support for transit vehicles can improve overall transit system performance and make operations more efficient. Current US DOT support for these systems is demonstrated by their inclusion within the Intelligent Transportation Infrastructure initiative.

Traveler Information:

Broadcast Traveler Information. It satisfies the core criteria in that most of the collection and processing capabilities of this package can be used for other ATIS packages. This package provides many of the traveler information functions in basic forms. It is currently in use today through mediums such as FM subcarrier in Europe. This market package does require the establishment of national standards for basic viable implementations.

Interactive Traveler Information. This package is a foundation for interactive ATIS and provides the interconnects for the two-way interchange. Examples of current usage are kiosks, telephone, and as an emerging information provider for on-line services and the Internet. Stated-preference surveys indicate that pre-trip access to information through these existing access mechanisms will be well received. More advanced implementations which seamlessly cater to the mobile traveler with en-route information require additional standards work.

Autonomous Route Guidance. Basic autonomous implementations are enjoying preliminary market success, at least in niche markets such as rental fleets. These deployments are not predicated on further technology, institutional policy, or standards development. The in-vehicle equipment provides core position location and routing functions that may be applied to a host of more advanced packages.

For AVSS:

Vehicle Safety Monitoring. This market package provides the processing and display basis for most of the AVSS market packages. In various simplified forms, this package already exists in vehicles, e.g., brake light outage indicators, electrical system malfunctions indicators, etc. The benefits of these systems are validated by their growing usage by automobile manufacturers. Whether the existing electrical systems will accommodate requirements from this package is a current issue, especially in light of developments of data bus architectures such as J1850

Commercial Vehicle Operations:

Fleet Administration. This market package provide the capabilities of Automatic Vehicle Location and Fleet Management. These capabilities are in place and have proven benefit to the trucking industry.

Electronic Clearance. This market package established the dedicated short range communications between the vehicle and roadside that supports electronic clearance as well as many of the other market packages that are extended applications dependent on the short

range communications link. Time savings for participating carriers have been measured and reported in several operational tests.

Electronic Clearance *Enrollment.* This market package establishes electronic communications between the commercial vehicle administration and fleet management subsystems. This connectivity enablescarrier enrollment that provides a basis for paperless trucking and also supports many of the more advanced commercial vehicle services.

Roadside CVO Safety. The promise of improved safety is a principal motivator for application of ITS to commercial vehicle operations. The more effective and focused roadside safety inspections offered by this market package most directly address this objective. This market package also develops the roadside equipment and interfaces that will ultimately leverage the separate On-board CVO Safety market package.

HAZMAT Management. Hazardous material management addresses one of the more serious safety issues associated with commercial vehicle operations. This market package is also included within the Intelligent Transportation Infrastructure initiative.

Emergency Management:

Emergency Response. This market package is central to developing coordinated emergency management including emergency management, traffic, and transit stakeholders. This market package is a key component to enhancing safety in conjunction with the Incident Management and Mayday Support market packages.

Emergency Routing. An area of active private sector interest and public sector procurement, this market package leverages the same vehicle location, wide area digital communications, dispatch support, and in-vehicle interactive interface technologies that are instrumental to the related commercial and transit fleet support market packages. New standards are not required to support basic implementations. Progressive implementations which address more extensive inter-agency coordination in routing may be added as new standards become available and are adopted for the implementing region.

Mayday Support. Active private sector deployment of Mayday systems as value-added options on new automobiles highlights the potential for this package as an early deployment. Based on outreach performed through the architecture program and other industry activity, this appears to be an area of near-term and active development. Early deployments establish interactive, digital communications capabilities in the vehicle which can be leveraged by other market packages. National standards may enhance the performance and reliability of the service provided.

2.8 Intelligent Transportation Infrastructure

On January 10, 1996, Secretary of Transportation Federico Pena set a national goal: To build an Intelligent Transportation Infrastructure across the United States. As part of this goal, a very tangible target was set for implementing this Intelligent Transportation Infrastructure (ITI) in the 75 largest metropolitan areas within 10 years. The concept of an ITI is compelling since it focuses attention on what can be implemented today in metropolitan areas where transportation problems are most pronounced.

This section takes a closer look at the Intelligent Transportation Infrastructure (ITI) and connects its nine elements with the National Architecture definition and market packages which were defined earlier in section 2. Through this mapping, the subset of the national architecture is identified as a national interoperability framework within which an Intelligent Transportation Infrastructure may be deployed. The remainder of this Implementation Strategy then emphasizes the ITI elements that are the best candidates for near term implementation.

2.8.1 INTELLIGENT TRANSPORTATION INFRASTRUCTURE OVERVIEW

The U.S. DOT has defined nine components within the ITI:

1. *Regional Multimodal Traveler Information Center.* This system is a repository for current, comprehensive and accurate roadway and transit performance data. It directly receives this data from a variety of public and private sector sources, combines and packages this data, and provides the resulting information to travelers and other customers via a variety of distribution channels. The RMTIC may be a single physical facility or an inter-connected set of facilities.

2. *Traffic Signal Control System.* This system provides coordinated traffic signal control across the metropolitan area. Traffic information is shared between jurisdictional systems as necessary to support the extended coordination area. Variations in control sophistication range up to automated generation of timing plans and adaptive traffic signal control.

3. *Freeway Management System.* This system monitors traffic conditions on the freeway system, identifies recurring and non-recurring flow impediments, implements appropriate control and management strategies (such as ramp metering or lane control), and provides critical information to travelers using dissemination methods such as variable message signs and highway advisory radio.

4. *Transit Management System.* This system provides reliable and timely bus position information to the dispatcher. The dispatcher or a central computer compares the actual location with the scheduled location, enabling positive action to improve schedule adherence and expanded information to the RMTIC. In addition, on-board sensors automatically monitor data such as vehicle passenger loading, fare collection, drive line operating conditions, etc., providing for real-time management response. In the event of an on-board emergency, the dispatcher can inform the police and direct them to the vehicle's exact location.

5. *Incident Management Programs.* An organized system for quickly identifying and responding to incidents that occur on area freeways and major arterials. The objectives are to rapidly respond to incidents with the proper personnel and equipment, to aid accident victims, and to facilitate the rapid clearance of the accident from the roadway. Timely execution of these activities will save lives and minimize the delay and frustration of the traveling public. To accomplish this, real-time input from the freeway and arterial surveillance systems and the agencies responsible for managing them is critical.

6. *Electronic Fare Payment System.* The system(s) include hardware and software for roadside, in-vehicle, and in-station electronic payment of transit fares, parking fees, etc. Both debit and credit systems would possibly be included. The system eliminates the need

for travelers to carry exact fare amounts and facilitates the subsequent implementation of a single fare payment medium.

7. *Electronic Toll Collection System*. The system(s) include hardware and software for roadside and in-vehicle use which will allow drivers to pay tolls without stopping. It includes driver payment cards or tags, financial and card accounting system(s), roadside systems at mainline plazas or toll road entry and exit points, and a communications system between vehicles and the roadside. The system performs automated vehicle identification, automatic determination of tolls for differing classes of vehicles, automated enforcement of violations, and flexibility in financial arrangement.

8. *Highway-Rail Crossing Protection:* This system supplies real-time information on train position and estimated time of arrival at Highway-Rail Intersections, real-time traffic conditions at Highway Rail Intersections, pro-active train control by train control centers, and interactive coordination between roadway TMCs and train control centers. This ITI element will interface with Advanced Train Control Systems at central dispatch stations and on-board the locomotive, Vehicle Proximity Alerting Systems on board special classes of vehicles (e.g., school buses, hazardous materials haulers, and emergency vehicles), and Remote Monitoring Systems at Highway Rail Intersections.

9. *Emergency Management Services:* This system supports coordination of emergency services across jurisdictional boundaries, makes emergency fleet management more efficient through application of AVL and dispatch-support systems, provides coordination with traffic management systems to further reduce emergency response times, and improves HAZMAT material tracking and HAZMAT incident response through provision of timely and accurate information to emergency personnel

2.8.2 RELATING INTELLIGENT TRANSPORTATION INFRASTRUCTURE TO NATIONAL ARCHITECTURE

This section provides a direct technical mapping between the elements defined by ITI and the equivalent elements defined by the National Architecture.

As defined in section 2.1, the National Architecture consists of nineteen interconnected subsystems. Each subsystem is, in turn, made up of at least one equipment package. Market Packages provide another perspective that groups equipment packages that must be deployed together to provide a service. To define an "ITI Architecture", the subset of these National Architecture elements that is necessary to support the Intelligent Transportation Infrastructure must be identified.

The nine Intelligent Transportation Infrastructure elements neatly correspond with a subset of the physical subsystems defined by the National Architecture as presented in table 2.8-I. A more detailed view of the applicable National Architecture requirements is developed by mapping the functional description for each Intelligent Transportation Infrastructure element to the National Architecture Market Packages. To accomplish this, the table lists the major functions identified for each of the Intelligent Transportation Infrastructure elements and selects the Market Packages that provide the same capabilities.

Table 2.8.1: Relating Intelligent Transportation Infrastructure to National Architecture

Intelligent Transportation Infrastructure		National Architecture	
Element	**Identified Functions**	**Subsystem**	**Equivalent Market Packages**
Regional Multimodal Traveler Information	• Real-time Multi-Modal Data Repository • Broadcast Information Distribution • Interactive Information Distribution • Central or Distributed Facilities	**Information Service Provider**	• Broadcast Traveler Information • Broadcast Traveler Information • Interactive Traveler Information • Interactive Traveler Information
Traffic Signal Control System	• Monitors Arterial Network Traffic • Range of Adaptive Control Strategies • Area-wide Signal Coordination • Integration with Freeway Management	**Traffic Management, Roadway**	• Network Surveillance • Surface Street Control • Regional Traffic Control • Regional Traffic Control
Freeway Management System	• Monitors Freeway Conditions • Identifies Flow Impediments • Ramp Metering/Lane Controls • HARs/VMSs	**Traffic Management, Roadway**	• Network Surveillance • Network Surveillance • Freeway Control • Traffic Information Dissemination
Transit Management System	• Monitors Transit Vehicle Position • Disseminates Real-Time Schedules • Computer-Aided Dispatch • Vehicle Passenger Loading • Fare Management • Vehicle Condition Monitoring • On-Board Safety Monitoring	**Transit Management, Transit Vehicle**	• Transit Vehicle Tracking • Transit Vehicle Tracking • Transit Fixed Route Operations • Demand Response Transit Operations • Transit Passenger and Fare Management • Transit Passenger and Fare Management • Transit Maintenance • Transit Security
Incident Management Program	• Policy and Operations Agreement • Incident Detection/Verification • Incident Response/Clearance	**Emergency Management**	? Policy separate from architecture • Incident Management System • Incident Management System
Electronic Fare Payment Systems	• Credit or Debit Card Support • Payment at Station/Stop or In-Vehicle	**Transit Vehicle**	• Transit Passenger and Fare Management • Transit Passenger and Fare Management
Electronic Toll Collection Systems	• Short Range Communications • Automated Vehicle Identification • Vehicle Class Differentiation • Automated Enforcement • Credit/Debit Flexibility	**Toll Admin., Toll Collection**	• Dynamic Toll/Parking Fee Management • Dynamic Toll/Parking Fee Management • Dynamic Toll/Parking Fee Management • Dynamic Toll/Parking Fee Management • Dynamic Toll/Parking Fee Management
Highway-Rail Crossing Protection	• Monitor train position and crossing times • Interactive coordination between train and traffic control • Interface to VPAS systems • Remote Monitoring at Rail Intersections	**Roadway, Potential Additional Subsystem(s)**	• None currently defined • None currently defined • In-Vehicle Signing (Potential Applic.) • None currently defined

Intelligent Transportation Infrastructure		National Architecture	
Element	Identified Functions	Subsystem	Equivalent Market Packages
Emergency Management Service	• Coordinate Regional Response • AVL and Fleet Management Support • Coordination with Traffic Management • HAZMAT Tracking • HAZMAT Incident Response	**Emergency Management, Emergency Vehicle Freight and Fleet Mngt, Comm. Vehicle Comm. Vehicle Admin.**	• Emergency Response • Emergency Routing • Emergency Routing • HAZMAT Management • HAZMAT Management

The single issue that is identified by this comparison is the relatively sparse support for the Highway-Rail Crossing Protection element in the National Architecture at this time. As of this writing, the necessary updates to the National Architecture to incorporate support for this service are being planned.

Reviewing the above table, the following abbreviated list of market Packages support the Intelligent Transportation Infrastructure:

• **Network Surveillance**	• **Transit Vehicle Tracking**
• **Surface Street Control**	• **Transit Fixed Route Operations**
• **Freeway Control**	• **Transit Demand Response Operations**
• **Incident Management System**	• **Transit Passenger and Fare Management**
• **Regional Traffic Control**	• **Transit Maintenance**
• **Traffic Information Dissemination**	• **Transit Security**
• **Dynamic Toll/Parking Fee Management**	• **Emergency Response**
• **Broadcast Traveler Information**	• **Emergency Routing**
• **Interactive Traveler Information**	• **HAZMAT Management**

As the focal point for most of the deployment analysis performed for the National Architecture, the Market Packages provide a direct mapping to the complete set of required subsystems and equipment packages, the associated standard interface requirements, and the strategy for deploying the service.

Note that many of the ITI market packages include a mix of equipment; not all of which would normally be considered as "public infrastructure" and included in ITI under a strict definition. For instance, two traveler information market packages are required to support ITI; however, these market packages include vehicle and personal information access (e.g., personal computer) equipment that would not be classified as infrastructure and would not normally be eligible for public funds. Figure 2.8-1 presents all of the subsystems and interconnections necessary to support the Market Packages associated with Intelligent Transportation Infrastructure. This yield an inclusive view of ITS which includes elements that are not public infrastructure but are required for the ITI to provide a service to end-users.

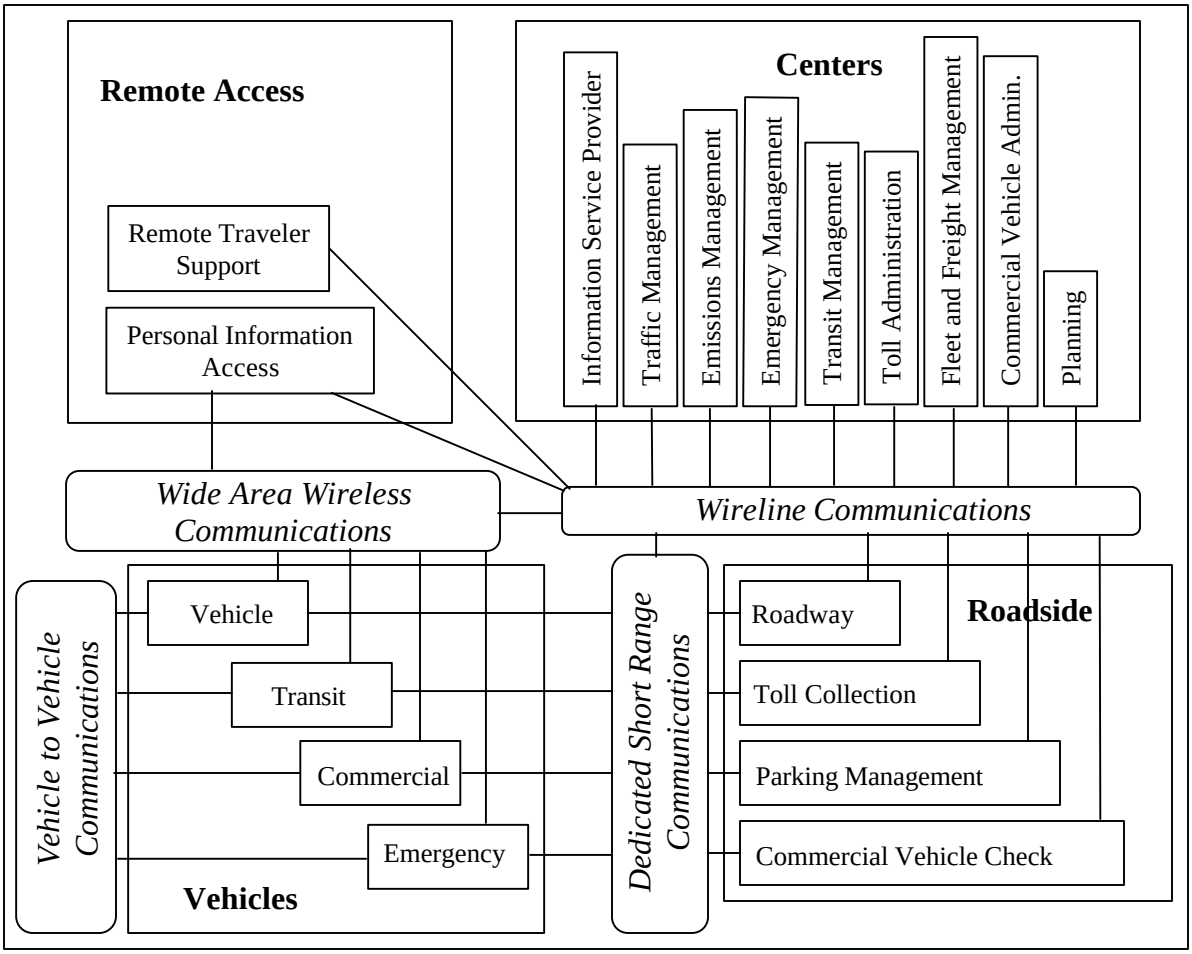


Figure 2.8-1: National Architecture Framework for Intelligent Transportation Infrastructure

2.8.3 COMPARING INTELLIGENT TRANSPORTATION INFRASTRUCTURE TO KEY MARKET PACKAGES

The previous translated ITI into a subset of the market packages defined by the National Architecture. Section 2.7 provides a similar list of Key Market Packages which constitute the key early deployments identified by the architecture implementation strategy. Table 2.8-2 presents the key market packages, and compares this list with the market packages that support ITI. As can be seen, the ITI market packages are a focused subset of the Key Market Packages. This additional focus is a natural by-product of the comparatively focused objectives of ITI. The ITI concentrates on metropolitan areas and public infrastructure. This focus provides clarity but also omits several areas that are addressed by the National Architecture sue to its more comprehensive scope. For instance, Key Market Packages defined by the Architecture include CVO services. Key Market Packages also include autonomous route guidance systems, mayday services, and other consumer elements that are produced, purchased, owned, and operated with the private sector.

Table 2.8-2: Comparing ITI to Key Market Packages

Market Packages	Key	ITI	Explanation
Traffic Management			
Market Packages	Key	ITI	Explanation
Network Surveillance	Ö	Ö	
Surface Street Control	Ö	Ö	
Freeway Control	Ö	Ö	
Incident Management System	Ö	Ö	
Regional Traffic Dissemination	Ö	Ö	
Dynamic Toll/Parking Fee Management	Ö	Ö	
Transit Management			
Transit Vehicle Tracking	Ö	Ö	
Transit Fixed Route Operations	Ö	Ö	
Transit Passenger and Fare Management	Ö	Ö	
Transit Maintenance	Ö	Ö	Viewed as an optional capability.
Transit Security	Ö	Ö	Viewed as a principle option rather than a basic service.
Traveler Information			
Broadcast Traveler Information	Ö	Ö	
Interactive Traveler Information	Ö	Ö	
Autonomous Route Guidance	Ö		An area of active private sector interest that provides tangible benefits to the user and yields a potential in-vehicle building block for advanced systems.
Commercial Vehicle Ops			
Fleet Administration	Ö		Stakeholder area not addressed by Intelligent Transportation Infrastructure
Electronic Clearance	Ö		Stakeholder area not addressed by Intelligent Transportation Infrastructure
Electronic Clearance Enrollment	Ö		Stakeholder area not addressed by Intelligent Transportation Infrastructure
HAZMAT Management	Ö	Ö	
Emergency Management			
Emergency Response	Ö	Ö	
Emergency Routing	Ö	Ö	
Mayday Support	Ö		Included to address key rural service need and reflect current private sector activity in this area

NITSA DOCUMENT, IMPLEMENTATION STRATEGY, APPENDIX A: DETAILED MARKET PACKAGE DEFINITIONS

To provide visibility into the service options that must be considered by the ITS implementation, a set of *market packages* have been defined. The market packages provide an accessible, service oriented perspective to the national architecture. They address the specific service requirements of traffic managers, transit operators, travelers, and other ITS stakeholders. To achieve an implementation orientation, the market packages were defined with enough granularity to support specific benefits analysis and clear ties to transportation problems. Some of the user services are too broadly defined to allow this sort of evaluation. 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., ATMS01 is a market package primarily of interest to transportation managers).

Table A-1: Market Packages Summary

Market Package	Market Package Name
ATMS01	Network Surveillance
ATMS02	Probe Surveillance
ATMS03	Surface Street Control
ATMS04	Freeway Control
ATMS05	HOV and Reversible Lane Management
ATMS06	Traffic Information Dissemination
ATMS07	Regional Traffic Control
ATMS08	Incident Management System
ATMS09	Traffic Network Performance Evaluation
ATMS10	Dynamic Toll/Parking Fee Management
ATMS11	Emissions and Environmental Hazards Sensing
ATMS12	Virtual TMC and Smart Probe Data
APTS1	Transit Vehicle Tracking
APTS2	Transit Fixed-Route Operations
APTS3	Demand Response Transit Operations
APTS4	Transit Passenger and Fare Management
APTS5	Transit Security
APTS6	Transit Maintenance
APTS7	Multi-modal Coordination
ATIS1	Broadcast Traveler Information
ATIS2	Interactive Traveler Information
ATIS3	Autonomous Route Guidance
ATIS4	Dynamic Route Guidance
ATIS5	ISP Based Route Guidance
ATIS6	Integrated Transportation Management/Route Guidance
ATIS7	Yellow Pages and Reservation
ATIS8	Dynamic Ridesharing
ATIS9	In Vehicle Signing
AVSS01	Vehicle Safety Monitoring

Market Package	Market Package Name
AVSS02	Driver Safety Monitoring
AVSS03	Longitudinal Safety Warning
AVSS04	Lateral Safety Warning
AVSS05	Intersection Safety Warning
AVSS06	Pre-Crash Restraint Deployment
AVSS07	Driver Visibility Improvement
AVSS08	Advanced Vehicle Longitudinal Control
AVSS09	Advanced Vehicle Lateral Control
AVSS10	Intersection Collision Avoidance
AVSS11	Automated Highway System
CVO1	Fleet Administration
CVO2	Freight Administration
CVO3	Electronic Clearance
CVO3a	Electronic Clearance Enrollment
CVO4	International Border Electronic Clearance
CVO5	Weigh-In-Motion
CVO6	Roadside CVO Safety
CVO7	On-board CVO Safety
CVO8	CVO Fleet Maintenance
CVO9	HAZMAT Management
EM1	Emergency Response
EM2	Emergency Routing
EM3	Mayday Support
ITS1	ITS Planning

The service-oriented market packages are traceable to the interface-oriented architecture definition. Once a particular market package is selected for implementation, the required subsystems, equipment packages, and interface requirements are readily identified due to this traceability. This approach allows the implementor (and this Implementation Strategy) to first consider service needs and later concentrate on those pieces of the architecture necessary to provide the selected service.

It is important to note that the market packages are illustrative rather than prescriptive. The actual implementation variations that are possible across the country are myriad and cannot be enumerated through a finite set of packages. The market packages are tools that allow this Implementation Strategy to discuss incremental deployment of ITS services in a manner that is relevant to the underlying architecture definition.

The remainder of this appendix defines each of the market packages in more detail. A description of the service offered by each market package is coupled with a graphic that identifies how the architecture framework supports the market package. Where several major implementation options are supported by the market package, these are also identified and differentiated in the descriptions.

Figure A-I provides a legend to assist in interpretation of the market package diagrams. In general, only the most salient elements from the architecture definition (e.g., directly involved subsystems, system terminators, and the highest level data flows) are depicted in each graphic to ensure clarity.

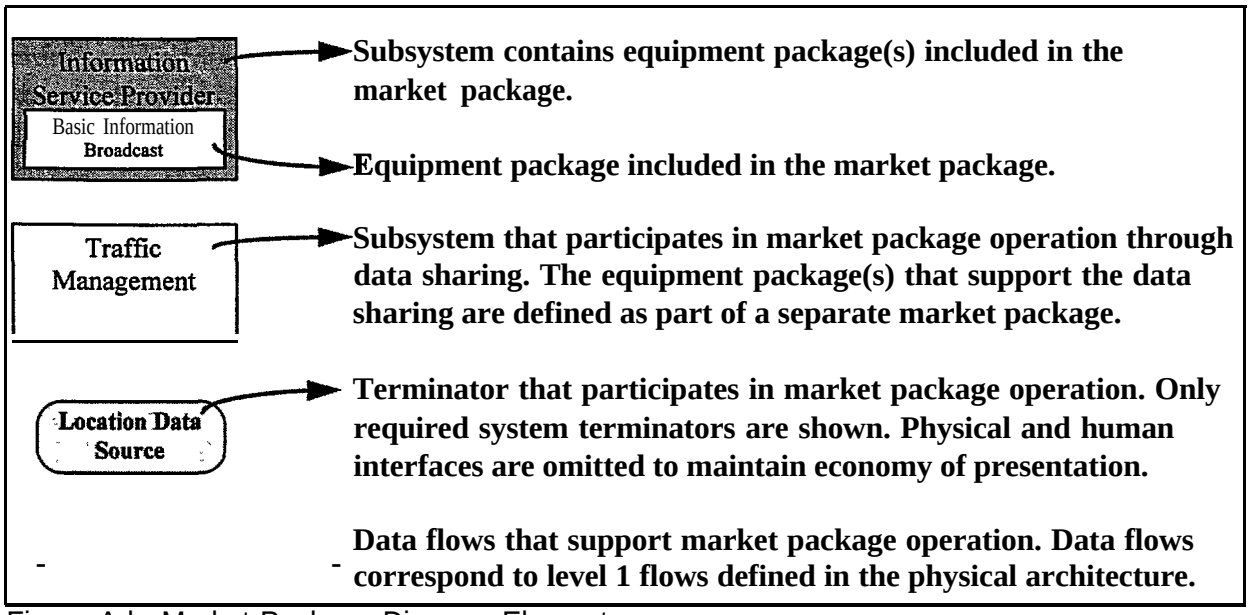
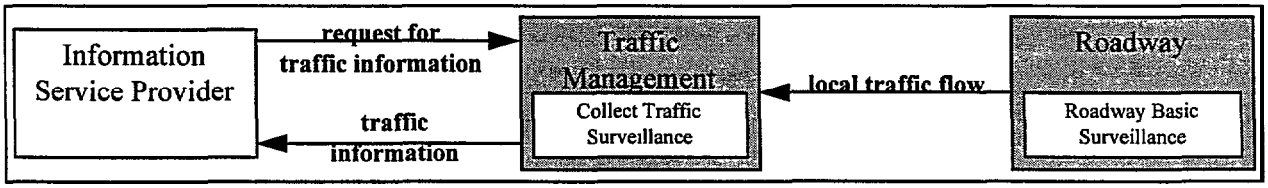


Figure A-I : Market Package Diagram Elements

A.1 Traffic Management Market Packages

A. 1.1 NETWORK SURVEILLANCE (ATMS1)

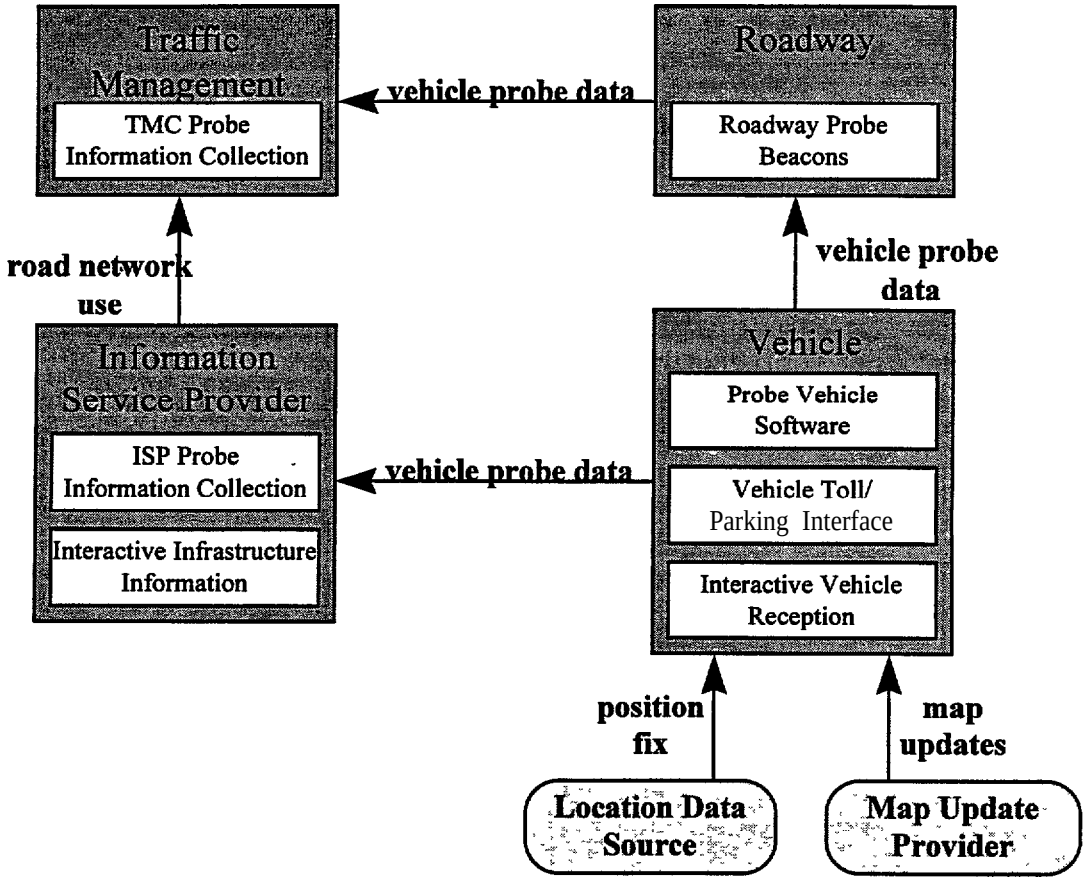
This basic market package provides the fixed roadside surveillance elements utilizing wireline communication to transmit the surveillance data. It can be used completely local such as loop detection connected with signal control or it can be CCTVs sending back data to the traffic management centers. This enables traffic managers to monitor road conditions, identify and verify incidents, analyze and reduce the collected data, and make it available to users and private information providers. It requires road sensors, communication links between the sensors and the traffic management system, data reduction software, and utilizes the existing wireline links between the Traffic Management Center and the traveler information providers.



A. 1.2 PROBE SURVEILLANCE (ATMS2)

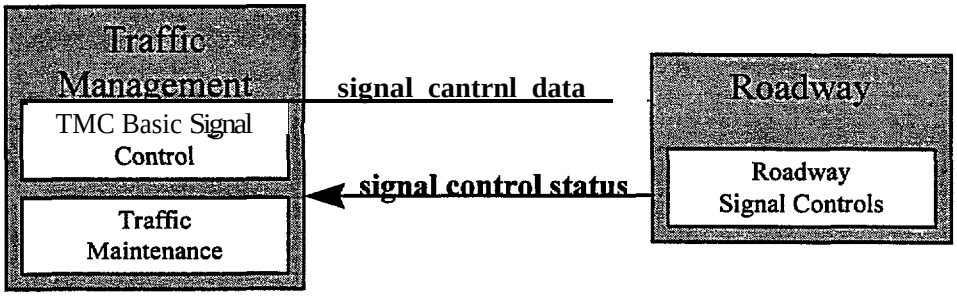
This basic market package provides the mobile surveillance elements utilizing wireless communication to transmit the surveillance data. It can be used in conjunction with vehicle probe information for link time data or can be a helicopter in the air proving surveillance data back to the traffic management center. This enables traffic managers to monitor road

conditions, identify and verify incidents, analyze and reduce the collected data, and make it available to users and private information providers. It requires road sensors, communication links between the sensors and the traffic management system, data reduction software, and utilizes wireless links between the Traffic Management Center and the traveler information providers. This market package supports collection of traffic congestion and incident detection using cooperative vehicle probes. Vehicles sign-up with a service and shares the equipment already on the market for custom reception of personal travel data. The user always 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.



A. 1.3 SURFACE STREET CONTROL (ATMS3)

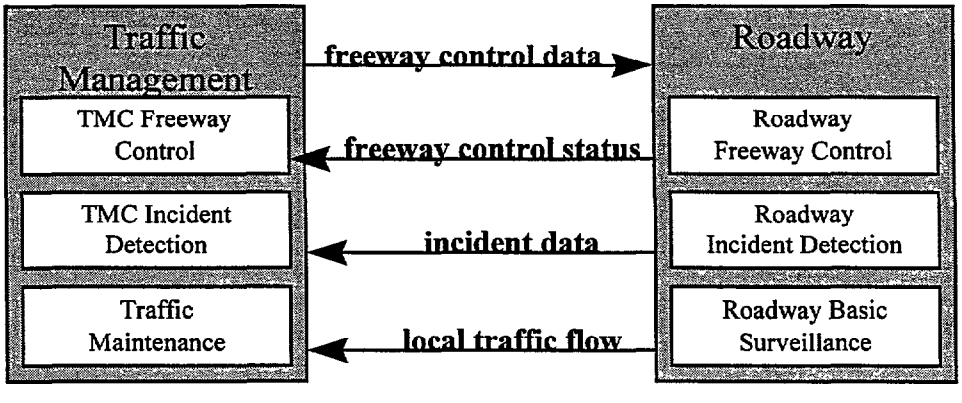
This basic market package provides the communication links and the signal control equipment for completely local surface street control and/or arterial traffic management control. An example would be arterial signalization control. This market package is considered as a intra-jurisdictional package. This package is consistent with typical urban traffic signal control systems.



A. *1*.4 FREEWAY CONTROL (ATMS4)

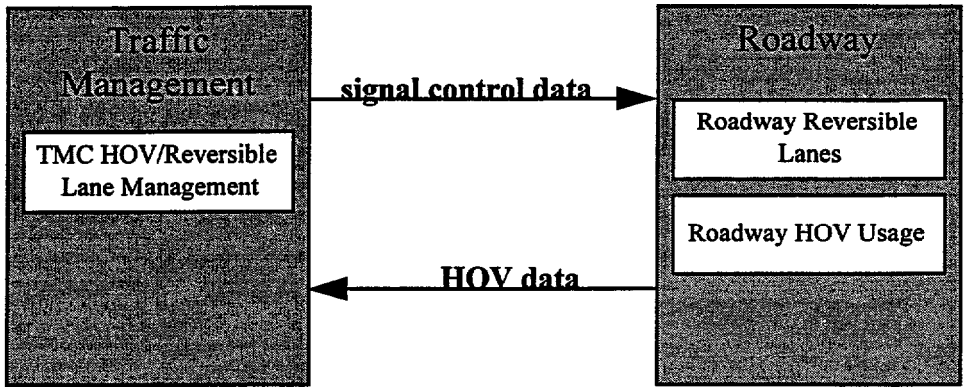
This market package provides the communications and roadside equipment to support ramp control, lane controls, and interchange control for freeways. Coordination and integration of ramp meters are included as part of this market package. This package is consistent with typical urban traffic freeway control systems. This package also 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. The equipment associated with incident detection that is distributed along the roadway and included within the Traffic Management Center is separately identified within the architecture so that incident detection may be considered and analyzed as an elective based on local needs and preferences.



A. 1.5 HOV AND REVERSIBLE LANE MANAGEMENT (ATMS5}

This market package provides management of HOV lanes by coordinating freeway ramp meters and connector signals with HOV lane usage signals. Preferential treatments are given to HOV lanes. Vehicle occupancy detectors may be installed to determine if vehicles are HOVs. This market package also provides the capability for the traffic managers to access and manage reversible lane facilities. Additional hardware and software is needed to process traffic information and control reversible lane activities. This also includes the hardware to electronically reconfigure intersections to manage dynamic demand changes and special events.



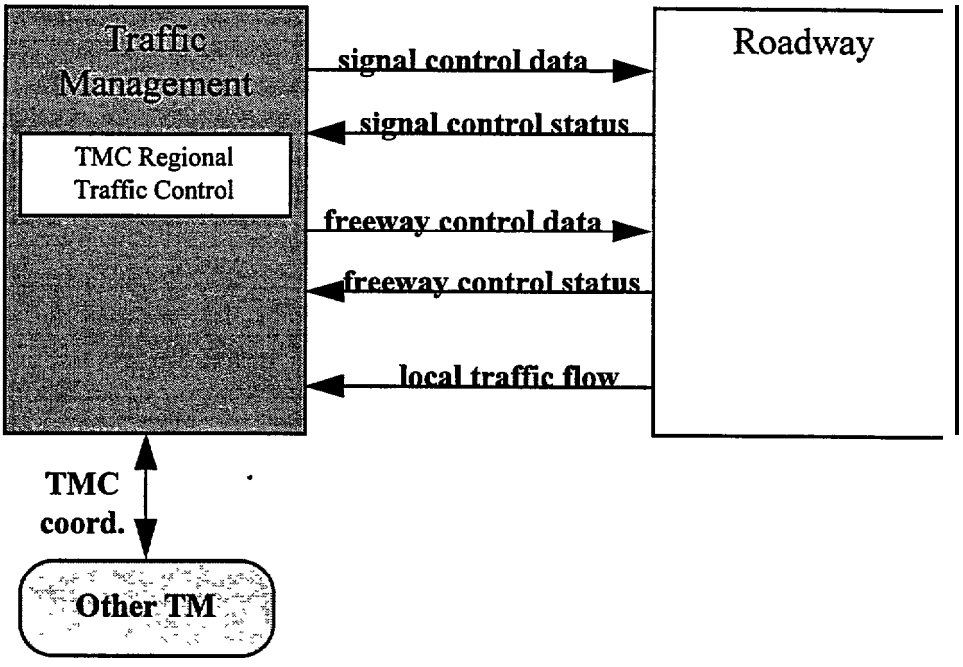
A. 1.6 TRAFFIC INFORMATION DISSEMINATION (ATMS6)

This market package allows information to be disseminated. This package would most likely be a supplement to the incident detection as a complementary reaction in an incident management plan for CMS and/or HAR information dissemination. This package could also ensure that information is available in a format for media usage, such as a fax output or a direct tie-in to radio and television station computer systems. This market package does not require a vehicle to have any special-purpose equipment. For example, an AM radio can be used for receiving HAR broadcast.

A.1 .7 REGIONAL TRAFFIC CONTROL (ATMS7)

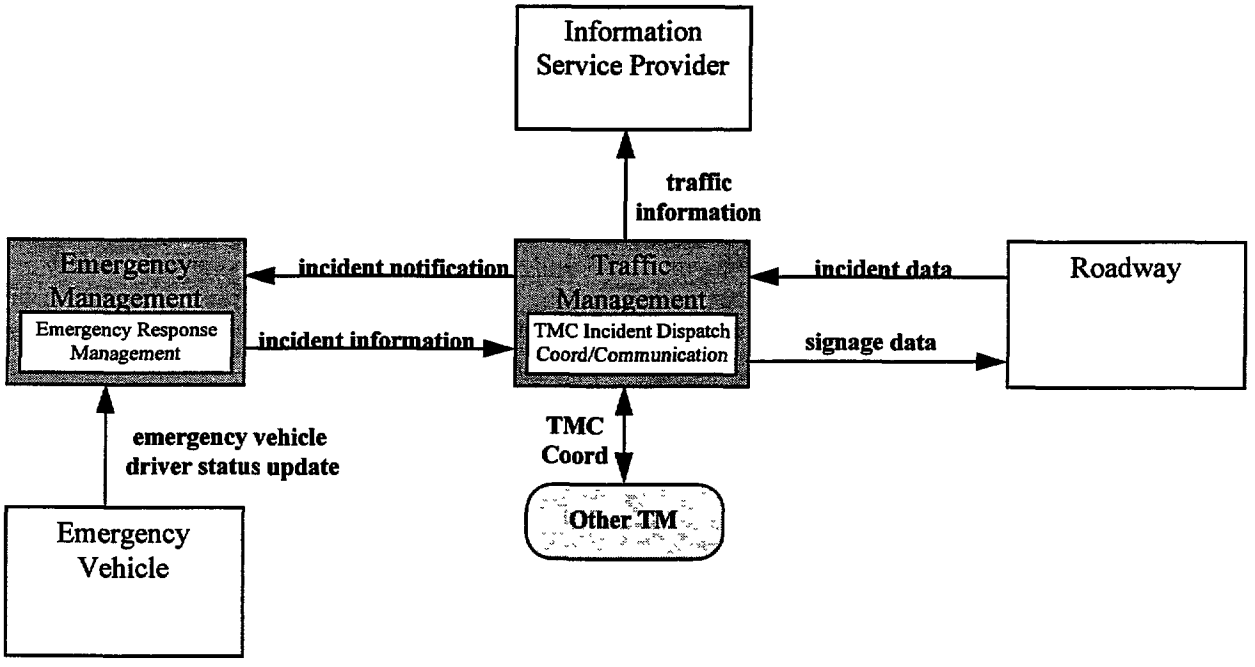
This market package advances the Surface Street Control and Freeway Control market packages by allowing integrated interjurisdictional traffic control. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions; however, the optimization is for a larger network than the Surface Street and Freeway Control market packages provide. This market package provides capabilities to share traffic information and control between traffic management centers to support a regional control strategy. This package relies principally on roadside instrumentation supported by the Surface Street Control and Freeway Control market packages and adds additional hardware, software,

and wireline communications capabilities to implement coordinated traffic management measures (metering, signalization, coordination).



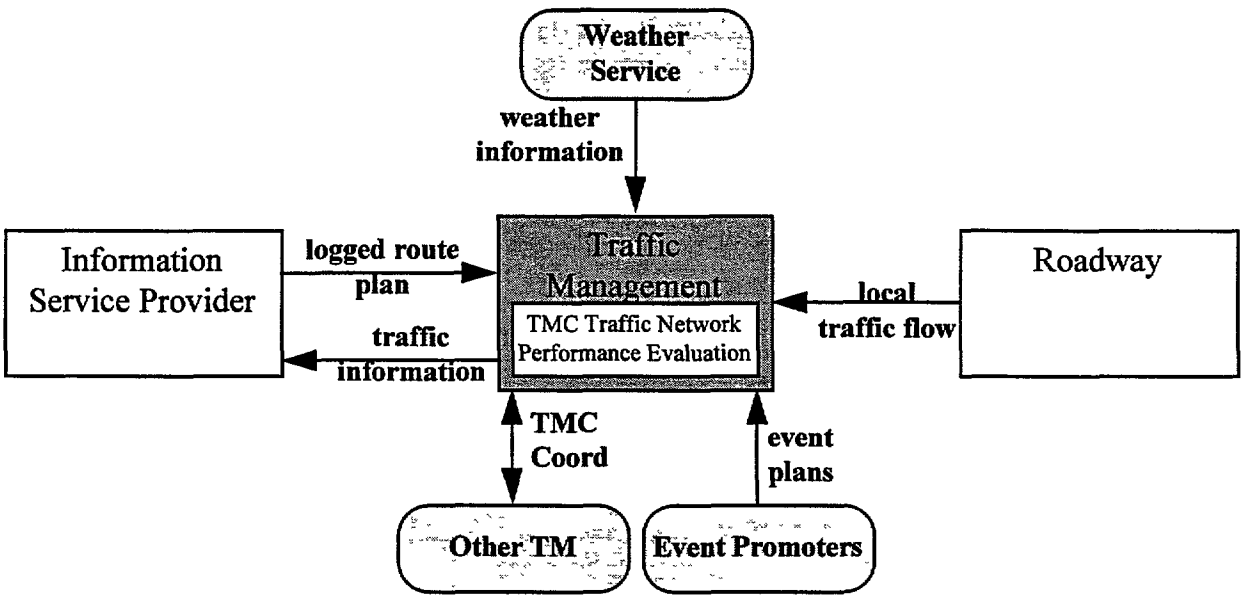
A.1.8 INCIDENT MANAGEMENT SYSTEM (ATMS8)

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 supported by this market package. Information from these diverse sources are collected and correlated by this market package to detect and verify incidents. This market package provides traffic management center 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.



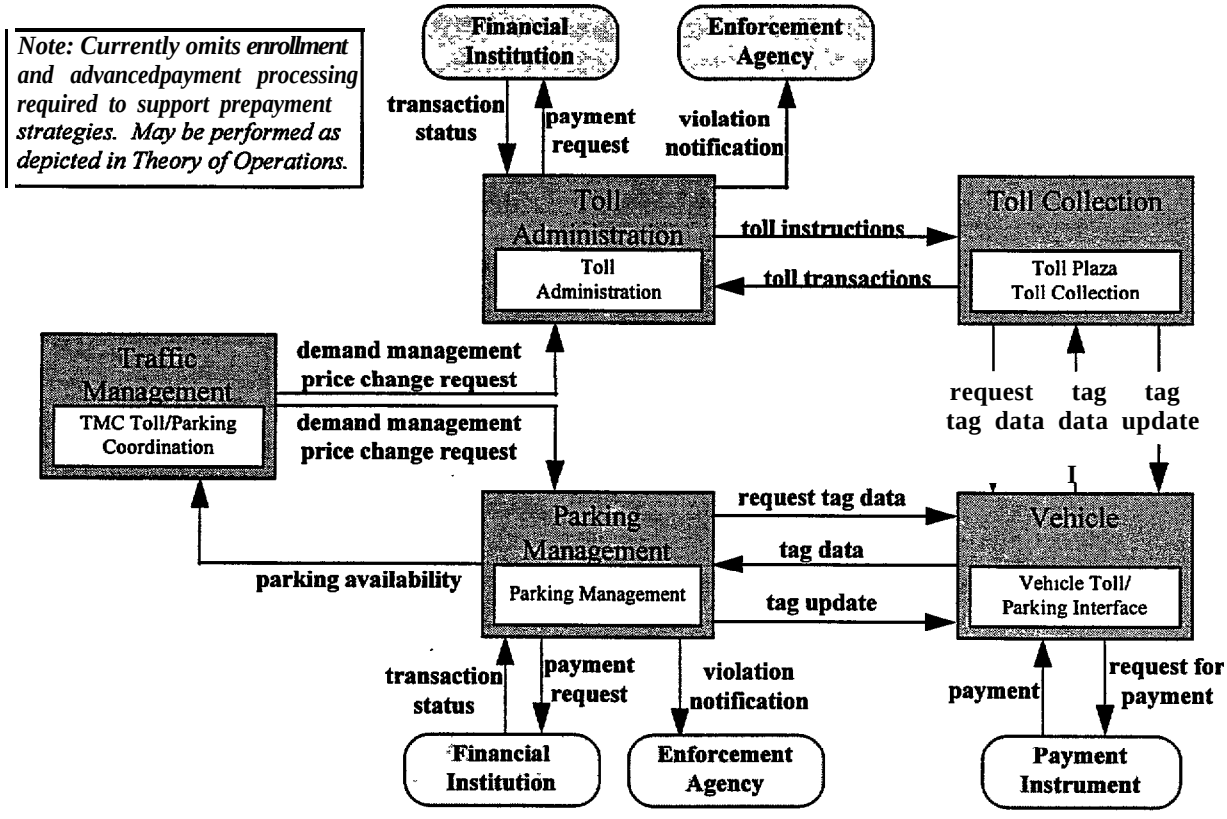
A.1.9 TRAFFIC NETWORK PERFORMANCE EVALUATION (ATMS9)

This market package supports advanced algorithms that support historical evaluation, real-time assessment, and forecast of the traffic network performance. This includes the prediction of travel demand patterns to support better link travel times for route planning customers. The source data would come from the traffic management center itself as well as emergency management plans and predicted traffic loads derived from route plans supplied by the ISP. In addition, interface with transportation planners is required. 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.



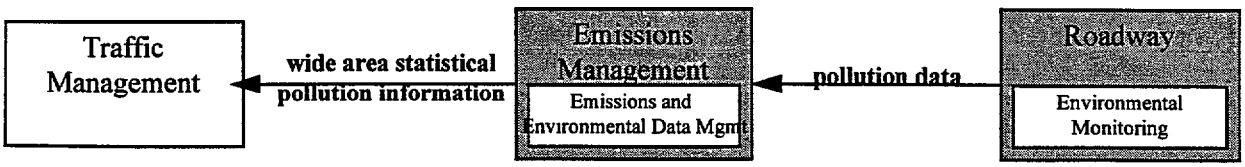
A.1.1 0 DYNAMIC TOLL/PARKING FEE MANAGEMENT (ATMS1 0)

This market package provides toll operators with the capability of electronically collecting tolls and detecting and processing violators. It also provides highway authorities with road use statistics and enables them to implement demand management strategies. Two-way short range communication with the vehicle (tag or beacon) is required as well as wireline interfaces to traffic management and billing systems. Vehicle tags of toll violators are read and electronically posted to vehicle owners. Users of the package will be able to utilize the same equipment to pay for parking. This market package also provides toll operators with the capability of electronically collecting tolls and detecting and processing violators. It also provides highway authorities with road use statistics and enables them to implement demand management strategies. Two-way short range communication with the vehicle (tag or beacon) is required as well as wireline interfaces to traffic management and billing systems. Vehicle tags of toll violators are read and electronically posted to vehicle owners. This market service allows a parking facility to manage its parking operations, coordinate with the transportation authorities and collect parking fares. This is performed by sensing/collecting parking data, sharing it with information providers and traffic management subsystems over the wireline infrastructure, and automatically billing using the available wireless media (either vehicle tag or cellular data). Users of the package will be able to utilize the same equipment to pay for tolls and parking.



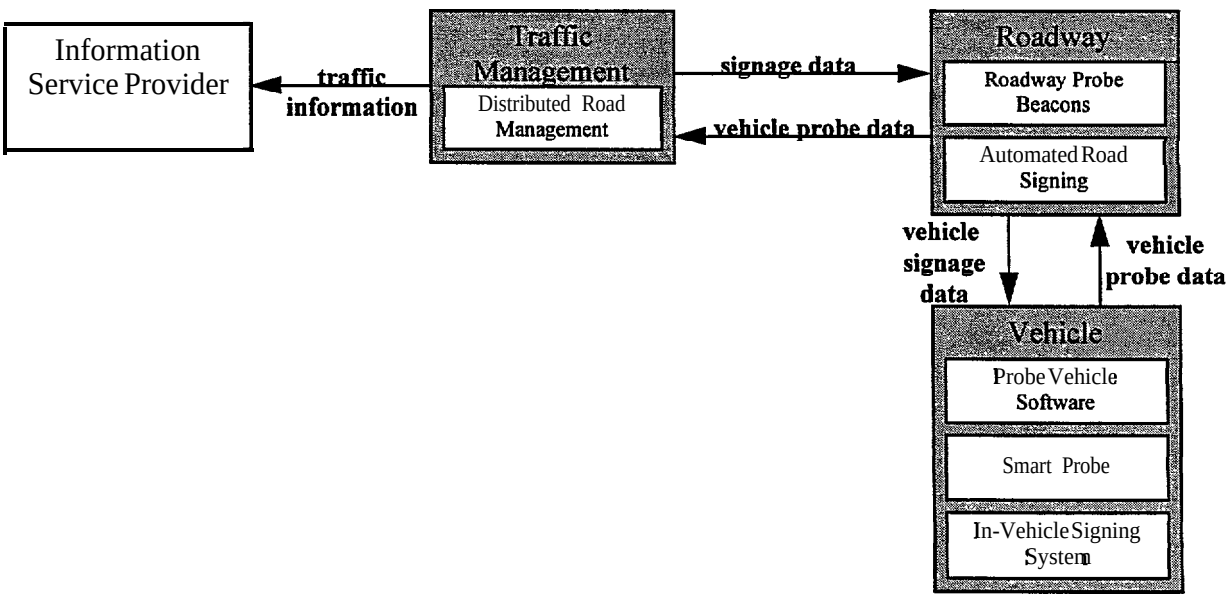
A. 1.11 EMISSIONS AND ENVIRONMENTAL HAZARDS SENSING (ATMS1 1)

This market package provides monitoring of the emissions levels using roadway sensors to collect the data. The data are transmitted to a center for processing and used by traffic management. It may include machine vision-based equipment to identify violators' license plates for appropriate actions. This market package also includes sensors to detect environmental hazards such as icy road conditions and dense fog, and communications equipment to transmit data to a center. The gathered information can be used to implement environmentally sensitive TDM programs, policies, and regulations.



A.1.12 VIRTUAL TMC AND SMART PROSE DATA (ATMS12)

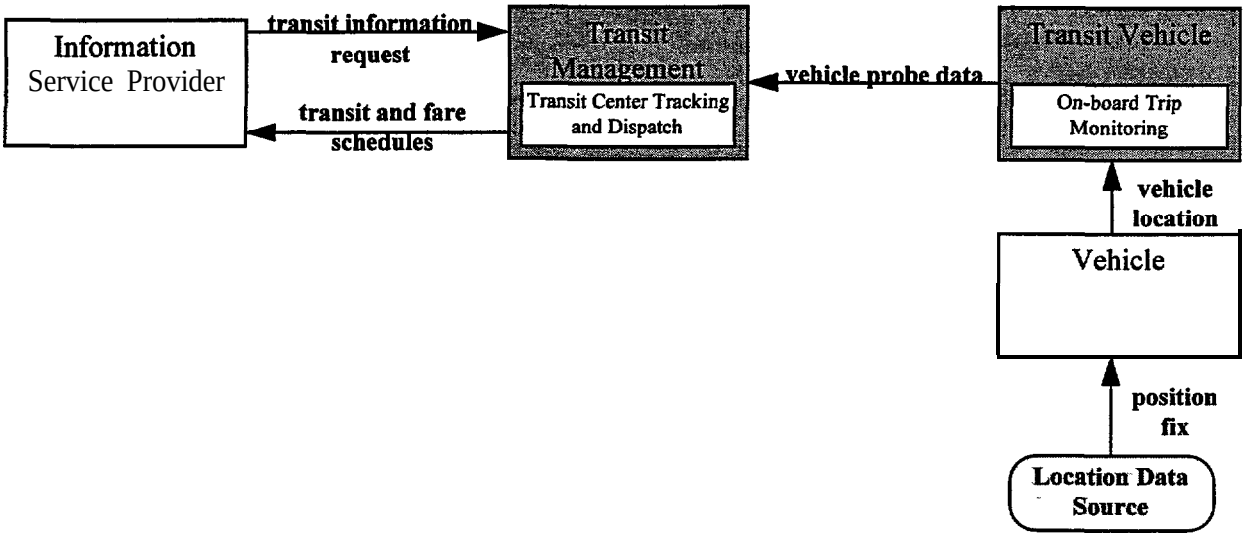
This market package provides for special requirements of rural road system. Instead of a central TMC, the traffic management is distributed over a very wide area (e.g., a whole state or collection of states). Each locality has the capability of accessing available information for assessment of road conditions. The package uses vehicles as smart probes that are capable of measuring road conditions, and in-vehicle signing for informing drivers of detected road conditions.



A.2 Public Transportation Market Packages

A.2.1 TRANSIT VEHICLE *TRACKING (APTS1)*

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 center 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 center processes this information, updates the transit schedule and makes real-time schedule information available to the information service provider via a wireline link.

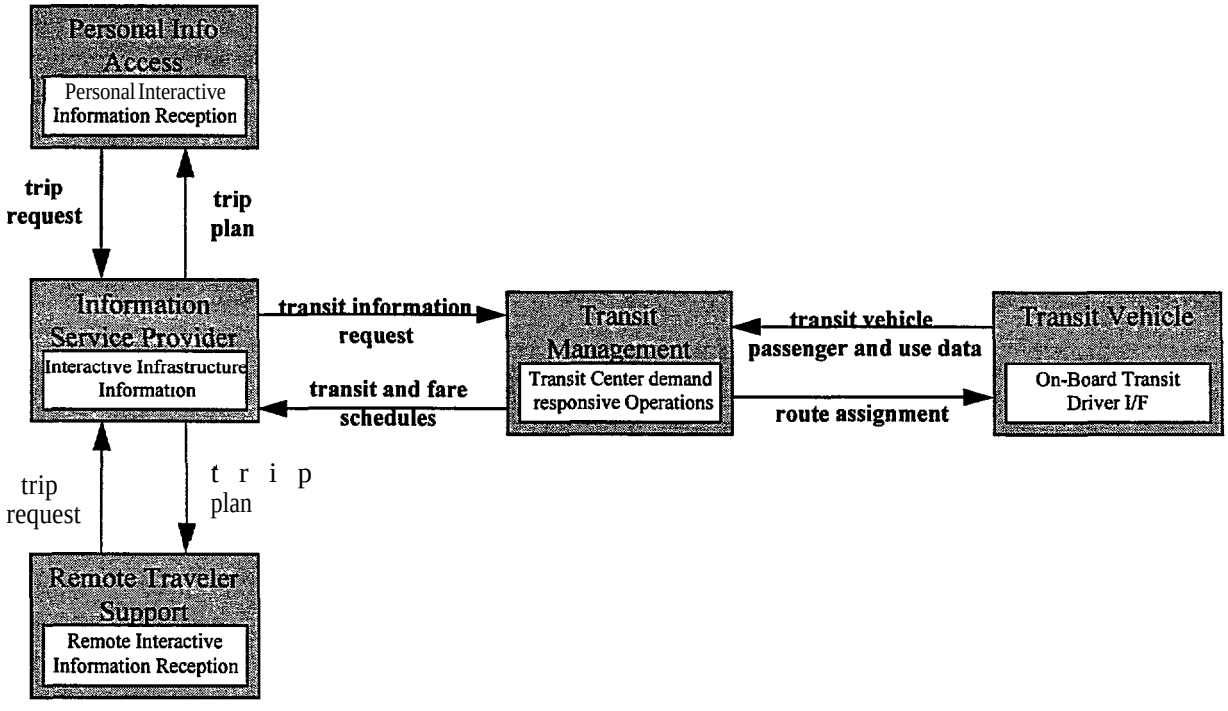


A.2.2 TRANSIT FIXED-ROUTE OPERATIONS (APTS2)

This market package performs automatic driver assignment and monitoring, as well as, vehicle routing and scheduling for fixed-route services. This service 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.

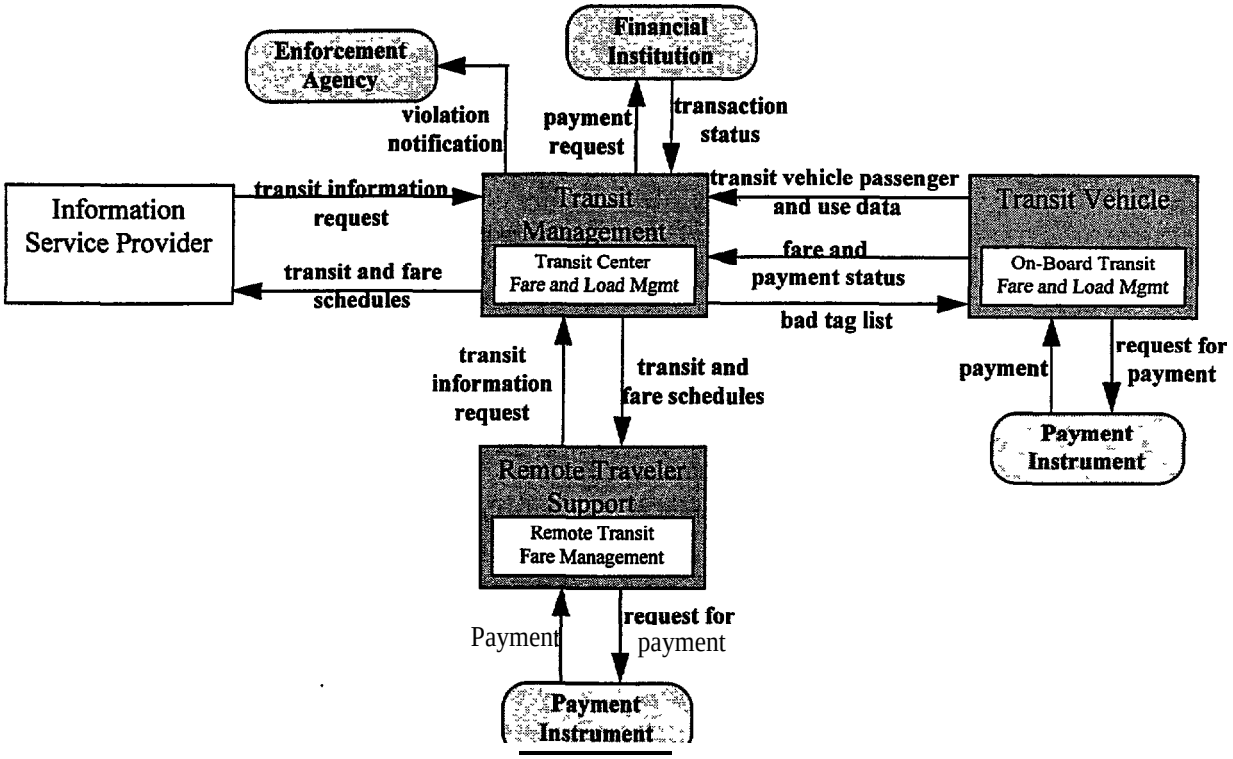
A.2.3 *DEMAND RESPONSE TRANSIT OPERATIONS (APTS3)*

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. 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. Traveler equipment is also included within this market package to enable traveler requests for flexible route transit and paratransit service. The Information Service Provider that provides the interface to the traveler devices may be either part and parcel of the 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.



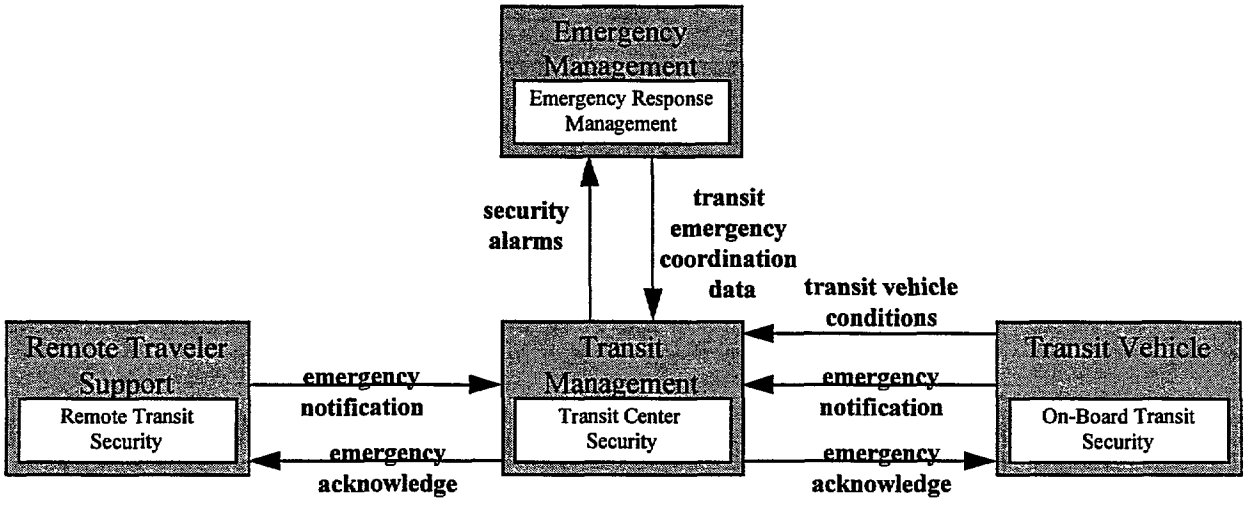
A.2.4 TRANSIT PASSENGER AND FARE MANAGEMENT (APTS4)

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 in the Transit Management Center using existing wireless infrastructure.



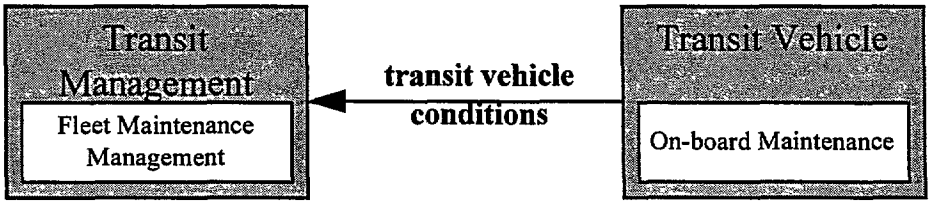
A.2.5 TRANSIT SECURITY (APTS5)

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. Transit areas (e.g. stops, park and ride lots, stations) are also monitored. Information is communicated to the Transit Management Center 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 Center when an emergency is identified that requires an external response.



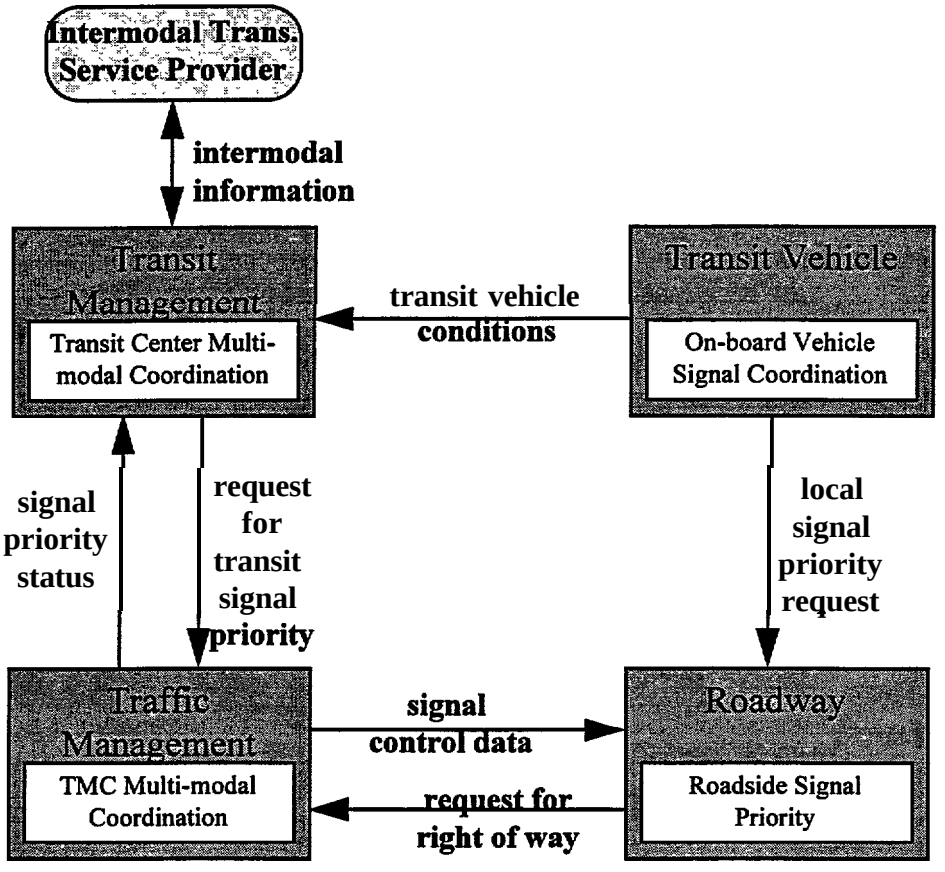
A.2.6 TRANSIT MAINTENANCE (APTS6)

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 center. Hardware and software in the transit management center processes this data and schedules maintenance activities.



A.2.7 MULTI-MODAL COORDINATION (APTS7)

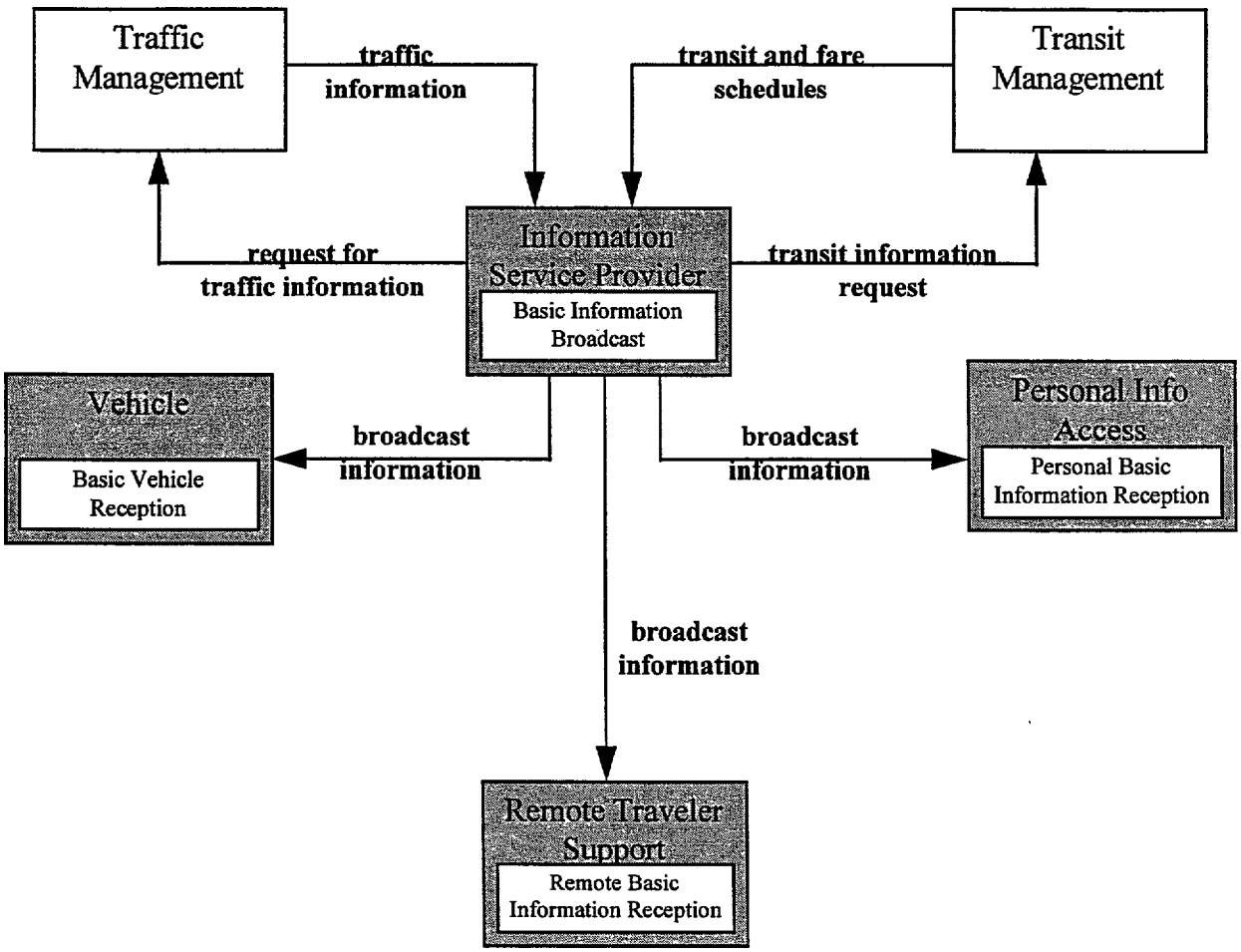
This market package establishes two way communications between multiple transit and traffic agencies to improve service coordination. Intermodal coordination between transit agencies can increase traveler convenience at transfer points and also improve operating efficiency. Coordination between traffic 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.


Intermodal Trans. Service Provider
intermodal information
Transit Management
Transit Center Multi-modal Coordination
transit vehicle conditions
Transit Vehicle
On-board Vehicle Signal Coordination
signal priority status
request for transit signal priority
local signal priority request
Traffic Management
TMC Multi-modal Coordination
signal control data
request for right of way
Roadway
Roadside Signal Priority

A.3 Traveler Information Market Packages

A.3.i BROADCAST TRAVELER INFORMATION (ATIS1)

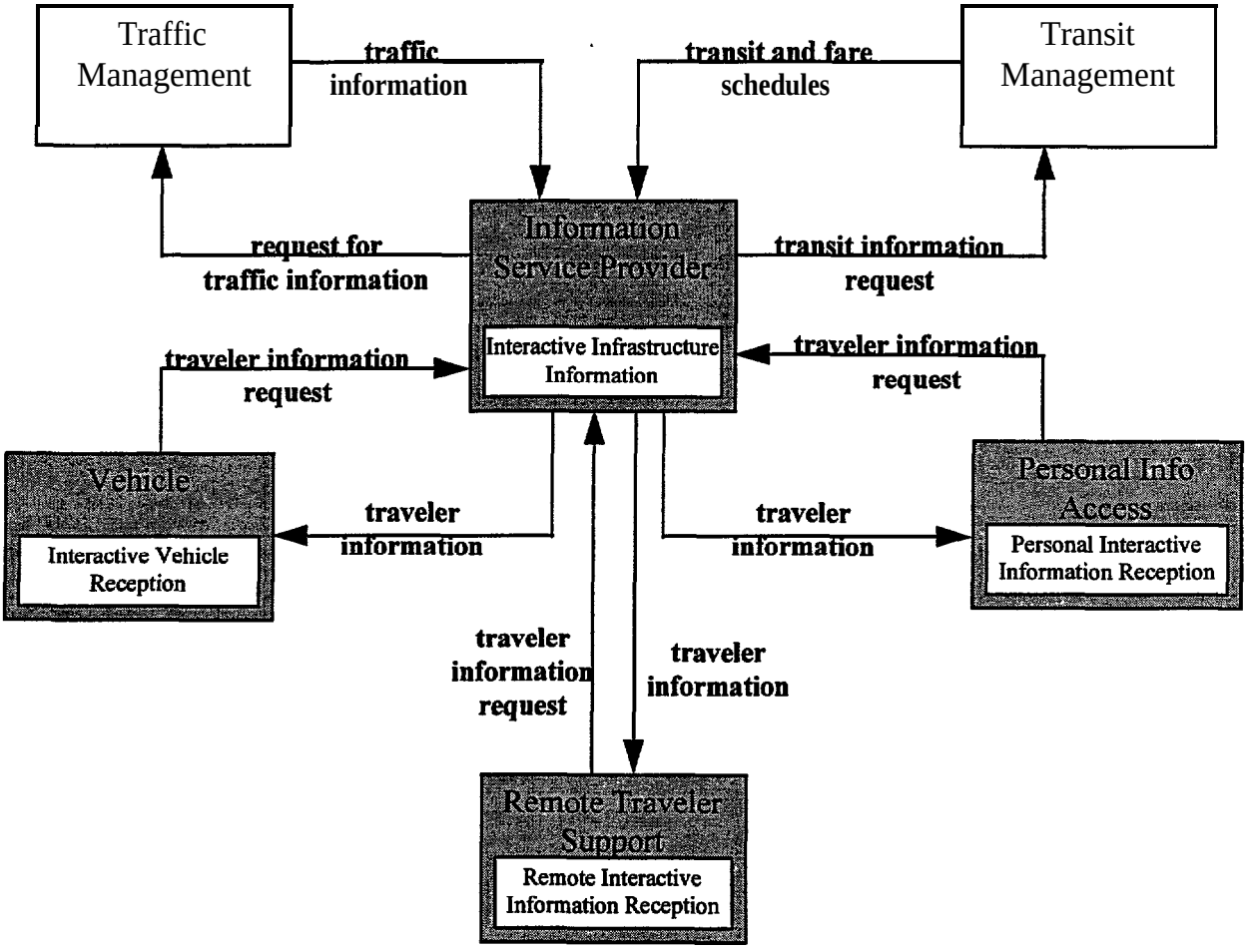
This market package provides the user with a basic set of ATIS services; its objective is early acceptance. It involves the collection of traffic conditions, advisories, general public transportation and parking information and the near real-time dissemination of this information over a wide area through 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 VMS 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.



A.3.2 INTERACTIVE TRAVELER INFORMATION (ATIS2)

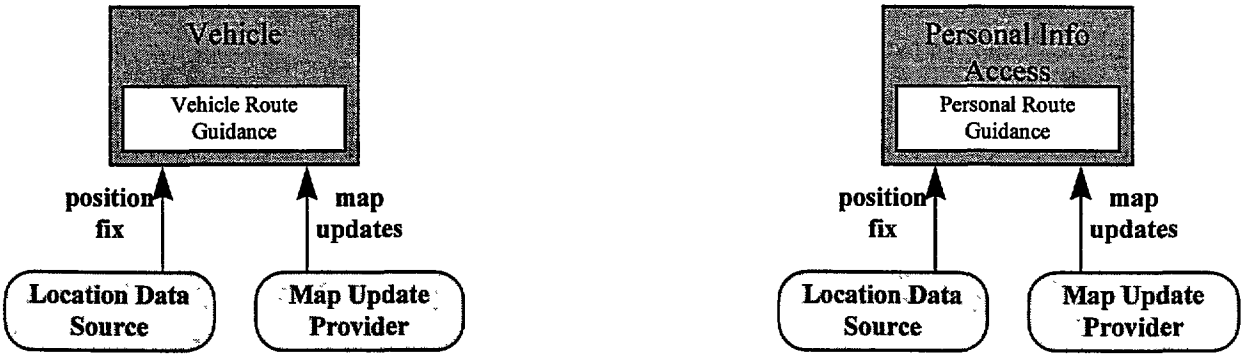
This market package provides tailored information in response to a traveler request. The user can request and obtain current information regarding traffic conditions, transit services, traveler services, ride share/ride match, parking management, and pricing information.. A range of two-way wide-area 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, home 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.



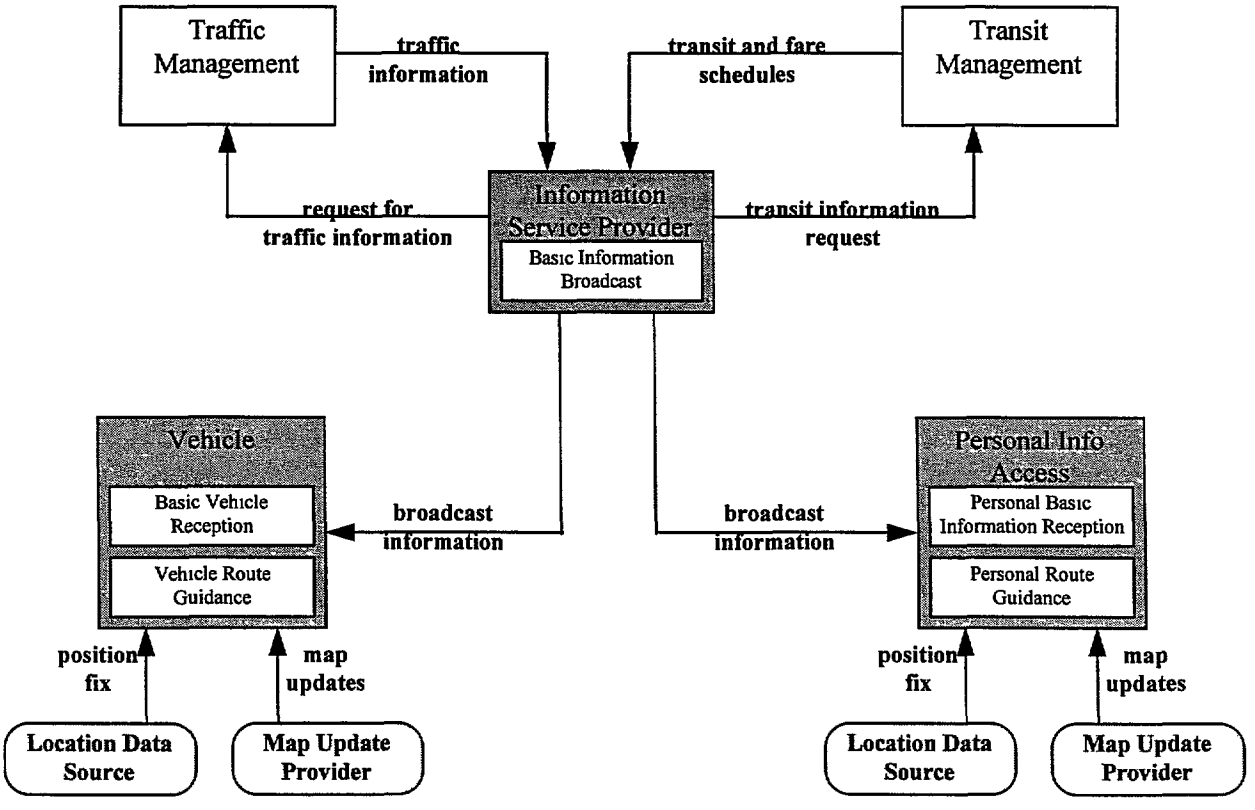
A.3.3 AUTONOMOUS ROUTE GUIDANCE (ATIS3)

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.



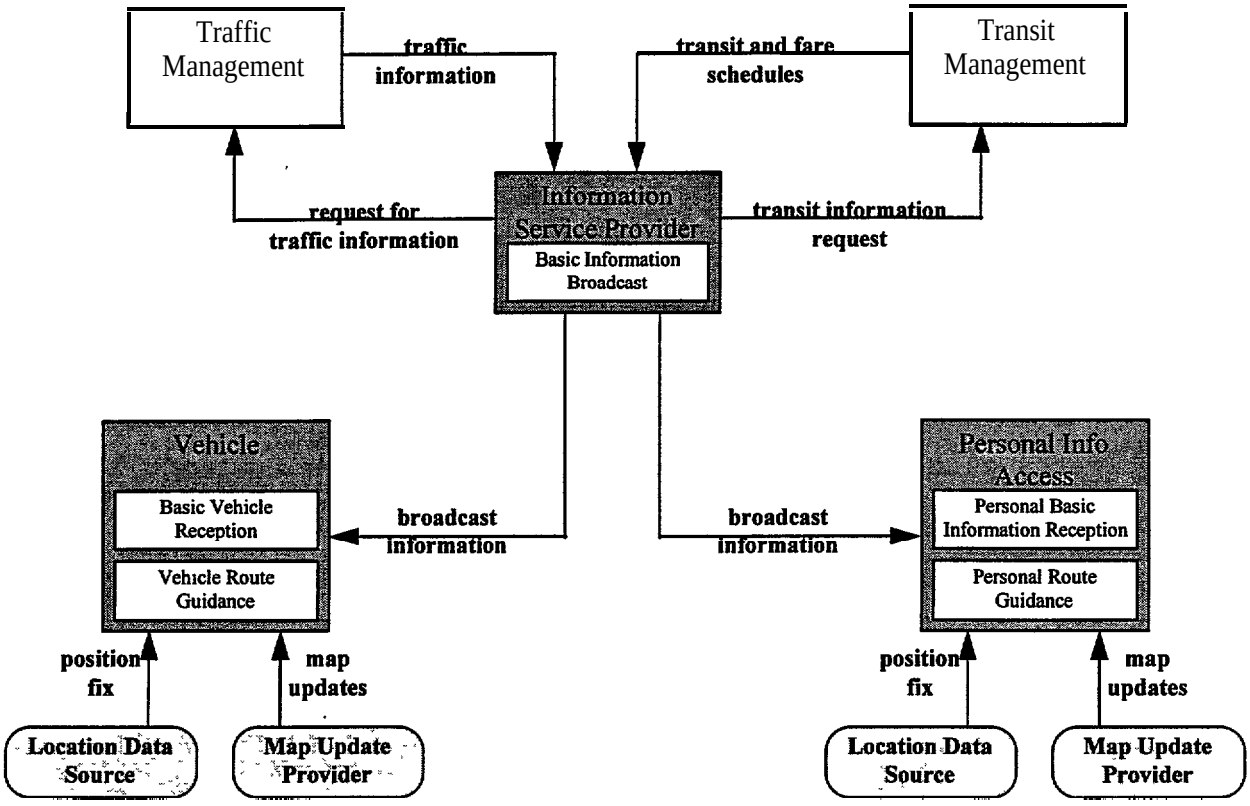
A.3.4 DYNAMIC ROUTE GUIDANCE (ATIS4)

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.



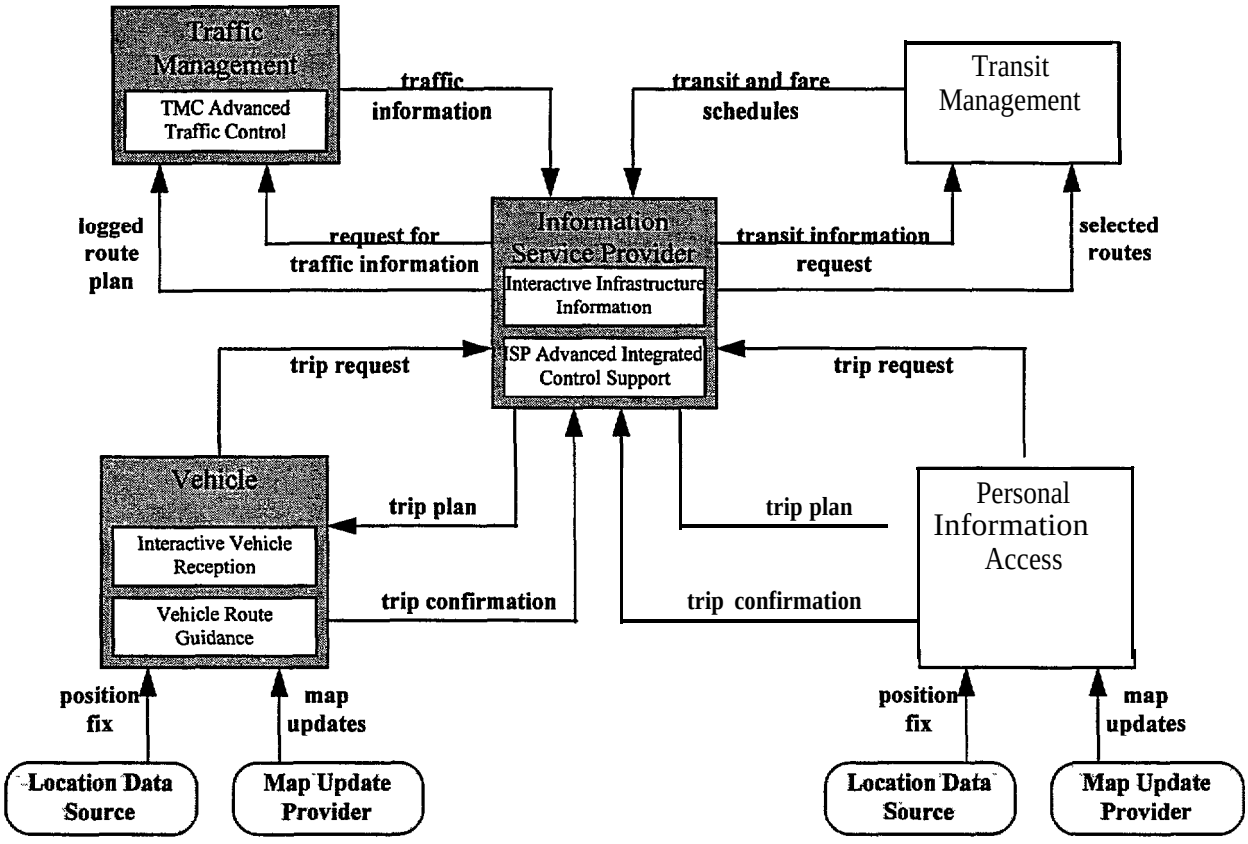
A.3.5 ISP-BASED ROUTE GUIDANCE (ATIS5)

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 supports basic route planning with minimal user equipment. The package includes two way data communications and optionally also equips the vehicle with the data bases, location determination capability, and display technology to support turn by turn route guidance.



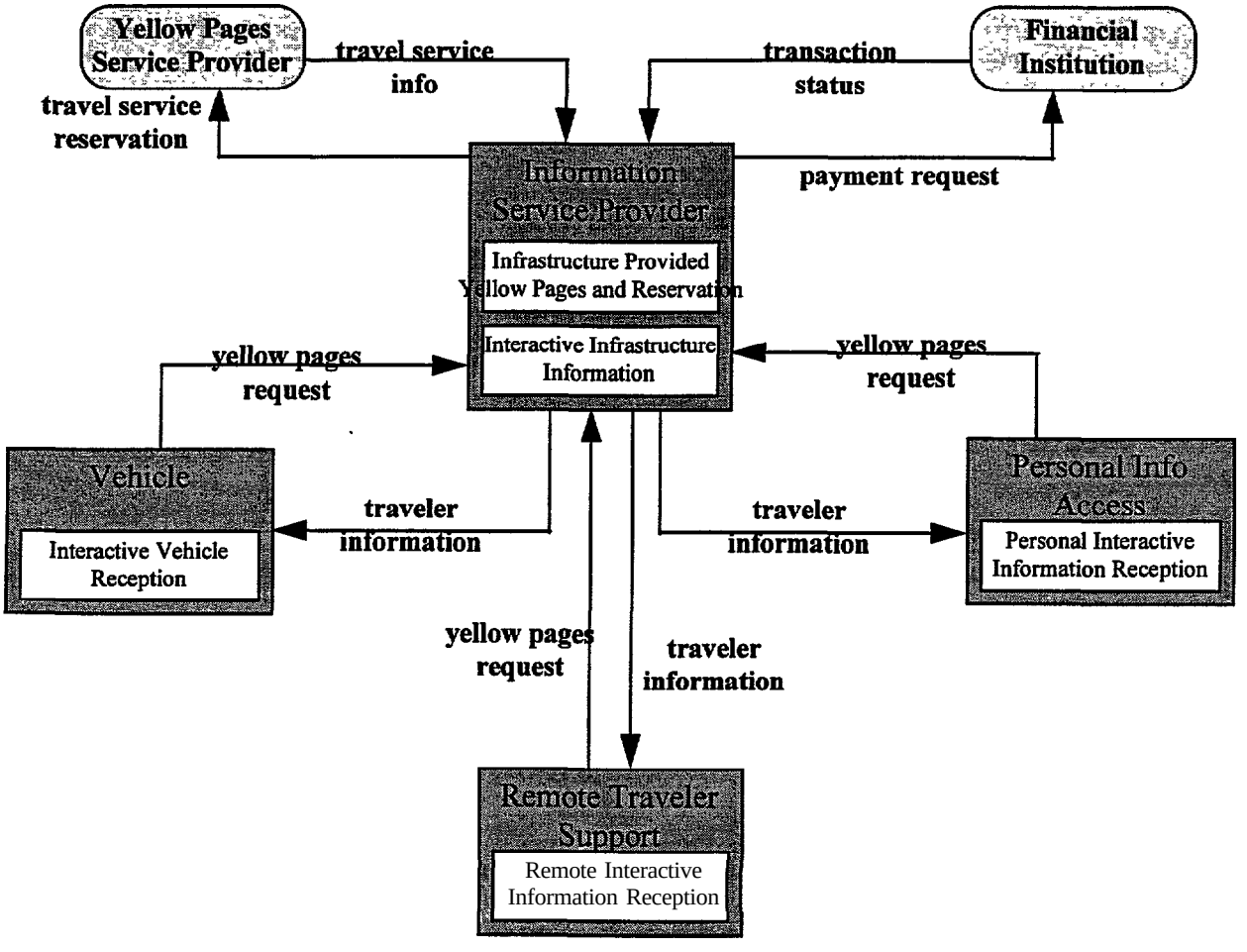
A.3.6 INTEGRATED TRANSPORTATION MANAGEMENT/ROUTE GUIDANCE ***(ATIS6)***

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. 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 Network Performance Evaluation--at the traffic management center.



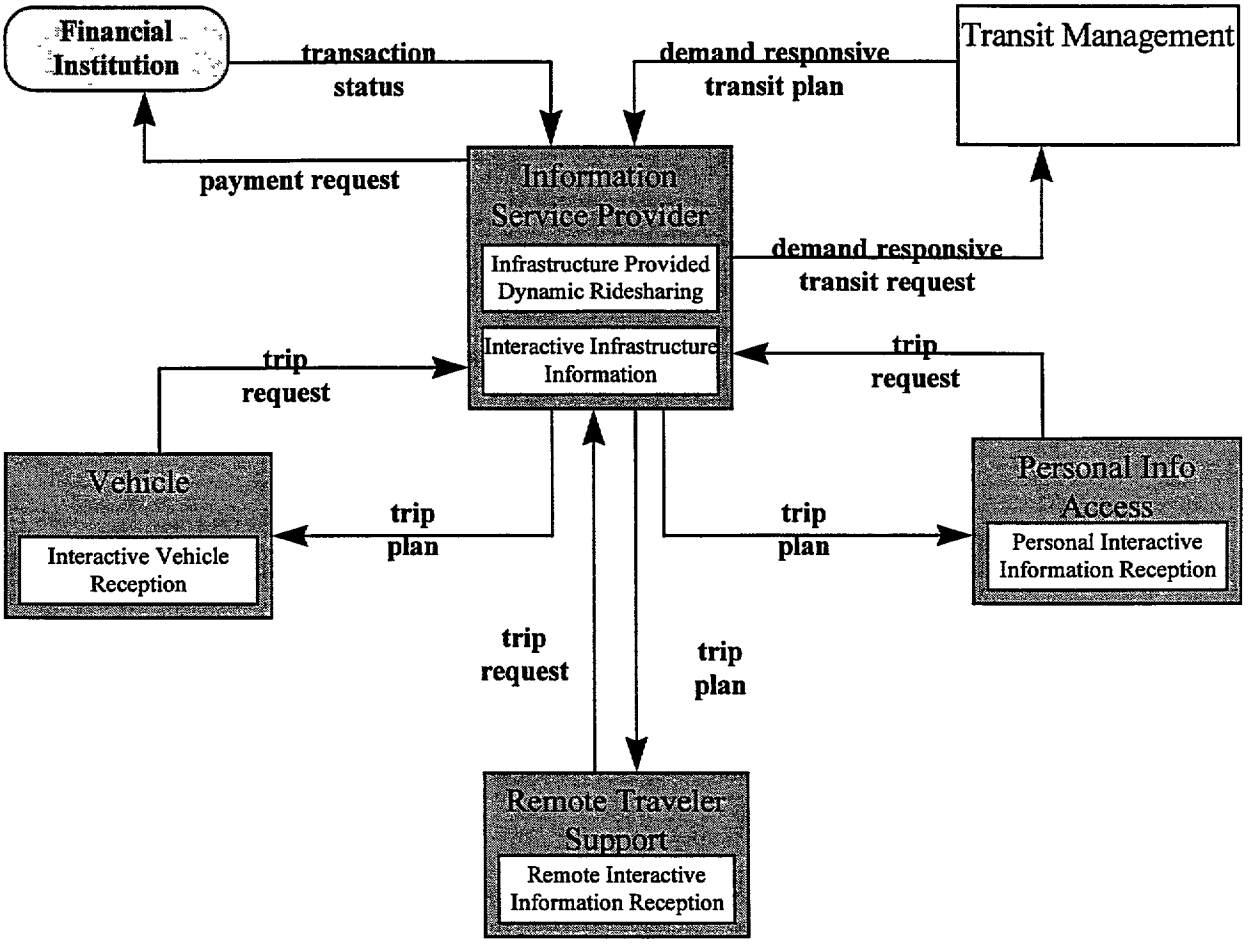
A.3.7 YELLOW PAGES AND RESERVATION (ATIS7)

This market package enhances the Interactive Traveler Information package by adding infrastructure provided yellow pages and reservation capabilities. The same basic user equipment is included; service or advertising fees should allow recovery of the ISP investment. This market package provides different ways for accessing information, either while en-route in a vehicle, pre-trip via wireline connections, etc.



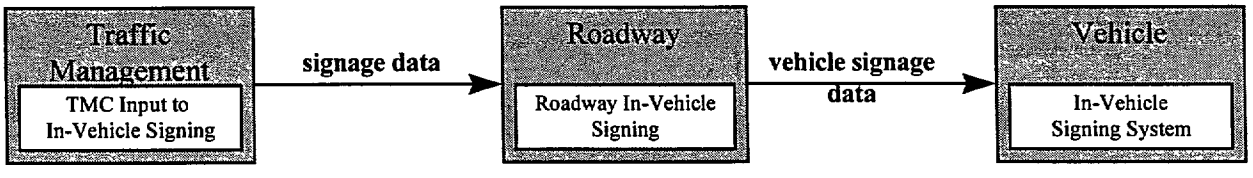
A.3.8 DYNAMIC RIDESHARING (ATIS8)

This market package enhances the Interactive ATIS with Infrastructure Driver and Traveler Information package by adding infrastructure provided dynamic ridesharing capability. The investment to the driver or traveler should not increase. 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.



A.3.9 IN VEHICLE SIGNING (ATIS9)

This market package supports local distribution of information regarding immediate roadway condition, especially weather-related (e.g., ice, fog, etc.). This package is not an increment over another one, but is a modular addition. It includes a short range radio transmission capability (e.g., beacon) and wireline connections to the TMC for coordination and control. This market package includes information distribution to perform the function of intersection safety warning.



A.4 Advanced Vehicle Safety System Market Packages

Many of the advanced vehicle market packages are autonomous systems that do not interact with other systems within the architecture definition. Each of these autonomous package is briefly described in the following. The most advanced implementations that do require communication between the infrastructure and vehicle (e.g., AHS) are described at the end of this section.

A.4.1 VEHICLE SAFETY MONITORING (AVSS1)

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.

A.4.2 DRIVER SAFETY MONITORING (A VSS2)

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 and performance, determine on-board safety data and display information.

A.4.3 LONGITUDINAL SAFETY WARNING (AVSS3)

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.

A.4.4 LATERAL SAFETY WARNING (AVSS4)

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.

A.4.5 PRE=CRASH RESTRAINT DEPLOYMENT (AVSS6)

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.

A.4.6 DRIVER VISIBILITY IMPROVEMENT (AVSS7)

This market package will enhance driver visibility using an enhanced vision system. On-board display hardware is needed

A.4.7 ADVANCED VEHICLE LONGITUDINAL CONTROL (AVSS8)

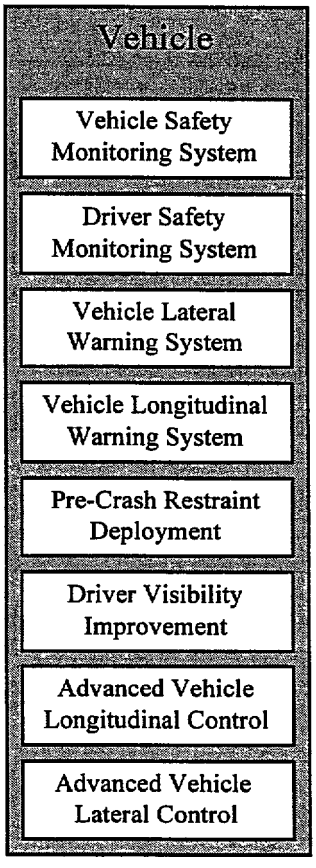
This market package automates the speed and headway control functions on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to

control the throttle and brakes. It requires on-board sensors to measure longitudinal gaps and a processor for controlling the vehicle speed.

A.4.8 ADVANCED VEHICLE LATERAL CONTROL (AVSS9)

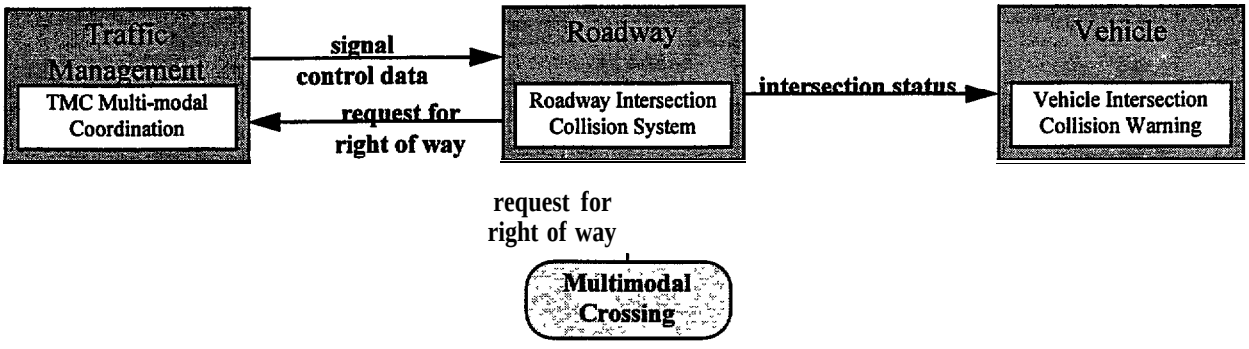
This market package automates the steering control on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to control the steering. It requires on-board sensors to measure lane position and lateral deviations and a processor for controlling the vehicle steering.

Many of the vehicle safety system market packages are autonomous vehicle systems that involve only vehicle equipment, Note that human (driver) and physical (sensor) interfaces exist but are excluded from these diagrams by convention. Each of the marketpackages includes one of the identified equipment packages.



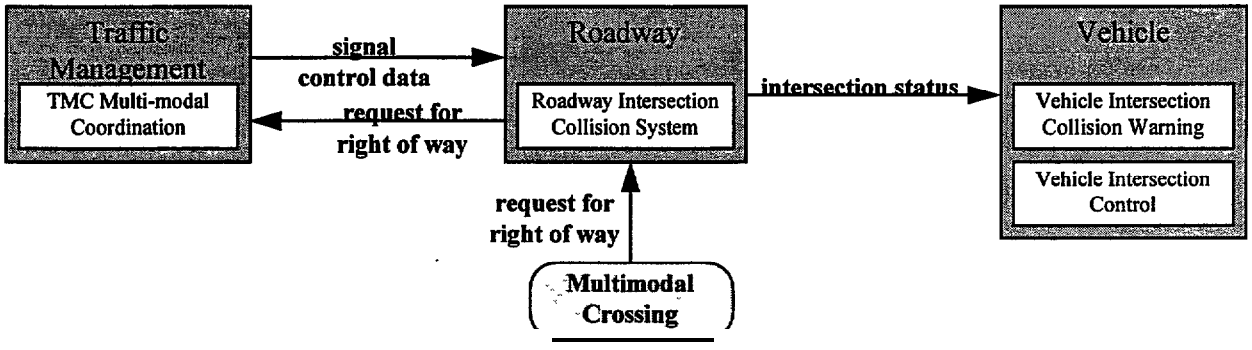
A.4.9 INTERSECTION SAFETY WARNING (AVSS10A)

This market package will determine the probability of an intersection collision and provide timely warnings to drivers in response to hazardous conditions. Monitors in the roadway infrastructure are needed to 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.



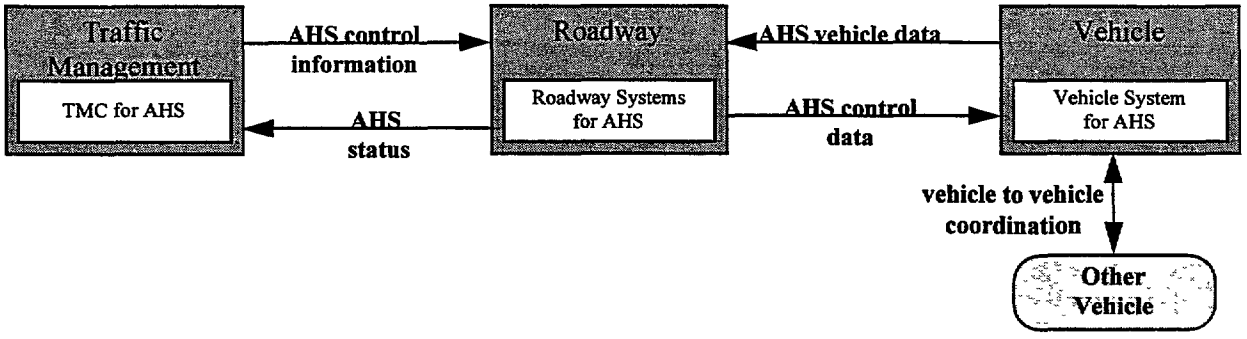
A.4.10 INTERSECTION COLLISION AVOIDANCE (AVSS10)

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.



A.4.11 AUTOMATED HIGHWAY SYSTEM (AVSS11)

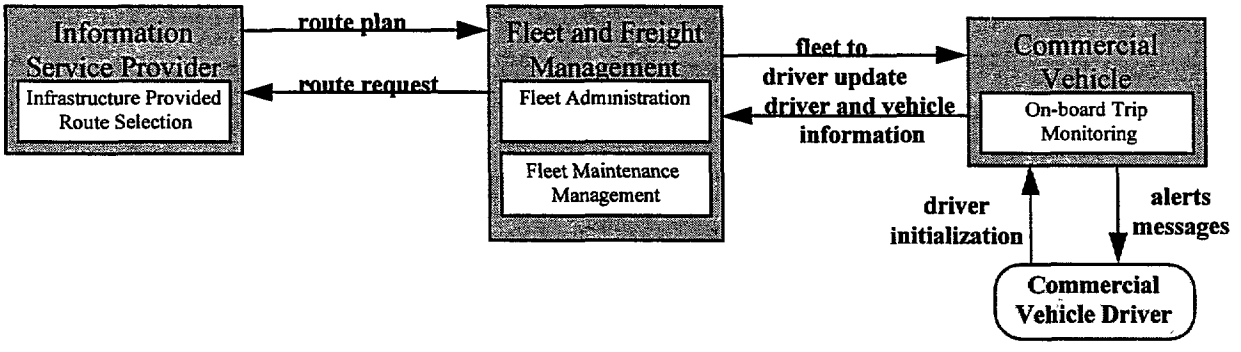
This market package enables "hands-off" operation of the vehicle on the automated portion of the highway system. Implementation requires lateral lane holding, vehicle speed and steering control, and Automated Highway System check-in and checkout. This market package currently supports a balance in intelligence allocation between infrastructure and the vehicle pending selection of a single operational concept by the AHS consortium



A.5 Commercial Vehicle Operations Market Packages

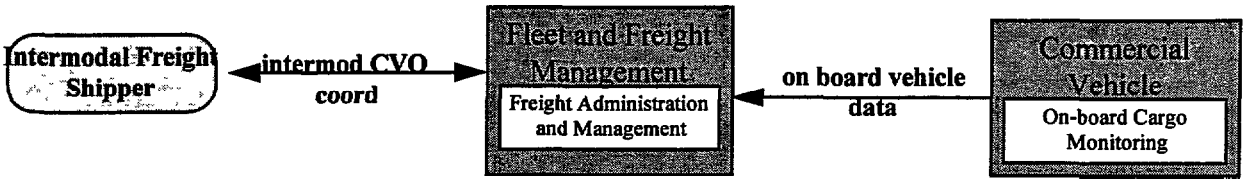
A.5.1 FLEET ADMINISTRATION (CVO1)

This market package keeps track of vehicle location, itineraries, and fuel usage at the Fleet and Freight Management Center using a cell based or satellite data link and the preexisting 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 Center 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.



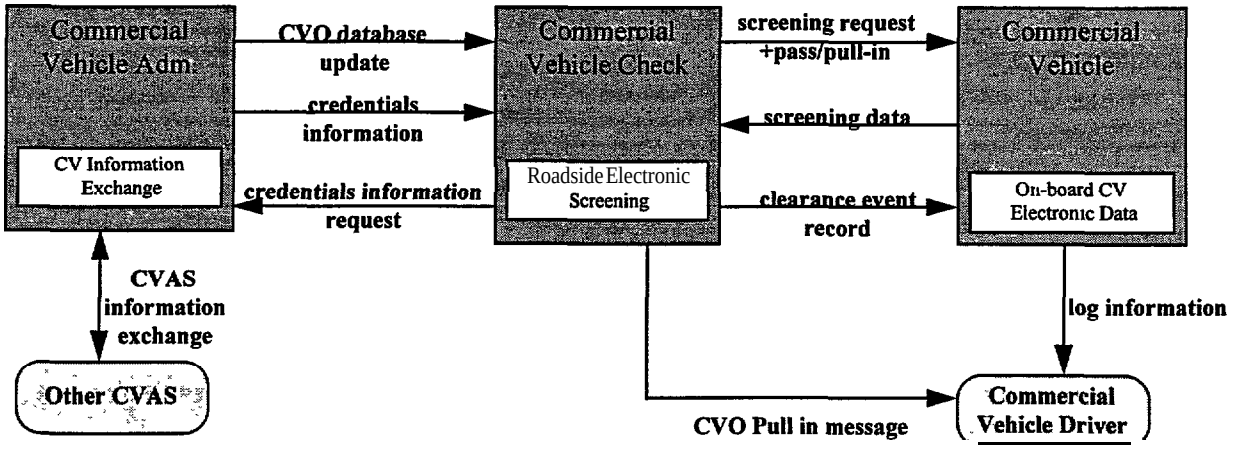
A.5.2 FREIGHT ADMINISTRATION (CVO2)

This market package tracks cargo and the cargo condition. This information is communicated with the Fleet and Freight Management Center via the existing wireless infrastructure. Interconnections are provided to intermodal shippers and inter-modal freight depots for tracking the cargo from source to destination. Interfaces are also provided to an ISP to calculate optimum cargo routing.



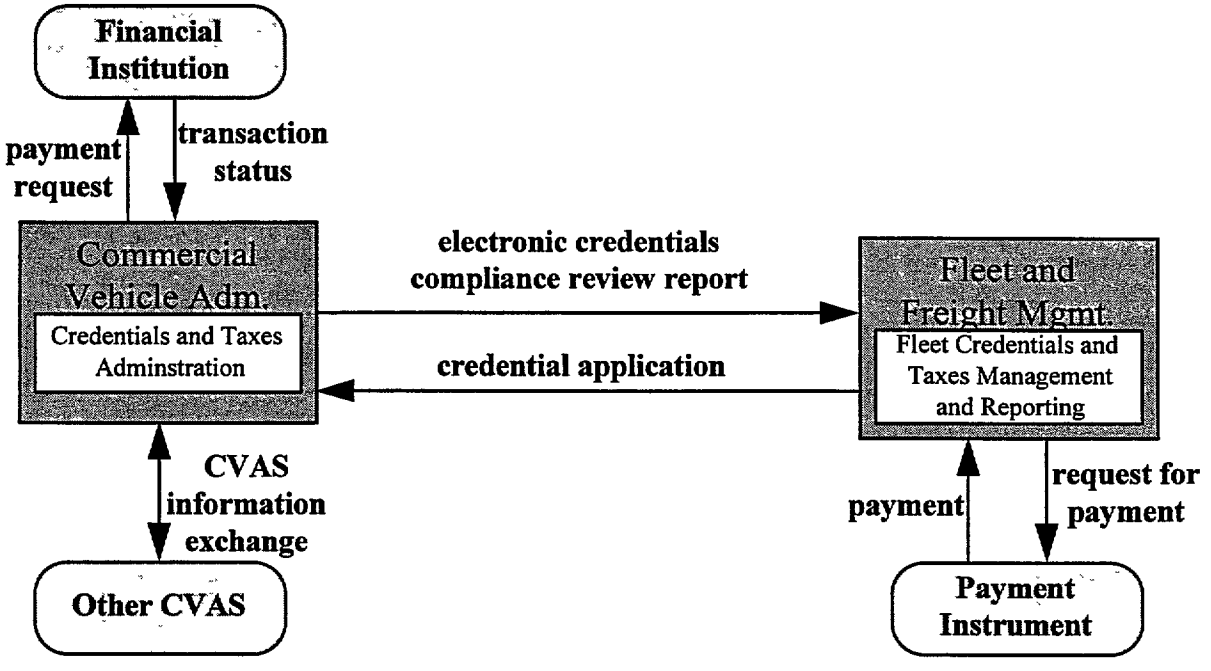
A.5.3 ELECTRONIC CLEARANCE (CVO3)

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.



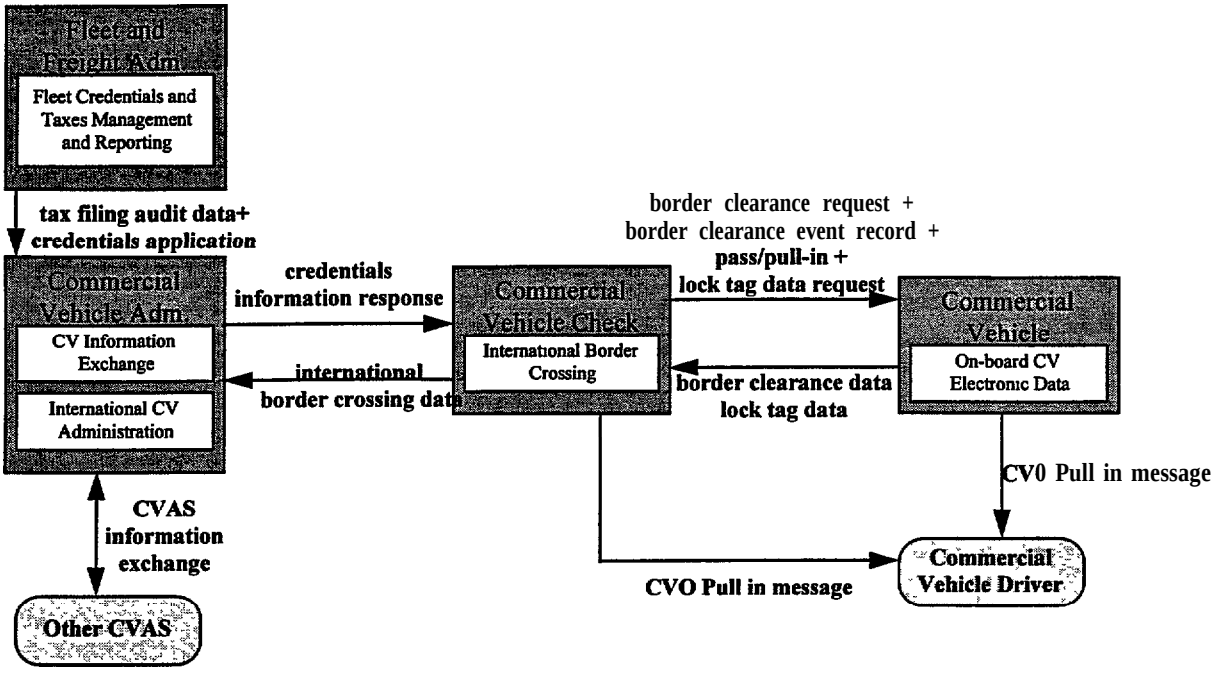
A.5.4 ELECTRONIC CLEARANCE ENROLLMENT (CVO3A)

This Market Package supports the registration (electronic credential and tax filing) of drivers, vehicles, and carriers. Through this process, carriers, drivers, and vehicles are 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.



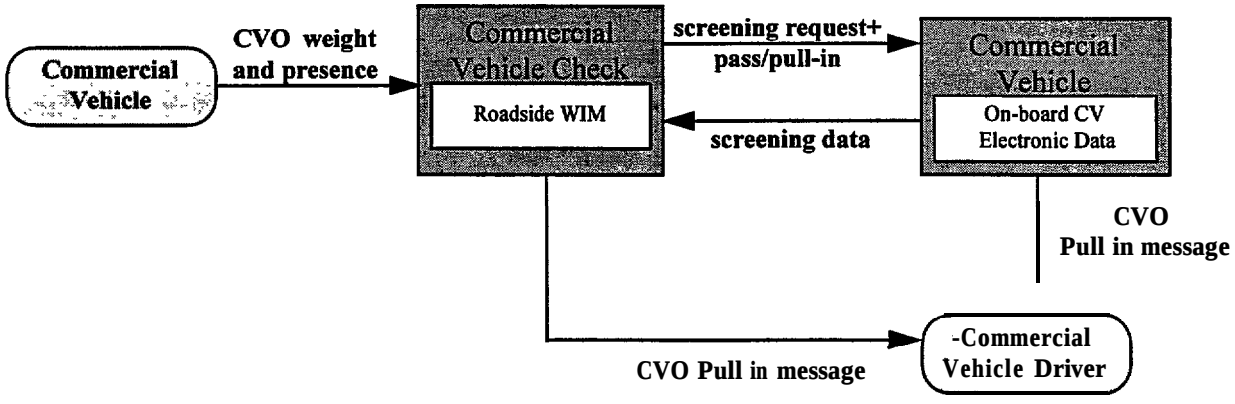
A.5.5 INTERNATIONAL BORDER ELECTRONIC CLEARANCE (CV04)

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.



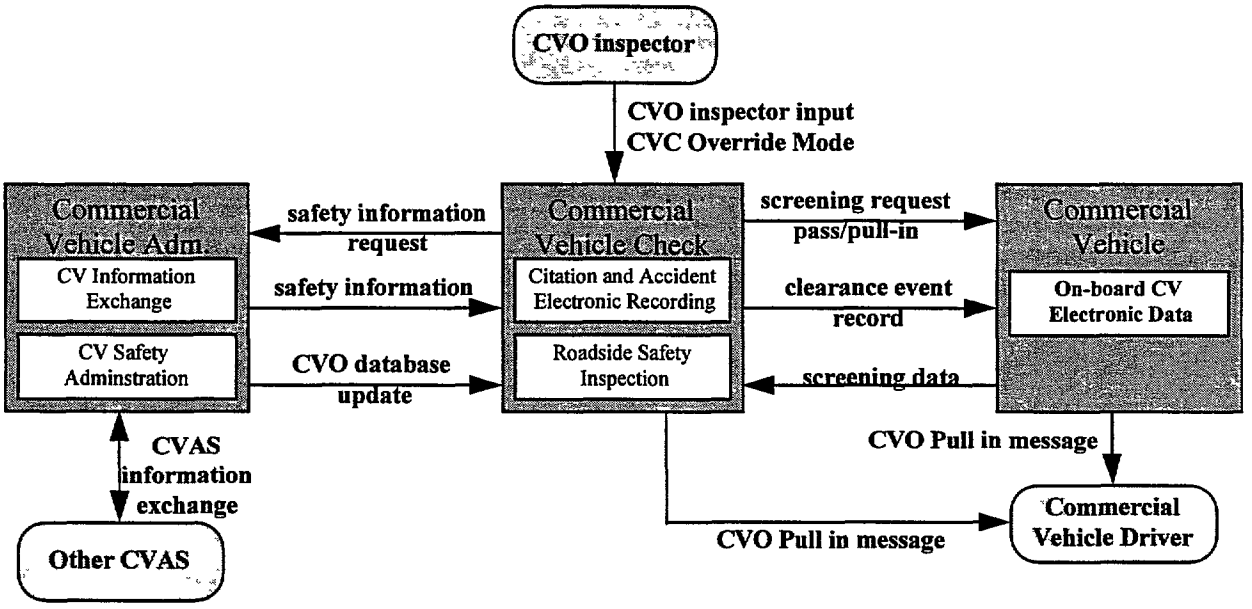
A.5.6 WEIGH-IN-MOTION (CVO5)

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.



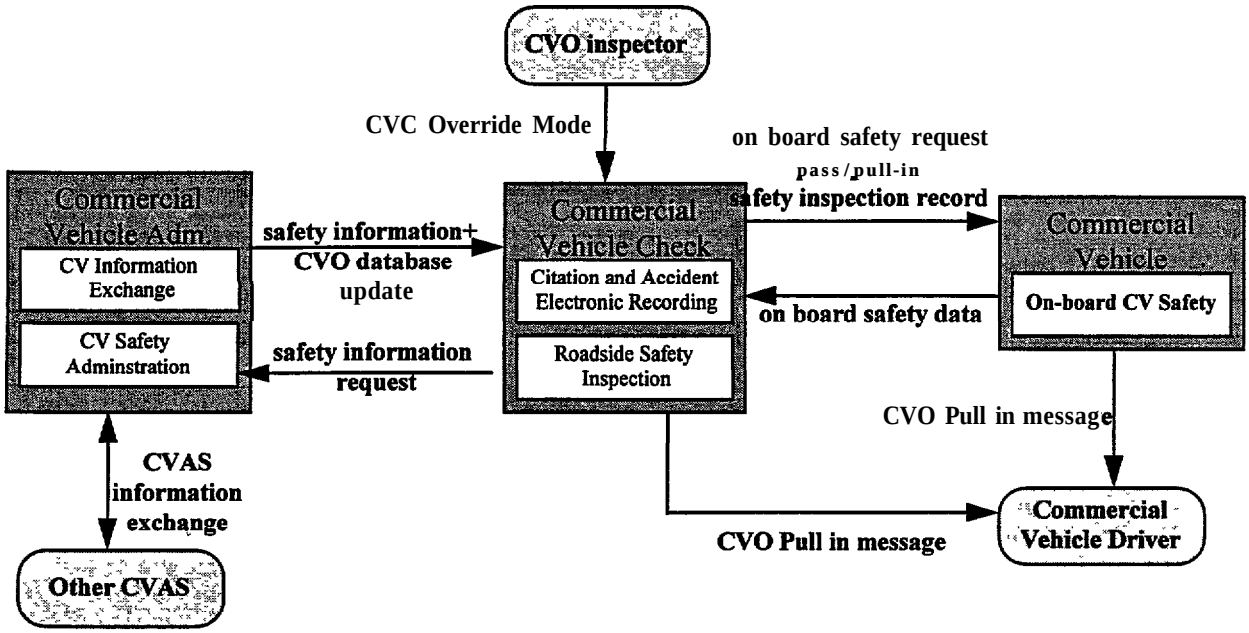
A.5.7 ROADSIDE CVO SAFETY (CVO6)

This market package provides for automated roadside safety monitoring and reporting. It automates commercial vehicle safety inspections at the commercial vehicle check subsystem. 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 package, distribute additional vehicle safety monitoring and reporting capabilities to the commercial vehicle.



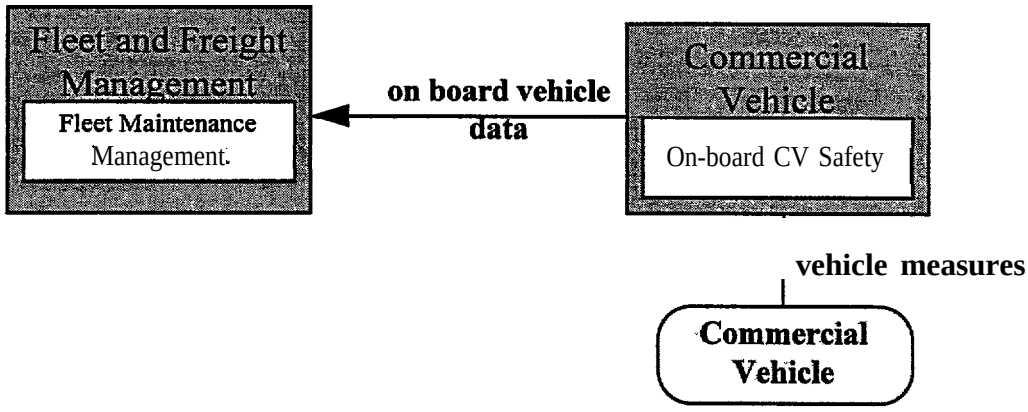
A.5.6 ON-BOARD CVO SAFETY (CVO7)

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 cellular link (data and possibly voice) to the Fleet and Freight Management and the Emergency Management Centers. 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.



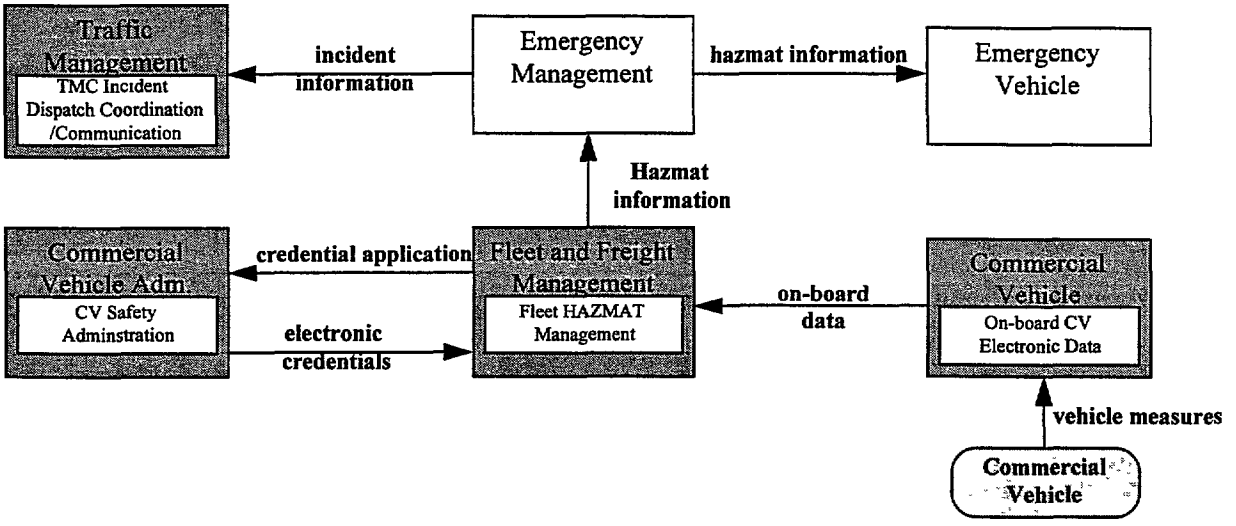
A.5.9 CVO FLEET MAINTENANCE (CVO8)

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 Center. Records of vehicle mileage, repairs, and safety violations are maintained to assure safe vehicles on the highway.



A.5.10 HAZMAT MANAGEMENT (CVO9)

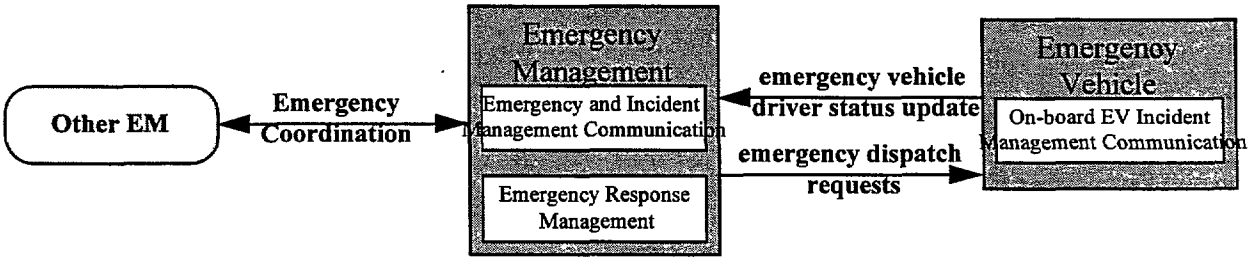
This market package integrates TMS incident management capabilities with commercial vehicle tracking and credentials management and safety to assure effective treatment of HAZMAT material and incidents.



A.6 Emergency Management Market Packages

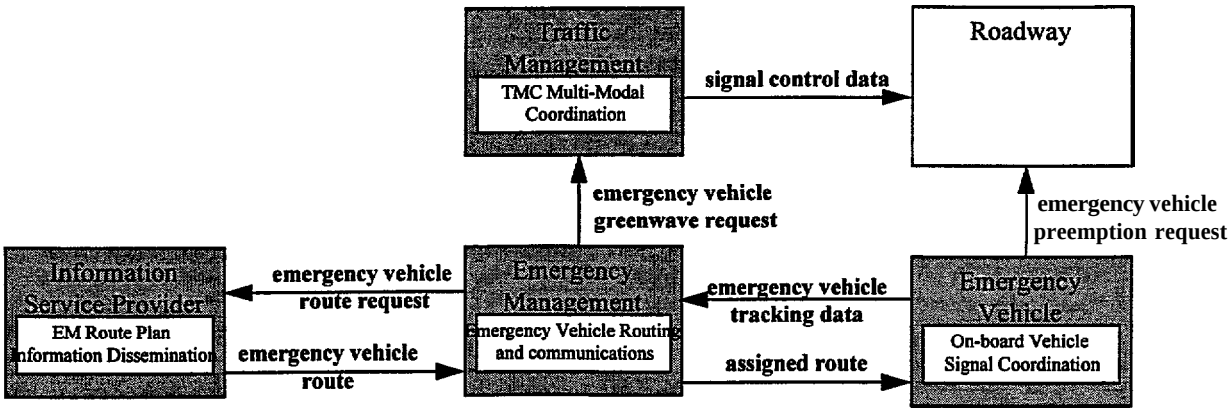
A.6.1 EMERGENCY RESPONSE (EV1)

This market package automates emergency vehicle notification upon verification of incident, location, and nature of incident by the Emergency Management center. This package uses existing and emerging wireline interconnects to sensors, and vehicle position locators for incident detection. Mayday signals will also be received via wirelines from other centers or from phone lines. It would utilize existing links or add cell based links between the emergency vehicle and the Emergency Management Center and an emergency vehicle based display for instructions. Emergency vehicle have short wave RF links to allow for local signal preemption. The Emergency Management Center would include hardware and software for tracking the emergency vehicles. Law Enforcement would normally be an integral part of this package as well processing violation notifications and supporting incident clearing efforts.



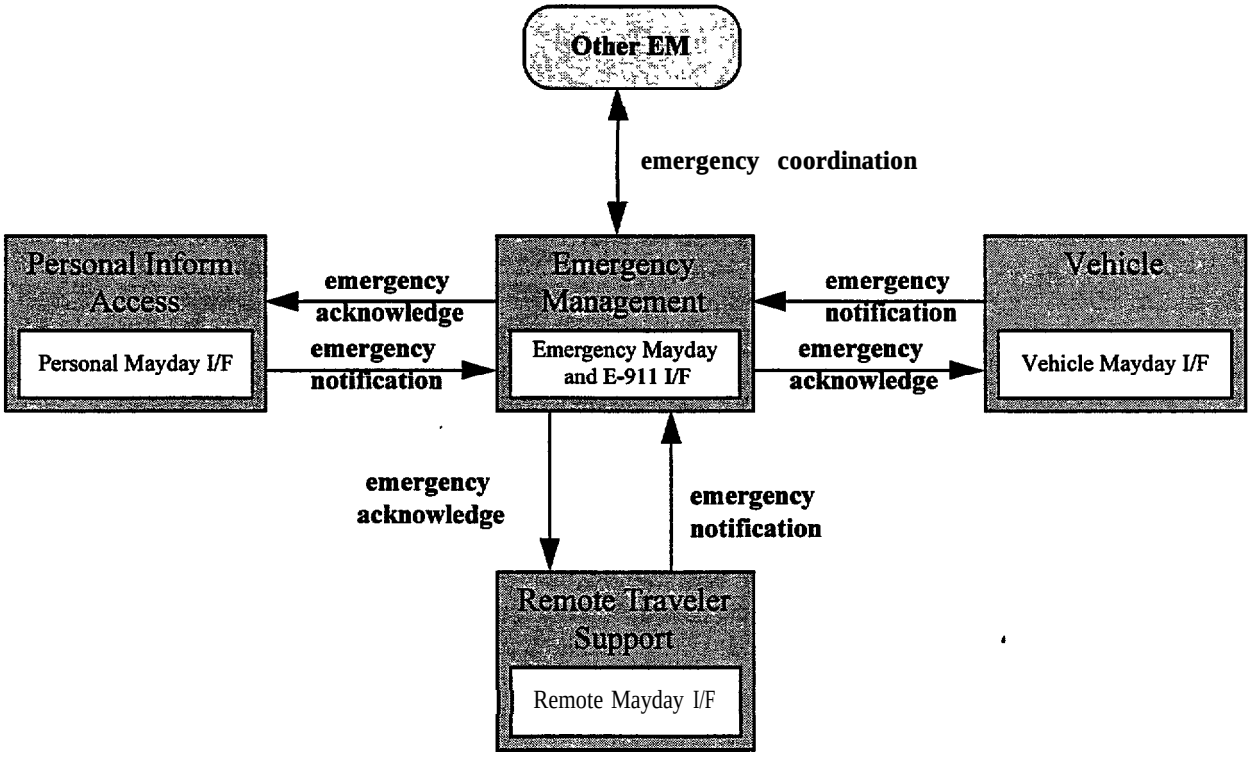
A.6.2 EMERGENCY ROUTING (EV2)

This market package provides the support for dynamic routing of emergency vehicles and coordination with TMS for green wave functions and ISP for best route.



A.6.3 MAYDAY SUPPORT (EV3)

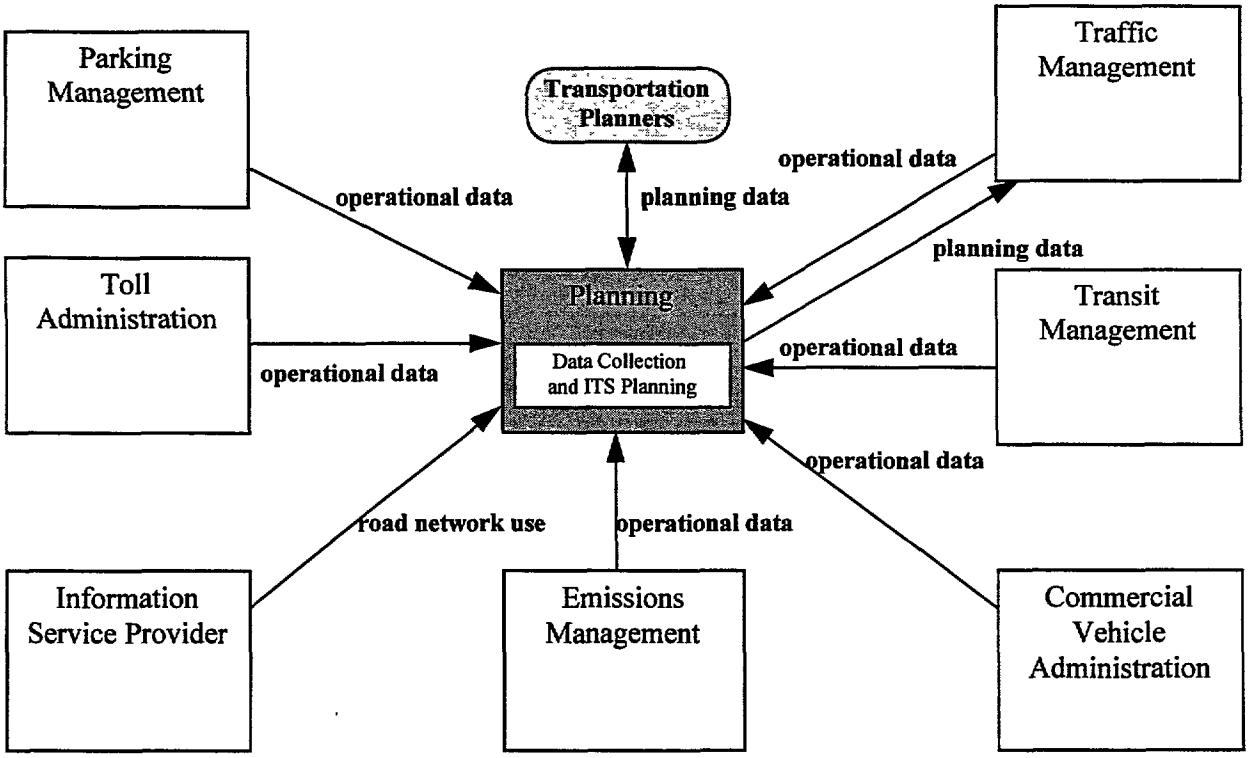
This package allows the user (driver or non-driver) to initiate a request for emergency assistance and enables the Emergency Management Center (EMC) to locate the user for efficient dispatch. The request may be manually initiated or automated and linked to vehicle sensors. The data is sent to the EMC using a cellular data link with voice as an option. Providing user location implies either a location technology within the user device or location determination within the cellular infrastructure.



A.7 ITS Planning Market Package

A.7.1 ITS PLANNING (ITS1)

This market package supports ITS planning functions. It accepts data from every center subsystem and uses this data to plan new deployments and new Market Packages. This data also supports policy decision making, allocation of funding, allocation of resources and other planning activities.



APPENDIX B: WEATHER SYSTEMS TECHNOLOGY ASSESSMENT

This scope of this Work Element is:

> Technology will be assessed which has the potential to address weather related problem areas as identified through the Corridor Needs Assessment. Specifically, weather related accident trends and problem areas, as discussed through the outreach effort, will be examined to determine if weather system technology systems would enhance safety and operations. Functional areas considered shall include advance driver information applications, and WSDOT Maintenance and WSP response and communications interface. Weather monitoring devices, roadside variable message signs, and highway advisory radio systems will be considered under this assessment . Results of this work element will be incorporated into a technical memorandum.

B.1 GENERAL

Weather equipment and systems have represented mature technologies for many years, and recent developments have significantly enhanced both the quantity and quality of weather data available to anyone who needs it. Weather communication networks are also among the most frequently used throughout the world, primarily for flying operations and severe weather advisories and warnings. These networks are generally open systems with free exchange of weather information in all forms, both nationally and internationally. However, due to lack of standard protocols and the proprietary nature of highway weather systems, significant problems occur in the acquisition, sharing, and transmission of weather information in the ground transportation arena.

Before commenting on the overall state of weather technology for the respective corridors, it is appropriate to explain the major weather technology areas that will impact the use of weather information for ITS applications.

B.2 WEATHER OBSERVING SYSTEMS

B.2.1 Sensors

Weather sensors can detect, record, and transmit changes in weather elements to a degree of accuracy which meets all ITS environmental needs. Developments during the last five years in sensor technology have significantly reduced the need for moving parts in these sensors, providing greater reliability, reduced cost, and lower maintenance requirements. For example, infrared visibility sensors have been developed which are smaller and less costly than the older focused light-beam transmissometers; a newer variety of wind sensor has no moving parts; and, the very first freezing precipitation sensor has recently been approved for fielding by the National Oceanic and Atmospheric Administration's (NOAA's) National Weather Service (NWS).

Pavement temperature sensors are usually considered to be a part of airport runway or highway weather systems, since they are normally integrated with remote processing units for weather sensor information. These have also evolved into very accurate and reliable sensors which now can detect more than just pavement temperature. Other capabilities include temperature of the subsurface below the pavement (for detecting soil freeze and thaw), moisture on the pavement, and percent of deicing chemicals in solution on the pavement surface in order to determine when to reapply more deicing chemical.

B.2.2 Automated Surface Observing System

In 1990, the NWS began fielding the Automated Surface Observing System, or ASOS. This program continues. As of May 8, 1998, the latest status report by the NWS, ASOS had been installed at 711 airports nationwide, with 191 scheduled for addition, for a total of 902 procured systems.

ASOS operates continually in the observational mode, recording weather observations every minute around the clock. At airports, these observations are displayed at the NWS office, FAA towers, and airline displays, and can be queried by users at any time by telephone. ASOS currently has limitations, primarily consisting of the inability to observe surrounding or nearby

weather conditions such as approaching thunderstorms . However, the fielding of these systems will increase the national weather observing network.

B.2.3 Weather Radar

A big leap in technology took place nearly four years ago when the NWS began fielding the Next Generation Weather Radar, also commonly referred to as "NEXRAD" or doppler weather radar. Unlike previous weather radars, this radar has the capability of analyzing winds and moisture in the atmosphere surrounding the radar out to 248 nautical miles (460 km), and to an altitude of 70,000 feet (20 km) above ground level. This enables the assessment of both current and potential precipitation rates, and the strength and circulation of the overall wind field, including wind shear; previous radars in use had extremely limited or no capabilities in these areas. The NWS has plans to field a total of 161 of these radars. As of May 8, 1996, 152 radars had been delivered, and 112 had been fully commissioned for operational use, for a total of 264 systems.

B.2.4 Next Generation Geostationary Operational Environmental Satellite (GOES-Next)

The NWS also has a program of fielding state-of-the-art weather satellites. A new GOES satellite carrying the best civilian instruments built for meteorology was recently placed into orbit over the midwest United States, and is now providing effective weather satellite coverage of all areas of the continental United States for the first time,

GOES satellites provide crucial information to meteorologists and other users regarding the type of existing weather over specific areas. More importantly, through time-image looping, weather systems can be tracked as they move and intensify. Users of this data are thus provided with an "eye in the sky" view of weather systems from which they can gauge movement, development, moisture, frontal system positioning, aerial coverage and other important factors in determining the impact of weather systems.

B.2.5 Other Applications

A unique application of technology for detecting highway visibility without the use of meteorological instruments is being explored. This includes the use of highway television cameras for determining visibility measurements. The Hokkaido Development Bureau in Sapporo, Japan has developed such a system. The concept of calculating visibility using the images of ordinary highway monitoring TV cameras has been accomplished using digital image processing via personal computer without specific targets. The Japanese study found a correlation coefficient of 0.92 of the brightness of the TV camera images to the visibility. The detected visual range can be transmitted to any traffic and/or emergency management point when visual range falls. What makes this study promising for greater use of visibility information is the increasing use of TV cameras for traffic surveillance and management throughout the United States.

B.3 WEATHER FORECASTING SYSTEMS

Concurrent with weather observing systems, there have been significant advances in weather forecasting capabilities as well as a surge in meteorological research.

Increased satellite coverage and the improved weather radar capabilities cited above are two key technologies critical to the improvement in accuracy and timeliness of weather forecasts. Use of NEXRAD is proving to be a revolutionary tool in weather forecasting. A fiscal year (FY) 1995 study by the NWS found that lead times for tornado warnings increased by 30 percent, with a forecast accuracy increase of 25 percent. Additionally, important to snow and ice control, accuracy of snowfall forecasts increased by seven percent using NEXRAD. Operational effectiveness assessments of NEXRAD are continuing, and more improvement in forecasting accuracy is expected as experience is gained in use of NEXRAD's many capabilities (more than 75 displays of various derived products are available). Data provided by these observing systems provide transportation managers the ability to watch and track the weather systems affecting their resources.

The Advanced Weather Interactive Processing System (AWIPS), explained in Section IV below, will integrate satellite and radar data and provide forecasters with the capability to significantly improve forecasts and warnings.

In addition to the systems already fielded and being developed by NOAA and NWS, commercial enterprises have entered the market to provide forecast services beyond the scope of NWS. One such effort in the weather forecasting area is the development of personal computer (PC) based automated weather forecasting systems, aimed at support of agencies involved with snow and ice control. These programs provide PC-based software with graphical user interfaces for highway maintenance managers which display weather forecasts presented as icons superimposed over terrain, cities, and road networks. The software is programmed to update the forecast using changes in weather observations selectively input by the maintenance supervisor. With the dramatic increases now being realized in PC computing power, the application of these PC-based programs is expected to increase.

The increased volume, quality, and different types of data generated by the GOES satellites and the NEXRAD radar have provided universities and private research agencies with a high volume of quality environmental data. Combined with new computing power, this has provided the motivation for research studies that were not possible just a few years ago. Detailed wind shear studies, for example, can now be done using NEXRAD due to it's capability to define detailed wind and wind velocity patterns at all levels within specific storms.

NEXRAD data has also provided other researchers outside of the meteorological community with the opportunity to do unique studies. A 1995 study using NEXRAD data was performed by Professor Seliga at the University of Washington Department of Electrical Engineering. This study, supported by WSDOT, related NEXRAD rainfall rate data to conditions on the highway. It examined the potential to use NEXRAD data for highway management by the introduction of three radar-based, rainfall-dependent indices that affect driving: Highway Wetness Index (HWI), Visibility Impairment Index (VII), and Combined Hazard Index (CHI). A methodology for deriving these indices along prescribed routes in real-time is described and illustrated for the Seattle area.

Further study on this application of NEXRAD to traffic management depends on funding. However, Professor Seliga has been invited by the NWS to provide expertise in development of NEXRAD precipitation algorithms during the summer of 1996. His work should result in better development and use of NEXRAD data for all transportation requirements. A quote from the TRAC Research Review, November 1995, summarizes the importance of this work:

Eventually, a deeper understanding of the relationships between weather and traffic may be used to reduce traffic congestion, save lives, and increase transportation efficiency through approaches such as automated speed limit adjustments, rerouting of traffic, more effective communication of highway conditions, designation of alternative routes, accurate on-line estimations of travel times, and automatic alerting of police, fire, and other emergency response agencies of weather factors that would affect service delivery.'

Another application of this study would be to eventually relate rainfall rates to vehicle braking action.

8.4 COMMUNICATIONS SYSTEMS

Communications for weather networks are among the most mature and widely used of all communications systems, both nationally and internationally. However, weather communications networks have evolved over the last half century with primary emphasis on air transportation. A public safety emphasis followed later for severe weather advisories and warnings for resource protection and general transportation requirements, with a continued emphasis on safety of air transportation. Specific programs exist for upgrading national aviation support. These include the Aviation Gridded Forecast System being developed by the NWS Forecast Systems Laboratory, the Aviation Weather Products Generator under development in the Research Applications Program of the National Center for Atmospheric Research, and the Integrated Terminal Weather System being developed by the Lincoln Laboratory of Massachusetts. There are no specific national weather communications systems being developed for ground transportation, although the development of AWIPS, explained below, will serve all transportation users.

Communications systems in support of weather technology are open and very accessible, nationally and internationally. However, commercial vendor weather systems fielded in support of surface transportation, specifically for state departments of transportation for road maintenance (primarily snow and ice control), have evolved with closed systems and proprietary components (primarily communications software). At this writing, the National Transportation Communications ITS Protocol (NTCIP) has not been developed for application to the weather information and technology area. This must be done if weather information in support of road users is to be integrated with other weather information systems in support of air transportation, flood management, crop management, forest fire management, and other important areas. This would also allow the integration and sharing of weather information for all ITS user areas. It is our belief that the recent development of the NTCIP for traffic signaling, and the State of California's formal acceptance of this protocol, will help drive the development of the NTCIP for weather communications in support of all transportation systems.

One significant improvement in the advancement of communications for the weather technology area is the NWS initiative to field the AWIPS. Since this system will serve all transportation

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[1] TRAC. 'NEXRAD System Will Integrate Weather Data With Traffic Database To Improve Motorist Safety," Research Review, University of Washington, Seattle WA, November 1995.

customers through the faster acquisition and processing of meteorological information, it deserves specific discussion.

B.4.1 Advanced Weather Interactive Processing System (AWIPS)

AWIPS will provide information processing and forecast workstations at each NWS field forecast office with an interactive communications link among all the offices. This system will be critical in assisting NWS forecasters to assimilate observations from all data sources (e.g., ASOS, NEXRAD, GOES), numerical (computer-generated) weather forecasts, and other information as well as to generate improved forecasts and weather warnings. Advanced supercomputers and numerical models of the atmosphere at the National Meteorological Center will improve the timeliness and accuracy of operational numerical weather forecasts. The benefits of AWIPS will be directly translated into better centralized forecast guidance for weather service vendors, providing support to all ITS user areas. AWIPS will provide the communications capability needed to allow internal (NWS) and external (vendors, etc.) users access to much of the nation's real-time environmental data.

Aligned with AWIPS will be a service called NOAAPORT. This service is the point-to-multipoint information dissemination system of AWIPS. It consists of a satellite-based broadcast segment that will pump millions of bits of weather and satellite data every minute from weather service central computers to nearly 120 NWS AWIPS forecast offices, as well as to private sector interests and universities.

An AWIPS prototype has been developed and a detailed design review held in January 1996. No major problems were identified. The NWS FY 1997 budget request includes an increase of $69.8 million for the AWIPS program to continue critical software development activities and to begin nationwide deployment of the AWIPS system.

B.5 I-5 CORRIDOR

B.5.1 Weather and Pavement Temperature Observations

Overall, the I-5 corridor has a number of gaps in weather and pavement temperature coverage which will make it very difficult for road and weather information ITS interfacing. For that reason, and to provide needed data for weather forecasting and road maintenance, the following recommendations are made:

- Road weather information system (RWIS) sites which have both weather and pavement temperature sensors, be located at:
  - SR 2 interchange (MP 193.5)
  - The vicinity of MP 246, south of the I-5 and SR 11 interchanges
  - State Visitor Information Center (MP 269)
- Pavement temperature sensor sites which do not need collocated weather sensors but which would provide valuable pavement data (primarily for forecasting bridge frosting/icing) for areas with a high incidence of accidents, located at:

- 220th Street SW interchange (vicinity of MP 179)
- SR 99 and SR 527 interchange
- Steamboat Slough Bridge (MP 197)
- Stillaguamish River Bridge (MP 209)
- Skagit River Bridge (MP 228)
- SR 539 interchange (MP 256)
- Nooksack River Bridge (MP 263)

The entire l-5 corridor has adequate weather satellite and radar data coverage which are accessible to transportation managers through data services providers. The NEXRAD radar at Camano island, north of Seattle provides complete coverage of the entire corridor.

B.5.2 Weather Forecasting

The l-5 corridor presents some very unique weather forecasting problems due to the void of data over pacific ocean source regions. However, the addition of the NEXRAD radar at Camano island north of Seattle now provides complete coverage of the corridor. Unlike pre-NEXRAD days, forecasters now have the ability to analyze approaching weather systems in great detail before they move onshore and over the l-5 corridor. For example, weather elements which lead to developments in the Puget Sound convergence zone can be detected earlier, and the zone can therefore be more accurately forecast in its impact (such as heavy precipitation) to specific areas of the corridor. With future refinement of NEXRAD precipitation algorithms, **and** application and further development of studies relating precipitation rates to traffic flow, weather forecasters will be better able to relate weather patterns to corridor traffic flow.

B.6 SUMMARY

The weather technology area has the potential to provide ITS user areas with near real-time weather information and improved weather and pavement condition forecasts. Advancements in equipment (such as NEXRAD) and communications (such as AWIPS) will allow greater speed and access of weather information, and better weather forecasting accuracy, to all ITS user areas.

However, weather technology is an area that needs attention from an ITS perspective in that no communications protocol exists which has the potential for standardizing weather communications to all users. This fact stands in stark contrast with surveys that have found that highway users have consistently specified weather information as among the top two or three travel and travel planning information elements. A recent (1995) study by the State of Minnesota found that all types of highway users ranked weather information as number one in their priority for travel information.

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APPENDIX C: COMMERCIAL VEHICLE OPERATIONS ENHANCEMENT OPPORTUNITIES

The Consultant shall identify and evaluate a range of ITS technologies specifically designed to improve the efficiency and operations of commercial vehicles. The technology assessment shall include an evaluation of: pre-trip and en-route commercial vehicle travel information; weigh-in-motion technology; route guidance; incident management; highway advisory radio; commercial vehicle pre-clearance; and, automated inspections and administrative procedures. The assessment shall identify the availability and potential application of each technology.

Information from this assessment will be used to identify specific locations for application of ITS commercial vehicle technologies in work element 3. The information assembled for this work element will be compiled into a technical memorandum.

It was determined that Commercial Vehicle Operations (CVO) and Border Crossing technologies would not be specifically addressed at the corridor level due to statewide work being conducted under two supplemental work orders to this contract. JHK and Associates, under separate cover, will produce two separate development studies that will address the future CVO needs, "Washington State CVO Strategic Plan" and "Information Technology Feasibility Study for the Washington State CVISN Deployment Plan".

APPENDIX D: TRAVELER/TOURIST INFORMATION OPPORTUNITIES ASSESSMENT

The Consultant shall identify and evaluate for this specific application, the applicable range of ITS technologies specifically designed to aid travelers and tourists through the provision of pre-trip, en-route, and real-time travel information. The provision of transit and auto traveler services information, route guidance, and incident information will be included. Special attention shall be given to incorporating traveler information into existing rest stops and other existing facilities. Information from this work element shall be compiled into a technical memorandum.

D.1 TRAVELER/TOURIST INFORMATION OBJECTIVES

The purpose of the following is to summarize traveler/tourist information needs in the I-5 corridor between Seattle and Vancouver, B.C., and to identify potential ITS technology solutions to help address them. Potential objectives that can be addressed through the provision of accurate, timely traveler/tourist information include:

- Enhanced corridor road, rail, marine, and possibly air travel for a variety of customer groups, including commuters/regular users, tourists, business travelers, and commercial vehicle operators.
- Support for local traffic management efforts in urban areas within the corridor to provide safe and efficient movement of people and vehicles, and to minimize or reduce traffic, parking, and other impacts.
- Promotion of tourism, recreational activities, and economic development consistent with local goals and objectives in urban and key recreational areas in the corridors.
- Promotion of the utilization and enhancement of local and intercity public transportation systems.
- Safety enhancement for travelers using the corridor.
- improved quality and availability of traveler information to promote informed trip planning and mode selection.

These objectives may be achievable through the deployment of a range of traveler information services, available on a pre-trip and/or en-route basis. A summary of potential ATIS services is provided in Appendix A, and discussed in terms of application to the corridor in the main body of this memorandum.

D.2 POTENTIAL TRAVELER/TOURIST INFORMATION SERVICES

D.2.1 Service Stratification

There are various ways of stratifying or organizing traveler information services, including by mode, by trip type, by customer type, by access method, or by location. For the purposes of this section, the discussion of traveler information technologies focuses on two major categories including:

- **Pre-trip information** which is accessed by the customer prior to embarking on the trip for the purpose of making route or mode decisions, planning destination activities, identifying stops along the way, planning departure or predicting arrival times, determining special requirements (e.g. carrying chains or emergency supplies during winter weather conditions), and/or connecting with other modes of travel such as scheduled rail and marine transportation.

- **En-route information** that the traveler receives during the trip. This information could warn the traveler of unusual upcoming conditions such as traffic congestion, public transportation system delays, accidents, localized inclement weather, or other factors affecting travel time, safety, or mode choice. En-route traveler information can also be used to provide additional local information as the traveler nears an interim destination or recreational area along the route, or to provide information on diversion routes or modes as the traveler reaches a decision point.

Within each of these two broad categories, there exists a number of customer groups that can be broadly classified in terms of:

- **Passive users** who prefer to only receive information as it is broadcast or disseminated, mentally filtering out those elements of the information pertinent to his or her specific trip. Examples of passive users are travelers who listen to radio, TV, or other broadcasts to make initial trip planning decisions, and use VMSs, HAR, or broadcast radio to make en-route decisions.

- **Active users** who prefer interaction with the information provider to determine trip-specific information. Examples of active information access include using the World Wide Web to get trip-specific information, calling an information hot line, or using an in-vehicle route guidance device to make en-route trip or routing changes.

The following discussion focuses on what information technologies may be feasible/desirable in the corridors for pre-trip and en-route information, and identifies how these technologies might be targeted to passive and/or active users.

D.2.2 Information Technology Options

D.2.2.1 COMMERCIAL BROADCAST SYSTEMS

Perhaps the most common sources of traffic (and occasionally transit) information are commercial radio and television broadcasts. This information is oriented towards passive users, and is typically delivered live from a studio in short (30 second or less) traffic reports at 10 to 30 minute intervals. Companies such as Metro Traffic Networks and Shadow Broadcast Services often provide this service on a contractual basis to multiple radio or TV stations.

Radio can be used for both pre-trip and en-route planning, while television is generally only suitable for pre-trip planning. Television reports may, however, include live video from CCTV cameras and/or map displays to provide a visual depiction of potential problems and to identify alternative routes.

Status and Emerging Technologies

Commercial broadcast technology is fairly well established and deployed in most urban areas. The use of dedicated cable TV stations for displaying traveler information is beginning to gain acceptance in some of the larger metropolitan areas in other parts of the country. Weather and cable news networks are available in the northwest that could provide corridor traveler information.

Interactive television is one emerging technology that might provide enhanced traveler information capabilities. The concept involves two-way communication between a cable TV provider and customer for the purposes of in-home services such as on-demand video, billing, shopping, and other services. A possible adjunct to interactive television services would be to include interactive route or trip planning capabilities, such as those currently provided through the RiderLink Internet home page in Seattle.

Advantages and Disadvantages

The advantage of broadcast services is that most customers have a television and/or radio and can easily access the information at home, at work, or en-route. There is also no additional cost to the user for receiving this information (costs are borne by the broadcaster).

The problem with most broadcast information services is lack of information on rural or intercity areas; most information is targeted towards the urban commuter during peak commute periods. The extent of information is also limited by a 30 second or less time slot.

D.2.2.2 RECORDED BROADCAST SYSTEMS

Recorded broadcast systems are typically operated by government transportation agencies, and are primarily used to provide both regional and localized information via radio or telephone. Examples include pre-recorded transit schedules, fares, and other information, or localized HAR. Both telephone and highway advisory radio systems are generally considered to be passive, although the availability of alternate menu selections may make the former semi-active.

Status and Emerging Technologies

Both telephone and HAR represent mature traveler information technologies. For both systems, research is proceeding on the use of voice synthesizers to automatically generate message information. Most customers, however, do not like the quality of synthesized voice messages, and find them difficult to interpret while in a moving vehicle or other high noise environment.

For message generation, one technology enhancement that has been deployed by a number of DOTs is a digitally recorded audiotext system. A digital message library can be created, and specific messages activated to respond to changing travel conditions. A software program updates the information on a regular basis without interrupting the service. An example is the menu-driven SmarTraveler service operated by the Massachusetts DOT which conveys information by route through a recorded human voice digitally stored on a computer disk. Future generations of audiotext systems. are expected to incorporate callback technology, where the system will initiate a telephone call to users from a subscriber database, updating them on changes in travel conditions.

Technology advances in HAR technology include:

- New transmitters that operate on the FM band and use a "leaky cable" antenna alongside the roadway to avoid some of the transmission problems of conventional AM transmitters.

- Early attempts to use very low power (100 mW) synchronized transmitters that were exempt from FCC licensing. So far these attempts have not been very successful, and transmission distances has been limited to a few hundred feet.

Advantages and Disadvantages

As with commercial broadcasts, the primary advantage of this type of service is that most users have either a telephone, cellular phone and/or radio. The service is also typically free or low cost, and easily accessible. Longer messages (than those used for commercial broadcast traffic reports) can be provided, though they are still somewhat limited by the attention span and message retention capability of the user, and by transmission distance and time.

Pre-recorded messages require frequent updating, usually by a human operator, to remain current. Early systems used analog recordings with continuous loop tapes, and each time the message was changed it had to be re-recorded. The tapes often wore out quickly, and were difficult to change if installed in field cabinets. Messages were often static in nature (or updated very infrequently), did not contain current, real-time information, and were of limited use to the traveler. Newer systems use digital recording systems that allow a library of messages to be established and chosen from, can be accessed remotely, and do not have problems with tapes wearing out or breaking.

HAR stations can only be operated by government agencies. Conventional AM transmitters have a number of constraints that impact the suitability of this technology for traveler information dissemination, such as:

- FCC rules for licensed HAR stations limit power output to a maximum of 10 Watts, and antenna height to approximately 50 feet above ground. Signal transmission distance is therefore limited to a maximum distance of a few miles or less.

- Although FCC regulations allow licensed HAR stations to operate on any available AM frequency, in urban areas there may be few (if any) frequencies available outside of the bottom (530 kHz) and top (1610 kHz) of the spectrum. Older radios often cannot access these frequencies at the extreme ends of the spectrum.

- Commercial AM broadcast stations operate at significantly higher power outputs (thousands or millions of Watts, as opposed to 10 Watts for an HAR transmitter), and commercial broadcast signals on adjacent frequencies can virtually "wipe out" a HAR signal. Because of the way radio waves propagate, interference may also occur from commercial transmitters a long distance away as their signals reflect off of the upper atmosphere. This problem is most prevalent at night.

D.2.2.3 *TEXT MESSAGING SYSTEMS*

Text messaging systems encompass a variety of information dissemination technologies, including:

- Variable message signs (VMSs)
- Alphanumeric pagers
- Personal digital assistants (PDAs)
- Fax services

VMSs are passive display devices used for providing en-route driver information on unusual roadway conditions immediately downstream of the sign or at a key diversion points. They are used primarily on freeways, though applications on arterial networks do exist in some cities across North America. Message length is limited by the size of the sign (usually 2 to 3 lines, with 15 to 25 characters per line) and the time available for the motorist to read the information at normal roadway speeds. Where additional information must be conveyed, the sign may direct motorists to dial a telephone information system or tune their radio to a local HAR.

Alphanumeric text pagers can be used to receive traveler information broadcast by a sub-carrier or through a radio data network. Alphanumeric pagers have limited message storage capability and, like VMSs, can display only a limited number of characters simultaneously.

PDAs are essentially compact, limited-function notebook computers where an electronic "pen" or other device is used to enter information, and a liquid crystal panel used for display. PDAs can display significantly more information than a pager or other text device (including graphics), but are currently cumbersome and awkward to use for en-route traveler information.

Fax service is a relatively low cost approach that can be used to disseminate traveler information to offices or customers equipped with a standard fax machine. Standardized traveler information reports can be electronically generated at the operating agency, and faxed to a pre-defined set of customers as defined in a subscriber database. Depending upon the sophistication of the fax generation system, it is possible to custom generate traveler information reports to meet unique timing or information requirements of specific customers.

Status and Emerging Technologies

VMSs are a relatively mature information dissemination technology, and with the exception of advances in light display technology are not expected to significantly evolve.

Pager and PDA text messaging technologies offer good potential for providing en-route passive information, despite somewhat limited market penetration. This type of technology is currently being showcased in the Central Puget Sound Region through the Seattle Wide Area Information for Travelers (SWIFT) project, which is using Seiko message watches and PDAs to display traveler and other information.

Advances in two-way paging and messaging capabilities may allow customers to interactively select from traveler information menus in the future, thus transitioning this technology from passive to active, and improving customer ability to get route- or mode-specific information as opposed to general broadcast information.

Fax technology is relatively well established, though future advances in color faxing capabilities may allow for transmission of improved graphics.

Advantages and Disadvantages

The advantage of VMSs is that information immediately applicable to the trip is provided en-route in a passive manner without the need for special in-vehicle devices. The disadvantages are that the amount of information that can be conveyed is limited, and the signs are costly to install and visually intrusive. Early studies by the Texas Transportation Institute also suggested that drivers have limited capability to understand and retain complex or multi-part messages, which limits the amount of information that can be conveyed with this type of device.

Pagers and PDAs can receive both pre-trip and en-route information. This information is typically area-wide, and may or may not include information specific to the trip the traveler is making (although it is feasible to set up a subscriber database and only transmit selected information). Pagers are low cost and are in common use, but have limited display capabilities. PDAs have much better display capabilities, but are expensive and not yet in common use.

Fax service is relatively low cost, but is generally only suitable for pre-trip information services, except where such information is provided to a commercial broadcaster or other service provider who can in turn provide the information to travelers while en-route. Changes in information requirements require editing and updating of the subscriber database information file.

D.2.2.4 COMPUTER DATA SERVICES

Computer data services include:

- Bulletin Board Services (BBS)
- On-line services
- Internet services

BBSs were used before wide scale adoption of on-line and Internet services to provide registered users with information through a direct dial-up. BBSs have not been widely used to provide traveler information; it is feasible to do so by providing additional information add-ons.

On-line services are those provided by a national or international service provider such as CompuServe, America On Line, and others. A monthly service fee is usually charged (with surcharges for special services), in return for which the user is provided with well organized information accessible through local service nodes throughout the country. On-line services are oriented to users with average computer skills, and/or those that travel frequently and need local access.

Internet services are typically not as well organized or as easily accessible as commercial on-line services, although more information may be available providing the user knows how to access it. For users with a reasonable degree of computer literacy and access to the World Wide Web, the Internet can provide an excellent source of traveler information.

Status and Emerging Technologies

The use of the Internet as an information delivery tool for a variety of services is exploding. Text, graphics, and photographs (including CCTV images) can be displayed with most Web browser packages and accessed by the user in a "point and click" format. New developments in Web browser software allow access to audio and video with motion. This may allow dynamic information such as changing freeway conditions or real-time location of transit vehicles (including transit movement through the system) to be displayed on the user's computer screen.

The market for home computers appears to be reaching a plateau, which may cap or limit the number of travelers with access to on-line or Internet information. Possible future development of a low cost "Internet appliance" is being considered by manufacturers such as Apple and Sun to improve home market penetration.

Advantages and Disadvantages

Most BBSs have been, or are now being, replaced by on-line and Internet based services. Further consideration of this technology for the I-5 corridor is therefore not recommended.

On-line and Internet services are an excellent way of providing both passive and active users with comprehensive pre-trip traveler information. Although such information is not available in-vehicle for the purposes of en-route traveler information, information kiosks at rest stops, and recreational areas along the route can allow a traveler to update trip information at periodic intervals.

Providing traveler information via on-line services or the Internet can be a very cost-effective means of disseminating both static and real-time information, as evidenced by the success of the RiderLink, WSDOT and other Web sites in the Seattle area. Automatic message generation and/or route and traffic flow maps can be provided through appropriate computer system interfaces, thus eliminating the need for manual updates.

The primary disadvantage of computer data services is that only a relatively small subset of travelers have access, and those with access have varying degrees of computer literacy. The information is primarily useful for pre-trip planning, with the exception of using PDAs with cellular phone or radio data links, and/or installing interactive kiosks en-route. Providing traveler information through an on-line service may also require a special agreement with the service provider.

APPENDIX E: ENFORCEMENT ENHANCEMENT OPPORTUNITIES ASSESSMENT

Enforcement enhancement opportunities associated with ITS applications will be examined under this work element. Enforcement opportunities developed under this work element may be for particular spot locations or on a regional level. Spot locations could include technologies associated with high speed areas, HOV lane violations, rest stop security, high accident areas, weigh station enforcement, vandalism prevention or construction zone enforcement. Functional ITS applications for region-wide enforcement could involve communication enhancements or regional interdiction efforts. Results of this will be incorporated into a technical memorandum.

E.1 INTRODUCTION

There are a variety of areas where enforcement opportunities can be assisted with ITS applications, many of these include surveillance systems. Surveillance systems can be used for HOV enforcement, during pursuits, for evidence if continuous video records are kept, for identification of license plates through video scanners, and in many commercial vehicle operation (CVO) enforcement applications. Enforcement efforts can also be aided with the use of shared WSDOT traffic data. A prime example of using shared data is information obtained during major incidents from a traffic operation center. The following discusses several opportunities for ITS enforcement applications.

E.2 HOV ENFORCEMENT

The use of video cameras and fixed location monitors would greatly assist enforcement of, and compliance to, HOV occupancy requirements. Troopers currently have very limited ability to see into vehicles, especially during darkness or inclement weather. They also have difficulty seeing into sports utility and other vehicles which are taller than patrol vehicles. The WSP has reduced the number of motorcycle officers, further reducing the tools usually associated with HOV enforcement.

Cameras strategically mounted on existing structures could provide a much better view of vehicle interiors. They would also provide a strong deterrent to non-compliance.

E.3 PURSUITS

Continuing problems associated with pursuits, such as injuries to innocent motorists, makes this a top priority for review of technology. Installation of devices with the capability to electronically track or disrupt a fleeing driver would give the WSP a strong tool to use in reducing the danger to the public. It is unknown whether technology exists for this application.

E.4 CONTINUOUS VIDEO RECORDING

Law enforcement agencies throughout the area routinely use tapes from businesses and agencies to prosecute a wide variety of crimes. As WSDOT expands their use of video surveillance for roadways and rest areas, the system should automatically record with a continuous tape to allow for review of major accidents, enforcement activities, vandalism, theft, or crimes against persons. The Dayton facility currently has the ability to record, but does so only on request.

Public and private partnerships can offer a cost effective method of technology deployment. In Tukwila, Washington, for example, a public-private program is being implemented. Tukwila has responsibility for SR 99 north of Sea Tac airport, one section of which has been plagued with a high crime rate. The City of Tukwila is installing video monitoring throughout this area with fiber optics being installed free of charge by TCI Cable Company and camera and power installation provided free of charge by Seattle City Light.

ES AUTOMATED LICENSE PLATE READERS

Automated license plate readers are currently being used in California on I-5 at the border with Mexico. Video cameras are linked to personal computers equipped with license reading software which are connected to a data base, resulting in the apprehension of fugitives, detection of stolen vehicles, identification of repeat commercial vehicle violators, and location of missing persons. This is one of the first complete systems in the U.S.

ALIS (Automated License Identification System) has also enhanced the ability of Customs officers to detect and apprehend all types of violators at the Blaine Border crossing. Each lane at the border crossing is equipped with cameras that read both front and rear plates on each vehicle as it approaches. The plate is automatically processed through the Customs data base and NCIC (National Crime Information System); and display results within two seconds. If a vehicle is identified as a stolen or connected to a "person of interest," the monitor emits an audible alarm to alert the officer. The information is verified and the driver is taken into custody at the checkpoint.

This system currently identifies plates from Mexico, California, Oregon, Washington, and British Columbia. Plates from other states or unreadable plates are entered manually by the officer. If the state prefix is missing, the officer enters the two digit code for the state; if the entire plate was misread, the officer enters the data manually. Officers frequently arrest and detain fugitives, recover stolen vehicles, and uncover custom and drug violations from information provided by the ALIS system. This system has seen recent improvements in accuracy and timelines.

The ALIS also keeps a record of each plate, allowing for tracking of vehicles by frequency and time of day. Data on traffic flows and origin of the vehicles is used for scheduling, statistical analysis, and other planning purposes.

Wisconsin and Minnesota have combined efforts on a License Plate Reader (LPR) system used in conjunction with their commercial vehicle enforcement program. A LPR system is connected with a data base containing records of inspections and violations. The data base is kept up to date through the on-line entry of information at 20 Wisconsin scales. Minnesota information is entered from paper inspection forms. Wisconsin also has a portable reader mounted on a tri-pod for use on scale by-pass routes and secondary routes which works off a laptop.

Each scale has one video camera that takes a picture of the front of each truck as it approaches the weigh-in-motion (WIM) platform on the ramp into the scale. The system is accurate to 90% of clean plates properly located on the vehicle at a speed of 25 MPH; testing has revealed that the system would work at posted speed limits. If the vehicle has previously been entered into the data base for inspections or violations, the computer gives the information via monitor to the scale operators.

ALIS and LPR systems can also be used for relaying messages to truck drivers at the request of the trucking company.

E . 6 CVO PROGRAMS

The Federal Highway Administration has two programs designed to assist states in implementing ITS applications for Commercial Vehicle Enforcement programs in a manner compatible to other states.

- "Mainstreaming" is designed to manage the deployment of ITS for Commercial Vehicle Operations (CVO). The services are provided to streamline the administration of motor carrier regulation, focus enforcement activities on high risk carriers, and reduce congestion costs for motor carriers. The services involve networking information systems, automating existing systems, and changing the way that states and carriers do business. The objectives of the Mainstreaming program are to incorporate ITS/CVO more fully into state and metropolitan transportation planning activities, to coordinate ITS/CVO activities among agencies and among states; and to explain the ITS/CVO program to key decision makers in the public and private sector. Mainstreaming is funded for participation by all 50 states. Funds allocated for states that do not chose to participate are reallocated to participating states. Policies, plans and projects are to be developed for the state, regional, and national levels.

- CVISN (Commercial Vehicle Information Systems and Networks) is a nationwide effort by the Federal Highway Administration (FHWA) to apply ITS technology to the regulation of commercial carriers. Through a series of matching grants, FHWA is partnering with the trucking industry, state commercial vehicle enforcement agencies, and departments of transportation on a regional and national basis to automate safety information for high risk carriers, electronically transfer inspection data to neighboring states and to SAFETYNET, implement electronic application for credentials, develop an electronic clearance process, and develop an International registration plan.

These two initiatives will benefit motor carriers by reducing the administrative burden in regulatory compliance, reducing delay for safe and legal carriers, and allowing enforcement efforts to focus on high risk carriers instead of all carriers. States will benefit by reduced administrative costs through electronic data interchange, improved safety due to focus on high risk carriers, more effective enforcement programs, and the ability to screen more vehicles through electronic means.

Partnerships between states, such as the one between Wisconsin and Minnesota, reduce delays for carriers that are in compliance while identifying a higher percentage of high risk carriers. Regional partnership will allow the same level of enforcement as information is made available electronically. The use of LPRs, weigh-in-motion, and transponders will further reduce the delays at commercial vehicle inspection locations.

APPENDIX F: ADDITIONAL USER SERVICES POTENTIAL

The transportation needs along each corridor shall be segmented by geographic area as noted in Work Element 1 and functional needs. Functional needs shall address commercial vehicle, tourist, and potential multi-modal person trip requirements not addressed in the other work elements.

Using the US. DOT's 29 ITS user services categories (pre-trip travel information through fully automated vehicle operations) as a framework, the CONSULTANT shall identify what additional transportation needs and problems are best addressed by these potential user services.

F.1 INTRODUCTION

F.1 .1 Overview

The goal of ITS is to provide safer roadways, better informed travelers, improved traffic management, and the increased efficiency of commercial goods movement by applying advanced technology to the transportation system.

This memorandum discusses how ITS-related technology can address identified needs to the I-5 Seattle to Vancouver B.C. corridor through the application of the following ITS User Services: Traffic Control, Incident Management, Public Transportation Management, and Advanced Vehicle Safety Systems.

F.1.2 Organization of the Technical Memorandum

This Technical Memorandum is presented in five sections. The first section is the Introduction, with an overview of the memo and organization of the report.

The second section demonstrates how traffic control can be applied to the I-5 Seattle to Vancouver B.C. corridor. This user service is defined, and potential deployment strategies are recommended for three areas of concern along the corridor.

The third section examines how incident management can be applied to the corridor. This user service is defined, and potential deployment strategies are recommended for two areas of concern along the corridor.

The fourth section discusses the application of public transportation management and operations to the corridor. This category includes four other user services which are defined, and potential deployment strategies are recommended for each user service.

The fifth section describes advanced vehicle control and safety systems of the existing ITS infrastructure.

F.2 TRAFFIC CONTROL

F.2.1 Definition

Traffic control provides for the integration and adaptive control of freeway and arterial systems to improve the flow of traffic; to give preference to public safety, transit, or other high occupancy vehicles; and to minimize congestion, all while maximizing the movement of people and goods. Through appropriate traffic controls, it also promotes the safety of non-vehicular travelers, such as pedestrians and bicyclists. The system requires advanced surveillance of traffic flows, analysis techniques for determining appropriate traffic signal and metering controls, and communication of these controls to the roadside infrastructure. Data is gathered from the transportation system and organized into usable information to determine the optimum assignment of right-of-way to vehicles and pedestrians. The real-time traffic information collected by the traffic control system also provides the foundation for many other user services.

The surveillance component is achieved through the deployment of traffic sensors throughout the transportation facility, including vehicle detection loops and CCTV cameras. The control element uses a variety of strategies and technologies, including advanced signal control, variable message signing, ramp metering, and dynamic infrastructure control. These measures attempt to ensure the most efficient use of the transportation facility through smoothing and limiting of traffic flow. The relative cost of arterial traffic control systems is decreasing and should soon be within the reach of small cities.

F.2.2 Potential Deployment Strategy

The level of effort required to meet this need for traffic management varies directly with the level of traffic demand and congestion found along the corridor.

The most extensive level of deployment would include a fully integrated advanced traffic management system (ATMS) which combines the resources of the WSDOT Surveillance, Control, & Driver Information (SC&DI) freeway based system with local and state arterial control systems. The ATMS would be characterized by extensive CCTV and sensor deployment, traffic management centers, dedicated communications, and full time staffing. Primary areas of recurrent congestion which would make good deployment sites are:

- SR 526 interchange (MP 189)
- North of Marysville (MP 200)
- 300th Street NW interchange (MP 215)
- Mount Vernon area (=MP 225-230)
- SR 539 interchange (MP 258)

In the Puget Sound region, these would expand the current SC&DI facilities. Within a short to medium time frame, these facilities should be extended to all of the metropolitan area transportation facilities.

The Puget Sound regional ATMS should be linked to the TravelAid project. Electronic sensing equipment has been installed to monitor traffic, speeds, and road and weather conditions.

Deployment should include signing which provides real-time traveler information about the Washington State Ferry terminals in downtown Seattle and recreational routes.

Several locations along the corridor experience seasonal traffic congestion due to weather, annual events, or concerts. A portable traffic management system for these types of occurrences should be considered.

F.3 INCIDENT MANAGEMENT

F.3.1 Definition

Incident management has the following three primary goals:

- To reduce incident clearance time, thereby reducing the period of time for which the capacity of the roadway is reduced.

- To provide incident information dissemination to travelers to both smooth the flow of traffic around the incident location and to facilitate diversion to less congested facilities where appropriate.

- To warn motorists of the existence of a traffic queue upstream of the incident to attempt to avoid the occurrence of secondary incidents.

As a user service, incident management is a natural extension of SC&DI systems.

F.3.2 Potential Deployment Strategy

Incident management along the I-5 corridor could be enhanced in the following areas:

- Around the Mount Vernon area
- Around the Bellingham area

Incident management uses the advanced sensors, data processing and communications common to SC&DI systems to improve the incident management and response capabilities of the WSP, WSDOT officials, the towing and recovery industries, and others involved in incident response. By deploying sensors at high accident locations, incident detection, response and congestion times can be reduced. The ultimate beneficiaries are commercial vehicle operators and the traveling public.

The two major urban areas on the corridor are prime candidates for more extensive deployment of technology-aided incident management as part of planned SC&DI projects. Use of dedicated incident response vehicles and coordinated communications with WSP would be required.

Another problem which results in delays to the traveling public are unstable slope locations along the corridor. These conditions can result in rocks falling on the roadway and causing injuries and accidents. Railroads currently use rock fall detection technology to warn trains of blockages ahead. A demonstration of this technology should be implemented on a segment of I-5 between MP 244 and 249 to assess the feasibility of this technology to roadways. Potential sites for deployment, listed in decreasing order of rockfall potential, are displayed in Table F-I below.

Table F-1

Potential Sites for Unstable Slope Technology Deployment

BEGIN MILEPOST	END MILEPOST
247.95	248.05
248.40	248.50
244.65	244.75
247.85	247.95
248.20	248.40
190.70	190.85
190.89	190.95
248.05	248.20
247.45	247.55
248.70	248.90
244.75	244.80
246.20	246.25
244.55	244.60
189.90	189.95
215.05	215.06
215.06	215.07
246.69	247.77
247.48	247.53
247.79	248.51
247.85	248.26
248.26	248.43
248.65	249.00

F.4 PUBLIC TRANSPORTATION MANAGEMENT

F.4.1 Definition

Along the corridor, most of the public transportation services are provided locally at the county or city level. Service within each area can be very good, but travel between other systems and modes within the broader region and between cites can be difficult. Local initiatives in the Puget Sound region are moving toward the implementation of new high capacity transit service and expanded bus service. In addition, the State is making a large investment in high speed inter-city passenger rail service along the corridor.

These investments can be supported and enhanced by the introduction of ITS technologies. It can help increase the productivity of existing services and provide mechanisms to help connect different systems and cities. The ITS areas of public transportation management include the ITS user services of en-route transit information, public transportation management, personalized public transit, and public travel security.

F.4.1.1 EN-ROUTE TRANSIT ADVISORY

This service involves provision of real-time information on the status of connecting transit services to transit users. It also attempts to encourage a mode shift from automobile to transit, with the goal of increasing average vehicle occupancy and reducing vehicle demand on the freeways.

F.4.1.2 PUBLIC TRANSPORTATION MANAGEMENT

This service incorporates a number of different sub-services that are provided to public transportation operators, including operation of vehicles and facilities, planning and scheduling of services, and personnel management.

The goal of this service is to automate these three individual sub-services in order to improve the efficiency of public transportation and to offer the traveler a better range of transportation alternatives.

F.4. 1.3 PERSONALIZED PUBLIC TRANSIT

This service encompasses the deployment of para-transit type operations to facilitate more flexible transit services, and can be considered a form of ridesharing using public or possibly private transportation vehicles. Similar to the ridesharing services, this service may be either scheduled in advance or involve "instant" or dynamic ridematching.

F.4. 1.4 PUBLIC TRAVELER SECURITY

The aim of this service is to create a safer environment for travel and public transportation, thereby encouraging an increase in public transportation ridership and the subsequent decrease in the number of vehicles on the road. This service encompasses both safety on public transportation vehicles and at transit stops. At present, this service is in its very early development stages, and tests of its suitability and applicability are being envisioned for the next few years. The Puget Sound Help Me operational test is evaluating emergency notification devices that could potentially be used to provide transit vehicle security. Similarly, an Automatic Vehicle Location (AVL) system could be used to detect operator alarms and direct emergency response vehicles.

F.4.2 Potential Deployment Strategy

King County Metro is planning to implement, or is in the process of implementing, a full range of advanced technology to improve transit operations. These activities include an AVL system, recording fare boxes, integrated electronic fare collection, en-route traveler information systems, AVI based transit priority signal systems, and a wide range of methods to distribute transit information.

Park and ride lots plus inter-city rail and bus terminals within the corridor offer excellent opportunities to install transit information systems. These transfer points are key nodes for all of these systems; they are locations where travelers are naturally looking for information on other connecting modes. Telephone-based information services, kiosks, or other forms of interactive display would be prime candidates for implementation at the terminals and at park and ride lots.

Rail and bus information which could be provided would include schedules, connections, and real-time schedule information. Information should be available at kiosks, over the telephone, and on the Internet.

F.5 ADVANCED VEHICLE SAFETY SYSTEMS

Advanced vehicle safety systems push the technology of the vehicle forward to enhance driver control and to make travel safer and more efficient. The promise of this technology is significant and fills an ITS need for improved vehicle safety along this corridor and all other highways. Most deployments of this technology should occur as additional safety features are available on new vehicles. The public sector should encourage these actions, as appropriate. In the long term, more infrastructure based systems will be developed and deployed as a result of the federal automated highway system (AHS) research program. This activity is most likely beyond the planning horizon of this study effort. However, the benefits of AHS are profound.

APPENDIX G: BORDER CROSSING TECHNOLOGIES ASSESSMENT

The Consultant shall identify and evaluate a range of ITS and other transportation technologies to consider for application at the Blaine and Pacific Highway Border crossings, These technologies shall be designed to reduce congestion and generally improve the movement of people, goods, and information, for purposes of commerce, recreation, cultural exchange and information sharing.

Information gathered for this work element shall be compiled into a technical memorandum including: general operations; pre-clearance of people and goods through electronic data interchange, smart cards, and transponders; automated driver information including pre-travel and en-route information, variable message signing and highway advisory radio; surveillance, enforcement, and incident management technologies. This technical memorandum will also identify relevant technological applications from other border crossings around the country for consideration.

It was determined that Commercial Vehicle Operations (CVO) and Border Crossing technologies would not be specifically addressed at the corridor level due to statewide work being conducted under two supplemental work orders to this contract. JHK and Associates, under separate cover, will produce two separate development studies that will address the future CVO needs, "Washington State CVO Strategic Plan" and "Information Technology Feasibility Study for the Washington State CVISN Deployment Plan"