ITS User Services Document

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Federal Highway Administration
US Department of Transportation
Washington D.C. 20590

January 2005

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1. Introduction

Intelligent Transportation System (ITS) user services are surface transportation services that can be provided by some aspect of ITS. These ITS user services document what ITS should do from the user's perspective. A broad range of users are considered, including the traveling public as well as many different types of system operators.

This ITS User Services Document consolidates the descriptions of all 33 current user services into a single document. Prior to creating this document, the user services existed in a variety of places and formats (discussed in Section 2). In addition, the information provided in the definition of a user service has varied widely. The primary objective of this document is to provide a single place where all the user services are described in a consistent manner. If additional ITS user services are defined in the future, this document will be updated to include them.

(Note: in practice the user services are most commonly described without the term "ITS" in front of them and this convention will be used throughout the remainder of the document.)

Although each user service is unique, they share common characteristics and features, as described below.

- Individual user services are building blocks that may be combined for deployment in a variety of ways. The combination of services deployed will vary depending upon local priorities, needs, and market forces.
- User services are composed of multiple technological elements or functions that may be common with other services. For example, a single user service will usually require several technologies, such as advanced communications, mapping, and surveillance, which may be shared with other user services. These common technological functions are one reason for the "bundling" of services.
- User services are in various stages of development and will be deployed as systems according to different schedules. Most of the technologies required by the user services are currently available in the marketplace, but some will require significant research and development before they can be deployed. The development and deployment of an individual service will be guided by the policies and priorities established by both public and private sector stakeholders. These policies and priorities will evolve based on changing technologies, economic factors, and market conditions.
- Costs and benefits of user services depend upon deployment scenarios. Once the basic technological functions, such as communications or surveillance, have been deployed for one user service, the additional functions needed by one or more related services may require only a small incremental cost to produce additional, often significant, benefits.
- Many user services can be deployed in rural, suburban, and/or urban settings. User services are not specific to a particular location. Rather, the function of the services can be adapted to meet local needs and conditions.

1.1. User Service Bundling

Although it may be possible to deploy a system that provides a single user service, in many cases, services are more likely to be deployed in combination with other services in a "bundle" which share some commonality. The 33 user services have been sorted into categories termed "bundles." The services within these bundles may be related in a number of different ways. In some cases, organizations that will deploy the services provided the rationale for the formation of a specific bundle. Other bundles were organized around common technical functionalities. The bundles of user services, which will serve as the organization for describing the services later in this document, are shown below. Each bundle is described in detail following the list.

1. Travel and Traffic Management
    - 1.1 Pre-Trip Travel Information
    - 1.2 En-Route Driver Information
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Travel and Traffic Management. The Travel and Traffic Management user services deal with information collection, dissemination, and processing for the surface transportation system. These services collect and process information about the surface transportation system, and provide commands to various traffic control devices. Travel management services disseminate this information to travelers. These services also provide information to support the Public Transportation Management and Information Management bundles. Thus, the Travel and Traffic Management bundle will be of interest to transportation policy makers, public and private sector operators of transportation management centers, those involved in accident response or travel demand management, and private sector vendors supplying travel information products and services.

Public Transportation Management. The Public Transportation Management user services describe those services provided by public transit organizations throughout the country. They address both fixed route and demand response systems, as well as those passenger rail systems operated by transit agencies. Aspects of the transit system ranging from operations, to maintenance and security are covered. This bundle includes a transit traveler information aspect that also supports services in the Travel and Traffic Management bundle.

Electronic Payment. While this bundle contains only one user service, electronic payment services for tolls, fares, and parking; it supports deployment of many other services, both within and outside the transportation arena. This service will be developed, deployed, and operated by both public and private organizations.

Commercial Vehicle Operations. These user services support the goals of improving the efficiency and safety of commercial fleet operations, and will benefit both the states and the motor carrier industry. The bundle is organized around the use of advanced computer and communication technologies to improve the safety and productivity of the motor carrier industry throughout North America. From a technical perspective, the foundation for all the commercial vehicle operations user services is the exchange of information on the motor carrier, the vehicle, the driver, and, in some cases, the cargo. The services are interrelated in terms of the specific types and functionality of information and data required. This network of information will be accessible by states and motor carriers nationwide.

Emergency Management. Emergency management and public safety (police, fire, and emergency medical services) agencies use emergency management services to improve their management of and response to emergency situations. In addition this bundle covers the coordination between public safety organizations and the other transportation organizations (e.g. traffic, transit, and maintenance) to address situations ranging from traffic incidents to disasters to evacuations.

Advanced Vehicle Safety Systems. Although each of these services addresses a separate function, they all contribute to the common goal of improving vehicle safety. With the exception of Automated Vehicle Operations, all these user services are characterized by reliance on self-contained systems within the vehicle. Supplementing the on-board capabilities with additional sensors deployed in the infrastructure, however, can enhance the functionality of these user services. Within the vehicle, common functional elements, such as data storage, processing units, sensors, or actuators, could be shared among the user services in this bundle, including Automated Vehicle Operations.

Information Management. This bundle is the logical offshoot of both the Travel and Traffic Management and Public Transportation Management user service bundles. Both of the two original bundles focus on measuring transportation data for real-time use and disseminating it to the traveling public. However, the copious amount of data gathered in the process is also useful to planners, safety personnel, and other organizations. The single user service in the Information Management bundle addresses how to process and store the data acquired by ITS monitoring systems in a manner that is efficient, thorough, and user-friendly.

Maintenance and Construction Management. This bundle addresses the monitoring, maintaining, improving, and managing of the physical condition of the roadway, associated infrastructure equipment on the roadway, and the available resources necessary to conduct these activities.

Since publication of the 1995 National Program Plan, the National ITS Program has made some revision to how user services are bundled. Two previously separate bundles, “Travel and Transportation Management” and “Travel Demand Management”, have been combined into a single bundle labeled “Travel and Traffic Management.” In addition the 7^{th} and 8^{th} bundles are new creations to accommodate new user services.

1.2. Document Organization

The remainder of this document is organized as follows:

Section 2 describes the background, history, and usage of the ITS user services.

Section 3 provides details of each of the 33 user services. The section is organized by the bundles shown above. For each user service the following information is provided:

- Introduction to the user service
- Summary of the need for the user service
- Description of the user service
- Operational concept describing how the service might be deployed.

In addition, where applicable, a section on references is provided. All of the user services have been reviewed and revised as appropriate to remove old references and to update information as appropriate.

Section 4 describes the procedure that is in place for adding additional user services to the current set.

2. Background, History, and Usage

The Intelligent Vehicle Highway Systems Act within the Intermodal Surface Transportation Efficiency Act (ISTEA) established the IVHS (now ITS) program in the United States and called for the development of the US DOT Strategic Plan for IVHS. The purpose was to provide a new vision of surface transportation in America. The initial version of the strategic plan was created as the National ITS Program Plan, whose first edition was published in March 1995. The plan was subsequently updated and published as the National Intelligent Transportation Systems Program Plan Five-Year Horizon in August 2000.

The National ITS Program, as described in the original Program Plan was focused on the development and deployment of a collection of interrelated user services. The original 1995 plan defined 29 user services. The initial user services were jointly defined by USDOT and ITS America with significant stakeholder input and documented in the National ITS Program Plan. Subsequent to the development of that plan, four additional user services have been developed. These new services (and the date of their development) are:

- Highway Rail Intersections (in January 1997)
- Archived Data (in September 1998)
- Maintenance and Construction Operations (in January 2001)
- Disaster Response and Evacuation (in July 2003)

This list of user services is neither exhaustive nor final. There are several transportation services that could be developed which are not included in this list. In addition, the services here are expected to continue to change over time. This list of services and the accompanying descriptions are expected to evolve and will be included in updates to this document.

The user services have served several purposes since their creation. First they helped to organize the strategic planning activities for ITS throughout the 90's. Second the user services, along with a set of user service requirements, form the basis for the National ITS Architecture development effort, by defining the scope of the National ITS Architecture. Third, the concept of user services allows system or project definition to begin by establishing the high level services that will be provided to address identified problems and needs.

3. User Services

The sub-sections that follow contain the user service descriptions, organized by bundles as discussed in section 1.1.

3.1. Travel and Traffic Management

The ten user services in this bundle are designed to use advanced systems and technologies to improve the efficiency and operation of the existing surface transportation infrastructure and create safer and better-informed travelers. As discussed in more detail later, these services will help to achieve the ITS program goals of enhancing mobility and productivity, increasing efficiency, and reducing the energy and environmental impacts of surface transportation.

These services are described briefly below:

- The **Pre-Trip Travel Information** service allows travelers to access a complete range of real-time multimodal transportation information at home, work, and other major sites where trips originate. Information on road network conditions, incidents, weather, and transit services, are conveyed through these systems to provide travelers with the latest conditions and opportunities in order to plan their travel. Based on this information, the traveler can select the best departure time, route and modes of travel, or perhaps decide not to make the trip at all.
- The **En-Route Driver Information** service provides driver advisories to convey information about traffic conditions, incidents, construction, transit schedules, and other mode choice options to drivers of personal, commercial, and public transit vehicles. This service also includes in-vehicle signing, which provides the same types of information found on highway signs today but displays it directly in the vehicle. Full deployment of in-vehicle signing would also include customized information, such as warnings of hazardous road conditions (e.g., fog, ice) or the safe speed for a specific type of vehicle (e.g., autos, buses, large trucks).
- The **Route Guidance** service provides travelers with a suggested route to reach a specified destination, along with simple instructions on upcoming turns and other maneuvers. When fully deployed, route guidance systems will provide travelers of all modes with directions to their destinations based on real-time information about the transportation system, including traffic conditions, road closures, and the status and schedule of transit systems.
- The **Ride Matching and Reservation** service provides real-time ride matching information and reservations to travelers in their homes, offices or other locations, and assists transportation providers with vehicle assignments and scheduling. The user service provides one of the basic tools for altering the travel behavior of individuals who drive alone during congested periods. This service will expand the market for ridesharing as an alternative to single occupant automobile travel, and will provide for enhanced alternatives for special population groups, such as the elderly or the handicapped.

- The **Traveler Services Information** service provides a business directory, or "yellow pages," of information on travel-related services and facilities, for example the location, operating hours, and availability of food, lodging, parking, auto repair, hospitals, and police facilities. Traveler services information would be accessible in the home, office or other public locations to help plan trips, and it would also be available en-route. The service includes not only the traveler services information, but the capability to make reservations for many of the traveler services.
- The **Traffic Control** service provides for the integration and adaptive control of the freeway and surface street systems to improve the flow of traffic, give preference to transit and other high occupancy vehicles, and minimize congestion while maximizing the movement of people and goods. This service gathers data from the transportation system, fuses it into usable information, and uses it to determine the optimum assignment of right-of-way to vehicles and pedestrians. The real-time traffic information collected by the Traffic Control service is also disseminated for use by many other user services.
- The **Incident Management** service uses advanced sensors, data processing, and communications to improve the incident management and response capabilities of transportation and public safety officials, the towing and recovery industry, and others involved in incident response. This service will help these groups to quickly and accurately identify incidents and implement a response which minimizes traffic congestion and the effects of these incidents on the environment and the movement of people and goods.
- The **Travel Demand Management** service uses advanced technologies to support policies and regulations designed to mitigate the environmental and social impacts of traffic congestion. This service generates and communicates management and control strategies that support the implementation of programs to reduce the number of individuals who choose to drive alone; increase the use of high occupancy vehicles and transit; and provide a variety of mobility options for those who wish to travel in a more efficient manner, for example in non-peak periods. The service also allows employers to better accommodate the needs and lifestyles of employees by encouraging alternative work arrangements such as variable work hours, compressed work weeks, and telecommuting.
- The **Emissions Testing and Mitigation** service uses advanced vehicle emissions testing systems to identify environmental "hot spots" and implement strategies to reroute traffic around sensitive air quality areas, or control access to such areas. Other technologies provide identification of vehicles that are emitting levels of pollutants that exceed state, local or regional standards, and provide information to drivers or fleet operators to enable them to take corrective action. The service also provides transportation planning and operating agencies with information that can be used to facilitate implementation and evaluation of various pollution control strategies.

- The **Highway Rail Intersection (HRI)** service uses ITS technologies to provide improved control of highway and train traffic to avoid or decrease the severity of collisions that occur between trains and vehicles at HRIs.

3.1.1. Pre-Trip Travel Information

3.1.1.1. Introduction

The Pre-Trip Travel Information user service provides travelers with information prior to their departure and before a mode choice decision is made. The service integrates information from various transportation modes and presents it to the user through electronic communications or public information centers. Users of the service include all travelers, including commercial vehicle operators, as well as providers who will develop and market pre-trip information services.

Although related, information provided to travelers once a trip is underway is covered under En-Route Driver Information (Section 3.1.2) and En-Route Transit Information (Section 3.2.2). Also related, Traveler Services Information (Section 3.1.4) provides for a more effective selection of destination, for example the closest location of a product or service.

3.1.1.2. Needs

The ITS program is a response to the increasing social and monetary costs of traffic congestion and poor mobility. Before a trip begins is the time when accurate information can be used to influence the traveler's choice of travel mode, travel schedule, or routing. Pre-trip travel information, if it is timely, accurate, and reliable, can assist travelers in choosing alternatives to single occupant automobiles, in deciding when, or even if, to begin a trip, and in selecting a route to desired destinations.

Before starting a trip, a traveler must select the time of departure and the mode or modes of travel. Based on pre-trip information, a person may decide to delay the trip, or not take the trip at all. One reason that mode choice often results in driving a car may be that information about other available modes is difficult to obtain, inaccurate, or not timely. The intent of this user service is to ensure that people making mode and trip decisions have access to real-time information for the full range of existing travel options.

3.1.1.3. Service Description

Pre-Trip Travel Information systems allow travelers to access a complete range of multimodal transportation information at home, work, other major sites where trips originate, and from personal portable devices. These systems provide timely information on transit routes, schedules, transfers, and fares; multimodal connections to rail or other transportation systems; and access to ridematching services. Also included are updates of traffic and highway conditions; real-time information on incidents, accidents, road construction, road weather conditions, alternate routes; predicted congestion and traffic speeds along specific routes; parking conditions and fees; availability of park-and-ride facilities; tolls; special event information; and weather information. When fully integrated with Electronic Payment Services (Section 3.3.1), the traveler could also make reservations and pay applicable fees when planning a trip.

3.1.1.4. Operational Concepts

Through Pre-Trip Travel Information, the traveler, including a commercial vehicle operator, gets a quick picture of travel conditions, options, and services for a particular time, along a chosen travel path. In its more advanced forms, Pre-Trip Travel Information performs a practical service, calculating routes and itineraries, and providing mode choices for the traveler based on real-time travel conditions and parameter variables provided by the traveler. Time of departure, time of arrival, total travel time, maximum number of mode transfers, preferred routes and modes, intermediate stops, weather conditions, and other such information could be included. Using these "parameter variables," the system considers current and predicted travel conditions, and presents one or more alternate itineraries.

To provide travelers with a common information medium for all transportation modes, integration of multimodal information must occur. Traffic management systems generating data about highway conditions must be integrated with public transportation systems providing transit location and route information. Paratransit services and access to ridematching systems could also be included. Integration of this service with electronic payment systems will allow travelers to pay transportation-related fees as part of the trip-planning process, and will also provide transportation pricing information that could affect mode choice and departure time decisions.

Pre-Trip Travel Information systems will likely become a part of wider information services that appeal to a range of consumer needs in addition to transportation. As interactive video interface and other advances by the telecommunications industry emerge, Pre-Trip Travel Information systems will complement other home information networks such as home shopping, banking or educational services, perhaps even using the same electronic payment system used for personal transactions.

3.1.2. En-Route Driver Information

3.1.2.1. Introduction

The En-Route Driver Information user service provides travel-related information to drivers after their trips have begun. This user service includes the Driver Advisory sub-service which provides real-time information on traffic, transit, roadway conditions and weather conditions. The In-vehicle Signing sub-service provides in-vehicle displays of roadway signing and warnings of road hazards, traffic controls or special roadway conditions. Users of the service include drivers of private, commercial and transit vehicles.

Related services include information provided to transit riders during the trip through En-Route Transit Information (Section 3.2.2). Information received before the start of a trip is covered under Pre-Trip Travel Information (Section 3.1.1). Traveler Services Information (Section 3.1.4) and Route Guidance (Section 3.1.3) could be provided in conjunction with the Driver Advisory component of this service.

3.1.2.2. Needs

The nation's highways are faced with high levels of congestion. Congestion, both recurring and non-recurring, has become a national issue, with the extent and duration of congestion increasing throughout the past decade in metropolitan regions throughout the country. Projected traffic growth, coupled with the difficulty of providing adequate additional lanes for new capacity, suggests that congestion will continue to be a major issue in many metropolitan areas.

Traffic network efficiency may be increased by permitting drivers with better information about the traffic network to choose routes that avoid congested areas, thus helping to balance the demand on the network through better use of its capacity. Advisory information will be updated dynamically throughout the trip as traffic, weather, or other conditions change. Drivers may be advised to switch to another mode of transportation, and provided with information on transit schedules and parking availability at the nearest transit stop. Currently, some of this information is available through commercial radio broadcasts, dynamic message signing, and highway advisory radio broadcasts. Intelligent Transportation Systems (ITS) technologies hold the promise of providing more timely and reliable information to drivers.

Safety is a continuing problem on the nation's highways. Rural accidents are of special concern, since 60.9% of fatal accidents occur in rural areas where collision speeds are likely to be higher. Train-related incidents in rural areas are also a concern. Traffic accidents cost the country an estimated $70 billion in lost wages and other direct costs annually. The economic loss from traffic accidents is 2% of the U.S. gross national product.

Drivers require information related to the roadway and driving environments in order operate their vehicles in a safe manner. Providing information that more closely reflects the actual conditions of the roadway and driving conditions can enable drivers to operate their vehicles more safely by either avoiding dangerous conditions or driving in a more alert manner.

3.1.2.3. Service Description

En-Route Driver Information is composed of two sub-services: driver advisory and in-vehicle signing.

Driver advisory information benefits the driver in terms of convenience, cost, time, perceived safety, and reliability when incidents, roadway congestion, construction, or hazardous environmental situations occur on the roadways. Smoother traffic flow resulting from reduced congestion, improved route selection, and trips shifted to public transportation systems can significantly reduce air pollution. Driver advisory information is presented to vehicle operators through visual means (e.g. dynamic message signs) or through audio means (e.g. highway advisory radio). A wide array of information, including real time conditions, can be provided.

In-vehicle signing is a more advanced application that has not yet seen any extensive deployment. Its early implementation might be for a limited number of signs with the capability limited to small groups of users with special requirements. These could include control signs (stop, yield, etc.) and warning signs (curve, intersection, etc.). Examples of potential users include:

- Transit or commercial vehicle operators receiving warnings relating to restricted height access, ramp speed or bridge conditions.
- Rental vehicle drivers who would receive voice or visual prompts at airports giving them directions on how to find the rental agency parking lot or how to exit the airport, e.g., "To head downtown, turn left at this intersection."
- Rental vehicle drivers in a resort/recreation area that would receive safety warnings for drivers unfamiliar with treacherous terrain or potentially poor visibility.

3.1.2.4. Operational Concepts

Driver advisory information is widely provided by traffic management organizations through the local infrastructure based technologies such as dynamic message signs and highway advisory radio. These visual or audio messages provide advisories on traffic conditions, incidents, and road weather conditions. Over time additional infrastructure-based technologies (e.g. short range wireless communications such as WiFi) might be used to provide local advisory information. These advisories could be provided by the traffic management organizations (like the current dynamic message sign advisories) or they might be provided by the private sector. Driver advisory information that is provided into vehicles via a wide area wireless mechanism has long since been shown to be technically feasible, but has not had widespread deployment because of the lack of accurate real time advisory information and the inability to develop a profitable business model for providing the service. In the future, as the use of wireless technology evolves, this concept for delivering driver advisory information may gain increased popularity.

In-vehicle signing will probably never replace existing roadway signage (particularly "official" road signage such as speed limits, stop signs, etc.). The likelihood of equipping all vehicles with the necessary instrumentation is low and liability concerns must be addressed. Therefore, in-vehicle signing will likely be primarily used to support specialized situations and specialized groups of users. If automated highways are ever developed, they might make extensive use of in-vehicle signing integrated with the systems that provide vehicle automatic control. Many of the same types of data provided to drivers today using physical signs could be provided to automated vehicles via the same technology used to communicate in-vehicle signs.

Use of in-vehicle signage for the general public will only be possible as new vehicles come equipped with ITS equipment that might be used for this function (i.e., video displays, heads-up displays, voice input/output). Stand-alone vehicle signing equipment has not been developed in the past decade and does not seem likely to find its way into the general motoring public vehicles in the next decade. Potential long term in-vehicle signing applications include:

- Providing warnings based on the characteristics of the vehicle (e.g., warning trucks about steep ramps) or the current environmental conditions (e.g., wet pavement, ice, snow, etc.)

- Alerting motorists that they are exceeding the safe speed limit
- Warning motorists of unsafe curves, and providing safe speeds based on vehicle type and road conditions
- Warning motorists of unsafe weather conditions (e.g., ice, snow, fog, dust clouds) based upon roadside environmental sensors.

3.1.3. Route Guidance

3.1.3.1. Introduction

The Route Guidance user service provides travelers with instructions on turns and other maneuvers to reach their destinations. These directions could be based upon static information (e.g., the road network, transit schedules). As the service matures, static information about the transportation system will be supplemented by real-time information. Thus a fully deployed Route Guidance service will rely heavily on real-time information provided by the following user services: Traveler Services Information (Section 3.1.5), Traffic Control (Section 3.1.6), Incident Management (Section 3.1.7), Travel Demand Management (Section 3.1.8), Emissions Testing and Mitigation (Section 3.1.9), , Public Transportation Management (Section 3.2.1), and En-route Transit Information (Section 3.2.2).

This service is closely related to En-Route Driver Information (Section 3.1.2). In many implementations, the two services could rely on the same information. However Route Guidance also processes that information into directions for the traveler. Thus a map display (possibly supplemented by indications of roadway congestion) is considered En-Route Driver Information; Route Guidance would use this information to derive a suggested route and instructions.

Users of Route Guidance include drivers of private automobiles, High Occupancy Vehicles (HOV) and van pools, commercial vehicle operators, and public transit vehicle operators, especially for non route-specific services such as paratransit and demand responsive transit. Thus Route Guidance is also closely related to Ride Matching and Reservation (Section 3.1.4), Personalized Public Transit (Section 3.2.3), and Freight Mobility (Section 3.4.6), especially for time-sensitive commercial deliveries. In addition to in-vehicle devices, Route Guidance would be available through hand-held or other personal portable units, to non-vehicular travelers such as pedestrians or bicyclists.

3.1.3.2. Needs

When travelers are in familiar surroundings and the conditions of the transportation systems remain somewhat constant, generally the maneuvers required to travel to desired locations are well-known. However, as conditions change, being able to determine whether better routes exist, and what they are, is a challenge to the traveler. It is also very discomforting not knowing how to maneuver through unfamiliar areas. Traveler safety can also be increased by alerting a driver, pedestrian or bicyclist to unknown route impediments, such as dangerous alignments or unusual geometries.

Real-time route guidance information can also assist commercial vehicle operators in locating delivery points and in facilitating "'just-in-time" pick-up and delivery services. Commercial productivity can be improved with better routing information.

This service will also facilitate carpooling, ride matching, and flexibly routed paratransit services by providing routing instructions to passenger pick-up points based on real-time traffic information.

Providing travelers with improved routing instructions and better routes can improve the quality of travel for the entire transportation network. Overall delay can be decreased by allowing informed travelers to avoid unnecessary delays. Travel delay, wasted fuel, and subsequent environmental pollutants can be reduced by reducing wasted travel time due to navigational error and lost travelers. Traveler stress is decreased by providing additional confidence and comfort in traveling to desired destinations.

3.1.3.3. Service Description

When fully deployed, Route Guidance systems will provide travelers with directions to selected destinations. These directions will be based on information about current conditions of the transportation systems. This will include current traffic conditions and information on events that are taking place that influence travel routes, such as street closures or construction. Route guidance systems will also have access to status and schedules of transit, rail and other transportation systems to facilitate multimodal connections. Portable devices for use by pedestrians or bicyclists will provide directions that avoid unsafe or inaccessible routes. Directions will generally consist of simple instructions, such as arrow displays or simple voice messages instructing which way to turn onto particular streets, roads, walkways, or transit facilities.

3.1.3.4. Operational Concepts

Route Guidance systems have essentially two modes of operation: static and real-time. Static systems rely upon unchanging transportation network information to provide travelers with routing instructions to specific destinations. This static information includes mapping information about the roadways and scheduling information for transit, rail or other systems. Real-time systems enhance the information of static systems by providing current travel condition information, such as traffic conditions or dynamic transit schedule information. Further developments in areas such as dynamic traffic assignment, will allow routing instructions to be based on predictions of the traffic conditions that will occur as the trip progresses.

Route Guidance systems operate in two different configurations, depending on the location of the route determination function. Route determination can either be done onboard a vehicle (or other mobile device) or by processors installed in the transportation system infrastructure. The location of this function determines whether the system is mobile-based or infrastructure based. Mobile-based static systems are autonomous guidance systems that can operate independent of any infrastructure. Mobile-based real-time systems can operate as autonomous systems, but when available, receive information about the transportation network from the infrastructure and use this real-time information to determine routing. Infrastructure-based static systems use communications between route guidance devices and the infrastructure to receive information on the traveler's desired destination, calculate a route and then provide directions back to the traveler. If current, real-time information is included in the route determination, these systems become infrastructure-based real-time systems.

There are a number of ways that the route guidance device can exchange information with the traveler. Visual displays, keypads, and other touch-sensitive devices can be used by the traveler to enter information and view routing instructions. Audible instructions also may be provided to travelers through computer-generated voice. The traveler may also be able to enter information into the device through a voice-recognition system.

There are a number of different procedures that can be used to determine the traveler's routing. Mobile-based systems will use programs that use the best information available to provide routing instructions to the traveler based upon certain parameters provided by the traveler. These parameters might include avoiding expressway-type highways or areas inaccessible or unsafe for bicyclists. These parameters enable a traveler to customize the routing selection process. Likewise, infrastructure-based systems can permit a traveler to customize a routing, but they can also use the destination of the traveler to determine the extra demand on a transportation system and provide routing information to travelers that is based upon this predicted demand.

3.1.4. Ride Matching and Reservation

3.1.4.1. Introduction

The Ride Matching and Reservation user service includes ITS technologies to automate the process of ride matching, with options for the matching to be done in real time, or for reservations to be made in advance. The service could be used to expand the market for car-pools and vanpools. Ride Matching and Reservation is a key Travel Demand Management strategy for reducing roadway vehicle demand by developing and encouraging ridesharing as an alternative form of travel. This user service will enable shared-ride vehicles to operate more efficiently through integration with other ITS services, and provide users of shared ride vehicles with improved access to needed transportation services.

3.1.4.2. Needs

Metropolitan areas in the United States are experiencing unprecedented challenges to mobility. In the decade of the 1990's, metropolitan traffic grew by 30 percent. In the first decade of the 21st century, the number of cars on our roads and highways will increase by another 50 percent. Because Americans spend 2 billion hours stuck in traffic every year, the annual cost of congestion, measured in lost productivity, has skyrocketed to over $48 billion.

Until recently, congestion was mitigated by building new roads and expanding facilities. This option has become more difficult to achieve. Aside from the economic infeasibility of building "enough" roads, there is a continued environmental sentiment against building new highways, as evidenced by public opinion and the Clean Air Act Amendments which mandate vehicle trip reductions in urban areas. Construction of additional highway lanes, except for high occupancy vehicle (HOV) lanes, is prohibited in areas that do not attain Clean Air Act standards.

It is important to note that there is currently sufficient passenger capacity in observed automobile usage to reduce congestion. This capacity is significantly underutilized due to the large number of SOVs. The high density of single-occupant vehicles is a principal contributor to congestion. Ridesharing, such as car-pooling and vanpooling, represents an existing strategy for mitigating traffic congestion and improving management of existing facilities. Indeed, initial development of ridesharing can be seen as far back as the 1940's with the promotion of carpooling to save gasoline and rubber during World War II. Although ridesharing increased immediately after the war, recent statistics show a decline, and this transportation alternative is now vastly underutilized in most urban areas. There is a need to take steps to encourage the public to make greater use of this option. The application of proven advanced technologies to make ridesharing more user-friendly and accessible can help reverse the declining trend in use of ridesharing.

3.1.4.3. Service Description

The Ride Matching and Reservation user service is a mechanism for expanding the market for shared-ride transportation by quickly matching the preferences and demands of users with providers and providing a clearinghouse for financial transactions. This will expand the market for ridesharing as an alternative to single occupant automobile travel and will provide for enhanced alternatives for special population groups.

An individual desiring to travel would make contact with the ride matching and reservation service. The traveler would provide a travel itinerary including date, time, origin, and destination. The information would also include any specific restrictions or preferences such as wheelchair requirements or mode of travel. The traveler would then receive ridesharing options for that date, time, and mode with consideration for the restrictions and preferences given.

A database of transportation providers would also be established. The various providers would have billing arranged through this central clearinghouse. Electronic safeguards would protect against fraud and abuse, and the system would automatically generate needed reports and financial documentation.

Instant carpooling has already been established, without direct government involvement, in two notable locations: the Shirley Highway corridor in Washington, D.C. and the Bay Bridge in Oakland. While these operations involve daily commuters, full implementation of this service would provide options for occasional travelers or visitors to the area who are not familiar with local travel options.

3.1.4.4. Operational Concepts

The basic operation of this user service connects travelers with drivers for providing shared-ride or transportation. Although this user service is primarily aimed at private vehicle owners/operators, it could also include the occasional commercial operator (i.e. vanpool operator, taxi operator) where or when private passenger vehicles are not available. An additional feature of the user service could be to create communication links to a wide range of travel options including bus, rail, vanpools, carpools, express bus, and specialized services. The communication link is electronic with each transportation service provider retaining their individual identities, policies, and subsidy mechanism. The user service would not establish fare, subsidy, or eligibility policy. It would act as a coordinator, operating and administering a clearinghouse network governed by the rules or programs established by others and providing documentation which verifies that transactions have been conducted in accordance with prevailing guidelines and regulations. Integration of this service with Electronic Payment Services (Section 3.3.1) would allow users and providers to quickly and conveniently process financial transactions.

This user service assumes that adequate transportation resources exist in the selected community for ridesharing. These resources would provide the informational infrastructure and market mechanisms needed to connect consumers (individuals or organizations) with suitable providers and manage the financial transactions. The system would offer users information on local transportation options through a single point of contact. This service is closely related to other informational user services, most notably Pre-Trip Travel Information (Section 3.1.1), which could help to provide some of the supporting infrastructure required by Ride Matching and Reservation.

There may be a possibility of this user service being operated privately with funds from transaction fees paid by providers or sources of subsidy such as employers or human service agencies. Transportation service providers would benefit from additional business. Market information could be provided to assist in planning service improvements and maintenance operations.

3.1.5. Traveler Services Information

3.1.5.1. Introduction

The Traveler Services Information user service provides the traveler with access to information regarding a variety of travel-related services and facilities. In general, this information will be of the "yellow pages" type, organized to provide quick access to services in the local vicinity of the traveler.

The information will be accessible to the traveler in the home or office to support pre-trip planning and while en-route, either in a vehicle or at public facilities such as public transit terminals or highway rest stops to help the traveler locate critical local services. Information would be available regarding the location and status (e.g., operating hours, etc.) for a variety of services, such as food, lodging, parking, car service/repair facilities, hospitals, and police stations. This service could also be useful to the commercial vehicle operator traveling in unfamiliar areas. An additional feature of this service would allow the traveler to communicate with service providers interactively to make and confirm reservations, and possibly, to purchase tickets, or guarantee payments for reservations.

The type of information that will be available to the traveler and the nature of the presentation will vary depending upon whether the service is accessed by the traveler in fixed locations, while riding in a transit vehicle, or while driving a private or commercial vehicle. Safety considerations will tend to restrict the type and amount of visual information that will be provided to a driver while the vehicle is in motion. When the vehicle is parked, the driver will be free to access all available information and to conduct transactions in an interactive manner.

3.1.5.2. Needs

This service addresses several traveler needs, including the safety-related need to quickly locate nearby support facilities such as car service/repair stations, hospitals or police stations, etc. The ability to identify nearby facilities and to determine the traveler's location will reduce traveler anxiety, add to the feeling of security, and also reduce the possibility of the driver becoming lost while searching for them. Additionally, travelers in remote areas would be advised of the unavailability of certain services which also reduces time spent searching for them.

Another need that will be partially satisfied by this service will be the ability to inform the traveler of the status and location of facilities such as parking or other concessions in highly congested commercial/tourist areas, thereby helping to reduce congestion levels caused by drivers searching for a business establishment or for available parking nearby.

3.1.5.3. Service Description

The Traveler Services Information user service will provide up-to-the-minute information related to the conditions, status, and availability of traveler services, including motorist services, tourist services and other travel-related items, regardless of the traveler's mode. When fully deployed, this service will connect users, sponsors, and providers in an interactive manner to request and provide needed information. Travelers may request general information about an area or specific information about a desired service, e.g., lodging, food, parking, or special events. This would be analogous to yellow pages directory that is available on-demand. A further capability that could be supported would permit the traveler to request actions of the service provider, for example, making lodging or dining reservations or to purchase tickets to an event. Also, more specific information may be requested, such as hours of operation, parking, tourist activities, daily events, etc.

3.1.5.4. Operational Concepts

Traveler Service Information would be provided to travelers in several ways. In some areas a limited amount of information would be provided as pre-recorded verbal information that is broadcast on a special radio channel or accessed through dial-up telephone lines. As personal portable advanced traveler information systems become more prevalent, traveler service information may also be provided via personal portable advanced traveler information systems.

The internet has provided a convenient source of travel service information in the last decade, which should continue to evolve in the next decade. Travel service information can be read/accessed by properly equipped computers at the home or office, or at information kiosks. Kiosks could be located in key public areas such as at rest areas along the interstates or near major cities, service plazas, activity centers, or tourist attractions. A motorist could access the system while in the vehicle, requesting information on service facilities or lodging.

Airline travelers looking for local points of interest and/or special events could access the system through kiosks located at the airport. This capability could be closely integrated with the services provided by the Pre-Trip Travel Information user service. Traveler

Services Information may overlap with other electronic traveler services such as banking, shopping, ticket purchase, etc. A more comprehensive, integrated service could include the ability to support financial transactions where the traveler could be billed automatically for the purchase of tickets or reservations.

3.1.6. Traffic Control

3.1.6.1. Introduction

The Traffic Control user service manages the movement of traffic on streets and highways. It includes surface street controls such as adaptive signal systems and freeway control techniques such as ramp metering and lane control. Traffic Control will help to ensure the safe and efficient movement of all users of the surface transportation system, including private automobiles, emergency, commercial, and transit vehicles, as well as non-vehicular travelers such as bicyclists and pedestrians. In addition, traffic control will help to maximize the use of the public's investment in the nation's transportation system by striving for optimum use of traffic control strategies.

Traffic Control is one of the most fundamental of the user services. The surveillance, control, communications, and support system activities covered by traffic control form the basic framework upon which many of the other user services depend. Traffic Control provides the real-time transportation network performance information, which many of the other Intelligent Transportation Systems (ITS) services use. In particular, the data collected, processed, and used by Traffic Control will be needed by virtually all of the other services in the Travel and Traffic Management bundle, as well as various services in the Public Transportation Management and Emergency Management bundles.

Traffic Control gathers data from the field, fuses it into usable information, and uses it to assign right-of-way to users of the transportation infrastructure. The goal of this service is to maximize the efficiency of people and goods movement through the transportation network. This often involves the preferential treatment of emergency, transit and other high-occupancy vehicles (HOV) to ensure equitable treatment of the multiple travelers they carry. If implemented properly, it will also help to alleviate congestion problems, and improve air quality. Traffic Control information will be disseminated to the general public and other service providers, laying the foundation for many other user services. In order for Traffic Control to operate properly, a sustained commitment to maintenance and operations is required.

Closely related services that can be used in conjunction with Traffic Control to provide overall transportation management include Incident Management (Section 3.1.7), Travel Demand Management (Section 3.1.8), Electronic Payment Services (Section 3.3.1), Public Transportation Management (Section 3.2.1), Emergency Vehicle Management (Section 3.5.2), and Maintenance and Construction Operations (Section 3.8.1). Although they are not direct users of this service, the traveling public, commercial and transit vehicle operators, employers and shippers of goods will be the ultimate beneficiaries.

3.1.6.2. Needs

Vehicle miles traveled (VMT) in the U.S. has doubled from 1 trillion to 2 trillion in the past 30 years. Unless actions are taken to reduce demand and increase operational efficiency, VMT is forecasted to double again in the next 30 years, with no substantial increase in physical capacity, such as the construction of the Interstate Highway System. ITS, and particularly Traffic Control, provides the ability to partially cope with this increase in demand, and utilize the existing capacity in a more efficient manner.

3.1.6.3. Service Description

Traffic Control is an array of institutional, human, hardware, and software components used to efficiently manage the movement of people and goods on streets and highways. Traffic Control can contribute significantly to the people movement capacity of the system by giving preferential treatment for mass transit and other types of high occupancy vehicles (HOVs). Traffic Control will also help to ensure the safe movement of non-vehicular travelers, such as bicyclists and pedestrians.

Traffic Control includes the control of network signal systems to achieve specific objectives such as maximizing system throughput while minimizing delay, energy use, and air quality impacts. Freeway control alternatives such as ramp metering and lane usage signals are also included to maintain a desired vehicle to capacity ratio. Integration of the control of freeways and network signal systems aids in area-wide optimization of traffic movement which will allow this ITS service area to optimize goods and people movement over a large geographic area. Institutional arrangements and increased interjurisdictional cooperation will be necessary in many areas to allow for the unified operation of control systems owned by several jurisdictions.

Improved surveillance techniques, real-time traffic adaptive control, and support systems are needed to implement this service. Surveillance of traffic conditions is an essential first step. The collection and processing of basic traffic data is necessary for the development and implementation of proactive control strategies and feedback on the effect of these strategies. Improved surveillance technologies will provide enhanced levels of information on traffic movements, which in turn will allow implementation of more sophisticated control strategies, and dissemination of more accurate and reliable information to other user services. Improvements and new approaches to electronic vehicle detection should improve the reliability and performance of measuring traffic flow at specific locations. Advanced surveillance techniques provides a means for automatically determining vehicle occupancy data, which will facilitate maximizing people movement and enhance travel demand management strategies.

“Area-wide” surveillance, which provides vehicle speed and congestion level information on a large number of roadway segments, will measure relative traffic loads throughout the network. This will allow the control system to react and maintain an optimum balance of traffic flow among all parts of the roadway network. The availability of information from area-wide surveillance systems will also greatly improve the operation of other user services that rely on information about the condition of the transportation system.

Given the availability of accurate real-time traffic information describing existing conditions of the road network, real-time traffic-adaptive control can be implemented. Various optimization strategies for obtaining the proper mix of vehicle speed, people and vehicle flow, fuel consumption, and pollution emission will be deployed. Real-time tactics such as signal priority or pre-emption schemes will be used to allow automobiles, emergency and transit vehicles, bicycles, pedestrians, and other modes to share the traffic right-of-way more safely and efficiently. In addition, these tactics can provide priority to HOVs and other shared-ride vehicles to facilitate implementation of travel demand management strategies.

The appropriate traffic control is implemented by communicating control data to such devices as traffic signal controllers, information signs (e.g., dynamic message signs), freeway ramp meters, and devices for the dynamic control of infrastructure, e.g., reversible lanes, lane control signals, rush hour turn restrictions, and HOV signals. The Traffic Control service will manage these control mechanisms such that control functions are provided on an area-wide basis, thus avoiding fragmented or conflicting control strategies. There is also the possibility of coordinating traffic control optimization with route guidance strategies in the future. Accurate and reliable feedback mechanisms are a key element of the Traffic Control service. These provide information on the network performance that results from the implemented control decisions, and adjusts control strategies as needed.

3.1.6.4. Operational Concepts

Traffic Control will depend upon various support systems. Sophisticated traffic prediction models that use dynamic assignment and statistical analysis techniques will anticipate demand characteristics throughout the network. Incident reports and historical time-of-day patterns will also be factored into the traffic prediction process. Data fusion algorithms are needed to integrate incoming surveillance data as well as data from numerous other sources, including public safety or police reports, cellular telephone calls, media reports, or other sources of traffic information.

Operator support systems will provide the Transportation Management Center (TMC) operator with accurate, readily-understood depictions of current conditions on the transportation system. User input capabilities that enable the human operator to override automated control strategies will also be available. This human interface will be especially important in coordinating traffic control strategies with other TMCs in response to incidents.

Regional Traffic Control could be provided by a single TMC or by multiple TMCs that serve the area. In the decentralized approach, local TMCs would be linked through a communications network and a regional coordinating group might be formed to compile and disseminate multi-modal system data. Communications networking with other transportation operating agencies and jurisdictions would provide access to information on transit or paratransit schedules and routes, rail schedules and intermodal connections.

In a more centralized approach, a single regional TMC could be the central data collection and dissemination point for real-time multimodal information. Data from multimodal sources will be collected, processed, and any contradictions resolved to create an accurate picture of the transportation system that can be used for signal control and be disseminated for use by other user services.

3.1.7. Incident Management

3.1.7.1. Introduction

The Incident Management user service enhances existing capabilities for detecting traffic incidents and taking the appropriate actions in response to them. Both unpredicted incidents (e.g., vehicle accidents, flat tire, etc.) and predicted incidents (e.g., planned lane closures due to construction, special events, etc.) are covered. While the direct users of the Incident Management service are emergency response fleets, enforcement agencies, the private towing and recovery industry, and those that operate and maintain the transportation system, the ultimate beneficiary is the traveling public and commercial vehicle community that move goods.

Incident Management is closely related to Traffic Control (Section 3.1.6). The development of response actions is part of Incident Management, while the implementation of appropriate traffic control measures is executed through the Traffic Control user service. Incident Management is also closely related to Emergency Notification and Personal Security (Section 3.5.1) which provides notification of an incident and requests assistance; Emergency Vehicle Management (Section 3.5.2) which supports the dispatch and routing of emergency vehicles; and Hazardous Materials Security and Incident Response (Section 3.4.5) which provides a description of hazardous materials to emergency responders. Incident Management is also related to the travel management services, including Pre-Trip Travel Information (Section 3.1.1), En-Route Driver Information (Section 3.1.2), and Route Guidance (Section 3.1.3), as well as the Public Transportation user service En- Route Transit Information (Section 3.2.2).

3.1.7.2. Needs

It is estimated that over half of the traffic congestion in the U.S. is caused by incidents. Incidents such as accidents, construction and maintenance activities, adverse weather conditions, parades, sporting events, tourist events, or other events that can cause congestion by temporarily increasing demand or reducing the capacity of the transportation network. “Rubbernecking” by those not directly affected by the incident can lead to further congestion and delays and secondary incidents. Even minor incidents, such as a disabled or abandoned vehicle on the shoulder, can reduce roadway capacity and create a potential safety hazard. Over the past 30 years, Incident Management programs have been implemented in various locations throughout the United States as a systematic approach to minimizing the traffic congestion and safety impacts of incidents. These programs have proven that Incident Management is one of the most successful ways to reduce traffic congestion, however, the associated commitment of resources and institutional arrangements often appears daunting. The incorporation of ITS technologies and concepts promises to make Incident Management more effective, less resource-intensive, and more feasible for widespread application throughout the United States.

3.1.7.3. Service Description

The Incident Management user service will use advanced sensors, data processing, and communications to improve the capabilities of transportation and public safety officials to detect, verify, and respond to incidents. The service will help these officials to quickly and accurately identify and verify a variety of incidents, and to implement a set of actions to minimize the effects of those incidents on the movement of goods and people. In addition, the service will help officials to identify or forecast hazardous weather, traffic, and facility conditions so that they can take action in advance to prevent incidents or minimize their impacts. This may include coordinating the schedules of maintenance and construction or other planned roadway activities.

A major focus of the Incident Management user service is improving the response to unpredicted incidents. These include unforeseen occurrences such as accidents, vehicle breakdowns, and loss of cargo situations. Because there is little or no advanced warning, the speed of detecting the incident and implementing the proper response is critical. Detection systems will use advanced sensor technology, fusion of data generated by numerous sources, and sophisticated software analysis to quickly verify the location, characteristics, and potential impacts of incidents. In some cases detection, verification, and implementation of a response plan may be partially automated with manual supervision to increase the speed and suitability of the response. More advanced systems could use computer-based decision support systems to help all appropriate organizations to decide cooperatively on the best set of actions to minimize the effects of an incident and determine which organizations should be notified, and who is responsible for implementing each action. Whether done manually or automatically the response actions may involve dispatching emergency vehicles and maintenance and construction vehicles to the incident scene, providing information and routing instructions to travelers, rerouting or diverting commercial and transit vehicles, and notifying traffic management agencies of the situation to alter traffic control strategies.

The Incident Management user service will also help in scheduling or forecasting predicted incidents so that actions can be taken in advance to minimize their impacts. Predicted incidents include events such as roadway/transit facility construction and maintenance efforts, facility closures, special events, and certain weather conditions that can be anticipated. The Incident Management user service will support the development and implementation of appropriate incident response actions, such as changes in traffic control or provision of information to travelers, before predictable incidents occur. The service will also provide the capability to coordinate the scheduling of many predictable incidents to minimize their traffic flow impacts. Both predicted and unpredicted incidents will require detection, verification, and response activities.

In order to help develop and implement effective response plans, the Incident Management user service must closely link a variety of transportation and public safety systems. An effective response to any incident also requires extensive communication and institutional coordination. Due to the dynamic nature of incidents and their impacts, ongoing contact through the incident command center and among the responders must be maintained throughout the life of an incident. The Incident Management service will use advanced data management and communications technologies to help ensure that the best possible information on the nature of an incident, and the associated response effort is available to all participants at all times.

Transportation system users do not see the direct outputs of the Incident Management service. Instead, they see the traffic control, pre-trip and en-route driver and transit information, route guidance instructions, and response vehicles that are the outputs of other user services. Incident Management must provide information about the incident and the response to it to a wide variety of transportation and public safety systems.

3.1.7.4. Operational Concepts

ITS systems will continuously collect, fuse, and evaluate data from many surveillance sources to identify possible incidents. Conditions corresponding to an incident can be detected by a variety of fixed or mobile electronic sensors that monitor traffic flow and environmental conditions. These sensors will generally support traffic control and other ITS user services as well. Verbal or electronic notification of incidents may also come from public safety sources such as police and fire departments, maintenance and construction road crews, media services, weather services, other transportation service providers within or outside of the region, or travelers themselves. Data, such as desired time, location, and characteristics needed to pre-schedule construction and other events, will be supplied by those scheduling the events, but the actual occurrence and impacts of these predicted incidents will be verified and monitored through the surveillance sources, just as for unpredicted incidents.

Integration and analysis of data from the different sources can take place at a single location, often an area-wide traffic management center. In other deployment scenarios, incident detection and verification can occur at distributed centers. In either case, traffic management centers, transit operating agencies, and other transportation authorities could be connected through a communications network to share information about the transportation system. A regional coordinating committee or other organization might also be used to compile and disseminate incident-related information.

While detection and verification is most commonly done by operator review of sensor or camera outputs, in the future computer-based incident detection algorithms will be used to monitor all incoming data for unusual conditions or reported incidents. The algorithms will determine that an incident has taken place only when supported by sufficient credible data. For each incident, algorithms will verify details regarding location, characteristics, and potential traffic flow and environmental impacts. Verified incidents will also be monitored to determine whether changing conditions warrant new action. Automation of the detection and monitoring procedures will both reduce staffing needs and allow monitoring of a larger transportation network.

A determination will be made of the best way to respond to all verified incidents, including which organizations, resources, and procedures to use. This response plan will be developed and updated based on the latest information on the status of the incident and the response effort and will be developed in coordination with the responding organizations. Response plans for predicted incidents will be developed in advance based on predicted traffic conditions and other concurrently scheduled incidents. When possible, the schedule for an event will be arranged in order to lessen its impacts on traffic. Pre-determined response plans for many incident scenarios can be maintained as part of a decision support system, which will help to speed the response and minimize confusion among the responding organizations.

Although the use of computers for developing and selecting incident response plans is currently limited, this will change in the future. Computer algorithms employing artificial intelligence capabilities will be used to recommend response plans based on input incident characteristics and, in many cases, will “learn” over time which actions work best. Computer simulation modeling may also be used to predict potential incident and incident response impacts ahead of time. Data on each incident response will be stored for future analysis of the effectiveness of the response plan.

When a recommended response plan has been developed, the appropriate organizations are notified to implement it. The Incident Management service will provide the communication capabilities necessary to support a flow of information among all of the potential responders. This not only allows the cooperative implementation of response plans, but also enables continued monitoring of each incident and the effectiveness of the corresponding response. This involves communications among all pertinent public and private organizations and information sources, including mobile communications for on-site incident status updates. As conditions warrant, additional response actions may be implemented until the incident is finally cleared from the system.

In the fully developed Incident Management user service, incident response plans will be developed and implemented using incident status and decision support systems that link all potential responding organizations. This computerized system will integrate the communication, dynamic and static database, and data processing capabilities necessary to support the real time integration of systems from different response agencies. It will simultaneously track the status, response, and impacts of all verified, potential, and predicted incidents. It will access the computerized decision support algorithms and also contain information such as the current status of all potential responding organizations and their resources, predetermined incident characteristics and response actions, and roadway and transit facility characteristics. The system will allow data on incidents, incident response actions, and traffic conditions to be archived for future analysis. It will also be possible to link ITS emergency vehicle management services, maintenance and construction resources, and other resource management systems directly to this system to obtain information on the availability and response times of emergency vehicles and other resources. Eventually, this could lead to full automation of the incident response dispatch process under some circumstances.

3.1.8. Travel Demand Management

3.1.8.1. Introduction

The Travel Demand Management (TDM) user service generates and communicates operational, management, and control strategies that will support and facilitate the implementation of programs, policies, and regulations. TDM is designed to do the following: (1) reduce the number of individuals who choose to drive alone, especially to work; (2) affect and increase a mode change from SOVs to high occupancy vehicles (HOV) for certain user group markets; and (3) provide a wide variety of mobility options for those who wish to travel either in a more efficient manner, at a different time, or to a different location.

Often TDM programs are implemented in response to public or private sector policies or regulations designed to reduce traffic congestion, air pollution, parking space needs, and/or increase the number of persons using HOV lanes. The implementation and enforcement of federal, state, and local policies that are intended to reduce, control, and/or manage vehicle usage are enhanced through the TDM user service. In order to insure that the goals and objectives of TDM policies or regulations are being met, monitoring and enforcement are a support element of TDM program development.

The TDM user service supports policies designed to promote operational, environmental, and social efficiencies in the transportation system. This can occur in the following ways:

- Facilitating convenient and accessible alternatives to driving alone so as to foster a change of modes for certain trip types, e.g., the work trip.
- Managing and controlling the availability, location, and price of roadway and parking facilities in order to provide greater space utilization, traffic operations, and auto occupancies; and
- Managing and controlling the pricing of the roadways and related services to improve traffic operations, transit operations, and auto occupancies.

In addition to the services in the Travel and Traffic Management bundle, many other ITS user services support the effective application of the TDM user service. Examples of user services that can be used to enhance existing TDM policies, programs, and regulations include Pre-Trip Travel Information (Section 3.1.1), En-Route Driver Information (Section 3.1.2), Ride Matching and Reservation (Section 3.1.4), Traffic Control (Section 3.1.6), En-Route Transit Information (Section 3.2.2), and Electronic Payment Services (Section 3.3.1).

3.1.8.2. Needs

Population growth, coupled with an increase in vehicles miles traveled, has contributed to traffic congestion and air pollution problems that constitute a significant threat to the quality of life and productivity in the United States. Furthermore, there are more vehicles on the road because of the lifestyle, land use, and demographic changes that are making the traffic congestion problem a challenge to manage. The average trip length has increased because of suburbanization. Consequently, roadway demand often exceeds capacity. Many urban highways are already at capacity, and building additional highways as a single solution to accommodate growth would not, in many cases, be effective or feasible.

In order to address significant traffic congestion and air pollution concerns, many state and local jurisdictions are developing and implementing policies and regulations that will encourage and/or require the application of strategies to manage and control the growth in the number of persons driving alone; increase the use of carpools, vanpools, and public transport; and mitigate the impacts of high polluting vehicles. These strategies, known as TDM programs, will be required, especially at major employment sites, activity centers, and congested corridors. In addition to state and local policies and regulations, many urban areas will be required to institute employer trip reduction programs that reduce the impact of high polluting vehicles through a TDM program.

Given this background, there is a significant need for ITS technologies to facilitate the implementation, operation, and enforcement of these management and control strategies.

3.1.8.3. Service Description

TDM can be divided into three categories:

- Improved Alternatives -- includes transit service and HOV facility improvements, carpool and vanpool programs, and site improvements.
- Incentives and Disincentives -- includes parking management (including pricing), congestion pricing, transit and ridesharing pricing, and other employer support measures.
- Alternative Work Arrangement -- includes variable work hours, compressed work weeks, and telecommuting.

ITS technologies used by governments and private industry for facilitating TDM will support and encourage strategies to increase HOV use as well as reduce and/or control single occupant vehicles trips at employment sites, activity centers, or along congested corridors. For example, to promote mode changes, ITS technologies can be applied to HOV lane awareness of alternative modes for work/non-work trips and for emission reduction and environmental policy goals. The deployment of ITS technologies, such as those associated with electronic payment systems, will provide a practical opportunity for road pricing on non-limited access highways. Should jurisdictions so choose, they could adopt road pricing/congestion pricing schemes for the purpose of managing vehicle travel.

The TDM user service functions through interactive computer operations and communications centers that implement the TDM management and control strategies, by the following process:

- Receive information and data from transportation operators (e.g., state and local highway agencies, transit operators, parking operators, and ridesharing agencies) and/or users, on the current status, need, and level of activity.
- Send or disseminate operational information and commands to operators and/or users on how to control or manage activity to conform and comply with a TDM program, policy, or regulation.

Operational, management, and control strategies can be generated, implemented, monitored, and revised through this process in order to effectively meet the goals of TDM programs, policies, and regulations.

3.1.8.4. Operational Concepts

Once a program, policy, or regulation is established, then specific strategies are needed to implement it. Specific TDM strategies are discussed in the following paragraphs. Information on TDM strategies would be disseminated through other user services, especially Pre-Trip Travel Information, to enable travelers to make informed decisions on mode choice and departure time.

<u>HOV facility (lane ramp or parking area) management and control:</u> HOV lanes will be operated and enforced to respond to current conditions and situations. Occupancy requirements could be adjusted by the time of day or to reflect current demand and

congestion levels, incidents, and enforcement criteria. For example, these requirements could be increased in response to pollution alerts or could be reduced in response to an incident on a parallel roadway. Another example of this operational concept is for traffic management centers to give priority to the movement of carpools, vanpools, and buses at ramp-meters and signalized intersections. The resulting reduction in travel time will make ridesharing and public transit more attractive to current SOV drivers.

Congestion/Roadway Pricing: Financial incentives and services for toll booths, parking areas, and HOV modes (i.e. transit, carpools, and vanpools) could be used to encourage mode changes and reduce vehicle demand. Tolls could also be increased during pollution alerts, while transit fares are lowered to meet the increased number of users changing modes from driving alone. Congestion pricing could be used during peak times in urban areas as well as at tourist attractions or recreational areas.

Parking management and control: The allocation, price, and availability of parking spaces can be managed and controlled to effect a mode change to HOV lanes. Working from a central point (such as a traffic control center), fee collection equipment, dynamic message signs, and detection equipment could be used to respond to events by implementing TDM strategies by time of day or in a dynamic manner. For example, the control center could interact with parking facilities to implement TDM strategies that help optimize and enforce parking space use in order to encourage HOV use or off-peak travel. During peak periods or when there is an ozone alert, a TDM strategy could impose a higher charge for single occupant parking spaces, while discounting the charge for carpools and vanpools. Implementing this type of strategy makes parking lots more efficient and decreases the need for new parking spaces. Variable parking fees could also be paid electronically, enabling a greater response to trip reduction policies and requirements. Electronic payment technologies could be used under this strategy to enable a single payment for bus, rail and parking charges, as well as other, non-travel related transactions. This would increase the convenience and equity of the transportation system for the user.

Mode change support: One TDM strategy is to provide coordination capabilities to support mode changes by travelers. This strategy can support the Ride Matching and Reservation user service to provide the public with greater flexibility when carpooling. For example, a driver could arrange to pick up a traveler at a specific time going to a specific place through the Ride Matching and Reservation user service. The driver could receive carpool credits (through coordination between a TDM organization and the Information Service Provider managing the Ridesharing) that could be used for future travel.

A TDM organization can provide instant service to a large number of employers, allowing convenient and inexpensive guaranteed ride home programs. A TMC can also work with transit agencies to keep track of alternate mode users and adjust available transit service accordingly.

Telecommuting and Alternative Work Schedules: Advances in telecommunication technologies are making telecommuting and alternative work schedules, such as compressed work weeks, a viable and economically advantageous alternative to driving to work during peak periods. Telecommuting can increase employee morale and productivity, while reducing the cost of parking, office space, and equipment for the employer. An important element of this strategy is to educate both employees and employers on the benefits of telecommuting, job sharing, and other alternative work schedules, perhaps providing incentives to employers who participate.

3.1.9. Emissions Testing and Mitigation

3.1.9.1. Introduction

Advanced vehicle emissions testing systems can be utilized on an area-wide basis to assist in improving air quality levels. For example, emissions information can be used to reroute traffic around sensitive air quality areas, or even, under severe conditions, to control access to such areas. Vehicle, emission levels can also be monitored at one location under a given set of conditions (e.g., on metered ramps), and then compared with other locations to form a better foundation for developing decisions on traffic system improvements or traffic demand management strategies.

Other emission testing applications involve roadside identification of individual vehicles that are emitting levels of pollutants exceeding state, local or regional vehicular emission standards. Further developments in on-board diagnostic systems might also provide in-vehicle monitoring of emissions levels. These could provide the driver with an alert that the vehicle may not be in compliance with applicable standards, enabling them to take corrective action on a timely basis. Roadside technologies can also be used to continuously monitor the number of vehicles in the traffic stream that are in violation of pollutant emission standards, and provide the monitoring agency with other data that may be helpful in framing pollution control strategies.

3.1.9.2. Needs

State and local governments, particularly as a result of the Clean Air Act Amendments and ISTEA planning requirements, have been and are now establishing air quality control strategies. Approximately 200 geographic areas of the United States have been identified as non-attainment areas for one or more “criteria” pollutants. These areas must meet a series of deadlines for submitting attainment demonstrations, and states must also submit State Implementation Plans that demonstrate reasonable further progress toward achieving attainment by certain milestone years.

3.1.9.3. Service Description

Emissions testing equipment can be used to provide area-wide pollution information for use in monitoring air quality conditions and framing air quality improvement strategies. Either mobile systems or sensors installed in the infrastructure could identify problem areas, test results of different control strategies, serve as a foundation for rerouting or access control measures, and monitor changes in air quality conditions over time.

Roadside vehicle emissions testing technologies could provide an alert through a driver advisory, in-vehicle signing system, or a roadside message to the owner or operator of a motor vehicle that it is not in compliance with state or regional emissions standards. Owners of individual vehicles or fleets, if informed that their vehicles may be out of compliance, may be motivated to quickly correct the problem since excessive emissions often indicates that the vehicle needs a tune-up. This voluntary, low-cost approach can be a part of government efforts to improve air quality.

Systems could be developed that can define and display the specific pollutant involved and the level by which the standards have been exceeded.

3.1.9.4. Operational Concepts

National and state agencies collect air quality data which is provided to other agencies and the public via websites and used to analyze the long term trends of emissions. The Emissions Testing and Mitigation user service can provide additional inputs to the area-wide monitoring of emissions through the network of transportation related weather information systems, which can also monitor levels of various pollutants. This information can be shared with the national and state air quality agencies. In addition the user service can facilitate the increased sharing of air quality information between agencies by making raw and processed sensor information more widely available through the integration of systems that collect, process, and store the information.

Roadside emission testing technologies can also be utilized by government agencies to detect those vehicles that do not meet emission standards. Sensors could be installed at particular locations where emissions could be accurately measured and related to specific vehicles. Motorists with automobiles that have high emission levels could be identified and provided with incentives to correct the problem, information on alternative modes of transportation, etc. Enforcement approaches, or pricing strategies based on level of pollutants emitted, could be implemented at the state or local level, if the testing systems proved to have a high degree of accuracy or if follow-up measurements were taken.

3.1.10. Highway-Rail Intersection

3.1.10.1. Introduction

Highway-Rail Intersections (HRI), where highways cross rail lines at-grade, are a special case of Highway-Highway Intersections (HHI). The HRI user service describes systems that will provide improved control of highway and train traffic to avoid or decrease the severity of collisions that occur between trains and vehicles at HRIs. The primary users of this service are the highway vehicle driver (motorist) and the train crew responsible for operation of the train (e.g., locomotive engineer). Train types addressed by the HRI user service include freight, intercity passenger, light rail, and commuter rail. Highway users of this service (collectively referred to, as motorists) include highway transit, school bus vehicle operators, emergency vehicle operators, as well as motorcyclists, bicyclists, and pedestrians.

There are presently two general categories of warning devices at HRIs: passive and active.

Passive warning devices are used at approximately 202,000 public and private at-grade HRIs. The national standard passive warning device is the "crossbuck", a white, "X" shaped sign with the words "RAILROAD CROSSING" in large black letters. This is the standard traffic control and regulatory device used in all states to notify motorists that they should be alert to the possibility of a train approaching or moving through the HRI.

It has the same meaning as a yield sign. Railroad advance warning signs may also be installed on the highway prior to the HRI to alert the motorist of an HRI ahead.

Active warning devices are installed at HRIs where additional alerting capabilities are required. There are approximately 50,000 HRIs that have active warning devices. Active warning devices usually include two flashing red lights mounted horizontally below the crossbuck. Flashing Lights may be further augmented with "Automatic Gates" that lower when a train is approaching to serve as a barrier between the train and motor vehicles on the approach lanes of the highway on each side of the HRI. These are referred to as "Two Quadrant" gates. Limited deployment of "Four Quadrant" gates and "Median Barriers" has been made to improve safety at HRIs. Median barriers are placed along the center line of the highway for a distance of about 100 feet starting at each of the two quadrant gates. The median barriers help to prevent motorists from driving around the gate. Four quadrant gates close both the approach and opposite lanes of the highway on both sides of the crossing as a means of preventing motorists from driving around gates.

Railroad operations are designed to reduce incidents at HRIs by minimizing HRI blockage times, and sounding train horns, where not prohibited by local authorities. Also some railroads are installing additional alerting lights on locomotives, referred to as ditch lights or crossing lights, and turning these lights on, along with the standard locomotive headlight, whenever they are moving. Railroads control the movement of trains by train orders, time tables, manual block systems and providing visual signals to train crews (either on the wayside or in the locomotive cab) by means of wayside control systems which are activated by the presence of the train and/or other trains located ahead. These signal systems are interconnected to preclude the entry of two trains into the same controlled section of track. The signal may also be controlled by central dispatchers who may also be in voice contact with train crews. The advent of high speed passenger trains sharing trackage with lower speed freight trains has presented additional challenges to the design of safe and efficient train control systems.

The HRI user service will be used in coordination with the user services En-Route Driver Information (Section 3.1.2) and Traffic Control (Section 3.1.6).

3.1.10.2. Needs

HRI accidents are one of the most significant safety concerns of railroads and the Federal Rail Administration (FRA). In 2001, there were approximately 253,000 HRIs in the United States; 154,084 are public at-grade and 98,430 are private at-grade. Accidents at HRIs occur at a rate of about 3500 each year, resulting in about 400 fatalities and 1400 injuries annually.

Rail traffic volume is increasing to meet the growing demand for efficient intercity passenger and freight service, as well as light rail and commuter rail passenger service. Section 1010 of ISTEA, has also established the need to improve the safety of HRIs to permit the implementation of high speed rail passenger service on a limited number of rail corridors. The Secretary of the U.S. DOT has subsequently designated a number of corridors to provide high speed passenger rail service at speeds from 80 to 125 miles per hour. Higher speed passenger operations between 125 and 150 miles per hour are planned for the future. These high speed rail corridors cover some 2,600 miles and include some

2,800 public and private HRIs. The increased safety needs of passengers on future high speed trains exposed to the risks of HRIs must be addressed by the HRI user service.

Many design factors must be considered in determining appropriate safety improvements at HRIs including train length, weight, speed, and frequency, number of tracks, crossing closure time, the amount and type of highway traffic, along with HRI geometries such as highway sight distance. In addition, a number of human factors and motorist behavior issues need to be addressed. For example, motorists often take inappropriate risks at crossings based on the false assumption that trains can typically stop in time to avoid an accident at the HRI. However, a typical 100 car freight train traveling at 60 miles per hour would require more than one mile to stop, even using emergency braking. Motorists may also take risks to avoid delays at HRIs that have a history of long closures by freight trains. In addition, motorists might be confused as to how to interpret HRI warning devices that differ subtly from standard highway traffic signals. For example, the flashing red traffic light at an HHI signals motorists to stop and proceed when clear, whereas the flashing red lights at an HRI signals motorists to stop and always yield the right-of-way to trains. Furthermore, there are no national regulations on motorist responses to flashing lights; each state determines its own regulations on this issue.

Trains with operating speeds in excess of 79 miles per hour have special needs that must be addressed by the HRI user service. Because collisions between high speed passenger trains and highway vehicles will be more likely to result in significant casualties, it is essential that additional measures be taken to protect trains from highway traffic incursions. The FRA currently requires trains operating at speeds in excess of 79 miles per hour to be equipped with in-cab signals and recommends the following safety measures for HRIs:

- For train operations from 80 to 110 miles per hour, the HRI must be grade separated, or have special signing and active warning devices including automatic gates which provide constant warning time. Automatic four quadrant gates should be considered. Train activated advance warning systems should also be considered, especially where sight distance is restricted.
- For train operations from 111 to 125 miles per hour, a waiver from current FRA Track Regulations is required. The HRI must be either grade separated or blocked. The blocking device must provide an impenetrable barrier to protect passenger trains from highway vehicle encroachment onto the HRI.
- For train operations above 125 miles per hour, all HRIs must be permanently blocked, or grade-separated.

HRI user service is thus required to address the critical safety needs imposed by current rail operations (freight, intercity passenger, light rail, and commuter rail) over HRIs as well as additional needs created by future high speed rail passenger service. HSR user service systems will augment and replace current HRI warning devices to effectively enhance HRI safety. The fact that approximately 50 percent of all HRI accidents occur at HRIs with today's active warning devices is compelling evidence that these systems need to be improved..

3.1.10.3. Service Description

The HRI user service will integrate ITS technology into HRI warning systems to provide for improved control of train and highway traffic to avoid and reduce the severity of collisions at HRIs. The service helps to improve safety at HRIs by developing ITS technologies to enhance the safety effectiveness and operational efficiency of HRI safety devices. Two subservices are provided: (1) the standard speed rail (SSR) HRI subservice and (2) the high speed rail (HSR) HRI subservice. The HRI user service will be applicable to the unique safety needs of highway users such as highway transit and emergency vehicle operators, motorcyclists, bicyclists, and pedestrians, as well as rail transit users such as light rail and commuter rail.

Improved train control could be accomplished by providing advisories and alarms to train crews of HRI warning device operational status and highway vehicle intrusions onto HRIs; The first aspect of these advisories, HRI device operational status, is incorporated into the SSR subservice. The second aspect of these advisories, warning of intersection blockage, is incorporated into the HSR subservice and is intended primarily to address the additional safety demands of high speed passenger trains (although it is equally applicable to HRIs with safety concerns due to their physical layout, or due to the train or vehicle traffic that uses them.

Improved highway traffic control could be accomplished through a variety of ITS functions available under the HRI SSR subservice. First, the HRI user service will provide improved HRI warning devices for motorists. These improved devices will incorporate ITS technologies that will enhance their alerting capabilities, reduce their costs, and increase their performance in terms reliability, maintainability, energy use, etc. The improved HRI warning devices could also provide warnings to the motorist that are either consistent with or incorporate standard highway traffic signals making them less likely to be misinterpreted by motorists. The HRI warning devices will also include features that allow them to be integrated effectively with nearby highway traffic signals to maintain safe traffic patterns at HRIs.

In addition to HRI warning devices, the HRI user service could provide roadside dynamic message signs for motorists. These message signs will effectively inform motorists of an HRI ahead and the need to exercise caution. These signs will also inform the motorist of the time to train arrival, expected delay times, and possible alternative routes to avoid excessive delays resulting from signal malfunctions or unusually long or slow trains. Furthermore, the message signs will inform the motorist if a train is already in the HRI and warn the motorist to stop.

The HRI user service could also provide for a wide range of ITS in-vehicle motorist advisory and warning functions. The most basic function is advisory only and does not require train based information for implementation. The advisory function simply informs the driver that an HRI is ahead and caution should be exercised. The warning function will require train data and will provide the motorist with information such as the time to train arrival, the need to stop to avoid a collision with a train in the HRI, expected delay times, and possible alternative routes to avoid delays. This information could be initially provided only to priority vehicles such as school buses, ambulances, police cars, and other emergency vehicles prior to wide scale implementation. These in-vehicle HRI user services can be particularly effective in achieving safety benefits since all passive HRIs can in essence be made active without the expense of providing them with active warning devices. In its most extended form, the HRI user service can provide automated stopping of vehicles to avoid an HRI collision.

The HRI user service will also help to reduce the severity of HRI collisions by providing collision notification functions. This function would permit the rapid notification of emergency response teams in the event of an HRI incident. The capability, if train based, could be either manual (e.g., the train crew initiates the notification) or fully automated (not requiring train crew intervention).

3.1.10.4. Operational Concept

Long term implementation of the HRI user service could be supported through establishment of Train Control Centers (TCC) and Traffic Management Centers (TMC). The fully deployed concept of operation is for the HRI user service to provide real-time information on train position and estimated time of arrival at HRIs, HRI status, and roadway traffic conditions at HRIs.

3.1.10.4.1. Train Control Functions

The HRI user service could interface with the TCC and the train to provide HRI status to train crews and facilitate automated stopping of high speed passenger trains on designated corridors in rare emergency situations when a collision with an obstructing highway vehicle on the HRI can be avoided. TCCs could accomplish these train control functions through Advanced Train Control (ATC) technologies such as the Advanced Train Control System (ATCS), and the Positive Train Separation (PTS) and Positive train Control (PTC) systems. The HRI user service will not directly control trains, but will provide advisories and alarms to train crews of HRI warning device operational status and highway vehicle intrusions onto HRIs. These crew advisories and alarms, apply to all types of rail service including freight, intercity passenger, high speed passenger, light rail, and commuter rail, and are incorporated into the SSR subservice.

Early implementation of the SSR subservice can be accomplished by communicating operational status of traffic control systems and vehicle intrusions directly to the crew of an approaching train as advisory and warning information for their appropriate action. Effective means of providing this information to train crews and training of crews on appropriate response actions are important areas of research. The communication could be established from the wayside equipment to the train via existing wireless communications technologies. Later stages of implementation could be accomplished by communication of this data to the train crew through the TCC. In addition to notifying train crews for collision avoidance actions, notification of signal malfunctions can also be sent to the railroad dispatcher, signal maintainer, local police, and maintenance and construction divisions for purposes of corrective action to prevent future incidents.

The HSR subservice will provide information about HRI blockages that could lead to automated stopping of high speed (greater than 79 mph) passenger trains on designated corridors in rare emergency situations when an obstructing highway vehicle on the HRI can be automatically detected in sufficient time to avoid a collision. This function could be accomplished through communication with the TCC and the capabilities of ATC technologies such as ATCS, PTS, and PTC. The HSR subservice will verify proper operation of HRI warning devices and will detect intrusions onto HRIs. Where the HRI employs barrier systems (e.g., four quadrant gates), detection devices will be in place to ensure that there is no entrapped highway vehicle or other obstruction in the HRI. Early detection by HRI sensors of malfunctioning devices or of stalled, disabled, or trapped vehicles blocking the HRI in the path of an oncoming high speed passenger train would permit the train to be automatically stopped or slowed to prevent or reduce the severity of an HRI collision. This function will require that HRI warning devices be activated 1 to 3 minutes before the arrival of a high speed passenger train.

The HSR subservice provides real-time interactive coordination of highway traffic and train operations via TMCs and TCCs. These services will require information on train location, speed, weight, length, type of train (e.g., freight, high speed passenger), and type of cargo (e.g., coal, hazardous materials). It will also be necessary to detect, depending on the level of user services provided, highway vehicle location, speed, and type of vehicle. This coordination permits the TCC to improve the efficiency of train operations as well as minimize travelers' delay.

3.1.10.4.2. Highway Control Functions – Detection and Warning Devices

The SSR and the HSR subservices will both require information on the operational status of traffic control systems at the HRI (e.g., is the device operational, fully deployed, etc.). Information on the operational status of traffic control systems can be obtained by HRI remote monitoring systems using appropriate sensors technologies. If a malfunction of the traffic control system is detected, this information will be communicated to the TMC, which can communicate it to the TCC. The HSR subservice requires information on whether a highway vehicle has intruded onto the HRI. Vehicle intrusions can be detected using electronic vehicle detection equipment (e.g., inductive loop, radar, and video technologies). Intrusion detection systems can be used with HRI barrier systems, for example four quadrant gates, where a highway vehicle could become entrapped between the barriers. Intrusion detection systems employing video technologies can also be particularly effective in supporting efforts to enforce HRI traffic regulations by law enforcement officials.

The HRI active warning system's ability to control highway traffic will be improved through the use of ITS technologies that will enhance their alerting capabilities, reduce their costs, and increase their performance in terms reliability, maintainability, energy use, etc. HRI active warning systems will be capable of adaptive signal operation to account for the train's location, direction and speed status to yield an estimate of train arrival time at the HRI and provide for constant warning times to the motorist. These systems will benefit from improved wayside or train-borne train detection technologies. Early implementation of these services can be accomplished by direct communication between the train and the HRI warning devices. Later, the required information can be enhanced through communication with TCCs and TMCs.

Four quadrant gate technologies will be developed as an improved deterrent to motorists going around gates. These gates block both lanes of the highway on each side of the HRI. If all four gates are lowered simultaneously, a motorist could pass under the gates being lowered on the near side of the HRI only to be blocked by the gates that have lowered on the far side of the HRI. However, delayed lowering of the gates on the exit lane of the highway on the opposite side of the HRI would provide additional time for a potentially entrapped motorist to safely exit the HRI. The exit gates could also have swing away features which would allow an entrapped motorist to break through the gate with minimal damage to his or her vehicle. Motorist awareness of this feature and ability to take advantage of it in a crisis situation are implementation issues to be addressed. Median barriers may also be used to inhibit motorists from going around gates. These barriers could be rigid or flexible to provide more or less of a physical barrier to motorists.

HRI active warning systems will provide for improved integration of their operation with highway traffic control systems on adjacent roadway facilities. The improved HRI active warning systems may also incorporate red-yellow-green lights, consistent with standard highway traffic signals, to replace the flashing red lights used at HRIs today. This feature would give positive train movement information to the motorist in a manner consistent with HHIs. When current warning devices at HRIs display a "dark" indication, it means GO, while a flashing red indication means stop and always yield to the train; these messages that may not be properly understood by motorists. The use of standard highway traffic control signals may also be more cost-effective than traditional HRI warning systems.

The TMC would be able to determine the activation status of HRI signal systems and thus monitor the progress of train movements and take action to alleviate the effects upon traffic congestion on intersecting and adjacent roadways. Possible responses might include temporary adjustment of traffic signal phasing and timing, the implementation of lane use and turn restrictions through dynamic lane assignment, and dynamic message signs. The information could also be relayed to emergency services personnel, police, fire, and ambulance services, to facilitate routings which avoid blocked HRIs and thereby optimize emergency response time. Similar actions could be implemented by the TMC in the event of HRI signal malfunctions.

3.1.10.4.3. Highway Control Functions - Dynamic Message Signs

Highway traffic control devices at the HRI will be supplemented with roadside dynamic message signs. These devices will provide information necessary for motorists (typical highway users as well as transit and emergency vehicle operators, motorcyclists, bicyclists, and pedestrians) to take appropriate safe action at HRIs. The signs may be at the HRI or on adjacent roadways. These signs can provide real-time information about the location and arrival time of trains so that traffic can be managed to minimize delay times that may result, for example, from signal malfunctions or unusually long or slow trains. Information on train movements relative to HRIs can be provided to the TMC via the TCC or through remote systems that monitor the operational status of HRI.

3.1.10.4.4. Highway Control Functions - In-Vehicle Services

The HRI user service will include in-vehicle functions at three basic levels of interaction with the motorist (typical highway users as well as transit and emergency vehicle operators, motorcyclists, bicyclists, and pedestrians): (1) driver advisories, (2) driver warnings, and (3) automatic stopping of the highway vehicle. This service is intended to take advantage of other in-vehicle ITS user services such as En-Route Driver Information and Route Guidance.

In-vehicle driver advisories are the most basic service and can be accomplished without information about train operations. These services will advise the driver that an HRI is ahead and caution should be exercised. To provide this service it will require that the location of HRIs be included in their geographic databases and that the necessary software is included to provide the advisory messages. The advisories would most likely be in the form of graphic displays as well as voice and/or alarm audible messages.

In-vehicle driver warnings will require information about train operations. These services will inform the driver of an HRI ahead and will warn the driver to take appropriate action if a train is approaching or is in the HRI. This service requires data on train location, direction, and speed. This data can be provided to the vehicle in several different ways. Early implementation of this concept could be achieved by providing the data directly to the vehicle via communications with the train or through a wayside train detector located at the HRI or along the track approach to the HRI. An advanced concept for this service would involve interaction between the vehicle, TMC, and TCC. This service concept would permit the TMC to provide train arrival time information, expected traffic delay times, alternative routings to minimize traveler delays, and most importantly warnings to the driver to avoid collisions at the HRI. This service will also be extremely useful to highway transit vehicles and priority vehicles such as school buses and emergency vehicles to assist in avoiding collisions and responding rapidly to emergency situations. In its early stages of implementation, this service could be targeted to priority vehicles prior to wide-scale use.

The most advanced form of this service would involve automatic intervention of the in-vehicle system to stop the vehicle if a collision is imminent at an HRI. This service will require accurate data on vehicle and train dynamics as well as sensor, information processing, and vehicle control technologies. Information transmitted to the vehicle from the TMC may require augmentation with data obtained from infrastructure sensors to obtain the necessary accuracy on vehicle and train dynamics.

3.1.10.4.5. Automated Collision Notification

The HRI user service will help to reduce the severity of HRI collisions by providing automatic collision notification functions. This function would permit the rapid notification of emergency response teams in the event of an HRI incident. The effectiveness of these response teams can be significantly improved if they have advanced information on the nature of the collision. This information can be provided by the HRI user service by combining data on train characteristics (e.g., location of incident, train speed, train type, involvement of passengers, hazardous materials, etc.) obtained from the TCC and data on highway vehicle characteristics (e.g., type of vehicle, speed, acceleration forces, involvement of passengers and hazardous materials, etc.) obtained from the TMC. This service can be based on the train, the highway vehicle, or both. If train based, the notification to the TCC could be either manually initiated by the train crew or fully automated through the use of appropriate sensor and communication systems. The notification, if highway vehicle based, would most likely be provided by the Automated Collision Notification user service described elsewhere in the National ITS Program Plan. The TMCs and TCCs will require integration with control centers for emergency response teams.

3.2. Public Transportation Management

The four services described in this chapter relate to public transportation, which includes urban, suburban and rural transit in fixed route, route deviation and demand-responsive modes operated by bus, heavy rail, light rail, commuter rail and van or car-pool or shared ride taxi. In short, all forms of short distance transportation not involving a single occupant automobile will benefit from these services.

The ITS Advanced Public Transportation Systems (APTS) program aims to decrease reliance on the personal auto by enhancing the efficiency, convenience, cost effectiveness, safety and security of public transportation. Particular attention is paid to those aspects of public transportation which have heretofore diminished the popularity of this type of transportation or caused resistance to its use.

These services are described briefly below:

- The **Public Transportation Management** service automates the operations, planning and management functions of public transit systems. It provides real-time computer analysis of vehicles and facilities to improve transit operations and maintenance. The analysis identifies deviations from the schedule and offers potential solutions to dispatchers and operators. This service will help maintain transportation schedules and assure transfer connections from vehicle to vehicle and between modes and can be coupled with traffic control services to facilitate quick response to service delays. Information regarding passenger loading, vehicle running times, accumulated miles and hours and vehicle maintenance will help improve service and provide managers with a wealth of information on which to base decisions. Service schedulers will have timely data to adjust trips. Personnel management will be enhanced with the automatic recording and verification of operating and maintenance task performance. Reports, including management, operations, and legally required Section 15 reports, will be prepared with greater efficiency through the application of computers for this function. Security of transit personnel will be enhanced through providing access management of transit vehicles.
- The **En-Route Transit Information** service provides information to travelers using public transportation after they begin their trips. Real-time, accurate transit service information will be available on-board the vehicle, at transit stations and bus stops to assist travelers in making informed decisions and itinerary modifications while a trip is underway.
- The **Personalized Public Transit** service supports flexibly routed transit vehicles which offer more convenient, and often more cost effective, service to customers where traditional, fixed route operation cannot be economically justified. Small, publicly or privately operated vehicles provide on-demand routing to pick up passengers who have requested service and deliver them to their destinations. Route deviation schemes, where vehicles would leave a fixed route for a short distance to pick up or discharge passengers, is another approach employed to improve service. Vehicles providing this service can include small buses, taxicabs, or other small, shared-ride vehicles. This type of service can expand

transit service to lesser populated locations and neighborhoods and can potentially provide transportation at lower cost and with greater convenience than conventional fixed route transit.

- The **Public Travel Security** service creates a secure environment for public transportation patrons, operators, and support staff. It provides systems that monitor the environment in transit facilities, transit stations, parking lots, bus stops and on-board transit vehicles and generate alarms, either automatically or manually, when necessary. The service also provides systems that monitor key infrastructure of transit (rail track, bridges, tunnels, bus guideways, etc.). This improves security, and with it, the perception and acceptance of transit. Transit agencies can integrate this user service with other anti-crime activities.

3.2.1. Public Transportation Management

3.2.1.1. Introduction

The Public Transportation Management user service automates the operations, planning and management functions of transit systems. It provides real-time computer analysis of vehicles and facilities to improve transit operations and maintenance. The Public Transportation Management user service also applies advanced vehicle electronic systems to various public transportation modes and uses the data generated by these modes to improve service to the public.

Public transit agencies are the primary users of this service, but all aspects of the service could be applied to private transit systems as well. Some of the generated information can be made available to Pre-Trip Travel Information (Section 3.1.1), En-Route Transit Information (Section 3.2.2), Personalized Public Transit (Section 3.2.3), and Public Travel Security (Section 3.2.4).

3.2.1.1. Needs

It is imperative to manage the schedule adherence of transit vehicles operating on fixed routes so customers can rely on published schedules. Customer confidence in the system is needed to generate the ridership necessary to justify the fixed cost of providing the transportation service. From the transit agency's perspective, it is important that the fleet be managed in the most effective and efficient manner. Advances in the fields of communications and information systems can provide innovative methods to make transit more efficient and more attractive to potential riders, and thus more effective. It has been estimated that the diversion of just one of every five solo drivers would save $30 billion per year in congestion costs.

3.2.1.3. Service Description

The Public Transportation Management user service automates the operations, planning and management functions of transit systems by applying ITS technologies both on board transit vehicles and in transit operations, administration, and maintenance facilities. The Public Transportation Management user service consists of three sub-services: Operation of Vehicles and Facilities, Planning and Scheduling, and Personnel Management as it relates to operations, security, and scheduling. Each of these three sub-services can be performed manually; however, the use of advanced automated systems is more accurate and less costly, and provides better service to the traveler.

Operation of Vehicles and Facilities subservice includes automated dispatch of transit vehicles as well as an automated vehicle location function. The location information can be used by the operations facility to identify deviations from the schedule and to perform analysis that offers potential solutions to dispatchers and operators. This subservice will help maintain transportation schedules and assure transfer connections from vehicle to vehicle and between modes. In addition, the vehicle operation and can be coupled with traffic control services to provide transit signal priority which can facilitate quick response to service delays. Information regarding passenger loading, vehicle running times, accumulated miles and hours and vehicle maintenance will help improve service and provide managers with a wealth of information on which to base decisions. Service schedulers will have timely data to adjust trips. Security of transit personnel will be enhanced through providing access management of transit vehicles.

The Planning and Scheduling subservice will allow transit planners and schedulers access to operational data to assist in run-cutting. Reports, including management, operations, and legally required Section 15 reports, will be prepared with greater efficiency through the application of computers for this function. The schedules created by this subservice will be used to provide schedule information to transit customer information systems.

The Personnel Management subservice will enhance management of both operator assignment and maintenance personnel assignment through the automatic recording and verification of operating and maintenance task performance. Spin-off applications from personnel management systems include automated timekeeping and payroll entry of operator and maintenance employee time, automatic updates to parts and inventory systems and maintenance databases. All information would be available for off-line analysis and later review. Personnel management also includes aspects of security relating to transit vehicle access management, requiring some level of positive identification prior to operation of the vehicle and its systems.

3.2.1.4. Operational Concepts

In the Operations of Vehicles and Facilities sub-service, real-time data from individual vehicles (and facilities) is communicated via a digital data link and is compared with schedule information and other predetermined parameters. A computer identifies deviations, displays them to the dispatcher or controller, and determines the optimum scenario for returning the individual vehicle or fleet to the schedule. Corrective instructions are transmitted to the operator to adjust for the deviation and implement his portion of the service restoration process. If conditions warrant, the dispatcher will assume control. Additionally, integrating this service with Traffic Control (Section 3.1.6) can help maintain transportation schedules and minimize varied impacts on traffic congestion. Similarly, real-time operation of transportation facilities falls into this user service category.

Another application of this sub-service is connection or transfer protection. Connection protection will ensure that planned vehicle meetings will take place through interaction between computers on the two vehicles. Using the vehicle location sub-system, the computer will calculate the arrival times of two buses approaching a transfer point. The bus that arrives first will be instructed to remain at the transfer point and wait a reasonable, specified amount of time for the second arriving bus. This will permit transferring passengers to wait inside the safety and shelter of the bus instead of outside in the elements.

The Planning and Scheduling sub-service includes off-line storage and analysis of data that has been collected in real-time and stored in the computer for later analysis. These data include information on passenger loading, bus running times, and mileage accumulated by individual buses. These data are stored in a memory storage device and analyzed off-line by the computer so that schedules and plans can be revised using actual data. For example, using such data as route segment running-time and passenger boarding and alighting at each stop, transportation system schedules can be developed much more quickly or adjusted to changes in riding characteristics. The planning efforts required for route and service improvements will also use this data. Maintenance planning and reporting, Section 15, and other reports will be automatically generated by this function.

A principle user of Planning and Scheduling information is the off-line activity of the telephone customer service department. Transit authorities have customer information systems that permit almost instantaneous access to schedule information. Presently, telephone operators answer calls and look up schedule and route information contained in either printed or computerized schedules. Training a new customer service telephone operator on the intricacies of routes, schedules and fare information can take several weeks on large transit systems. Using the automated schedule preparation system, the schedules can be automatically entered into the customer service system as changes are developed. The customer service operator always has the most current information and, when combined with currently available software which automatically looks up route and schedule information based on the customer's origin and desired destination, the training time will be significantly reduced while offering better assurance that-the customer will be given the right information every time. In addition to updating schedule information, new schedules can also be developed for the benefit of the customer as well as the transit provider. The greatest benefit to transit planners, however, would come from the ability of an automated customer information system to document lost business opportunities - cases in which a potential rider's trip requirement could not be met -and help to quantify demand for additional transit services.

The third sub-service involves Personnel Management, as it relates to operations, security, and scheduling. Operators are assigned to individual daily work assignments (runs) based on seniority, preferences, garage assignment, vehicle qualification, etc. This is done to allow operators to exercise their seniority in picking their routes and runs while minimizing labor and overtime costs. At most systems this activity is performed manually. Using the off line data and analyzing it in accordance with operator seniority and schedule preferences lists, this "sign up" process can be automated to a greater extent than is possible now even at authorities which have a computerized sign up program.

Similarly, service technicians can be assigned by skill level to work on individual buses. Among the stored data is daily miles traveled by each vehicle. Periodic maintenance schedules can be automatically generated and specific buses assigned into the garage for planned maintenance, thus ensuring that the work is performed and the proper service personnel are available.

3.2.2. En-Route Transit Information

3.2.2.1. Introduction

The En-Route Transit Information user service provides information to transit riders after their trips have begun. The service will provide real-time, accurate, transit and high-occupancy vehicle information so that travelers can select the most convenient and time-effective choice of mass transit in order to reach their destinations.

En-Route Transit Information is distinguished from Pre-Trip Travel Information (Section 3.1.1) in that the Pre-Trip concentrates on travel and transit information prior to making a trip or mode choice. Once a trip is initiated, travel information still needs to be provided to the traveler. En-Route Transit Information discusses the service provided during trips using transit. Some of the information provided to transit users as part of the En-Route Transit Information service is also relevant to drivers and can be provided to them as part of the En-Route Driver Information (Section 3.1.2) service. Information such as transit schedules, schedule adherence, and parking availability can be provided to drivers to support mode change decisions mid-trip based on current traffic conditions.

3.2.2.2. Needs

Encouragement to use mass transit as a means of commuting will help alleviate traffic congestion while providing for better management of existing facilities. This transportation mode is under-utilized in most urban and suburban areas. In fact, census data indicates that use of transit throughout the country has been declining over the past decades. Like any other good idea, transit will not help solve the traffic congestion problem unless it is put into greater use. To increase ridership and attract riders from other modes of transportation, public transit must provide good service and deliver its product on-time.

It has been found that the perceived wait time for transit passengers is considerably longer than the actual wait time. This is particularly problematic in low density suburban areas, where service is generally infrequent. More widespread use of mass transit, and thus more effective and efficient transit operations, can be achieved through en-route transit information systems that provide better information to travelers and better integration of transit with other modes of transportation.

Transit status information provided at the appropriate time and place will assist the traveler in completing the trip with minimal disruption and with considerably less uncertainty. Thus, there is an urgent need to take steps to provide travel information while En-Route to encourage the public to make greater use of this travel option. Capabilities exist today to provide the information in a number of languages in addition to English. Also, there are many transit users with visual and hearing impairments that need special audio and visual assistance to receive information. The application of proven advanced technologies to enhance information on public transportation can help reverse the declining trend in the use of transit as a travel mode.

3.2.2.3. Service Description

The En-Route Transit Information user service provides travelers with real-time, accurate transit network information during their travel. This information assists travelers in making effective transfer decisions and modifications as needed to a trip underway. Information also provides traveler “comfort,” reduced anxiety, and convenience. The information provided is inclusive of all transit services and modes in a given area, including car and van pools and shared ride taxis and would, eventually, be available from a single source. The data would be collected from transit systems, traffic management systems, and rideshare programs; and integrated, stored, and maintained on-line for interactive access from a wide variety of locations.

3.2.2.4. Operational Concepts

A traveler, having already made his mode choice and initiated a travel plan, will be provided with information along the route. Interactive service would be provided through kiosks at travel information centers and other transfer points. Interactive displays on board the bus would allow queries to be made concerning various options while en-route to a destination. Similar interactive displays would also be available at a wayside stop or transfer point. Available options for completing the trip would be given to the traveler based upon real-time information. At bus stops, a visual display would give estimated arrival times of buses based on their actual location and an audio message would announce the arriving bus and route number. The traveler would board the bus and begin the trip. While on board, the traveler would determine if a transfer could be made at a rail station En-Route. If the on board display advises that the rail service is running late, the traveler could arrange to stay on the bus for the completion of the trip. When transferring to another bus is necessary, information about connections would be available on board the first bus.

These dissemination processes could be extended to include the integration and coordination with regional paratransit services. Public and private providers would be included in the information given throughout the jurisdiction of the service area. Each of the transit systems within the service jurisdiction would continually provide the integrated information service bureau with scheduled and actual service being provided. The information would include the next available vehicle based upon actual operating conditions. Information would be integrated with actual road and traffic data, resulting in on-the-fly route detours, where possible without missing riders.

During peak hours, there may be large crowds of people in several different queues at terminals or major stops where the same bay or stop is shared with more than one route. In these situations, the order of bus arrivals may be more important to the customer on the platform than the actual arrival time.

Since interactive displays at kiosks require on-line, interactive service similar to that offered by automatic teller machines (ATM’s), one future concept would be to combine the two services. For example, tickets and farecards could be obtained as well as cash withdrawals in future applications of this user service.

3.2.3. Personalized Public Transit

3.2.3.1. Introduction

Personalized Public Transit (PPT) involves the use of flexibly routed transit vehicles offering more convenient service to customers. These transit vehicles include small buses, taxicabs, other shared ride vehicles, or fixed-route transit buses that are detoured from their pre-established route to pickup/discharge passengers. They are able to provide essentially door-to-door service, thus expanding a route's service coverage area in lesser populated localities and neighborhoods. This type of service can offer shared ride transportation at lower cost, increased revenue and with greater convenience than can conventional fixed route transit. The users of this service are transit providers and the users of the flexibly routed transit vehicles.

3.2.3.2. Needs

Fixed route transportation service involves the operation of high occupancy vehicles over predetermined, fixed routes according to a published schedule. These services are most applicable to corridors with a relatively dense population to generate the ridership necessary to justify the cost of providing the service. In low density areas, conventional fixed route transit is prohibitively expensive and cost inefficient. The transit agency's desire to provide service is balanced by the need to manage the fleet in the most effective and efficient manner. In these lower density areas, flexibly routed transit offers a more cost effective transportation alternative to the single occupant automobile.

3.2.3.3. Service Description

The Personalized Public Transit user service involves flexibly routed transit operations that are tailored to specific applications and scenarios. These include random-route (Dial-A-Ride) transit, fixed-route transit capable of deviating on call and resuming the fixed route, and specialized transportation for the transit dependent. The principal characteristic of these services is that they involve shared ride services (i.e., multiple passengers sharing the vehicle). Small publicly or privately operated vehicles operate on demand assignments to pick up passengers who have requested service and deliver them to their destinations.

The key to PPT is flexibility. This flexibility translates into lower operational costs and gives each vehicle a larger service area. Assume that a passenger is willing to walk 4 blocks from his/her home to a bus stop (this may be less in bad weather); the service corridor for this route would then be 8 blocks wide. In low density areas, route deviation on request can broaden the service corridor and encourage additional people to use transit. Increased ridership lessens people's dependence on the single occupant automobile, increases transit revenues, and lessens the need for additional downtown parking facilities. Demand response systems have been widely introduced in throughout the country, serving both rural and urban areas.

Potential users of this service include several categories of people. One category includes the transit dependent (including the economically disadvantaged, the elderly, and the physically impaired). A second category of user consists of people living in low density areas in which fixed route service with large buses is impractical. These two categories of riders will benefit jointly by rapid service which permits spontaneous trip planning. A third user category includes travelers in low-demand time periods (e.g., night time and weekends). Children old enough to travel alone, but not old enough to drive, are also potential users.

3.2.3.4. Operational Concepts

There are two types of operations in PPT: flexibly routed operations and random route operations. For flexibly routed operations, fixed-route buses are detoured off the main route to pick-up and discharge passengers, thus expanding the vehicle's service area. For random route operations, the vehicles operate in without a fixed route, being assigned trip origin and destinations that fall within similar, general travel patterns. Vehicles are assigned on a reservation basis for random route operations. Most current reservation systems require passengers to place their request for service 24 hours (or longer) in advance of the need. This allows the system to plan routes and optimize the vehicle schedule. Tentative driver and vehicle assignments can be developed with consideration to cost effectiveness. "Instantaneous" requests for both flexibly routed and random routed operations will be honored only if there is enough slack in the system to allow an additional passenger pickup and delivery.

This service could also be operated with a base of subscriber passengers, who would get a fare discount for subscribing on a regular basis. These passengers would be supplemented by on-route or near-on-route dispatch pickups, who would pay the normal fare. Ultimately fares could also be paid electronically with a "smart" card (see Electronic Payment Services described in Section 3.3.1).

A goal of the PPT user service is to allow reservations, vehicle assignments, and scheduling assignments to be developed in real-time. Riders wishing to use PPT notify the dispatch center of the origin and destination of their trip. The computer then assigns the closest vehicle to service the request by matching the passenger's needs, for example, provision of a wheelchair lift, if required. Once the vehicle is assigned, the computer automatically informs the driver of the passenger's destination and directs the vehicle to the passenger's trip origin. The passenger is then notified that the trip is assigned and when to expect the vehicle's arrival. Passenger notification is important to relieve passenger uncertainty. Also it tells the passenger when to be at the curb to minimize vehicle waiting time and trip delays.

One key element of PPT is the requirement of keeping close track of the vehicles, the passengers, and the amount of time each passenger must ride in order to minimize passenger ride time and inconvenience. If the system attempts to pick-up too many passengers and expand its service area too much, excessive passenger ride times will result. This will decrease passenger satisfaction, and may result in lower ridership.

Although vehicle assignments can be made manually by a dispatcher who keeps track of the assignments using a simple cardex file or scheduling board, the complexity of the job generally limits the number of vehicles and trips-in-progress that can be tracked. Computers with advanced software algorithms have proven they can provide a significant increase in the number and complexity of the trips-in-progress. Also, the use of a computer can reduce the number of mistakes and customer inconvenience experiences.

Elderly/disabled systems in larger areas increasingly have the need to improve productivity by using the software to group two or more passengers traveling in a similar direction on one trip.

3.2.4. Public Travel Security

3.2.4.1. Introduction

The Public Travel Security (PTS) user service supports innovative applications of technology to improve the security of public transportation. The detection, identification, and notification of security incidents are within the scope of this service; limited response actions (e.g. remote shutdown of a transit vehicle) are also within the scope of this service. More general responses taken by public safety agencies (police, for example) fall outside the scope of this service.

Security concerns include protecting transit patrons and employees from street crime, maintaining an environment of actual and perceived security, reducing the vulnerability of public transportation to terrorist incidents, and developing innovative technical measures to respond to such incidents.

Users of the service include transit customers and employees, transit operators, law enforcement agencies, and the general public. Portions of this user service concerned with personal computing devices and personal alarms are also applicable to personal security of patrons of Ride Matching and Reservation as described in Section 3.1.4.

3.2.4.2. Needs

The U.S. DOT ITS program is a response to the increasing social and monetary costs of traffic congestion and poor mobility. By using ITS to improve public transportation, significant gains in solving these problems can be made.

Fear of street and on-vehicle crime has been cited as a significant detraction to public transportation use. Whereas the automobile separates its passengers from the surrounding environment and allows a sense of security and personal control, transit customers rely on the transit operator and local police for security. If customers do not perceive an atmosphere of control and security, ridership falls. Serious crime on public transportation is often highly publicized, increasing its negative effect. ITS offers potential solutions to security problems to enhance customer safety and increase the appeal of public transportation.

In addition to random street crime, organized terrorist activity may also threaten public transportation systems. Large numbers of people and easy public access can make public transportation systems vulnerable targets. ITS offers potential solutions to reduce the risk of terrorism on public transportation and enhance the response of transportation agencies to terrorist incidents.

3.2.4.3. Service Description

PTS services will help create a secure environment in public transportation where patrons will be more comfortable and fear of crime will not detract from transit ridership. This includes walking to bus stops or rail stations and park-and-ride activity, as well as riding on transit vehicles. PTS services will monitor transit facilities and transit infrastructure to help create a safe and secure environment for patrons and transit staff. PTS Services will interface with appropriate security agencies (e.g. the Transit Information Security Analysis Center) to assist in analysis of threats and to report threats. PTS services will include a security management and control capability that not only provides detection, identification and notification of threats or incidents, but also allows the transit agency to take response measures such as remote vehicle shutdown.

3.2.4.4. Operational Concepts

In transit facilities, transit stations, parking lots and at bus stops, advanced sensor technologies could monitor the surroundings and generate alarms. Alarms could also be generated manually. For example, push button alarm systems installed at these remote sites could be activated when an individual perceived a threatening situation. However generated, alarm signals would be monitored by central dispatch or the local police. In addition to video and audio surveillance, sensor systems could be used to monitor for chemical agents, toxic industrial chemicals, biological, explosive, and radiological threats. Video surveillance systems can include passive biometric analysis (e.g. facial recognition). Systems could also include analysis of sensor output for possible threats and automatic notification of appropriate transit personnel to potential threats. Security agencies or systems outside of the transit agency (e.g. the Transit Information Security Analysis Center) could assist with threat analysis or be provided reports of threats.

On vehicles, employees and patrons will be assisted by on-board silent alarms and connected microphones that allow central dispatch to monitor the vehicle when requested by the operator. Such systems are in use today in a number of locations. The security on-board transit vehicles could also be enhanced by using the audio, video, and threat sensor systems similar to those used in transit facilities. In real-time ridematching systems, participants may be identified through computerized identification cards, assuring mutual safety and an atmosphere of control and security.

The infrastructure of transit (rail track, bridges, and tunnels, bus guideways, etc.) could be monitored using sensor technologies to identify threats or incidents. In addition to video surveillance the monitoring could include object or motion detection as well as infrastructure integrity monitoring.

The same monitoring systems used in detecting street crime can also be used to prevent and assist in responding to terrorist incidents. Monitoring systems capabilities can be incorporated into transportation agencies' plans for addressing terrorism. In addition, response measures such as the remote shutdown of transit vehicles could be used in cases of vehicle hijacking.

3.3. Electronic Payment

Electronic Payment consists of one user service, Electronic Payment Services. This user service provides travelers with a common electronic payment medium for all transportation modes and services. It may, as envisioned, also serve broad non-transportation functions and may be integrated with credit and debit cards in banking and other financial transactions.

The users and operators of all modes of transportation will benefit from the high level of convenience this service introduces. Parking lot operators will benefit from electronic capture of fees, reduced cash handling and increased security. Electronic toll collection is already speeding up traffic and reducing backups at toll facilities. Public transportation systems should benefit from the increased user friendliness of the fare collection process, easing passenger transfers among bus, metro, and commuter rail systems. Electronic payment can also facilitate congestion pricing to help reduce traffic loads during the peak hours. Travelers benefit from the added convenience and security of electronic payment methods.

3.3.1. Electronic Payment Services

3.3.1.1. Introduction

Electronic Payment Services will allow travelers to pay for transportation services with electronic cards or tags. The goal is to provide travelers with a common electronic payment medium for all transportation modes and functions, including tolls, transit fares, and parking. Electronic Payment Services directly support integrating payment systems of transportation modes to create a multimodal user service. The service is also directed at improving the payment systems of separate transportation modes, because modal transportation payment systems will have to be further developed and perfected independently before they reach a state where integration is feasible. The goal of eventual integration should be recognized as payment systems are developed within each mode. A further goal of integration among systems in different states is a priority, particularly to facilitate toll payment. Users of the service include the traveling public as well as transportation agencies that will implement or support implementation of any aspects of the Intelligent Transportation Systems (ITS) program.

3.3.1.2. Needs

One area where significant gains in transportation efficiency can be made through ITS is in payment for transportation services. Delays at roadway payment barriers result in economic and environmental costs and potential safety hazards. Public transportation is seen as inconvenient because fare payment systems are awkward and inflexible, and transportation authorities shy away from estimating cash losses from fraud. New applications of technology provide potential solutions to these and other payment related problems.

In applying advanced technologies to transportation, however, it is desirable to develop systems that cross transportation modes. Applying technology independently to the various modes provides gains in productivity for those modes. However, integrating payment services across a number of modes should further increase convenience for private and commercial travelers and improved productivity for operators. Electronic Payment Services provides a plan for addressing the previously mentioned problems while ensuring a systemic approach through a multimodal plan for service development.

3.3.1.3. Service Description

Electronic Payment Services will allow travelers to pay for transportation services with a common electronic payment medium for all transportation modes and functions. Electronic toll collection, transit fare payment, and parking payment would be linked through a multimodal multi-use electronic system. A common transportation service fee payment structure could be used with all modes, possibly tying into roadway pricing options. Coordinated pricing strategies, including incentives for high occupancy vehicles, ride-sharing, congestion pricing, and transit are covered under Travel Demand Management (Section 3.1.8).

Electronic Payment Services has the following components:

- Electronic Toll Collection
- Electronic Fare Collection
- Electronic Parking Payment
- Integrated Electronic Payment Services

Electronic Payment Services also offers the possibility of facilitating the implementation of Travel Demand Management strategies as described in the user service of that name.

3.3.1.4. Operational Concepts

3.3.1.4.1. Electronic Toll Collection

Electronic Toll Collection (ETC) allows drivers to pay tolls without stopping or slowing from cruising speed, thus decreasing delays and improving system productivity. ETC systems are installed in various configurations, including at mainline barrier plazas, open highway collection systems at main line speeds and closed systems where tolls are based on entry and exit points and collected at the exit point.

ETC systems automatically determine tolls for classes of vehicles, such as passenger cars, small trucks, transit buses, and semi-trailer trucks. To assure customers that correct transactions have occurred, confirmation of toll charges are provided through roadside message signs or in-vehicle devices. Various methods could be used to provide receipts for transactions if required. Automated enforcement of violations is also part of the ETC system. Video cameras in the toll lanes take a photograph or video image of the vehicle and/or license plate whenever the system detects a violation.

Commercial vehicles may have their financial transactions handled under a commercial account, whereby the carrier makes a monthly pre-payment based on its historical usage of the toll road. Commercial carriers receive a statement of its monthly charges, and prepayment adjustments are made periodically based on increased or decreased usage.

Multiple toll authorities have joined together to offer unified services such as toll tag distribution, billing, and customer service. For cross-country commercial carriers, a standard Automated Vehicle Identification (AVI) tag could be used for all toll transactions and combined with other commercial vehicle operations (CVO)-related services such as transparent borders for permits, weighing, and safety inspections. Commercial vehicle services are already being implemented using AVI tags in several multi-state electronic screening programs including Heavy Vehicle Electronic License Plate (HELP) PrePass™ and North American Preclearance and Safety System (NorPass).

ETC systems already in use have shown they reduce the costs of collecting tolls as well as reducing the costs of cash handling, improving security and minimizing opportunities for fraud.

3.3.1.4.2. Electronic Fare Collection

Electronic fare collection eliminates the need for transit customers to provide exact change and facilitates the creation of a single fare medium for all public transportation services. Fare systems of multiple transportation providers are integrated from the point of view of the traveling public, while individual operators maintain the integrity of their fare systems. Distance-based or other fare structures are easier to implement for all public transportation modes. For example, transferring between modes or lines might not require additional fare, because the fare card would "remember" earlier trips. The service includes both debit and credit capability, and immediately identifies voided cards. Electronic card systems facilitate the participation of employers in transit benefit programs where employers pay for their employees' transit accounts which are debited only for work trips.

Paratransit operators will electronically verify rider eligibility upon boarding, and ride tracking capabilities will improve the efficiency of third party billing processes. Payment systems might also tie into private operations such as taxis and airport limousines.

Electronic fare collection serves all transit operators by reducing cash handling and losses from fraud. Substantial increases in prepaid fares are likely from the system, providing operators with additional revenue. Significant growth in ridership may also occur as card systems develop beyond transportation services and into retail, telephone and other areas.

Electronic fare systems also help transit operators in areas of operations and service and route planning. Operators will be able to collect accurate and precise data about passenger boardings on specific routes and trips at all times of the day. Bus trips can also be made in less time since there is a significant reduction in boarding times with the use of electronic passes.

3.3.1.4.3. Electronic Parking Payment

Electronic parking payment enables the automobile driver to pay for parking without cash. Upon entry or exit from a parking lot a driver would have the parking charge billed or debited by the use of an electronic card or tag system. In the optimally integrated Electronic Payment Service, the level of integration achieved with the other components may depend on the ownership of parking facilities involved. Transit operators providing park-and-ride lots will be able to easily integrate parking payment systems into their overall fare structure. Also, discounts may be provided to high occupancy vehicles.

3.3.1.4.4. Integrated Electronic Payment Services

Ultimately, Electronic Payment Services may be fully integrated across transportation modes, enabling one payment medium to be accepted for transportation services across a given region. For example, a traveler driving on a tollway to a park-and-ride lot to use commuter rail would be able to pay for all three transactions -- toll, parking, and fare -- with the same device.

In addition, the fare structures of public transportation agencies would be integrated with toll collection agencies. This would allow regional governments and transportation agencies to develop coordinated pricing strategies that could favor certain modes or routes. Such strategies could help reduce congestion and increase transit ridership.

3.3.1.4.5. Implementation of Travel Demand Management Strategies

The flexibility offered by Electronic Payment Services technologies, principally automated vehicle identification and electronic financial transactions, offers the possibility of facilitating the implementation of Travel Demand Management (Section 3.1.8) strategies. In particular, they will enable relatively easy implementation of road pricing policies. Discounts for high occupancy vehicles and congestion pricing are two such strategies. When coordinated with other transportation modes within an overall transportation fee structure, roadway pricing could significantly influence mode choice decisions.

3.4. Commercial Vehicle Operations

Commercial Vehicle Operations (CVO) encompasses a broad range of diverse operators and operating environments. The interstate motor carrier industry, which includes approximately 275,000 businesses operating trucks, 4,000 for-hire passenger carriers, and 6.6 million commercial drivers, is a complex mix of businesses that transport goods and passengers for profit or as part of another business function. A similar number of intrastate carriers may also benefit from ITS/CVO technologies.

The user services presented in this bundle are concerned primarily with freight movement and focus in two specific areas; those which improve private-sector fleet management and freight mobility, and those which streamline government/regulatory functions. While not directly addressed in the CVO user services, for-hire passenger carriers and buses may benefit from aspects these and other user services, including those described in the Public Transportation Management user services bundle. CVO operators and customers can gain direct benefits from a number of other user services presented in the plan. For example, the Advanced Vehicle Safety Systems user services include collision avoidance technologies which have direct application to heavy vehicle operations and safety; and those services intended to reduce congestion and delay will enhance the productivity of motor carriers operating in urban areas.

The Federal Highway Administration ITS/CVO program is a voluntary effort consisting of public and private organizations working together with the goal of improving highway safety and motor carrier productivity through the application of advanced technology. The primary “users” of the developed technology applications are the motor carrier industry and state highway and motor carrier regulatory authorities. The vision statement for the ITS/CVO program is:

> Assisted by advanced technology, trucks and buses will move safely and freely throughout North America.

This vision can be achieved by using cost-effective methods and technology to streamline current State regulatory and enforcement activities and motor carrier practices, while increasing levels of safety and productivity for both States and carriers.

The technology applications for CVO have been categorized into six user services, which are briefly described below:

- The **Commercial Vehicle Electronic Clearance** service will allow enforcement personnel to electronically check safety, credential, and size and weight data for transponder-equipped vehicles before they reach an inspection site, selecting only illegal or potentially unsafe vehicles for an inspection. Safe and legal carriers will be able to travel without stopping for compliance checks at weigh stations, ports-of-entry, and other inspection sites. This service also supports the North American Free Trade Agreement (NAFTA) by expediting international carriers at the Mexican and Canadian borders.
- The **Automated Roadside Safety Inspection** service will use safety data provided by the Electronic Clearance service combined with state-of-the-art technology to allow for more selective and rapid inspections. Through the use of

sensors and diagnostics, inspectors will eventually be able to check vehicle systems and driver requirements and ultimately driver alertness and fitness for duty.

- The **On-board Safety and Security Monitoring** service will non-intrusively monitor the driver, vehicle, and cargo and notify the driver, carrier, and, possibly, enforcement personnel if an unsafe situation arises during operation of the vehicle. Such an unsafe situation might involve the status of driver fatigue, vehicle systems, or cargo shift. This service will tie into the later stages of the Automated Roadside Safety Inspection and Commercial Vehicle Electronic Clearance services.
- The **Commercial Vehicle Administrative Processes** service will allow carriers to purchase credentials and to collect and report fuel and mileage tax information electronically. Through automation, this service should provide to carriers and States a significant reduction in the paperwork burden and has the potential for simplifying compliance operations.
- The **Hazardous Materials Security and Incident Response** system will provide emergency personnel at the scene of a hazardous materials incident immediate information on the types and quantities of hazardous materials present in order to facilitate a quick and appropriate response.
- The **Freight Mobility** service will provide information links between drivers, dispatchers, and intermodal transportation providers, enabling carriers to take advantage of real-time traffic information, as well as vehicle and load location information, to increase productivity.

These six user services do not necessarily represent the final or complete set of new services that ITS will offer CVO. The Commercial Vehicle Information Systems Network (CVISN) effort, undertaken through the Federal Motor Carrier Safety Administration (FMCSA) with support from Johns Hopkins University Applied Physics Laboratory, along with market assessment studies may identify other services and concepts that may extend these core services and support the ITS Program goals in other ways.

3.4.1. Commercial Vehicle Electronic Clearance

3.4.1.1. Introduction

The Commercial Vehicle Electronic Clearance user service consists of two parts:

- Domestic Electronic Clearance
- International Electronic Clearance

Today, commercial trucks and buses are required to stop at check points where they undergo routine weight, credential, and safety checks. For lengthy trips, the vehicles may be required to stop and undergo similar checks a number of times. Domestic Electronic Clearance will allow commercial vehicles, whether operating under interstate or intrastate registration, to continue past the check points at mainline speeds without stopping.

International Electronic Clearance will allow vehicles to pass international border checkpoints without stopping, or at least with expedited checks. Both parts will operate using Dedicated Short Range Communication (DSRC). As a vehicle approaches a domestic or international checkpoint, communications take place that identify the vehicle and make available to authorities the necessary data about credentials, vehicle weight, safety status, and cargo. Enforcement personnel can then select potentially unsafe vehicles for inspection and allow safe and legal vehicles to bypass the checkpoint.

The top priority of the CVO user services is for commercial vehicles, much like automobile traffic, to travel over the Nation's highways without having to stop in each State for weight, credential, or safety inspections. The challenge that faces CVO is to enhance the information available to officials at check points so they may clear vehicles or have them stop so specific items can be checked. The information used for clearance may be on the vehicle itself and/or in centralized or distributed databases. Regardless, this information exchange would be transparent to the users through advanced information systems and ITS technologies. The information used for electronic clearance will probably include the following:

- High-speed weigh-in-motion (HSWIM) system data to screen vehicle weight compliance;
- Motor carrier safety ratings, which are maintained by FMCSA;
- Vehicle/driver inspection and maintenance data, including date of last inspection and out-of-service verification;
- Credentials information, including annual registration, fuel use tax, operating authority, insurance, oversize/overweight permits; and
- Driver information, such as citation records.

As the capabilities of the Automated Roadside Safety Inspection and On-board Safety and Security Monitoring user services develop, the vehicle diagnostics, sensors, and real-time information will be integrated to supplement the historic information listed above. These sensor capabilities will become more and more sophisticated, from conducting advanced mechanical checks of the vehicle to assessing fitness of the operator by, for example, sensing driver alertness. The International Electronic Clearance component will extend the Electronic Clearance concept to the Mexican and Canadian borders and support NAFTA by facilitating the traffic flow of safe and legal carriers across international borders. The service will also have to address specialized enforcement and cargo issues associated with crossing national borders.

3.4.1.2. Needs

The Domestic Electronic Clearance component is needed primarily by States and carriers. Manually inspecting commercial vehicles to collect information on the driver and vehicle regarding weight, credentials, and safety status is labor intensive, but necessary to ensure safe, legal, and equitable transportation services, and to collect the revenue necessary to build and maintain highways. Through the electronic screening of commercial vehicles prior to reaching a weigh station or inspection facility, States' resources would be used more effectively by selecting only those vehicles that warrant safety and compliance checking. Thus, electronic clearance will allow recently checked safe, legal vehicles to bypass these facilities. Motor carriers that are safe and legal will have reductions in operational costs from this component by avoiding the time delays of manual compliance and safety checks. The States and carriers will also benefit from reducing the paperwork burden through automation.

Commercial truck and passenger transportation represents a vital link in the Nation's commerce. Currently, there are significant delays for auto and truck drivers crossing between the U.S. and both Canada and Mexico. While this poses an inconvenience for the occasional crossing, it creates a significant economic hardship for commercial carriers and drivers that regularly traverse these boundaries. The U.S. DOT is committed to provide a more efficient traffic flow through ITS/CVO technology. The International Electronic Clearance component will help provide relief to these problems by enabling border crossing officials to target their enforcement resources more effectively and allowing carriers to increase their productivity.

3.4.1.3. Service Description

The vehicles in the Commercial Vehicle Electronic Clearance service will be equipped with a transponder that will carry their unique identification code (and possibly some information about the carrier, vehicle, and/or driver) and be able to receive and send information to and from the roadside readers. Participation in the service will be voluntary for both carriers and States. Motor carriers that choose to participate in the service, and that are willing to go through an application process to certify that they have met both safety and legal requirements will be able to take advantage of significant savings by passing checkpoints, ports-of-entry, weigh stations, etc., at mainline speeds, thereby reducing regulatory impediments for safe, legal trucking operations. The system should accommodate both interstate and intrastate carriers. Less information may be required for intrastate carriers than interstate carriers, but they will still need to prove that their vehicles, drivers, and operations are safe and legal. The States will get maximum benefits from the system if the proper controls, procedures, and technologies are in place to facilitate the electronic exchange of information that is currently exchanged in paper form today.

The International Electronic Clearance component is specifically aimed at facilitating crossborder commercial vehicle traffic. Its purpose is to extend the service and technologies for Domestic Electronic Clearance at State borders to North American border crossings. This component, as envisioned, would allow automated clearance of cargo from frequent and known cross-border shippers through customs and automated immigration clearance of the driver. This would likely involve the development of electronic credentials and records that could be used to automatically verify the identity of the driver, the shipper, and the nature of the cargo, check carrier safety and credential records, etc.

The development and deployment of this service, while based on advanced technologies, will be dependent on a number of legal, technical, and institutional issues. These issues can be resolved through cooperation among U.S. DOT, States, carriers, shippers, and other relevant parties. Market analysis and outreach programs will be implemented to determine the institutional barriers and possible solutions. Continuing participation in these multi-agency efforts by representatives from U.S. DOT, States, carriers, shippers, and private investment firms will be necessary to reach resolution. Automating the international border crossing process will require the involvement and cooperation of the immigration and customs organizations of all three countries as well as shippers, carriers, local officials from the border States and provinces, and other relevant parties. While the general framework for this concept might be the same at either border, specific system designs will have to be developed and tested to accommodate the variations in border crossings, laws, and language.

3.4.1.4. Operational Concepts

When a participating carrier with a transponder-equipped vehicle approaches a mobile or fixed checkpoint site, it will cross a reader and HSWIM sensors upstream of the facility. The vehicle will be identified, classified and weighed. This information will be sent, via communication link, to the checkpoint.

The system will then check the weight, credential, and safety information by reading the information from a transponder on the vehicle or by using the vehicle's unique identification code to access the information. Examples of such information may include: weight information (thresholds for gross vehicle weight, axle weight, and actual weight versus registered weight), credentials information (registration to operate in the State, fuel tax payment, delinquent payment flags, etc.), and safety information (fitness rating, date of last check, and out-of-service violations). If any of the information warrants being checked, the vehicle will be signaled to pull into the checkpoint. The system will then alert the official as to the reason the vehicle was pulled in so that the vehicle check can be focused on the specific problem area.

If the information indicates safety and regulatory compliance, but the vehicle is selected for a random check, the vehicle will be signaled to pull into the checkpoint and the official will be notified. If the facility is closed or at capacity, the system will be overridden and the vehicle will continue uninterrupted. If the vehicle is stopped and checked, the information will be updated as to the last inspection date, any out-of-service violation, etc.

3.4.2. Automated Roadside Safety Inspection

3.4.2.1. Introduction

Safety is a special emphasis of CVO program. The Automated Roadside Safety Inspection service is specifically aimed at significantly enhancing the safety of commercial trucking and passenger transportation. Commercial vehicle operations and safety are paramount issues today. Vehicles have gotten larger and more complex, making the inspection task more important and more difficult. Advanced technology offers the potential for providing assistance to the inspector, improving the overall safety and operation of trucks and buses, and making the inspection process more efficient.

The Automated Roadside Safety Inspection service will provide automated inspection capabilities that check safety requirements more quickly and accurately during a safety inspection that is performed when a vehicle has been pulled off the highway at a fixed or mobile inspection site. These capabilities will include the more rapid and accurate inspection of vehicle systems such as brake performance. This service will also include a communications link for updated inspection data, such as out-of-service information, to complement the nationwide availability of CVO information discussed in the Electronic Clearance user service. These new capabilities will enable safety inspectors to check more vehicles that are likely to have safety violations and, thus, increase safety compliance and reduce the number of serious accidents caused by poor commercial vehicle safety.

Several States are beginning projects to test and evaluate innovative devices for vehicle safety performance testing under the Motor Carrier Safety Assistance Program (MCSAP). The Motor Carrier Safety Assistance Program is a Federal grant program that provides over $65 million to States to monitor vehicle and driver safety programs and reviews of safety activities at carrier offices. The technologies being tested include flat plate devices and rolling dynamometers that measure brake performance, some of which also include ways to check steering and vehicle suspension systems performance without having to manually inspect the vehicle. Prototype infrared brake inspection devices are also being tested. In addition, the Sandia National Laboratory is identifying other advanced technologies that can be used to enhance roadside inspections. These devices measure system performance rather than relying on manual measurements of individual components such as push rod travel in brakes. Future generations of these devices might be mounted onboard the vehicle or in the roadway to measure performance at mainline speeds.

The driver's condition and performance are the most critical elements in the safe operation of any vehicle. It is especially important to CVO given the potential injury and damage resulting from unsafe operation and/or accidents of large commercial vehicles. Driver issues are also the most difficult and complex to address. In addition to the ability to review an operator's driving history and violations, technologies will emerge to assess the driver's current performance and alertness. Both on-board sensing devices and driver fatigue issues are discussed further in the On-board Safety Monitoring user service.

3.4.2.2. Needs

Even though the rate of fatal accidents involving large trucks has leveled off in recent years (it was reported in MCMIS at 2.3 per 100 million miles in 2002), this rate is still significantly higher than for all vehicles (which was 1.5 per 100 million miles in 2002). In terms of losses, it is estimated that these accidents cost carriers, drivers, and the general public billions of dollars annually.

In an effort to reduce commercial vehicle accidents States receive over $65 million a year in Federal MCSAP grants to help support safety inspection activities. The States also spend many times this amount on their own local enforcement activities. Under MCSAP, over 1.6 million State-conducted roadside safety inspections of commercial motor vehicles occur per year. These inspections, however, account for only a small percentage of the vehicles that pass inspection sites yearly. The limited resources of time and space available to State enforcement personnel for inspecting commercial vehicles prevents the inspection of a large percentage of the population of commercial vehicles.

With the implementation of the Automated Roadside Safety Inspection service State enforcement personnel will be able to inspect more vehicles with their resources. Safety information provided by the Electronic Clearance service will enable inspectors to target problem areas during inspections. Advanced inspection technologies will reduce the length of time required to perform an inspection, which will enable enforcement personnel to check a larger percentage of vehicles yearly. These two major benefits will allow State inspection personnel to increase their productivity, which will potentially reduce commercial vehicle accidents.

It is envisioned that the Automated Roadside Safety Inspection user service technologies will be integrated with On-board Safety and Security Monitoring user service technologies. On-board technologies may be able to provide real-time safety data presenting a more accurate picture of the safety status of the vehicle and driver and could potentially further increase State inspectors' ability to rapidly and accurately inspect vehicles.

3.4.2.3. Service Description

The Automated Roadside Safety Inspection service is specifically aimed at significantly enhancing the safety of commercial motor vehicle operations through the development and integration of inspection technologies. These technologies include the inspection of vehicle systems (such as brakes), driver requirements, and ultimately driver alertness and fitness for duty through the use of sensors and diagnostics.

The service expects a phased approach for the development and implementation of these technologies. The first phase of this service will include the use of new brake inspection technologies and the aid of pen-based computers. A later phase of implementation will include integration with the Commercial Vehicle Electronic Clearance and On-board Safety and Security Monitoring user services.

3.4.2.4. Operational Concepts

After a vehicle has been selected for inspection and signaled to pull into the fixed or mobile inspection site, the inspector will use automated inspection technologies to more accurately and efficiently inspect the vehicle. The use of these technologies will reduce the amount of time spent per inspection and result in a more accurate picture of the safety status of the vehicle.

The automated inspection process will, initially, supplement the visual or manual procedures. It may include advanced flat plates and/or dynamometers to measure brake performance. Ultimately, this service might result in an automated "inspection pit" at the inspection station where all critical vehicle and driver components could be inspected rapidly with hand-held diagnostic devices. This inspection would not only provide pass/fail data but actual condition or expected life projections as well. Many of these technologies and approaches could also be used by carriers in their preventive maintenance operations.

The most effective safety assurance will occur as the Automated Roadside Safety Inspection, Commercial Vehicle Electronic Clearance, and On-board Safety and Security Monitoring user services are integrated. Since the three user services are only partially dependent on each other, a phased integration over an extended period of time is expected to occur. The overall CVO system design address the issues involved in a phased integration of these user services. Also, a strategy needs to be developed for carriers that already have on-board processing capability so that added processing for this service can be integrated with existing capabilities.

3.4.2.5. References

FMCSA, Motor Carrier Management Information System (MCMIS), Commercial Motor Vehicle Facts, February 2004

3.4.3. On-Board Safety and Security Monitoring

3.4.3.1. Introduction

The on-board safety monitoring portion of this user service will provide for the ability to sense the safety status of a vehicle, cargo, and the driver at mainline speeds. Driving time and driver alertness are the conditions sensed for the driver. Warnings or indications of the safety status are provided to the driver. This capability may be used for pre- or post-trip inspections by the driver, as well for warnings and indications while underway. Sensing the safety status of the vehicle, cargo, and driver on the vehicle and making provisions for reporting this status to the driver and to sources external to the vehicle will be provided by this service. The capability to read out this safety status at mainline speeds will be provided as part of the Commercial Vehicle Electronic Clearance service. The capability for an enforcement official to read out this safety status at the roadside will be provided as part of the Automated Roadside Safety Inspection service.

The on-board security monitoring portion of this user service will provide the ability to monitor and assure freight container, trailer, and commercial vehicle integrity. The freight container, trailer, and commercial vehicle will be monitored using on-board sensors for a breach or tamper event. The breach or tamper event information will be made available to the freight custodian and other freight data users. A freight custodian is the person or organization directly responsible for the freight container or trailer (e.g. commercial vehicle driver, customs, port operator, etc). The term freight data user used in this user service discussion is defined as a person authorized to have access to security and movement data about freight containers, trailers and commercial vehicles. Freight data users may include, for example, the dispatcher responsible for managing the movements of commercial vehicles, freight containers or trailers, gate controllers at yards where freight is transferred for shipment, shippers, or law enforcement personnel.

Another aspect of freight security is the concept of custodian/conveyance/freight container or trailer assignment integrity. Conveyance is defined as any motorized vehicle used to transport freight (e.g. truck). A custodian's identity will be linked to the freight container or trailer, and the conveyance at the beginning of each segment of the trip and can be monitored throughout the trip.

A number of potential safety applications of advanced technology have been identified. These include truck and bus specific highway warning systems, vehicle and driver monitoring/inspection systems, and driver sensory enhancements. In order to apply advanced technology practically to the problems of commercial vehicle safety and operation, it is necessary to comprehensively explore various proposed concepts while simultaneously searching out new technology that might be applicable. It will then be possible to determine where cost-effective applications of these technologies can make significant contributions to truck and bus safety and operation.

3.4.3.2. Needs

On-board diagnostic systems for commercial vehicles represent a possible opportunity for future safety inspection and security activities. The implementation of these on-board technologies would be market driven and would depend upon the feasibility of such systems. Today, several motor carrier firms use on-board diagnostics that monitor engine and vehicle systems for equipment servicing and maintenance. In addition, there is a growing interest for the use of on-board electronic seals (e-seals) and other sensor devices to secure and to provide status information regarding the integrity of freight containers or trailers. When on-board sensors detect an irregularity in system functioning, an event may be recorded or a message may be immediately sent from the vehicle to the firm's headquarters with information about the identity and location of the vehicle as well as the nature of the problem.

The need exists to review the inspection process and determine how on-board safety and security monitoring technologies, if proved practical, can be used to enable efficient and effective of commercial vehicle safety enforcement and freight security.

3.4.3.3. Service Description

The On-board Safety and Security Monitoring service will require (1) Vehicle-to-Roadside Communication technology as developed in the Commercial Vehicle Electronic Clearance user service, (2) the ability to identify the vehicle, freight container or trailer and driver and communicate with an on-board computer, which in-turn could relay this information to a roadside device or freight data user, and (3) the development and integration of the following functional capabilities:

- Sensing and collecting data on the condition and performance of critical vehicle components such as brakes, tires, and lights and reporting the exceeding of pre-defined thresholds for warning and countermeasures.
- Sensing shifts in cargo as the vehicle is moving and/or other unsafe conditions relating to the cargo.
- Sensing and collecting data on the integrity of the freight container or trailer.
- Sensing and collecting data on the integrity of the commercial vehicle.
- Monitoring driving time and time-on-task.
- Monitoring driver alertness level using non-obtrusive technology and developing warning systems for the driver, carrier, and/or enforcement officials.
- Monitoring custodian/conveyance/freight container or trailer assignment
- Sensing driver identification changes

A warning of unsafe condition would first be provided to the driver. Also, warning information would be accessible by carriers and roadside enforcement officials prior to the vehicle reaching an inspection facility. Roadside safety officials will then have access to both historical data provided by the Safety and Fitness Electronic Records system (SAFER), and real-time safety data to decide if a vehicle, driver, or cargo should be stopped and checked.

Security related warnings, which include freight container, trailer or commercial vehicle tampering, and custodian/conveyance/freight container or trailer assignment mismatches, would be recorded and/or reported. The security data would be made available to authorized freight data users, for example, a dispatcher or gate controller. The dispatcher or gate controller would use the on-board information to evaluate the situation and take appropriate actions, which might include notifying the freight custodian and/or appropriate law enforcement authorities. The freight custodian would also be immediately alerted of a freight container or trailer breach or tampering event.

3.4.3.4. Operational Concepts

The operational concepts of On-board Safety and Security Monitoring include:

- Safety warnings to the driver;
- Freight container or trailer chain of possession information to freight data users;
- Freight container, trailer or commercial vehicle breach or tampering event warnings to the freight custodian and other freight data users;
- Custodian/conveyance/freight container or trailer assignment integrity warnings to the dispatcher;
- Integrating real-time safety information on the vehicle, driver, and/or cargo with the Electronic Clearance user service; and
- Pre- and post-trip inspections.

Diagnostic and warning systems would alert drivers to pending emergencies, allowing corrective action to be taken. Also, real-time safety data would improve electronic clearance decisions. As a transponder and sensor-equipped vehicle approaches a weigh station or safety inspection station at mainline speeds, roadside sensors would identify the vehicle and driver. The appropriate safety data would be checked as well as transmitted from the on-board system to the roadside for processing automatically by a computer. The computer would recommend to an enforcement official candidate vehicles for inspection. The decision whether to check or allow a vehicle to pass, however, remains with the official.

Fleet and freight managers would use on-board safety and security systems to better manage and secure their assets. The freight container, trailer, and commercial vehicle would be monitored for integrity with the use of advanced on-board sensors. A chain of possession would be established to track the hand-off of freight containers or trailers from one custodian to another. The sensors would detect changes to the freight container, trailer or commercial vehicle which could indicate a breach or tampering event. (e.g. light in a sealed unit, radiation, structure modification (panel removed and replaced), etc.) Sensing such an event would enable dispatchers to provide the appropriate authorities with information that may lead to the interruption of the illegal or dangerous activity.

Customs or other law enforcement could check for security breeches when assessing a commercial vehicle, freight container or trailer.

The freight custodian and conveyance would be monitored throughout a trip and authorized freight data users would be alerted if an unauthorized custodian attempts to transport the freight container or trailer. For example, when a freight container is transported by a commercial vehicle, the driver(s) would be considered the custodian(s) and assigned to the commercial vehicle (conveyance) and freight container before the trip commences. A personnel management system in the commercial vehicle would confirm the driver's identity and provide this information to the dispatcher or gate controller. The driver's identity would be used to validate the custodian/conveyance/freight container assignment integrity. If a mismatch were detected, the dispatcher or other freight data users would be responsible for taking appropriate actions, which could include resolving the situation with the driver or notifying the appropriate authorities of a potential security breach.

Current research efforts underway in the Federal Highway Administration (FHWA) as well as the National Highway Traffic Safety Administration (NHTSA) include studies to investigate commercial vehicle driver fatigue, rest, and recovery. The NHTSA program emphasizes continuous in-vehicle monitoring of driver performance and psychophysiological status to detect driver drowsiness/fatigue. As research is conducted and technology improves, the ability to sense driver and vehicle characteristics will become more accurate and reliable. The ability to accurately detect some unsafe characteristics will develop before the ability to detect others. During this development, security and privacy issues will arise and need to be addressed. As these issues are resolved and reliable methods of detecting different driver and vehicle characteristics are made available, the system architecture should allow for the implementation and integration of On-board Safety and Security Monitoring components.

The technology to provide all on-board data, as envisioned above, is not yet available. Safety data and advanced roadside inspection technologies as part of Commercial Vehicle Electronic Clearance and Automated Roadside Safety Inspection will be available before on-board systems. The most effective safety assurance will occur if the Automated Roadside Safety Inspections, Commercial Vehicle Electronic Clearance, and On-board Safety and Security Monitoring user services operate interactively and are compatible with current carrier systems. Full implementation of all three services is achievable in the overall system design for these three safety-oriented services with a phased approach. For example, assuming on-board safety data is available, it could be accessed by inspectors after the vehicle is stopped for inspection rather than at mainline speeds in the first phase of this user service. If the records appear to be in order, the inspection could be waived. The next phase of deployment would include access to onboard safety data at mainline speeds. In all cases, the driver would be alerted whenever there is a critical safety problem.

3.4.4. Commercial Vehicle Administrative Processes

3.4.4.1. Introduction

The Commercial Vehicle Administrative Processes user service consists of two parts:

- Electronic Purchase of Credentials
- Automated Mileage and Fuel Reporting and Auditing

The original ITS vision for commercial motor vehicles, expressed in the Program Plan in 1995, was to create, by the year 2000, an electronic licensing system that would allow interstate and intrastate motor carriers of freight and passengers to electronically purchase and pay for vehicle registration and other motor carrier taxes and licenses. This electronic purchase of credentials component will allow carriers to file applications electronically for credentials such as registration, fuel use taxes, trip permits, oversize/overweight permits, or hazardous materials permits. The credentials will be approved in a much shorter time than with the current paper process, giving carriers greater flexibility in their operations. This component will provide States the opportunity to receive the data electronically and to process it with higher levels of automation, thereby reducing both the amount of manual processing required and the error associated with data entry. This component is also expected to permit carriers to pay for their credentials through some form of electronic funds transfer. Data received by the States from the electronic purchase of credentials is expected to form part of the information used by the Commercial Vehicle Electronic Clearance user service. To meet this vision the CVISN program was initiated to develop, on a statewide basis, systems to perform credential administration, electronic screening, and safety information exchange.

For mileage and fuel reporting and auditing purposes, an interstate carrier is required to collect, report, and maintain accurate mileage and vehicle information for each trip by State. Registration fees and fuel taxes are based on the proportion of miles traveled in each State during the previous year, with the amount of fuel tax paid by a carrier with each fuel purchase in a particular State deducted from the tax due as calculated by mileage. States must process this mileage and fuel purchase information to collect taxes, distribute the appropriate amount to each State, and audit carriers. The Automated Mileage and Fuel Reporting and Auditing component will allow carriers to automatically record the vehicle trip miles and fuel purchased in each State. This data could then be downloaded, compiled, and submitted electronically to the States as the required mileage and fuel tax reports. The necessary capabilities to allow States to audit the automatic recording and reporting will be incorporated into this service.

3.4.4.2. Needs

Even with greater standardization stemming from the International Registration Plan (IRP) and the International Fuel Tax Agreement (IFTA)--which all States were required to join by 1996-- the administrative burden on carriers to collect and report mileage and fuel information is significant. The States also experience a large administrative burden in processing the information. One estimate is that it costs carriers $1 billion to $2 billion annually.

An electronic purchase of credentials function will improve industry productivity and competitiveness by reducing the time and paperwork required for motor carriers to obtain a variety of annual and temporary credentials. The electronic purchase of credentials function will allow a carrier to receive all credentials within hours, rather than weeks. This service will also benefit States by reducing administrative processing.

Compliance service firms and technology firms currently offer carriers, to some degree, similar electronic purchasing services and automated mileage calculation. Compliance service firms provide an option for motor carriers, which may not have the time or resources to meet their multiple jurisdictional regulatory compliance, by acting as the carrier's agent in acquiring its necessary credentials. The Electronic Purchase of Credentials portion would complement existing compliance service functions and would look to provide opportunities to these firms for expansion of their operations. For mileage calculation, however, private sector automated mileage data collection systems have not been approved by State tax auditors. The compliance service firms, technology firms, the States, and the motor carriers must work together to define the requirements for the Commercial Vehicle Administrative Processes user service so that all can benefit.

The Commercial Vehicle Administrative Processes service will provide for the development of current and new technologies in these areas while incorporating the requirements of State authorities, such as controls against fraud.

3.4.4.3. Service Description

The electronic purchase of credentials component will provide the carrier with an option to electronically select and purchase annual credentials via computer link to its base-State and temporary credentials via computer link to individual States. Payment for the credentials could also be handled through electronic funds transfer. The cost of the credentials could automatically be deducted from the carrier's account with the State.

The automated mileage and fuel reporting and auditing component will enable participating carriers to electronically capture mileage, fuel purchase, trip and vehicle data by State. It would also automatically calculate mileage by State and fuel purchased within each State, eliminating the need to manually collect and prepare quarterly reports for fuel taxes and annual reports for registration.

The development and deployment of both of these components will be dependent on a number of legal, technical, and institutional issues. These issues can be resolved through cooperation among U.S. DOT, States, carriers, and private sector firms. Market analysis and outreach programs will be implemented to determine the institutional barriers and possible solutions. Continuing participation in these multi-agency efforts by representatives from States agencies and carriers especially will be necessary to reach resolution. The data for credentials and fuel use tax reporting status collected in this user service will be integrated in some degree with the Commercial Vehicle Electronic Clearance service.

3.4.4.4. Operational Concepts

Given a system for the electronic purchase of credentials, a carrier could apply for and obtain annual credentials, such as registration, fuel tax, trip permits, oversize/overweight permits, and hazardous materials permits, via computer link. Temporary credentials could be purchased under a separate set of options. A carrier could acquire multiple permits in one computer link (there will be multiple transactions) for infrequent trips that go beyond the carrier's normal operating territory. The carrier could also purchase oversize/overweight permits and hazardous material permits through the system in the same, or similar manner.

The State's system would receive the carrier's application(s) and scan the information on the application for completeness and accuracy. If the application is in order, the State's system, would then calculate and collect fees, and enter all of the licensing information into a shared information system. A receipt acknowledging the purchase would be faxed, mailed, or sent electronically to the carrier.

For registration and auditing purposes, a carrier is required to maintain accurate mileage and vehicle information for each trip on an Individual Vehicle Mileage Record (IVMR). Information including location, date, time, and mileage can be collected now by electronic log systems. Fuel purchases could be captured from credit card or smart cards. Alternatives will be tested for electronically documenting the odometer reading, date, time, and vehicle I.D. at State lines. This will be used for calculation and audit purposes. This information could replace the manual trip log and other receipts which are typically prepared by the driver. The mileage information could be stored in an on-board computer or on a land-based system. The date, time and odometer readings could be captured at State borders and provided to State agencies. This data would then provide the means to automatically create and audit tax reports.

3.4.5. Hazardous Materials Security and Incident Response

3.4.5.1. Introduction

Hazardous materials shipments cover a range of commodities and activities from paint being transported to the local hardware store, truckloads of gasoline being delivered to local service stations, and nuclear weapons or weapons-grade nuclear material being delivered to defense installations. These shipments all vary in frequency, travel patterns, and associated risk.

Applying advanced technology to hazardous materials shipments offers opportunities to improve the security of the shipments and, when an incident does occur, to enhance the safety of emergency response personnel and the general public. Providing increased security for hazardous materials shipments is built upon several technological approaches including vehicle tracking, driver authentication, and roadside remote sensing. This user service will describe how these technologies can be used by the private and public sectors to improve the security of hazardous materials shipments.

Hazardous material security is focused on detecting and appropriately reacting when a hazardous cargo (note that not all cargoes that are classified as "HAZMAT" are security sensitive) is detected to be under unauthorized control and/or is engaged in an unauthorized activity such as traveling on an unauthorized route (from a regulatory agency perspective) or unintended route (from a fleet management perspective). Implementing technology to support hazardous material security requires a balance of sensitivity to the privacy concerns of private sector shippers and carriers, as well as the overall public's security need that security sensitive hazardous cargoes are not diverted or hijacked.

Implementing technology to support incident response requires a good practical understanding of the safety issues involved, including the performance of the existing public safety communication systems, the information needs of emergency responders, and the development of cost-effective system concepts which address real problems. While these functions are all related, a universal, integrated low-cost incident response system that can be used by local responders is needed to reduce the vulnerability of first responders and others at the scene of a Hazardous Materials incident and to reduce the overall costs associated with such incidents. This user service will provide for such a system to convey to responders a description of the hazardous materials carried on a vehicle after an incident has occurred.

3.4.5.2. Needs

There are roughly 300 million hazardous materials shipments in the nation each year. These range from relatively innocuous products, such as hair spray and perfumes, to bulk shipments of gasoline to the movement of explosives or nuclear materials. Since the terrorist events of 11 September 2001, there is increased interest in and need for monitoring the movement of at least a subset of these shipments (i.e., the "security sensitive" hazardous materials). Recognizing that a security sensitive hazardous material shipment is undergoing unauthorized activity, or is entering a sensitive area, are potential security threats that can and should be taken seriously. Both private carriers and public sector transportation and public safety agencies have a vested interest in the security of security sensitive hazardous materials shipments.

Roughly 10,000 to 20,000 truck transportation incidents occur each year that involve release of a hazardous material or a circumstance that threatens a release to which public-sector emergency responders are dispatched. In some cases emergency responders were unable to obtain information that they sought or experienced significant delay in obtaining it. Highly publicized incidents have heightened the public awareness of the potential dangers in hazardous materials transportation. Quick response is a major concern because of the real and perceived risks hazardous materials can pose to public safety, health, and to the environment.

For those consequential hazardous materials incidents with information problems, the combined costs of property damage, evacuations, traffic delays, productivity losses, and response personnel and equipment could possibly amount to several hundred million dollars. Data is insufficient to estimate the environmental damage and cleanup costs. Improved information could prevent a fraction of the dollar costs of consequential incidents with information problems, for an annual savings in the tens of millions of dollars. Also, improved information probably would lead to more efficient use of emergency response resources in all hazardous materials transportation incidents, for additional savings.

3.4.5.3. Service Description

The National Academy of Sciences determined that it is not cost-effective to track all hazardous material shipments (TRB Special Report 239). However, tracking of some security sensitive subset of shipments is both possible and desirable. For certain types and amounts of hazardous materials tracking may not be necessary and it may only be important to locate these trucks when they are involved in a serious accident/incident and then provide specific cargo information to the appropriate emergency responders. This service has two primary objectives- to provide increased security for security sensitive hazardous materials shipments while in transit and to improve incident response in the event of an incident involving hazardous materials.

Improved security for shipments in transit is provided through the following functions:

Tracking of Security Sensitive Hazardous Materials Shipments- This function begins with tracking of vehicles using automated vehicle location, but goes beyond simple tracking to include the correlation of the vehicle location with the planned route (by the HAZMAT vehicle's dispatch function) and detection of when the shipment significantly deviates from its planned route or detection of unauthorized HAZMAT activity (by the public sector). In addition, the function provides recognition of when the vehicle is approaching or entering sensitive areas (e.g., power plants, the concept of geofencing).

Notification of Security Sensitive HAZMAT Unauthorized Activity- This function includes the capability for HAZMAT vehicle dispatch functions to notify public safety agencies when the dispatch function detects unauthorized activity such as a significant deviation from the planned route for a security sensitive cargo. While not explicitly identified in the user service as an ITS function, the assumption is that the public safety agency will use the information provided to mobilize to effect a "traffic stop" of the deviating security sensitive HAZMAT carrying vehicle.

Notification of Unauthorized Security Sensitive HAZMAT Driver – This function determines if the driver of a security sensitive HAZMAT vehicle is authorized. Detecting an authorized driver enables the operation of the vehicle and conversely, if an unauthorized driver is detected then, under some circumstances the vehicle may be disabled (in a safe way). Alternatively or in addition, detection of an unauthorized driver will cause the system to notify the appropriate public safety agency of the incident and to investigate or affect a "traffic stop".

Roadside Security Sensitive HAZMAT monitoring- This function provides roadside detection and classification capabilities along with the ability to compare detected security sensitive HAZMAT loads with unauthorized activity. Unauthorized security sensitive HAZMAT activities can trigger a "pull-in" message and/or notification of public safety to effect a "traffic stop".

This service is closely related to the On-Board Safety and Security Monitoring service, which provides enhanced inspection features as well as the capability to confirm that the authorized driver(s) is (are) in control of the security sensitive hazardous material shipment.

The second objective of the service, improving hazardous materials incident response, is accomplished by providing law enforcement and HAZMAT response teams with timely, accurate information on cargo contents. The system focuses on being able to identify the materials involved so they can be handled properly.

3.4.5.4. Operational Concepts

Tracking of security sensitive hazardous materials shipments focuses on improved fleet management systems. Fleet dispatchers track their own drivers and/or security sensitive hazardous material shipments and correlate the driver identification and/or AVL information with route plans to determine if the shipment is on time and on route within expected and allowable tolerances. The systems would have the capability of identifying significant route deviations. In addition the systems would have the capability of recognizing when shipments enter designated sensitive (i.e. "geofenced") areas. If a significant route deviation or unexpected entry into a sensitive area or unauthorized driver occurs, then the system alerts the appropriate public safety agency and/or safely disables the vehicle.

Roadside HAZMAT monitoring would be the responsibility of the public sector as part of the existing commercial vehicle electronic screening function. Additional processing would be used to include roadside remote sensing of presence and classification of security sensitive hazardous materials shipments. Additional processing could correlate the sensed information with authorized activities determined by using identification information provided by the vehicles transponder. The information could be used to make a determination if further inspection is necessary. The concept is to detect unauthorized activity in security sensitive hazardous material shipments where practical and feasible.

The Hazardous Materials Security and Incident Response service focuses on providing information to emergency responders at the scene of an accident. This information could reside in infrastructure-based systems such as existing carrier databases, State information systems, and other CVO user service systems or in vehicle-based systems such as transponders used for electronic clearance. If the pertinent information is stored in an infrastructure-based system, emergency responders will have remote access to pertinent data. If the information is stored in a vehicle-based system, emergency responders will be provided with readers to access the information from the vehicle at the scene of the incident and be able to respond quicker and more efficiently. One example of this concept is "Operation Respond." This program is a joint FRA-rail industry initiative to improve the flow of critical HAZMAT Information to first responders to rail accidents.

3.4.5.5. References

Transportation Research Board [TRB] special report 239, Hazardous Materials Shipment Information for Emergency Response, 1993

3.4.6. Freight Mobility

3.4.6.1. Introduction

This service will provide real-time communications between commercial vehicle drivers, freight data users, and intermodal transportation providers to locate, dispatch and track commercial vehicles, freight containers, or trailer. For over-the-road shipments, this will allow commercial vehicle drivers and dispatchers with real-time routing information to respond to congestion or incidents.

In-transit visibility offers an opportunity for freight data users and intermodal transportation operators to enhance the efficiency and security of their freight movements. The term freight data user used in this user service discussion is defined as a person authorized to have access to security and movement data about freight containers, trailers and commercial vehicles. Freight data users may include, for example, the dispatcher responsible for managing the movements of commercial vehicles, freight containers or trailers, gate controllers at yards where freight is transferred for shipment, shippers, or law enforcement personnel. Dispatchers and intermodal transportation operators will use the location information to assign a fully functional, available freight container or trailer closest to a pickup location, thereby improving the efficiency of the overall system. Route deviations of a freight container, trailer or commercial vehicle can be used by freight data users and intermodal transportation providers to adjust planned delivery times. In addition, in-transit visibility can be used to increase the security of the freight container or trailer. The appropriate freight data user will be alerted when a freight container, a trailer or a commercial vehicle deviates from its intended route. A carrier's dispatcher will forward real-time location information to the appropriate authorities if their involvement is warranted.

Research, operational tests, and deployment of ITS technologies for freight mobility activities have been, historically, a private sector activity with limited, if any, public sector involvement. Currently, advanced freight mobility systems are deployed in limited capacities by a small number of motor carrier companies.

Even though involvement by the public sector is limited, there is research currently underway that will assess the communication needs of dispatchers and fleet managers and other roles, if any, the Federal Government would play in furthering freight mobility and productivity.

3.4.6.2. Needs

The different segments of the freight industry will use this service to satisfy their varied business needs. The parts of the industry that would benefit the most from freight mobility are ones that are demand responsive. The need for compatible automated vehicle identification is apparent with intermodal operations. Just-in-time delivery as well as just-in-time pickup could be supported by technologies that track the location and movements of freight container or trailer, many of which are already equipped with transponders. In-transit visibility of freight containers, trailers and/or commercial vehicles will provide a greater level of security. Alerting a dispatcher of a route deviation can be a preventative measure taken to foil unauthorized or criminal activity. If a shipper learns of a route deviation, the planned delivery time may be adjusted.

The availability of real-time traffic and asset location information would help dispatchers optimize their operations. By adjusting driver assignments to meet real-time conditions, carriers would be able to cut down on dead-head miles. The information would also provide route guidance to avoid congested areas and improve the reliability of pickup-and-delivery operations. Curbside delivery of goods could likewise be improved by the availability of traffic and location information. In the congested streets of urban areas, parking spaces could be reserved for delivery of goods on a just-in-time basis. Seamless tracking of freight containers or trailers across all modes of transportation can improve the efficiency and reliability of intermodal operations.

Another need possibly addressed by this service would assure more compatibility between public and private sector information and mobile communication systems to minimize duplication and maximize benefits. For example, both private sector and public agencies would require access to much of the same information, such as safety and mileage data, and mobile communications are needed both for carrier operations and for many of the ITS user services offered through systems operated by the public sector.

3.4.6.3. Service Description

This service will provide real-time communications between commercial vehicle drivers, freight data users, and intermodal transportation providers, and their assets in order to improve the efficiency and reliability of their freight operations. This service will include a commercial vehicle fleet management function. Dispatchers and commercial vehicle drivers will be able to make real-time routing adjustments in response to congestion or incidents, or in response to other business needs, such as additional pickups and deliveries. Freight data users will have access to real-time fleet information, including location, in order to improve driver effectiveness, equipment maintenance and customer service.

This service will include a freight operations management function. This will allow freight data users the capability to monitor and track the location and movements of freight containers or trailers. The operating conditions of the freight container or trailer, including in some cases mileage, tire wear and brake wear, will be available to support equipment maintenance planning.

The freight mobility service will include a route management function. A route will be planned for an asset (i.e. freight container, trailer and/or commercial vehicle) at the beginning of a trip. The asset will be tracked in-transit and the dispatcher will be notified if it deviates from the planned route. The dispatcher will have the capability to notify the appropriate authorities if the situation warrants their involvement.

FHWA is investigating whether or not there is a need for public or Federal involvement in the development and deployment of this service to facilitate intermodal transfer and provide real-time traffic information to dispatchers. Depending on their assessment of benefits and needs, individual carriers will implement elements of this service at levels of sophistication ranging from low to high.

3.4.6.4. Operational Concepts

Motor carrier companies with substantial fleet sizes and intermodal transportation providers are investing in computer, communication, and position determination technologies to improve efficiency and effectiveness. The operational concepts for the application of technologies may vary with the number of technologies employed, but they share a common objective of providing freight mobility headquarters or dispatch centers with data on vehicle location, driver hours of service, freight container or trailer location, freight container or trailer condition, estimated and actual delivery times, fuel consumption and general trip condition information. Integrating these categories of information enables fleet managers to make timely decisions designed to improve customer service, driver effectiveness, and equipment maintenance. A subset of this data, including freight container or trailer location and condition, could be utilized by other modes of transportation such as rail.

A dispatcher's in-transit visibility of their asset (i.e. freight container, trailer and/or commercial vehicle) would increase their utilization and at the same time provide an increased level of security. A dispatcher would implement appropriate security procedures when it has been determined that an asset has deviated from its intended route. The real-time location information could be forwarded to the appropriate authorities if the dispatcher believes their involvement is warranted.

The CVO architecture will accommodate and will be upwardly compatible to current communication systems between commercial vehicle drivers, freight data users, and intermodal transportation providers.

3.5. Emergency Management

The Emergency Management user service bundle contains user services that relate directly to the detection, notification and response to emergency and non-emergency incidents which impact the transportation system. The focus of this bundle is the improvement of the ability of police, fire and rescue operations to provide an appropriate response to such situations, thereby saving lives and reducing property damage, as well as the ability of roadside service providers to expedite responses to emergencies.

The Emergency Management user service bundle is made up of three individual user services, which are briefly described below:

The **Emergency Notification and Personal Security** user service focuses on reducing the time from occurrence of an emergency or non-emergency incident until the notification of the appropriate response personnel and on providing an accurate estimate of the location of the vehicle in need of assistance. This user service is divided into five subservices.

- The Driver and Personal Security subservice will provide the ability to manually initiate the notification of emergency and non-emergency incidents such as mechanical breakdowns, fire, non-injury accidents, or injury accidents where a person on the scene is able to manually initiate the notification.
- The Automated Collision Notification subservice will provide automatic notification of automobile crashes. This subservice has the goal of reducing the response time for medical assistance in incidents where serious injury has occurred to the vehicle occupants rendering them unable to initiate manual incident notification.
- The Remote Security and Emergency Monitoring subservice will provide monitoring, threat alerts, and automated security system support in secure areas. Secure areas encompass physical areas related to travel including remote areas and critical transportation infrastructure.
- The Wide Area Alert subservice will notify the traveling public in emergency situations such as child abductions, severe weather watches and warnings, natural and human-caused disasters, military operations, and civil emergencies where lives and/or property are at stake.
- The Protect Sensitive Traveler Information subservice addresses the monitoring and managing of traveler information to preserve individual privacy and public safety.

The **Emergency Vehicle Management** user service is oriented towards reducing the time from receipt of notification of an incident by a Public Safety Answering Point operator to arrival of the emergency vehicles on the scene. This user service is divided into three subservices: Emergency Vehicle Fleet Management, Route Guidance, and Signal Priority.

- The Emergency Vehicle Fleet Management subservice will provide improved display of emergency vehicle location and automation support to dispatchers to help them dispatch the vehicle that can most quickly reach the incident site. It includes improving communications between response vehicles and the dispatch center.

- The Route Guidance subservice will assist the dispatcher and emergency vehicle driver in determining the minimum time route to reach the incident scene, and, if required, from the incident scene to a suitable hospital. It will also provide in-vehicle route guidance for directing the emergency vehicle driver to the destination. This subservice will provide capabilities needed by emergency response vehicles that are not provided by systems developed for private or commercial vehicles under the Route Guidance user service.
- The Signal Preemption subservice will provide the capability to preempt traffic signals on an emergency vehicle's route so that the emergency vehicle is nearly always presented with a green signal. It includes the capability to warn drivers of affected vehicles that an emergency vehicle is approaching.

The **Disaster Response and Evacuation** user service uses ITS to enhance the ability of the surface transportation system to respond to disasters. The user service provides enhanced access to the scene for response personnel and resources, provides better information about the transportation system in the vicinity of the disaster, and provides more efficient, safer evacuation for the general public if needed. In addition, the transportation system includes a wealth of trained professionals and resources that constitute a portion of the disaster response. Use of ITS to prioritize, allocate, and track these personnel and resources also provides a more effective response to disasters.

3.5.1. Emergency Notification and Personal Security

3.5.1.1. Introduction

The Emergency Notification and Personal Security user service includes five capabilities: the Driver and Personal Security subservice, the Automated Collision Notification subservice, the Remote Security and Emergency Monitoring subservice, the Wide Area Alert subservice, and the Protect Sensitive Traveler Information subservice. The Driver and Personal Security subservice provides the capability for the user to manually initiate a distress signal for incidents like mechanical breakdown or non-injury accidents. The Automated Collision Notification subservice helps ameliorate the consequences of a serious collision by automatically sending information regarding the location, nature, and severity of the crash to an emergency medical services (EMS) dispatcher. The Remote Security and Emergency Monitoring subservice helps detect and deter threats to travelers in remote areas or to critical transportation infrastructure and alert agencies and travelers of such threats. The Wide Area Alert subservice notifies the traveling public in emergency situations such as child abductions, severe weather watches and warnings, natural and human-caused disasters, civil emergencies, and other situations that pose a threat to life and property. The Protect Sensitive Traveler Information subservice protects information from public distribution that may compromise individual privacy or public safety.

There are three sets of primary users of this service. The first are travelers, who will benefit from more timely information and more timely responses in emergency situations. The second set of users are the operating transportation agencies, including agencies responsible for the critical transportation infrastructure, who will benefit from early detection of and more effective response to emergencies affecting the transportation infrastructure. The third set of users are the emergency management, public safety (law enforcement, fire and rescue, emergency medical services) and other allied response agencies including towing, telematics service providers, and motorist assistance services, who will benefit from improved, more timely emergency information and use of ITS technologies to disseminate emergency information to the traveling public.

This service directly addresses the ITS goal of improving safety and security by improving emergency responses, reducing the number of fatalities and the severity of injuries resulting from an emergency, and reducing the number of pedestrian and vehicle collisions secondary to an incident. Driving stress is reduced by providing a means of summoning assistance in the event of an emergency. Security is increased by adding sensors, surveillance, and traveler notification systems to detect dangerous or suspicious activity, deter and control with physical security systems, and alert appropriate agencies and travelers of the threat or incident.

3.5.1.2. Needs

Thousands of roadway incidents occur every day on our nation's highways. Most highway incidents, such as disabled or abandoned vehicles and minor crashes, are not serious in and of themselves; however, delay in providing notification of the location and nature of an incident often exacerbates the safety, mobility and environmental consequences of the incident. These incidents not only cause capacity reductions on freeways that result in congestion and delay, they can be dangerous for motorists, police officers, and other response personnel who are out of their vehicles as a result of an incident. Studies have shown that 20 to 30 percent of freeway pedestrian fatalities are associated with disabled vehicles. The motorist may also be personally at risk, particularly late at night or in isolated areas, due to criminal acts or exposure to a harsh environment.

The Driver and Personal Security subservice will directly reduce the personal risk to motorists, police officers and other response personnel, as well as other motorists. This will be achieved by reducing the time necessary to notify response personnel that an incident has occurred, and thus will reduce the time a disabled vehicle is in the roadway.

The ability to respond quickly to serious injury crashes is directly limited by the ability to notify EMS personnel that the crash has occurred and to identify precisely where the crash took place. Studies have shown that the likelihood of fatality and long-term health consequences of injuries increases as the response time of medical service personnel increases. This can be particularly important in rural areas. Data from the Fatal Accident Reporting System (FARS) show that, in 1991, the average elapsed time between a fatal crash and notification of the dispatcher is about 5 minutes in urban areas and about 10 minutes in rural areas. This increase in response time is attributed to the lack of traffic providing the opportunity for someone to see and report the crash, travel distance to a telephone to report the crash, or difficulties in locating crash sites. Data also exists that indicate that once notified, the response time of EMS personnel is significantly greater in rural areas compared to urban areas. This can be attributed to the longer distances that may have to be traveled by the EMS personnel to arrive at the scene of the crash, and the inability of witnesses to accurately identify the location of the crash.

The Automatic Collision Notification subservice will directly address the issues associated with providing fast, appropriate response to serious automobile crashes, by providing the capability to automatically sense that a serious crash has occurred, and to immediately relay critical information on the severity of the crash and the crash location to an EMS dispatcher.

The Remote Security and Emergency Monitoring subservice will directly address the need for security in remote areas frequented by travelers and for security of critical transportation infrastructure. This includes a need for awareness of dangerous or suspicious activity, the need to deter or at least mitigate such activity and to alert other agencies of the activity.

The Wide Area Alert subservice will directly address the need for rapid public notification in emergency situations, supplementing the Emergency Alert System (EAS) that delivers alerts through radio, TV, and cable media. Important information can be quickly provided using ITS technologies in emergency situations such as child abductions, natural disasters, and civil emergencies. Studies indicate that time is of the essence in these situations; in the case of child abductions, 75% of the children who were abducted and later found murdered were killed within three hours of the abduction, according to the Department of Justice. ITS technologies can be used to alert travelers who may not otherwise receive the emergency alert.

3.5.1.3. Service Description

The Emergency Notification and Personal Security user service is divided into five subservices; Driver and Personal Security, Automated Collision Notification, Remote Security and Emergency Monitoring, Wide Area Alert, and Protect Sensitive Traveler Information.

Driver and Personal Security: The Driver and Personal Security subservice will provide the ability to manually initiate notification of emergency and non-emergency incidents such as mechanical breakdowns, medical emergencies, fire, non-injury accidents, or injury accidents where a person on or observing the scene is able to manually initiate the notification. Requests for assistance can be directed to telematics service providers who in turn relay the request for assistance to emergency or non-emergency responders including emergency medical, fire, law enforcement, as well as towing or repair assistance to deal with a disabled vehicle. The systems providing this capability will determine the vehicle's location and will transmit the location as part of the notification message. Initially this service will provide for manually initiated notifications, however, future enhancements may allow automatically initiated messages. Primary service providers include telecommunications carriers (such as telephone and cellular companies), providers of real time location services (such as the Global Positioning System), Telematics Service Providers (e.g., OnStar and ATX Technologies), public safety responders (law enforcement, fire and rescue, and emergency medical services), as well as those providing towing and other motorist assistance services.

ITS Auto Theft Recovery and Prevention systems may incorporate driver-specific recognition systems already being provided for motorist-security or convenience. For example, personalized door-locking/unlocking or vehicle-interior adjustments might be embellished to link driver identification codes (e.g. voice, smart card/key) with ignition locks and other electronic controls. Alarm signals of unauthorized starts might be automatically transmitted to police receivers, or vehicle owners who discover a theft could trigger unannounced locator transmittals from the stolen vehicle (similar to the system marketed by LO JACK). New cellular systems technology will allow vehicles to be located even if the phone is off. With owner approval, police departments might have electronics and the staff to track stolen vehicle movements. On board transmitters and wide spread standardized passive detectors could also hasten vehicle interception. Interception and remote control would lessen the risks of thieves, hazardous driving, and vehicle dismantling by professional “chop shops”.

Automated Collision Notification: The Automated Collision Notification subservice will provide automatic notification of serious automobile crashes. The systems providing this capability have the ability to automatically detect that a serious crash has occurred, and automatically send a notification message to a Telematics Service Provider that includes the location of the crash and an indication of the severity of the crash. Additional information that may be transmitted as part of the notification message might include vehicle identification information and data on the vehicle condition, e.g., indication of roll over or fire, final vehicle orientation, and indication of the number of occupants of the vehicle. Primary service providers include telecommunications carriers (such as telephone and cellular companies), providers of real time location services (such as the Global Positioning System), Telematics Service Providers (e.g., OnStar and ATX Technologies), public safety responders (law enforcement, fire and rescue, and emergency medical services), as well as those providing towing and other motorist assistance services.

Remote Security and Emergency Monitoring: The Remote Security and Emergency Monitoring subservice will provide monitoring, threat alerts, and automated security system support in secure areas. Secure areas encompass physical areas related to travel including remote areas and critical transportation infrastructure. Remote areas include rest stops, park and ride lots, tourism and travel information areas and emergency pull off areas. Critical infrastructure includes transportation infrastructure locally determined to be critical. In these secure areas, surveillance (audio, video and other) and sensing systems (including seismic, nuclear, biological, chemical, intrusion, motion, acoustic, object and other) will be monitored. Secure areas may have traveler- and operator-activated alarms, as well as automatically activated alarms from surveillance and sensor devices. System preparedness will be increased as the likelihood of an incident is increased based on alert levels. In order to preclude an incident, secure an area or mitigate the impact of an incident, automated barriers, lock gates, blast shielding or other systems may be used. Travelers and appropriate agencies and organizations may be informed of system deployment.

Wide Area Alert: The Wide Area Alert subservice will notify the traveling public in emergency situations such as child abductions, severe weather watches and warnings, natural and human-caused disasters, military operations, and civil emergencies where lives and/or property are at stake. This subservice utilizes ITS driver and traveler information technologies to immediately provide information and instructions to the traveling public, improving public safety and enlisting the public's help in some scenarios. The ITS technologies will supplement and support other emergency and homeland security alert systems such as the Emergency Alert System (EAS). When an emergency situation is reported and verified and the terms and conditions for system activation are satisfied, a designated agency broadcasts emergency information to traffic agencies, transit agencies, information service providers, the media, and other ITS systems that have driver or traveler information capabilities. The information that is provided identifies the message originator, the nature of the emergency, the geographic area affected by the emergency, the effective time period, and information and instructions for the public. The ITS systems, in turn, provide the alert information to the traveling public using ITS technologies such as Variable Message Signs, Highway Advisory Radios, in-vehicle displays, transit displays, 511 traveler information systems, and traveler information web sites. The service providers for this subservice include the emergency management, homeland security, military and public safety agenc(ies) that issue the Wide Area Alert, the traffic, transit, and traveler information organizations that convey the information to the traveling public, and the traveling public itself.

Protect Sensitive Traveler Information: Traveler information must be monitored and managed to preserve individual privacy and public safety. Although the information collected by ITS sensors and surveillance systems is normally public information that requires no special safeguards, this information may compromise individual privacy or public safety operations in certain scenarios. For example, close-up CCTV views of a crash can provide important information for incident response, but these views may also violate privacy principles if they are disclosed to the public. In another example, when law enforcement establishes checkpoints, information from ITS devices that may disclose checkpoint locations could be used by the suspect to avoid the checkpoints. In scenarios like these, the information that must be protected is identified by geographic area and information type or by specific device. The information protection request may be made by a public safety agency or made directly by the transportation agency or information service provider that collects the information. The identified sensitive information is not disclosed to the public until information access restrictions are removed and normal traveler information distribution is resumed.

3.5.1.4. Operational Concepts

The operational functions of the Driver and Personal Security subservice, the Automated Collision Notification subservice, the Remote Security and Emergency Monitoring subservice, the Wide Area Alert subservice, and the Protect Sensitive Traveler Information subservice of the Emergency Management and Personal Security user service are described below.

Driver and Personal Security: The Driver and Personal Security subservice has two basic operational functions: a communications link and a navigation or vehicle location capability. When a vehicle driver experiences a mechanical breakdown, or other situation that requires assistance, he would manually initiate a call for help. The communications link may be two-way voice communications, some kind of electronic messaging, or even something as simple as pushing a button. In any case, the notification message would include some indication as to the nature of the incident and the type of assistance required, such as: minor property damage crashes; break downs due to mechanical failure, flat tire, overheating, or running out of gas; medical emergencies; or police emergencies. The ability to manually send a cancellation message in the event the system is improperly activated is required.

The second major operational function is some means of identifying the location of the vehicle. The Driver and Personal Security subservice will include a navigation or vehicle location capability. Location information will be automatically obtained by the in-vehicle system and will be included as part of the notification message. It may also be desirable to include an estimate of the accuracy of the location estimate, if such is available.

One possible approach is to have the in-vehicle system automatically route the incident notification message directly to the appropriate response personnel (i.e., mechanical breakdown to a repair or towing service, a medical emergency to EMS dispatcher, or a police emergency to the police department). Another approach is to utilize a centralized Telematics Service Provider that would decide on the appropriate response and route the message accordingly.

Aspects of this service can tie into the existing infrastructure of Public Safety Answering Points (PSAP). A PSAP is a communications center operated by public safety agencies that are responsible for answering 9-l-l calls. If the PSAP operates as a combined call-taking and dispatch center, it dispatches a response from Emergency Response Agency (ERAS, e.g. police, fire, or emergency medical services). If the PSAP center does not provide a dispatch function, it transfers the call to the appropriate ERA dispatch center for dispatch. Basic 9-l-l services direct phone calls to the appropriate PSAP or, if no PSAP exists, to the designated agency responsible for answering emergency calls. Enhanced 9-l-l services incorporate additional Automatic Number Identification and Automatic Location Identification features. With Enhanced 9-1-1, the call-taker's computer display shows the caller's phone number and address, and identifies which agency would respond for law enforcement, fire, and EMS. The addition of location technology to cellular and other wireless communications systems will allow PSAP personnel to locate wireless emergency calls.

Automated Collision Notification: The Automated Collision Notification subservice is made up of three basic operational functions; incident detection, vehicle location, and communications. The first operational function, incident detection, allows the system to sense that a serious crash has occurred. It would be desirable for the system to also provide some indication of the severity of the crash and to provide supplemental information on the condition of the vehicle (e.g., has the car rolled over, is the car on fire, how many occupants were in the car when it crashed). It is not necessary for the crash detection portion of the Automated Collision Notification system to survive the crash; it only has to sense that a crash has occurred and relay that information to the communications component before it fails.

The second operational function of an Automated Collision Notification system is the ability to identify the location of the vehicle. The system must include a navigation or vehicle location capability. Location information will be automatically obtained by the in-vehicle system and will be included as part of the notification message. It may also be desirable to include an estimate of the accuracy of the location estimate, if such is available. As with the crash sensing portion of the system, the navigation portion of the system may not be required to survive the crash if accurate location information can be obtained and forwarded to the communications component before it fails. However, as the vehicle may travel a significant distance after the initial impact has occurred, it would be desirable for the navigation component to survive the crash.

The communications component is the third operational function of an Automated Collision Notification system. This component will automatically establish a communications link with a Telematics Service Provider and pass a notification message containing the vehicle location, an indication of the crash severity, and possibly additional supplemental information. The Telematics Service Provider, in turn, relays the emergency information to the appropriate response agency. Obviously, it is critical that the communications capability must survive the crash. The ability to manually send a cancellation message in the event the system inadvertently sends an inappropriate notification message may also be needed.

The first two subservices of the Emergency Management and Personal Security user service (Driver and Personal Security, Automated Collision Notification) share several key operational characteristics:

- Information sent by the vehicle must reach an appropriate response facility or dispatcher in a timely and efficient manner.
- It is a goal of the system to have full coverage, i.e., drivers should be able to contact at least one response facility or dispatcher from any given location in the United States. This full coverage capability may be phased in to the system over some period of time.
- A driver should be able to travel region to region without adjustments to in-vehicle equipment or changes in procedures.
- Incident notification communications systems should take advantage of the various existing networks (e.g., 9-l-l services for emergency situation notification) to the extent possible.
- The communication system may support one-way or two-way transmission to notify the appropriate response facility or dispatcher of an incident, and it may use voice or data or a combination of the two.

Remote Security and Emergency Monitoring: The Remote Security and Emergency Monitoring subservice is made up of four basic operational functions: monitor secure areas, provide alarms, adjust alert level and deploy physical security systems. The first operational function, monitor secure areas, allows secure areas to be monitored using surveillance equipment and sensors. Sensors may detect threats (i.e. seismic activity, nuclear, biological or chemical presence, etc.), infrastructure condition or integrity, motion, objects or intrusion. Sensor data may be input to advanced data processing systems that identify threats, or to operators, who monitor for suspicious activity. Potential threats may be forwarded to operators, travelers and appropriate agencies and organizations. Operators are able to verify threats.

The second operational function, provide alarms, allows travelers or operators a mechanism for notifying appropriate agencies of a threat. Alarms could also be automated from sensors and surveillance equipment. Other agencies such as the Coast Guard and weather service may be monitoring conditions in or near secure areas. Alarms for threats to a secure area may be received from such agencies.

The third operational function, adjust alert levels, allows the system to adjust preparedness based on alert levels. An increased alert level, received from an agency or due to detected dangerous or suspicious activity, may lead to increased operator awareness, increased surveillance and activation of physical security systems or other activities.

The final operational function, deploy physical security systems, includes the capability for an operator to remotely deploy systems, such as barriers or gates, as a deterrent, as a means to minimize access to an area in the case of a threat or incident or minimize the impact of an event. Travelers and appropriate agencies and organizations are informed of security system deployment.

Wide Area Alert: The Wide Area Alert subservice is made up of three operational functions: initiate alert, notify public, and discontinue alert. The first operational function, initiate alert, receives, verifies, and authenticates the Wide Area Alert message that is issued by an emergency management, public safety, homeland security, military, weather, or other designated agency depending on state and local plans and the nature of the alert. The alert originator, effective time period, affected geographic area, the nature of the alert, and alert information and instructions are extracted from the received message, checked, and prepared for public distribution.

The second operational function, Notify Public**,** uses available ITS resources to notify the traveling public of the emergency situation. These resources include variable message signs, highway advisory radios, in-vehicle display systems, and other advanced roadside information systems. In addition, wide-area traveler information systems including 511, web sites, and broadcast traveler information systems are used to notify the public. Depending on the nature of the alert and the ITS technology used, complete information and instructions may be provided or information may be limited to a short notification message and a reference to additional information sources (e.g., radio or other broadcast media). All agencies are informed of the current status of the alert dissemination

The third operational function, Discontinue Alert, receives, verifies, and authenticates the termination message that discontinues the Wide Area Alert. On receipt, the alert messages will be removed from all traveler information systems. If the effective time period elapses without receipt of a termination message or reissuance of the alert message, the system will provide a notification that the designated alert time period has expired.

Protect Sensitive Traveler Information: The Protect Sensitive Traveler Information subservice is made up of two operational functions: identify sensitive information, and protect sensitive information. The first operational function, identify sensitive information, defines the impacted location(s), effective times, and types of information that are sensitive and must be protected. Sensitive information may be identified by public safety agencies or transportation agencies and information service providers that own and operate the information collection and distribution systems. The second operational function, protect sensitive information, inhibits public distribution of the sensitive traveler information, including video surveillance, specific incident information, and any other information deemed sensitive until information access restrictions are removed.

3.5.2. Emergency Vehicle Management

3.5.2.1. Introduction

The Emergency Vehicle Management user service is oriented toward reducing the time from the receipt of notification of an incident by a Public Safety Answering Point (PSAP) operator to arrival of the emergency vehicles on the scene. It consists of three subservices:

- Emergency Vehicle Fleet Management
- Route Guidance
- Signal Preemption

Emergency Vehicle Management (also called Public Safety Services or PSS) will respond to the full range of needs that may arise in ITS operations including intervention by police, emergency medical services, fire services, and allied public safety services. The same PSS that serves the mobile needs of ITS users will also serve to reduce deaths, injuries, and property damage arising from natural, or manmade mishaps at fixed locations accessible to PSS vehicles. A common need of these services for ITS response purposes therefore, is the ability to access, process, and exchange real-time information on the location and nature, of mishaps on roadways, both those included and those not included in the ITS infrastructure, so as to enable appropriate PSS responses to be promptly programmed and implemented at all potential response sites within the designated area of coverage of PSS.

This service has three primary users: law enforcement services, emergency medical services (EMS), and fire services. These primary users may have need for assistance by rescue services, extrication services, hazardous materials clean up services, and other such secondary responders, as the nature of the incident demands.

3.5.2.2. Needs

Data from the U.S. Department of Transportation and the National Safety Council document situations where injury has, or may, occur and where timely attention will reduce the severity of consequences to the victims. Thus, there is a need for timely intervention to improve the likelihood of recovery for those cases where injury or illness have already occurred and the likelihood of preventing injury in those hazardous situations where injury has not already occurred.

3.5.2.3. Service Description

The Emergency Vehicle Management service has the following three subservices:

- Emergency Vehicle Fleet Management subservice provides improved display of emergency vehicle location, and automation support to dispatchers to help them dispatch the vehicle that can most quickly reach the incident site. It includes improving communications between the response vehicles and the dispatch center. This subservice covers police, fire, and EMS fleets.
- Route Guidance subservice assists the dispatcher and vehicle driver to determine the minimum time route to reach the incident scene, or a suitable hospital. It also provides in-vehicle route guidance for directing the driver to the destination. This subservice provides capabilities needed by emergency response vehicles that are not provided by systems developed for private or commercial vehicles under the Route Guidance service.
- Signal Preemption subservice provides for preemption of traffic signals on an emergency vehicle's route so that the emergency vehicle is nearly always presented with a green signal. It includes the capability to warn drivers of affected vehicles that an emergency vehicle is approaching.

For the purposes of this user service, two terms, Emergency Vehicle Management and Public Safety Services (PSS), will be used interchangeably. All references to PSS should be interpreted as being equivalent to Emergency Vehicle Management.

ITS technologies can enable PSAP operators receiving first notification of response requirements, to immediately identify the appropriate, closest, available PSS responder or mix of responders, and to transfer complete, accurate information regarding the nature and location of the response need, resulting in more effective, safer, and less costly operations.

PSS is the primary or core ITS user system whose operations are directed to responding to, and preventing or reducing the consequences of mishaps requiring emergency services. The PSS System uses a broad range of ITS capabilities that can provide the dispatchers with accurate information on the location of the appropriate, available vehicle closest to the scene, so shorter response times can be achieved. For example, an ambulance may be considered to be out-of-service while it returns to its station at the completion of an emergency dispatch. Until it arrives back at its station, it is generally not dispatched again. With vehicle location technology, the dispatcher can identify and dynamically dispatch the vehicle nearest to the scene of an emergency. This can reduce response times and improve public service.

The underlying concept of this service is that savings in time of intervention translate directly into health benefits for the victim. These individual health benefits compound into societal benefits through reduction in insurance costs and public service costs. The systems which provide this service are designed to minimize the time between notifying a dispatcher of the need and the availability of appropriate intervention to the victim(s). Thus, the primary measure of effectiveness of a concept or system is the reduction in time between notification and availability of intervention.

3.5.2.4. Operational Concepts

PSS vehicles (police, EMS, and fire) operate as authorized by State or local governments, to respond to reported emergent needs of citizens for police, emergency medical, fire, and similar interventions. PSS vehicles may be owned by governmental or private sector organizations, and may be operated by government employed responders, such as sworn police officers, by private sector employees such as hospital employed Emergency Medical Technicians (EMTs) who are certified by State Emergency Medical Services authorities, or by a mix of volunteer, government employed and private sector employed personnel such as in paid, volunteer and privatized fire services.

PSS deliver direct aid to individuals (or groups) in situations requiring intervention by police, emergency medical technicians, or fire fighters. Present control of PSS vehicles is often based on assumed location information and decisions are made on these assumptions. ITS technologies can enable PSAP operators receiving first notification of response requirements, to immediately identify the appropriate, closest, available PSS responder or mix of responders, and to transfer complete accurate information regarding the nature and location of the response need, resulting in more effective, safer, and less costly operations.

In the case of fire trucks and ambulances, the dispatcher generally assumes that the vehicle is located at a known facility (e.g. fire station or hospital). For police patrol cars, the dispatcher assumes that the car is located somewhere within its assigned patrol area. In each case, there may be another vehicle closer to the scene of the distress.

The systems that implement the Route Guidance subservice provide the emergency vehicle driver with guidance on how to achieve “minimum-time” response to the scene of the emergency and other locations, such as hospitals. One key component of these systems not found in the requirements for “routine” route guidance for private citizens is the monitoring of other emergency vehicles responding to the same location. The systems should be integrated with an external automated crash detection location and reporting system.

The systems that will provide the Signal Preemption subservice are a part of the traffic management infrastructure. Many of the system concepts for this subservice will include direct communication between ITS/PSS dispatcher and the traffic signal; direct communication between the emergency vehicle and someone or something else; such as, the private automobiles within a certain radius so that the drivers are aware that an emergency vehicle is approaching, or an emergency vehicle communicates directly with traffic signal controls to provide right-of-way for the vehicle.

3.5.3. Disaster Response and Evacuation

3.5.3.1. Introduction

The surface transportation system plays a crucial role in responding to natural disasters, terrorist acts, and other catastrophic events. The Disaster Response and Evacuation (DRE) user service uses ITS to enhance the ability of the surface transportation system to respond to such disasters. The user service provides enhanced access to the scene for response personnel and resources, provides better information about the transportation system in the vicinity of the disaster, and provides more efficient, safer evacuation for the general public if needed. In addition, the transportation system includes a wealth of trained professionals and resources that constitute a portion of the disaster response. Use of ITS to prioritize, allocate, and track these personnel and resources also provides a more effective response to disasters.

All types of disasters are considered in this user service including natural disasters (hurricanes, earthquakes, floods, winter storms, tsunamis, etc.) and technological and man-made disasters (hazardous materials incidents, nuclear power plant accidents, and national security emergencies such as terrorism, nuclear, chemical, biological, and radiological weapons attacks terrorist acts.). Broad inter-agency coordination is critical in disaster scenarios, with transportation professionals performing well-defined roles in the larger context of the multi-agency response to the disaster. The user service describes the need to coordinate and integrate DRE activities within diverse organizations in order to improve the safety of the responders and the public at large, and improve the performance and effectiveness of the transportation system as a part of the overall disaster response.

The primary purpose of the DRE user service is to identify the transportation-related needs of the relevant stakeholders. Based on these needs, the DRE user service describes the services that ITS should provide and the accepted disaster response operational concepts that provide the context for this user service. The DRE user service provides a starting point to help the transportation community and other emergency responders to use technology and data communications to improve disaster planning and response performance.

The DRE user service is closely related to the Incident Management user service (Section 3.1.7). Both user services cover the various aspects of emergency response including situation awareness and resource coordination. This user service focuses on larger scale events that require coordination outside the community/affected area, including state and possibly Federal support.

3.5.3.2. Needs

Every year, natural disasters including hurricanes, floods, severe winter storms, and earthquakes require an effective coordinated response by agencies at the federal, state, and local level. In addition, the events of September 11, 2001 dramatically underscored the need for effective planning and response for terrorist acts.

A major disaster may severely damage the transportation system in the impacted area. Local transportation activities will be hampered by damaged facilities, equipment, and infrastructure, as well as disrupted communications and electrical services.

This section is focused on identifying the needs of state and local transportation agencies that participate in a broader disaster response by emergency management, public safety, and many other allied agencies. The needs are defined in two subsections:

<u>Disaster Response:</u> The needs associated with providing an effective response to a disaster or pending disaster, using transportation assets to minimize the loss of life and damage to property, and effectively manage the surface transportation system before, during, and after the disaster.

Evacuation Coordination: The needs associated with evacuating the general public from the affected area and managing reentry. These needs address disasters that are anticipated or occur slowly (e.g., hurricanes) as well as disasters that occur rapidly, without warning, and allow little or no time for preparation or public warning (e.g., terrorist acts).

3.5.3.2.1. Disaster Response

The following needs are partially derived from "A Guide to Updating Highway Emergency Response Plans for Terrorist Incidents". This Guide was itself developed based on the best relevant practices from State DOTs, including those that cope with major emergencies such as earthquakes and hurricanes. The user needs identified in the Guide were expanded and refined to cover all transportation agencies and all types of disasters. The user needs for Disaster Response are as follows:

- **Planning/Preparedness**: Support by coordination of plans between agencies to include identification of conflicts or dependencies among agency plans. This includes coordination of general emergency management plans continuity of operations plans, and shorter-duration operational plans prepared during a disaster response. Improve access to alerting systems and information regarding threat levels. This includes the Homeland Security Advisory System (HSAS) and related systems for terrorist alerts, the weather forecasts, watches, and warnings issued by the National Hurricane Center, other National Weather Service components and other weather service providers, and the various early warning systems operated by federal, state, and local emergency management agencies.
- **Detection**: Use surveillance systems to detect indicators of a potential disaster, a disaster that is occurring, or a disaster that has occurred. This includes, but is not limited to, environmental sensors, threat sensors (e.g., radiological, nuclear, biological, and chemical), and infrastructure monitoring sensors. Surveillance capabilities must be able to distinguish between normal every day operations or incidents and major catastrophic events. Transportation systems and personnel must coordinate with and alert other agencies to recognize a disaster is in progress.
- **Verification**: Transportation systems and personnel need to coordinate with field personnel and equipment to verify that a disaster is occurring or has occurred and communicate relevant information to all responding agencies. Provide assistance in determining the nature of the disaster, extent of damage, and any potential hazards.
- **Availability/Survivability**: Improve operational availability of critical management, information, communications, and control systems in potential disaster scenarios. Deploy transportable ITS systems when local system operations are impacted by the disaster.
- **Initial Response**: Assist with evacuation of persons from immediate peril. Identify those personnel and resources that would be involved in an initial response and provide these personnel with timely, accurate information on applicable hazards. Transport materials, personnel, and supplies in support of emergency activities. Assess the condition of the transportation infrastructure including highways, bridges, tunnels, transit facilities, traffic management centers, and other components of the

transportation infrastructure. Perform actions such as closing those determined to be unsafe, transferring transportation control/management to alternate centers, posting signs and barricades, notifying emergency management agencies, develop detour routings, and review or terminate existing work zone closures. Assess and report impacts to airports, ports, waterways, and other transportation facilities in the disaster area. Support hazardous materials containment response and damage assessment. Receive information to determine the extent of the impact area. Adapt traffic control strategies and provide driver and traveler information to support the establishment and minimize the impact of a secure perimeter around a disaster area in these scenarios.

- **Resource Management**: Prioritize and/or allocate resources necessary to maintain and restore the region's transportation infrastructure. Provide all available and obtainable transportation resource support including: transportation equipment (e.g., transit vehicles, trucks and/or trailers) and ground and operations personnel (for transportation of emergency officials and emergency response personnel), transportation facilities, (e.g., vehicle repair facilities) that can be used for staging, parking, and storage of emergency vehicles; motor pool and vehicle service facilities and personnel for refueling and servicing emergency vehicles; transportation personnel, vehicular traffic management and vehicular traffic flow information. Assign personnel to emergency operations center(s) to coordinate with and assist public safety agencies and other agencies involved in disaster response efforts. Support communications between transportation personnel and their families and loved ones.
- **System Surveillance and Management**: Monitor and control transportation systems and infrastructure, and coordinate transportation activities with other agencies (local, state, and Federal). Monitor and coordinate the closure of high-risk facilities (e.g. bridge and tunnels). Assist state and local government entities in determining the most viable available transportation networks to, from, and within the disaster area and regulate the use of those networks for the movement of people, equipment, supplies, records, etc. Establish and manage emergency access. Identify specific traffic management actions to maintain a smooth flow for transport of emergency resources, including traffic control points, barricade plans, and potential one-way/reverse lane operations.
- **Critical Service Restoration**: Coordinate roadway clearance activities. Remove and/or assist in debris removal and disposal to provide emergency access to disaster areas or to assist in eliminating health and safety problems associated with debris. Prioritize, and perform emergency repairs in the disaster area. Coordinate with other jurisdictions that are managing, supporting, or are impacted by the repair activities. Assist in the design and implementation of alternate transportation services, such as transit systems, to temporarily replace transport capacity lost to disaster damage. Coordinate with efforts to restore utilities. Provide needed equipment and/or technical assistance to support restoration of critical public works.
- **Agency Communications**: Share disaster response and evacuation information among all allied agencies, including transportation (e.g., traffic operations,

maintenance, transit) and non-transportation (e.g., public safety and emergency management) agencies. Coordinate traffic control strategies supporting emergency response across jurisdictions. Coordinate transit service changes across jurisdictions. Integrate with existing Incident Command System practices of public safety agencies.

- **Public Information:** Provide information on road closures, infrastructure damage, debris removal, and restoration activities related to highway systems and facilities. Provide real-time traffic information and traffic reports for roads within the affected area or on roads leading into the area. Provide updated transit service information for the disaster area.
- **Special Needs Associated with Terrorist Attacks**: Basic training and information is needed so that transportation personnel can identify possible signs and consequences of terrorist incidents and take appropriate actions including the consideration of their own safety and initial management of the area as a potential crime scene. Response resources may be required far beyond those originally anticipated, especially where a weapon of mass destruction (WMD) is used that initially leaves few distinguishing marks. Transportation response resources need to be available but may also need to be protected as the consequences spread.

3.5.3.2.2. Evacuation Coordination

The following needs are based on a study of the hurricane evacuation performed for Hurricane Floyd in 1999. Over 3 million people were evacuated as a result of Hurricane Floyd, which skirted the east coast of Florida and made landfall in South Carolina. This evacuation resulted in overloading of evacuation routes, causing extreme delays and exposing evacuees to personal risk. In South Carolina, in-state trips took six times longer than normal. In Florida, Interstate 10 motorists traveling out of Jacksonville reported traveling just 35 miles in seven hours. Citizens and government officials expressed their dissatisfaction with the management of the evacuation process and the lack of information regarding travel conditions and services along the routes and at evacuation destinations.

The needs identified by this analysis were reviewed, revised, and extended to ensure that evacuations associated with all types of disasters are addressed. Hurricanes are anticipated and occur slowly, providing time for adequate warning and an orderly, well-planned evacuation. Other types of disasters may occur rapidly, without warning, and allow little or no time for evacuation preparation or public warning. Whether an evacuation is pre-planned and directed by local government, or is a spontaneous evacuation by a portion of the population, many agencies will be involved and must coordinate. The identified needs for evacuation are:

- **Planning/Preparedness**: Develop evacuation plans at the county, state, and multi-state levels. Coordinate evacuation routes across jurisdictional boundaries. Examine and modify evacuation route designs if necessary to accommodate evacuation management strategies. Coordinate current work zone activities so they do not all impact traffic at the same time for parallel routes in case of a terrorist incident or other incident with no forewarning. Develop service restoration plans for the transportation system. Reduce the time required for implementation and setup of various evacuation strategies due to the short time period available for evacuation in some types of disasters. Identify strategies improve the management of the evacuation process such as identifying shelters near evacuation origins, increasing the use of transit, and evacuating in shifts rather than all at once. Improve management of evacuation routes to accommodate evacuation for events of various severities ranging from small localized flood evacuations through large-scale weapons of mass destruction (WMD) evacuations. Plan for the evacuation of those with special needs (e.g. elderly and handicapped as well as hospitals)

- **Evacuation Management:** Efficiently utilize the available capacity to reduce the potentials for operational failures during evacuation. Improve management of the local streets that provide access to and from evacuation routes. The capacity of these streets should be increased and efficiently utilized to prevent creating bottlenecks at the access points. Improve the efficiency of detecting, responding to, and clearing incidents on evacuation routes. Improve the warning and preparation information provided to evacuation destinations. Evacuee traffic information can be used by transportation management at the destination to pre-configure their systems to anticipate and better handle the increased demand. Provide shelter-in-place information and utilize transportation resources to expedite relief to the endangered population in cases where evacuation is not possible because little/no warning is provided and transportation resources are limited or severely impacted. Maintain emergency services access to the disaster area and the evacuation routes themselves by providing for and managing emergency service access routes in the opposite direction and/or across the major evacuation routes where necessary. Improve management of evacuation termination under emergency circumstances. Ensure the efficient, safe and secure reentry of the evacuees to their counties.
- **Public Information**: Coordinate evacuation public information between emergency management, transportation, and other allied agencies so that consistent, accurate information is provided to evacuees. Provide real-time information to evacuees regarding: the services available at the evacuation destinations and along the evacuation routes; the evacuation route conditions such as the expected travel time to their destinations, incidents, road closures, lane closures, weather, the route to a certain destination, and the availability of alternative routes; information regarding conditions in their home counties; and information regarding available transit services supporting evacuation. Provide alternative evacuation destinations to evacuees that request this information.
- **Agency Communications:** Share current and forecast evacuation information between transportation, emergency management, law enforcement, and other allied agencies at the county, multi-county, and multi-state levels. This coordination must include the evacuated counties (evacuation origins), host and response counties (evacuation destinations and counties that provide assistance in the evacuation process) and counties on evacuation routes. Multi-state response is also important to ensure that evacuees from one state do not compound evacuation problems in another state. Establish policies, controls, and interfaces that support the lifting of the toll and transit fees.

- **Special Needs Associated with Terrorist Attack**: Develop evacuation plans that provide alternative routing for the possibility that a terrorist attack has rendered critical infrastructure or a quarantined area unavailable for evacuation. Provide evacuation planning for high visibility events (e.g., Olympics) where there may be a great influx of visitors not normally accounted for in disaster evacuation scenarios. Provide for evacuation contingencies with respect to multiple, and/or clustered disasters impacting evacuation in a relatively short timeframe

3.5.3.3. Service Description

The following major ITS functions support disaster response and evacuation, addressing the user needs identified in section 3.5.3.2. Each major function (in bold) is further explained with more detailed descriptions and narrative text.

3.5.3.3.1. Disaster Response

Coordinate Response Plans. Emergency response strategies and plans are developed and coordinated in advance of a disaster. Operational plans are developed and coordinated across agencies and jurisdictions in advance of a disaster and during the disaster response.

Monitor Alert Levels. As the likelihood of a natural disaster or terrorist attack increases, plans are executed, systems are brought on-line, resources are staged, and personnel assignments are made to increase readiness. Information from alerting and advisory systems such as the Homeland Security Advisory System and the National Hurricane Center are monitored and the transportation system is prepared to respond. For example, Emergency Operations Centers may be activated and transportation personnel assigned to those centers.

Detect and Verify Emergency. Although they are not a primary point of detection, transportation agencies may be among the first to identify and report a disaster due to the broad distribution of transportation personnel and surveillance systems. Once detected, the system must verify the emergency, identify potential hazards, define the impact area, and notify public safety and other allied response agencies. Conversely, an emergency notification system is used to alert transportation agencies to disasters that have been identified by other means.

Assess Infrastructure Status. The impact of the disaster on transportation infrastructure and associated ITS systems must be assessed using asset management systems, surveillance systems and sensors, built-in diagnostics of the systems themselves, on-scene reports, and inspections. Damage is assessed and detours or alternative transportation resources are identified.

Coordinate Response. Information is shared with the emergency operations centers and incident command during the course of the disaster response. The transportation system provides information on egress and ingress routes for the scene and staging areas, routes for specific origins and destinations on request, transportation system condition information including video surveillance information, and information on transportation resources and personnel that are available, en-route, or deployed at the scene. Transportation resources include construction and maintenance equipment used at the scene and transit vehicles that may be used to move emergency response personnel to and from the scene. The public safety systems provide current situation information and make requests for resources and information.

Critical Service Restoration. Critical transportation and utility services damaged by the disaster are restored. Emergency maintenance and construction activities are planned, coordinated, and initiated. Emergency access to right-of-way, permits, and needed equipment and resources are coordinated as necessary to support restoration of critical public works (e.g., utilities).

Manage Area Transportation. Depending on the nature of the emergency and the status of the infrastructure, closures and detours may be implemented and transit schedules may be modified. Closures may exclude all vehicles except for emergency vehicles or other special vehicles. Special traffic control strategies to manage traffic in the vicinity of the disaster may be implemented to limit and/or manage traffic in the area.

Provide Traveler Information. The transportation system will coordinate with public information offices of the allied emergency response agencies in providing traveler information for the disaster scene and surrounding area. Information provided would include information on special traffic restrictions, detours and closures, special transit schedules, and traffic conditions surrounding the scene. Information on care facilities, shelters, and evacuation information is also provided, as covered in the next section.

3.5.3.3.2. Evacuation Coordination

Evacuation Planning Support. Federal, state, and local transportation, emergency, and law enforcement agencies can be involved in evacuation planning, depending on the scale of the disaster and the evacuation. The evacuation plan may evacuate the affected population in shifts, use more than one evacuation route, maximize use of transit, and include several evacuation destinations to spread demand and thereby expedite the evacuation, where possible. All affected jurisdictions (e.g., states and counties) at the evacuation origin, evacuation destination, or along the evacuation route must be informed of the plan.

Evacuation Traveler Information. The public must be provided with real-time evacuation guidance including basic information to assist potential evacuees in determining whether evacuation is necessary. Once the decision is made to evacuate, evacuation times, one or more evacuation destinations, the evacuation route (tailored for the evacuee), available transit services, expected travel times, expected evacuation durations, and other information are provided that are necessary for an orderly evacuation. This function will also provide guidance for returning to evacuated areas, information regarding clean-up, and other pertinent information to be distributed from Federal, State, and Local Agencies.

Information on the services (shelters, medical services, hotels, restaurants, gas stations) along the evacuation route and at the evacuation destination are also important to the evacuee and should include real-time information on availability and address special needs (disabilities, the elderly, pets/livestock, etc.). Real-time information on traffic conditions, closures, road and weather conditions, and incident information are also provided along with information on alternative routes so that evacuees can better anticipate their travel times and select alternate routes where available.

Evacuation Traffic Management. Special traffic control strategies are implemented to control evacuation traffic, including traffic on local streets and arterials as well as the major evacuation routes. Reversible lanes, shoulder use, closures, special signal control strategies, and other special strategies may be implemented to maximize capacity along the evacuation routes. Incident management on the evacuation route is paramount with critical need for service patrols to minimize the traffic flow impact of minor incidents. Transit resources play an important role in an evacuation, removing many people from an evacuated area while making efficient use of limited capacity. Additional shared transit resources may be added and managed in evacuation scenarios. Toll and transit agencies must also be notified so that tolls and fares are eliminated during an evacuation. Traffic control strategies are also implemented to facilitate reentry to the evacuated area.

Evacuation Resource Sharing. An effective information sharing service is implemented that keeps all agencies in all affected jurisdictions appraised of the evacuation plan and evacuation status. Resources are coordinated through the same information sharing capability. Resource requirements are accurately forecast based on the evacuation plans, and the necessary resources are located, shared between agencies if necessary, and deployed at the right locations at the appropriate times. Current status of all resources are tracked so that resource status is known at all times.

3.5.3.4. Operational Concept

By definition, the disasters that are addressed by this user service are of a scale that overwhelms local agency resources and require state and possibly federal support. The operational concepts and the associated roles and responsibilities of federal, state, and local transportation agencies in such disasters are defined at the federal level in a Federal Response Plan (FRP) and for each state in emergency management plan(s). These broad multi-agency plans are often supplemented by Emergency Operations Plans that are specific to a particular transportation agency. Many of these plans have been or are in the process of being revised to reflect the increased awareness and focus on terrorist threats as a result of the events of September 11th, 2001.

This section distills the specific concepts of operations that are defined in these plans into typical high-level transportation-related operational concepts that provide a context for the user service. The presentation begins with a local operational concept and then moves to state, and finally Federal level operational concepts, consistent with the disaster response itself which frequently begins with a local response and then escalates up to include state and federal agencies. The operational concepts that are identified are only representative and should not be prescribed in the architecture. The local, state, and federal emergency management and operations plans are the authoritative source for detailed concepts of operations for disaster response and evacuation.

A major disaster may severely damage the transportation system in the impacted area. Local transportation activities will be hampered by damaged facilities, equipment, and infrastructure, as well as disrupted communications and electrical services. At the same time, the disaster will create significant demands for national, regional, and local transportation of resources to provide for relief and recovery. A coordinated effort by federal, state, and local agencies may be required to meet these demands for movement of essential resources, as well as for clearing and restoration of the transportation system.

Large scale disasters may also force the evacuation of at-risk areas. Whether an evacuation is pre-planned and directed by local government, or is a spontaneous evacuation by a portion of the population, many agencies will be involved and must coordinate. Some disasters are anticipated or occur slowly, providing time for adequate warning and an orderly, well-planned evacuation. Other disasters occur rapidly, without warning, and allow little or no time for evacuation, preparation or public warning.

3.5.3.4.1. Local Agencies

The following "typical" operational concept for local agencies is derived from a sampling of State, Regional, and Local Emergency Management Plans (listed in Section 3.5.3.5).

1. Emergency responses to individual incidents will be handled to the extent practical by local emergency response organizations (EROs, e.g., law enforcement, fire and rescue, and emergency medical services). The local EROs will be overwhelmed with calls for service, however, and will receive early assistance from surrounding jurisdictions under existing mutual aid agreements. Later assistance will come from more distant localities, and eventually also from the Federal Government in conjunction with a federal response to disaster, requested by the Governor, and managed by FEMA. The allocation of these mutual aid resources to the emergency calls for assistance, as well as the repair, recovery, reconstitution, remediation, and replacement actions will be managed by the closest Emergency Operations Center that remains in service after the disaster. Staging areas are established to hold resources, pending assignment. Comprehensive resource management principals are followed and a common resource tracking system is established to the extent practicable. A regional EOC may be established to oversee the response to large, multi-jurisdictional disaster areas. Continual coordination and liaison will be established and maintained between all of the EOCs involved in disaster response operations. Each EOC will establish and maintain connections to agencies under their control that will provide resources in support of the disaster response.
2. The entire disaster response will be organized using the principles of the Incident Management System, according to the Federal, State, and Local Response Plans. Each individual incident will be conducted by a designated Incident Command, and will involve resources from several jurisdictions. Incident Command itself may be a single individual, or may be a Unified Command involving command authorities from different jurisdictions. Each EOC will be organized using IMS principles, with several important differences, compared to IMS organizations at individual incidents. EOCs may be more likely to use Unified Command, more staff will be involved than for an individual incident, and a much greater emphasis will be placed on the planning, logistics, and finance/administration sections. Functioning at the Area Command echelon, EOCs will concentrate on policy formulation, strategic direction, and resource allocation. The operational sections at EOCs will concentrate on theater level operational matters, while individual incidents will emphasize tactical operations.

3.5.3.4.2. State Agencies

The following operational concept is derived from a sampling of State Emergency Management Plan Transportation Annexes (listed in Section 3.5.3.5). It represents a compilation and generalization of the more specific concepts of operations that are included in these plans.

1. A network of Emergency Operations Centers will be activated for a major disaster, including state, regional, and local centers. A State Emergency Operations Center, operated by the State Emergency Management Agency, is staffed by personnel from all functional areas including transportation. Other Emergency Operations Centers will be activated, normally including one or more EOCs operated by the State DOT. Exchange of information and coordination between these state EOCs and between these state EOCs and federal and local centers enables a coordinated multi-agency response to the disaster including, if necessary, evacuation.
2. Requests for transportation-related assistance may be generated in several ways. A request may be forwarded from the local and regional EOCs to the State EOC, or the request may be forwarded from one of the State DOT Emergency Operations Centers. In either case, coordination between the State DOT and the State EOC is essential so that the appropriate transportation response is carried out and all affected agencies have visibility into the status of this response.
3. When transportation requests exceed the capability of the state, the State DOT will coordinate transportation activities with adjacent states and the US DOT.
4. Damage assessments and situation reports flow into the EOC from local response agencies and the EOC relays this information to federal regional operations center(s) when federal agencies are involved.
5. Specialized tools may be used at the state and federal levels to support specific types of evacuations. For example, the Evacuation Traffic Information System (ETIS) is a travel demand forecasting model that can be used by states to forecast congestion levels and vehicles crossing state lines during hurricane evacuations and share this information with other affected states.

3.5.3.4.3. Federal Agencies

The Federal Emergency Management Agency (FEMA) Federal Response Plan (FRP) defines the concept of operations for coordinating delivery of Federal assistance and resources to State and local governments overwhelmed by a major disaster or emergency. The FRP defines the following set of Emergency Support Functions (ESFs)

- ESF 1-Transportation
- ESF 2-Communications
- ESF 3-Public Works and Engineering
- ESF 4-Fire Fighting
- ESF 5-Information and Planning
- ESF 6-Mass Care
- ESF 7-Resource Support
- ESF 8-Health and Medical Services
- ESF 9-Urban Search and Rescue
- ESF 10-Hazardous Materials

- ESF 11-Food
- ESF 12-Energy

The following operational concept is based on the ESF 1-Transportation annex, which is under the primary responsibility of US DOT and the primary area of ITS application. Many of the other ESFs could also use or indirectly benefit from ITS technologies. Consult the FRP for a complete detailed description of the Federal concept of operations for disaster response.

1. The Disaster Transportation Management System (DTMS) provides a structure for managing the acquisition of transportation services and the deployment of relief and recovery resources from around the Nation into the disaster area. The DTMS includes two components: Time-Phased Force and Deployment Lists (TPFDLs), which are planned, prioritized lists of the most critical Federal assets to be deployed rapidly to the disaster site; and Movement Coordination Centers (MCCs) to assist in the procurement of transportation assets and track the movement of resources to the disaster area. The MCC team is led by DOT and includes representatives from the Department of Defense (DOD), FEMA, General Services Administration (GSA), and Forest Service.
2. When a disaster occurs, the Secretary of Transportation will appoint a DOT Crisis Coordinator to manage the overall DOT response. Principal headquarters operations are conducted at the DOT Headquarters Crisis Management Center (CMC). DOT will also provide support to the Emergency Support Team at FEMA headquarters. The Activation Information Management System (AIM) is used to collect and report the status of the Transportation infrastructure and keep senior decision makers at the CMC and elsewhere within DOT appraised of the disaster situation.
3. In the local disaster area, direction of the federal transportation response is provided by the DOT Regional Emergency Transportation Coordinator (RETCO). The RETCO is responsible for coordinating the Federal transportation response activities within the assigned jurisdiction. The RETCO will activate elements required to meet the demands of the disaster, including representation to the Regional Operations Center, Emergency Response Team, and the field MCC. A designated Emergency Coordinator in each FHWA division office supports the RETCO, provides situation information back to Headquarters, and coordinates the FHWA-portion of the response in the disaster area.
4. In specific types of disasters (e.g., terrorist events), federal agencies (e.g., the FBI) will assume command of the incident and establish a Joint Operations Center (JOC) that may or may not be physically collocated with the local EOC.

3.5.3.5. References

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New Mexico Emergency Management, “New Mexico All Hazards Emergency Operations Plan – Annex 8”, September 1999.

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US DOT Research and Special Programs Administration, “Activation Information Management System User’s Guide”, July 2000.

Washington DC DOT, “District Response Plan – ESF 1”, November 2001

Washington State Military Department, “Washington State Comprehensive Emergency Management Plan”, January 2000

Washington State University, “Washington State University Emergency Response Plan”, August 2002.

3.6. Advanced Vehicle Safety Systems

Driver error has been determined to be a contributory or causal factor in over 90% of the approximately 6 million reported motor vehicle crashes that occur in the United States each year. There are a number of ways in which driver error can be manifested as a crash factor. These include, for example: inattention, distraction, misjudgment or decision error, intoxication or fatigue, and reckless behavior.

Until recently, the existing level of technology did not offer the promise of enhancing the crash avoidance capabilities of motor vehicles. However, the past several years have seen advances in electronics, communications and processor and control systems that make such improvements more feasible than was previously thought possible. A wide variety of innovations can be implemented both inside and outside the motor vehicle to supplement the driver's ability to maintain vigilance and effective vehicular control. These innovations would monitor the driver's own physiological condition, enhance perceptions of the driving environment, provide additional information about potential safety hazards, warn of impending collisions, assist in making appropriate vehicle maneuvers, and, eventually, even intervene with automatic controls to help avoid such incidents.

The Advanced Vehicle Safety Systems, or AVSS, bundle contains seven user services. All of these user services relate primarily to the safety goals of ITS by having a direct impact on diminishing both the number and severity of crashes, thereby reducing injuries, fatalities, and societal costs. Services in this bundle can be provided by systems that are part of the vehicle. The seven user services included in this bundle are:

- Longitudinal Collision Avoidance,
- Lateral Collision Avoidance,
- Intersection Collision Avoidance,
- Vision Enhancement for Crash Avoidance,
- Safety Readiness,
- Pre-Crash Restraint Deployment, and
- Automated Vehicle Operations (AVO).

Most of these user services will also have an indirect impact on reducing costs to fleet operators and transportation dependent industries. This is accomplished by reducing the losses in productivity and other direct and indirect costs of crashes.

The Automated Vehicle Operations user service not only addresses the safety related goals and objectives, but also has direct impacts on the capacity of existing facilities, and on reducing travel time and the time delays associated with congestion. Indirectly, the AVO user service can reduce new right-of-way requirements by making better utilization of existing facilities and improving travel time predictability.

3.6.1. Longitudinal Collision Avoidance

3.6.1.1. Introduction

A longitudinal collision is a two-vehicle collision in which vehicles are moving in essentially parallel paths prior to the collision, or one in which the struck vehicle is stationary. This category includes rear-end, backing and head-on crash-types. In addition, this category could include collisions where objects, pedestrians or animals are struck on the roadway.

Systems providing this service augment the driver's ability to avoid or decrease the severity of longitudinal collisions. The following four types of systems are associated with providing the Longitudinal Collision Avoidance user service:

- Rear-End Crash Warning and Control,
- Adaptive Cruise Control (ACC),
- Head-On Crash Warning and Control, and
- Backing Crash Warning and Control.

The user for this service, which may be applied in both urban and rural environments, is the vehicle driver. This user service relates directly to the goal of improving safety and the objectives of reducing the number and severity of collisions and the level of resulting fatalities, injuries and societal costs. Longitudinal Collision Avoidance also relates indirectly to goals of enhancing productivity by reducing congestion delays due to crashes of this type, which in turn reduces costs incurred by fleet operators and transportation dependent industries.

3.6.1.2. Needs

More than 6.3 million police-reported motor vehicle crashes occurred in the United States in 2003. According to data from the GES (General Estimates System) and FARS (Fatal Accident Reporting System) databases, rear-end collisions are the second largest single category of collisions. They represent almost 30% -- or about 1.87 million -- of all collisions in 2003. Although the number is high, crashes of this type accounted for about five percent of all fatal collisions in that year. Backing collisions account for a much smaller number of such incidents -- only 1.8% of the total and just 0.3% of all fatal collisions. Trucks, especially combination-unit trucks, are from five to more than ten times more likely to be involved in backing collisions than are automobiles. (There is evidence, however, that the number of backing collisions not reported to the police is high, so the actual number of such incidents may be somewhat higher than the databases portray.)

The number of collisions represented by these categories is high, even though the likelihood of such an event being fatal is lower than with other collision categories. Approximately 70% of all rear-end collisions occur when the moving vehicle strikes a decelerating or stationary vehicle in front of it, while in the remaining cases the front vehicle is also moving. In over 90% of these events, either driver inattention and/or following too closely were identified as contributing factors. More than three-quarters of these incidents occur on straight, as opposed to curved, roadways. This situation is dramatically reversed, however, in the case of head-on collisions. These accounted for only 2.3% all collisions, but more than 10% of all fatal crashes, in 2003.

3.6.1.3. Service Description

The longitudinal collision avoidance service is specifically aimed at providing vehicle operators with assistance in avoiding longitudinal collisions to the front and/or rear of the vehicle. The four types of longitudinal collision avoidance systems will assist the driver by: (1) sensing potential and/or impending collisions or dangers to the front or rear of the vehicle; (2) eliciting proper collision avoidance actions from the driver; and/or (3) providing temporary automatic control of the vehicle to assist the driver in avoiding the potential collision situation.

- Rear-end collision warning: and control would, through driver notification and (possibly) partial vehicle control, help avoid collisions with the rear end of either a stationary or a moving vehicle or object. This type has been widely introduced as a parking assist feature.

- Adaptive Cruise Control (ACC) allows the driver to select a cruise control feature that tracks the vehicle in front of it and automatically maintains a 'desired' spacing between that vehicle and the one traveling in front of it. In more sophisticated systems, leading vehicles would include rearward-looking transponders or other means of transmitting information on vehicle dynamics to a following vehicle. This subservice would allow two or more vehicles to travel in a cooperative platoon on the highway.

- Head-On Collision Warning and Control would detect an impending collision with a vehicle moving in the opposite direction but in the same lane.

- Backing collision warning would detect slow moving or stationary objects, vehicles, livestock, and pedestrians in the path of a vehicle when it is backing.

3.6.1.4. Operational Concepts

There are many diverse causal factors involved in longitudinal collisions. These include, for example: driver inattention, following too closely, loss of vehicle control, and evasive maneuvers to avoid a sudden collision threat. Given this situation, no single countermeasure concept can cover this multiplicity of potential causal factors. Collision avoidance systems such as those in this user service category include the "three Ps" of "perceive, process and present".

3.6.1.4.1. Rear-End Collision Warning and Control

Rear-end collisions are often associated with maintaining an insufficient distance from the vehicle in front, or failure of the striking vehicle driver to perceive a slowing or stopped vehicle in the roadway ahead. These systems may simply warn drivers, or may incorporate some level of vehicle control. When the system senses a dangerous condition, such as a stationary vehicle on the roadway ahead, the driver is warned. If the driver does nothing, or is unable to react in sufficient time, automatic vehicle control actions might be initiated to avoid the danger.

Rear-end collision warning systems might be deployable as purely autonomous systems (wholly contained within the vehicle). Advanced systems, however, may require communication between vehicles and perhaps assistance from roadway instrumentation to eliminate path-of-travel ambiguities.

3.6.1.4.2. Adaptive Cruise Control (ACC)

ACC systems incorporate a cruise control feature that tracks the vehicle in front of it and automatically maintains desired minimum distance from that vehicle. When the minimum distance is maintained, the vehicle travels at the set speed. However, if the distance between the controlled vehicle and the one in front of it falls below the minimum, the system may warn the driver (who must then take action). The system may also initiate control actions (such as throttle closure, downshifting or braking) to slow the vehicle and reestablish the minimum spacing.

Leading vehicles could also include a means of transmitting information on vehicle dynamics to a following vehicle. Two or more vehicles with this capability could travel in a cooperative “platoon” on the highway using basic ACC sensing plus inter-vehicle communications and on-board computer processing. These concepts may also include receiving information from the infrastructure about roadway speed limits, in order to maintain a lawful vehicle speed.

3.6.1.4.3. Head-On Collision Warning and Control

These systems detect impending collisions with a vehicle moving in the opposite direction that is in the same lane as the vehicle equipped with this system. Head-on collision control must have a complete and accurate picture of the road configuration, adjacent vehicles, roadside hazards, and path alternatives if it is to assume control of the vehicle. Because of the distances at which these systems must operate, they are likely to require vehicle-to-vehicle communications.

3.6.1.4.4. Backing; Collision Warning and Control

These systems would detect slow moving or stationary objects, animals and pedestrians in the path of a vehicle when it is backing. Because of the generally lower speeds involved in backing movements and the kinds of objects that could be in the backwards path (dogs, children, bicycles), the required range of sensors will be relatively short. For crashes where the backing vehicle strikes or is struck by a vehicle traveling in a perpendicular direction, sensors with longer range will be needed.

3.6.1.5. References

National Highway Transportation Safety Agency, Traffic Safety Facts 2003 FARS/GES Annual Report, January 2005.

3.6.2. Lateral Collision Avoidance

3.6.2.1. Introduction

The Lateral Collision Avoidance (LCA) systems augment the driver’s ability to avoid collisions that arise when a vehicle leaves its own lane of travel while moving in a forward direction. Such collisions can involve one or multiple vehicles. These systems support the driver by providing warnings and/or assuming temporary control of the vehicle if a crash situation is imminent. Two types of subservices are associated with providing the LCA user service:

- Lane Change/Blind Spot Situation Display, Collision Warning, and Control
- Lane/Road Departure Warning and Control.

The user for this service, which may be applied in both urban and rural environments, is the vehicle driver. The LCA service relates directly to the goal of improving safety and the objectives of reducing the number and severity of accidents, as well as the number of fatalities and injuries. This service also relates indirectly to goals of enhancing productivity by reducing costs incurred by fleet operators and reducing costs to transportation dependent industries.

3.6.2.2. Needs

Lateral collisions are those resulting from a vehicle leaving, or attempting to leave, its own lane of travel while moving in a forward direction. Examples include collisions with fixed objects and lane change/merge (LCM) collisions. Together, these represent a significant highway safety problem. Preliminary estimates from 2003 data from the GES (General Estimates System) and FARS (Fatal Accident Reporting System) databases suggest that this category of collisions represents about 22% -- or almost 1.4 million -- of all vehicle collisions but about 34% -- or 13,000 -- of all motor vehicle fatalities in that year.

Recent studies suggest that in at least 75% of LCM collisions, the driver of the merging vehicle did not see the other vehicle until a collision with it was unavoidable. Ninety-five percent of LCM collisions are angle or sideswipe collisions, with the remainder being rear-end collisions. It is believed that a large portion of both collision with fixed objects and LCM incidents are amenable to reduction or even elimination by the application of ITS technologies.

3.6.2.3. Service Description

The Lateral Collision Avoidance service is specifically aimed at augmenting the vehicle operator’s ability to avoid collisions by first providing information, and second, if a crash situation is imminent, providing warnings and/or assuming temporary control of the vehicle. The service will produce a reduction in the number and severity of lateral collisions that occur.

- Lane Change/Blind Spot Situation Display Collision Warning and Control would provide information about the presence of vehicles in the driver’s blind spots, actively warn of potential collisions due to lane change or merging activities, and ultimately, assume temporary control of vehicle steering, braking and/or throttle actions to avoid collisions.
- Lane/Road Departure Warning and Control would assist in maintaining the vehicle in its proper lane of travel through driver warnings, advice on necessary actions, and eventually, assuming temporary control of vehicle steering and throttle to avoid a lane/road departure incident.

3.6.2.4. Operational Concepts

There are numerous and diverse causal factors involved in lateral collisions, depending on the specific situation and collision type. These factors include: driver intoxication, inattention or fatigue; slippery roads; excessive speed or reckless driving; blind spots in the driver's field of vision; evasive maneuvers to avoid another collision threat; and vehicle component failure. Given this situation, no single countermeasure concept can cover this multiplicity of potential causal factors.

Collision avoidance systems such as those in this user service category include the "three Ps" of "perceive, process and present".

3.6.2.4.1. Lane Change/Blind Snot Situation Display Collision Warning: and Control

The systems that provide this subservice incorporate three implementations or stages. At the first stage, drivers are continuously provided information about the presence of vehicles in the driver's blind spots (to the right-rear and left-rear sides of the vehicle). At the second stage, the driver is actively warned of potential collisions due to lane change or merging activities initiated by the vehicle upon which the sensor is mounted. This would be activated, for example, by the driver showing an intended lane change by using the turn signal. At the final stage, the system implements automatic control of vehicle systems such as acceleration, braking and steering.

One example of this type of system consists of a red light mounted inside the vehicle on the line of sight to the side view mirror. The light illuminates when another vehicle is in the driver's blind spot. Sensors will be primarily vehicle-autonomous, but may include exceptions such as transmitters on all vehicles that indicate when a lane change is being initiated or when a collision is imminent. Advanced versions of this system may include vehicle-to-vehicle communications, such as a vehicle about to change lanes issuing an electronic notification of that intent to adjacent vehicles.

3.6.2.4.2. Lane/Road Departure Warning and Control

Driver warning systems may indicate an impending road departure, based on road/lane edge detection capabilities. They may also provide advice on necessary actions. In addition, systems that provide partial control for lane keeping could include automatic control of the vehicle's steering, with manual override. In advanced versions of this capability, fully automatic lateral control of the vehicle's steering and throttle may be exerted to disallow dangerous movements from being made or to take evasive action to avoid making a dangerous maneuver. This capability would be a necessary component of any Automated Vehicle Operations system.

3.6.2.5. References

National Highway Transportation Safety Agency, Traffic Safety Facts 2003 FARS/GES Annual Report, January 2005.

3.6.3. Intersection Collision Avoidance

3.6.3.1. Introduction

The Intersection Collision Avoidance (ICA) user service systems will augment driver capabilities to avoid or decrease the severity of collisions that occur at intersections. The user for this service, which may be applied in both urban and rural environments, is the vehicle driver. The ICA service relates directly to the goal of improving safety and the objectives of reducing the number and severity of accidents, as well as the number of fatalities and injuries. This service also relates indirectly to goals of enhancing productivity by reducing costs incurred by fleet operators and reducing costs to transportation dependent industries.

3.6.3.2. Needs

The high number of both total and fatal incidents represented by intersection collision make this category a prime candidate for amelioration through the application of ITS technologies. According to data from the GES (General Estimates System) and FARS (Fatal Accident Reporting System) databases, intersection collisions (and intersection related collisions) are the second largest single category of collisions, representing almost 41% -- or over 2.5 million -- of all such crashes in 2003. Intersection collisions also accounted for almost 23% -- or 8,660 -- of all fatal collisions in that year. About 30% of these fatal incidents occurred at intersections with no traffic control device, such as a stop sign or signal light.

Two of the most common types of intersection collisions are straight crossing path (SCP) and crossing left turn (CLT). SCP collisions occur when two vehicles are both attempting simultaneously to pass straight through an intersection at right angles. In CLT incidents, one vehicle is attempting to turn left across the path of the second vehicle. The ICA service provides countermeasures to reduce both of these collision types.

3.6.3.3. Service Description

The intersection collision warning and control service is specifically aimed at providing vehicle operators with assistance in avoiding collisions at intersections. The situations addressed include those that arise when vehicles improperly violate the right-of-way of another vehicle, or when the right-of-way is not clear. The service will provide warnings of imminent collisions with crossing traffic, as well as warnings of stop control -- either a stop sign or a traffic signal -- in the intersection ahead.

There are many diverse causal factors involved in intersection collisions. Among the most common of these are driver inattention, failure to obey traffic control devices (red signal indications and stop signs), attempting to beat the yellow phase of traffic signals, proceeding against cross traffic due to faulty perception and obstructed view, and driver intoxication. A variety of countermeasures may be devised depending on both crash type (SCP, CLT or other) and intersection traffic control type (signalized, stop signs, and uncontrolled).

3.6.3.4. Operational Concepts

The function of this service is to track the position and state of vehicles within a defined area surrounding an intersection. The systems may involve infrastructure-to-vehicle and/or vehicle-to- vehicle communications. For example, if a vehicle is waiting to cross a high-speed roadway, the driver of the crossing vehicle could be alerted when there is high speed traffic approaching. In turn, once a vehicle begins crossing the intersection, the other vehicles could be warned and/or controlled to avoid a possible collision. One important operational approach is the Cooperative Intersection Collision Avoidance System, or CICAS. This system would include both vehicle-to-vehicle and vehicle-to-infrastructure links, incorporating both one-way and two-way communications. These communications technologies would provide various coverage zones and ranges. Several media can be used for this purpose, including spread spectrum, microwave, millimeter wave, and infrared.

A type of vehicle-based countermeasure for SCP collisions could utilize video and digital image processing to recognize traffic signs and signals and advise or warn the driver to stop the vehicle before it encroaches into the intersection in an unsafe manner. This concept could be integrated with the In-Vehicle Signing subservice, which is part of the En Route Driver Information user service (Section 3.1.2). In addition, several systems developed primarily for other collision categories, such as head-on collision warning and control , may also be useful in intersection collision situations. For additional information on HDS, please refer to Longitudinal Collision Avoidance (see Section 3.6.1).

3.6.3.5. References

National Highway Transportation Safety Agency, Traffic Safety Facts 2003 FARS/GES Annual Report, January 2005.

3.6.4. Vision Enhancement for Crash Avoidance

3.6.4.1. Introduction

The Vision Enhancement for Crash Avoidance user service will reduce the number and severity of collisions in which impaired or reduced visibility is a causal factor. Systems that provide this service will augment visually-acquired information in situations where driving visibility is low (such as night or foggy conditions). This service does not deal with overcoming obstructions to visibility or blind spots caused by the vehicle's body, and it does not deal with conspicuity enhancement of roadways or objects. The Longitudinal, Lateral and Intersection Collision Avoidance user services address other approaches to collision avoidance (see Sections 3.6.1, 3.6.2, and 3.6.3).

The user for this service, which may be applied in both urban and rural environments, is the vehicle driver. This user service relates directly to the goal of improving safety and the objectives of reducing the number and severity of accidents, as well as the number of fatalities and injuries. This service also relates indirectly to goals of enhancing productivity by reducing costs incurred by fleet operators and reducing costs to transportation dependent industries.

3.6.4.2. Needs

According to preliminary estimates based on 2003 data from the Fatal Accident Reporting System (FARS) and General Estimates System (GES) databases, approximately 738,000 collisions, or 12% of all collisions in that year, occurred during dark (unlighted) conditions. However, a much higher proportion of fatal collisions – 11,326 out of 38,252, or 30% -- occurred in these conditions. Nearly two thirds of all pedestrian fatalities -- 3,062 out of 4,749 in 2003 -- occurred between the hours of 6 pm and 6 am. The high level of fatalities associated with this category of collisions represents a significant highway safety problem.

3.6.4.3. Service Description

The Vision Enhancement for Crash Avoidance user service can reduce the number of vehicle crashes that occur during periods of poor visibility. The focus of this effort is on systems that can improve the ability of the driver to perceive the roadway itself and objects on and along the roadway. This improved visibility would allow the driver to avoid potential collisions with other vehicles, fences and railings, pedestrians, wildlife and livestock, or obstacles in the line of travel; and would assist the driver in complying with traffic signals and signs.

3.6.4.4. Operational Concepts

This service would be implemented through in-vehicle sensors capable of imaging the outside scene and producing a graphical display of the image, perhaps through a Head-Up Display that overlays the image on the out-the-windshield view. Both active and passive technologies may be applied to improve the driver's perceptual abilities during inclement weather or unlit conditions by transforming detected energies into a visual display that the driver can observe. Passive systems detect energy radiated by all objects without any system-generated illumination. For instance, passive far infrared (FIR) systems form images of the environment based on identifying differences in thermal energy intensity emanating from different objects. Passive millimeter-wave systems construct images based on an object's natural emissions at millimeter-wave frequencies, independent of light conditions. Active detection systems, on the other hand, need to illuminate the environment in order to obtain images of obstacles based on their reflection of the emitted energy. For example, active radar and laser radar (also known as lidar or light detection and ranging) can be used to form images by scanning the environment in both the azimuth and elevation directions. In addition, regular charge-coupled device (CCD) cameras may be employed for visual enhancement when an external light source is used to extend their visibility band.

3.6.4.5. References

National Highway Transportation Safety Agency, Traffic Safety Facts 2003 FARS/GES Annual Report, January 2005.

3.6.5. Safety Readiness

3.6.5.1. Introduction

The Safety Readiness user service will reduce the number and severity of collisions caused by impaired drivers, vehicle component failures, or degraded infrastructure conditions. Systems that provide this service warn about driver, vehicle or infrastructure conditions based on monitoring by in-vehicle equipment. This user service consists of three subservices:

- Impaired Driver Warning and Control Override,
- Vehicle Condition Warning, and
- In-Vehicle Infrastructure Condition Warning.

Warnings about infrastructure conditions derived from sensors or manual inputs from outside the vehicle are provided by the In-Vehicle Signing subservice of the En-Route Driver Information user service.

The user of this service, which is applicable in both urban and rural areas, is the vehicle driver. The Safety Readiness user service directly addresses the goals and objectives of improved safety by reducing injuries and fatalities, reducing the number of impaired drivers, and reducing the number and severity of accidents.

3.6.5.2. Needs

According to preliminary estimates based on 2003 data from the General Estimates System (GES) and Fatal Accident Reporting System (FARS) databases, in 2.7% of fatal accidents the precipitate cause was driver condition of drowsy, asleep, fatigued, ill, or blackout. However, a much higher proportion of motor vehicle fatalities -- 34%, or just above 14,600 -- involved a driver or other party (i.e., a struck pedestrian) with a blood alcohol level of more than 0.08 grams per deciliter (g/dl), which is considered the legal level of intoxication in most states. More than 32% -- or nearly 8,500 -- of all driver fatalities, and 46% of those between the ages of 21 and 34, had this or a higher blood alcohol level. Thus, it is obvious that impaired drivers -- particularly those under the influence of alcohol -- represent a significant highway safety threat. These accidents tend to occur at night, in non-urban areas with high (55 to 65 MPH) speed limits. The majority of these collisions are single vehicle roadway departures.

Failure of vehicle components is also a contributing factor to collisions. The GES and FARS databases do not report data on this any more, but in older surveys component failures accounted for about 4 % of all fatalities. The two most common component failures were brakes and tires. A high proportion of collisions occur on wet, icy or snowy road surfaces. More than 15% of all crashes in 2003 (or about 950,000), and 10% of all collisions fatalities (or about 3,800), occurred in such conditions.

3.6.5.3. Service Description

The systems which implement this service provide drivers with warnings regarding their own driving performance, the condition of the vehicle, and the condition of the roadway as sensed from the vehicle. At the more complex level, Safety Readiness systems will also include the ability to assume temporary, partial control of the vehicle in situations deemed to be highly hazardous.

Impaired Driver Warning and Control Override systems monitor driver performance features and either warn of impaired driver condition or take temporary control of the vehicle to prevent or discourage continued driving under such circumstances.

Vehicle Condition Warning systems monitor the performance of components, such as tires and brakes, whose degradation could have a significant impact on the safe operation of the vehicle, and warn of their imminent failure. In-Vehicle Infrastructure Condition Warning systems detect and warn the driver of unsafe conditions on the roadway or bridge infrastructure, such as the presence of ice or water.

3.6.5.4. Operational Concepts

Each of the systems that will provide the Safety Readiness service typically include three functions, sometimes described as the “three Ps” -- perceiving, processing, and presentation. These functions are for sensing critical information about the performance of the driver or vehicle or the condition of the infrastructure; processing that information into a form which is useable by the driver or an automatic controller; and presenting this information to the driver (or directly to the vehicle) in a manner which elicits appropriate action. In systems where partial automatic action is taken by a controller, it will be necessary to ensure that these actions are compatible with vehicle and driver capabilities and limitations. It is also important that the system be self-diagnosing, in order to limit the negative impact of system failures. Some in-vehicle infrastructure condition warning systems concepts also incorporate either one-way or two-way communications capabilities from the vehicle to the infrastructure and/or another vehicle.

3.6.5.4.1. Impaired Driver Warning and Control Override

These systems would monitor various driver performance features for indications that the driver may not be in a condition to continue operating the vehicle safely. If such a situation were detected, the driver could be warned of his/her impaired condition, or temporary control over the vehicle could be exercised to prevent or discourage continued driving. One possible method would be to utilize various ‘shut-down’ features that would render the vehicle temporarily inoperable until the operator is able to resume driving safely.

Research suggests that there are certain driver performance and psychophysiological characteristics that indicate the possibility of imminent unsafe driving behavior due to drowsiness or impairment. In most cases, drowsy drivers exhibit symptoms of that condition for periods of time before their driving abilities are noticeably impaired.

Significant research is currently underway to identify and understand these symptoms. Among the performance features being studied are: abrupt and unnecessary lateral vehicle lane changes, changes to the use of accelerator and brake pedals, and erratic driver seat shifting and steering movements, often called “drift-and-jerk” steering. Psychophysiological features being researched include: heart and respiratory rates, electrodermal activity, eye closure (blink rate), and head nodding. An Impaired Driver Warning and Control Override system that could monitor driver behavior and detect preliminary symptoms such as these, and then either warn the driver or render the vehicle inoperable until the symptoms dissipated, would offer obvious and substantial safety benefits.

3.6.5.4.2. Vehicle Condition Warning

Most modern motor vehicles already have a significant number of component and systems monitoring features -- oil pressure and level, engine temperature, brake pad thickness, alternator level, and so on. Vehicle Condition Warning systems would extend this internal monitoring capability to additional components with a specific safety aspect, such as tire pressure or brake temperature. This capability could also be expanded to alerting other nearby vehicles of a breakdown on the roadway through an extension of the Emergency Notification and Personal Security user service (Section 3.5.1), in which the disabled vehicle transmits a message to nearby emergency services centers. Conceivably, this same information could also be broadcast locally by the affected vehicle for reception by other vehicles in the immediate vicinity, so that collisions with the disabled vehicle could be avoided.

3.6.5.4.3. In-Vehicle Infrastructure Condition Warning

There are a number of potentially unsafe infrastructure conditions that could contribute to an accident. Among the most dangerous of these conditions is the loss of tire traction due to water or ice on pavement or bridges. These In-Vehicle Infrastructure Condition Warning systems would monitor the roadway from the moving vehicle and provide warnings to the driver of the presence of such unsafe conditions. The capability for equipment on the vehicle to receive warnings from infrastructure-based components -- as opposed to vehicle-mounted systems -- that monitor roadway conditions is provided by the En-Route Driver Information service.

An approach to implementing one aspect of this subservice is to exploit the existing traction control systems (TCSs) that are often integrated into anti-lock braking systems (ABS). The purpose of TCS, which is also known as an antiwheel spin regulation (ASR) system, is to deter the loss of vehicle traction due to excessive wheel spin which can occur when the vehicle is traveling on a slippery roadway. Wet or slick roadway surfaces, when combined with extreme roadway geometry such as sharp or inadequately banked curves, can be very hazardous. Using these systems to recommend a lower speed at a sufficient distance in advance of these conditions may prevent many of these crashes.

3.6.5.5. References

National Highway Transportation Safety Agency, Traffic Safety Facts 2002 FARS/GES Annual Report, January 2004.

3.6.6. Pre-Crash Restraint Deployment

3.6.6.1. Introduction

The Pre-Crash Restraint Deployment user service provides a means to anticipate an imminent collision and to activate passenger safety systems prior to actual impact, or earlier after crash onset than is currently feasible. The equipment implementing this user service is contained entirely within the protected vehicle. The user for this service is the vehicle driver and passenger. This user service relates directly to the goals of improving safety by reducing injuries and fatalities resulting from vehicle accidents.

3.6.6.2. Needs

Today's vehicle restraint and passenger safety systems -- including seat belts, air bags and rollover bars -- undoubtedly protect thousands of vehicle occupants each year from death or serious injury during a collision. NCSA has estimated that in 2002 alone, 14,164 lives were saved by the use of seat belts and 2,248 lives were saved by air bags. However, these systems are not perfect. For example air bags are occasionally deployed in relatively minor crashes in which lap-shoulder belt restraints alone would provide sufficient protection. The air bag deployment process itself is quite aggressive, involving the controlled explosion of a pyrotechnical device, the rapid splitting and pushing aside of the cover, and the inflation of the air bag itself directly at the vehicle occupant. Injuries or even death, have in fact occurred as a consequence of this process, especially when the occupant is closer than normal to the air bag at the time of deployment. This can happen, for example, when the occupant is sitting or leaning closer to the dashboard, or is shorter than average in height.

In addition to the potential for injury during deployment, until recently air bag systems are designed to be responsive primarily to longitudinal frontal collisions. In the past couple years individual side airbags and side airbag curtains have been introduced to better protect occupants from side-impact crashes. Ideally, any passenger safety system protecting against either longitudinal or side impacts should be able to anticipate or sense an imminent collision, determine whether the collision will be of a sufficient force to require deployment of a safety system, and begin the process of deploying the appropriate safety system prior to actual impact, or at least earlier in the crash event than is currently technologically feasible.

3.6.6.3. Service Description

The Pre-Crash Restraint Deployment service will reduce the number and severity of injuries caused by vehicle collisions. This is accomplished by developing means both to anticipate an imminent collision and to activate passenger safety systems prior to the actual impact, or earlier after crash onset than is currently feasible. These safety systems would be more effective if their deployment were based on information such as details of an imminent collision situation (velocity, mass and direction of the vehicle being hit and the vehicle or object it is hitting); and the number, location and major physical characteristics of the vehicle occupants.

3.6.6.4. Operational Concepts

Current passenger safety systems are designed to assess the severity of an impact after the onset of the crash, and determine whether a deployment of the safety feature (air bag inflation, belt tightening or rollbar deployment) is warranted. However, the most potentially injurious rate of vehicle crush is experienced during this initial stage of impact. If the occupant could be restrained to the passenger compartment structure before this early crush occurred, the crush loading on the occupant would in turn be significantly reduced.

Pre-Crash Restraint Deployment systems would use sensors capable of detecting the rapid closing of distance between the vehicle itself and other vehicles or objects presenting a collision threat before an actual impact occurs. This information would allow the appropriate safety system deployment to be initiated earlier in the period of fastest vehicle crush.

Early deployment is particularly important for side impact collisions, since most passenger vehicles lack sufficient structural strength or buffer space on the sides to absorb or dissipate the initial force of the impact. In the case of air bags, adequate pre-impact sensing could also enable the system to select the optimum gas pressure to use during deployment. Accurate information about the physical characteristics of vehicle occupants (seat location, weight, height and age) would also assist in selecting the appropriate safety system response.

Most Pre-Crash Restraint Deployment systems will include two phases. The first, or sensing, phase will gather appropriate information concerning the imminence of collision or rollover events from the driving environment. The second, or processing, phase will process this information and initiate the appropriate passenger safety system response when warranted. Responses could include tightening of lap-shoulder belts, arming and/or deployment of air bags, or deployment of rollbars.

3.6.7. Automated Vehicle Operations

3.6.7.1. Introduction

The Automated Vehicle Operations (AVO) user service describes the vehicle-roadway system that will substantially improve the safety and efficiency of highway travel, greatly enhance driver comfort, and help reduce air pollution. This will be achieved by moving suitably equipped vehicles under fully automated control (i.e., hands-off and feet-off operation) along dedicated highway lanes. The AVO interacts with a number of other user services including Longitudinal Collision Avoidance, Lateral Collision Avoidance, and Safety-Readiness. This service incorporates the ideas and concepts of the Automated Highway System, the research program that completed with its successful concept demonstration in 1997. AVO has a direct impact on several ITS goals and objectives including increased safety and efficiency.

3.6.7.2. Needs

Automated vehicle-highway systems offer the potential for a major breakthrough in the performance and safety of the nation's highways. Research has shown conceptually that an automated system has the potential to provide safe, dependable, highly efficient movement of vehicles on our nation's roadways. Specific examples of potential societal benefits that could be derived include the following:

- <u>Reduce the number and severity of crashes</u> Highway accidents cost this nation an estimated $230.6 billion in 2000 (according to the NHTSA's Traffic Safety Facts). Over 90 percent of all crashes are either directly caused, or contributed to, by human error. The AVO systems will be accident free in the absence of malfunctions because human errors will be eliminated; when AVO malfunctions do occur, crashes will be avoided and/or their severity will be minimized.

- Decrease congestion The vast majority of urban Interstate rush hour traffic is in congestion. This congestion costs the U.S. over $100 billion in lost productivity per year. AVO can significantly reduce congestion by moving vehicles more efficiently over the same highway right-of-way. Researchers estimate that AVO can increase vehicle-per-hour lane capacity by 200 to 300 percent, and provide more predictable travel times to commercial and private users.
- Reduce vehicle emissions and fossil fuel consumption The AVO can reduce both by moving vehicles more efficiently (i.e., less accelerating and decelerating) and by reducing idling in traffic jams.
- Enhance operation of multiple occupant vehicles AVO can substantially enhance the operation of non-rural transit operations, including buses, urban rapid transit systems, and multiple passenger private vehicles. AVO will improve service by providing (1) safety and efficiency of travel; (2) more predicable travel times; (3) enhancement of dedicated lane operation; and (4) support of congestion pricing of single occupancy vehicles.

3.6.7.3. Service Description

The long range goal is to develop a practical, affordable, user-friendly, fully automated vehicle-highway system in which instrumented vehicles operate on instrumented roadways without operator intervention. This section describes the service and how the nation's highway and vehicle industry may evolve to it.

The target system for providing this service is a fully automated vehicle operations system. Drivers will enter an AVO lane through a check-in area where the AVO system will 1) check the worthiness of the vehicle and driver, 2) accept or reject vehicles for operation in the AVO lanes, and 3) divert disapproved vehicles back to the non-AVO lanes or assume control of approved vehicles. The AVO system assumes control of an approved vehicle and moves it onto an AVO lane, merging it with the other automated vehicle traffic. Vehicles are moved as part of the traffic flow; and when the destination exit is reached, the system moves the vehicle to an off-ramp where control is returned to the driver after the driver's ability to resume control has been demonstrated.

The AVO target performance specifications in key areas include the following:

- Safety - Improve safety through collision free operation in the absence of malfunctions, and a malfunction management capability that minimizes the number and severity of collisions that occur as a result of AVO malfunctions
- Efficiency - Decrease congestion in a traffic corridor by significantly increasing the efficiency with which today's highway right-of-ways are used by (1) increasing traffic density and speed of AVO lanes because of faster system reaction times, (2) eliminating traffic flow variances caused by humans such as uneven performance, weaving and distractions; (3) managing entries and exits so that AVO lanes maintain optimum speed and spacing in heavy demand traffic; and (4) increasing the number of traffic lanes possible on the highway right-of-way.

- All-weather operation - The operational capability of the AVO system must meet or exceed that of an un-instrumented vehicle and driver on the roadways for complete range of weather conditions that are typical in the continental U.S.
- Level of Service - provide a full range of dependable service to passenger vehicles, heavy commercial vehicles, and transit vehicles (not necessarily intermixed) in both urban and rural environments as an integrated part of a community's transportation system.
- More user comfort - reduce the strain on drivers, provide trust in the system
- Fossil fuel consumption and emissions - reduce fuel consumption and emissions per vehicle mile traveled by reducing delay.

3.6.7.4. Operational Concepts

The AVO system assumes fully automated control of vehicles as they travel on instrumented and/or specially designated highways. The AVO target system characteristics and assumptions include the following:

- The AVO system must be practical, affordable and/or cost-effective, desirable and user-friendly
- AVO lanes will have freeway-type design characteristics. AVO operation must be consistent with the continued efficient operation of near-by non-AVO traffic.
- Vehicles will contain instrumentation that will allow their fully automated operation on instrumented segments of roadway
- Vehicles will be "dual mode";
  - Instrumented vehicles will be able to operate on regular (non-AVO) roadways and use the AVO instrumentation for collision avoidance and/or lane-keeping
  - Only instrumented vehicles will be allowed to operate on AVO lanes
  - Future vehicles may be instrumented on a retrofit basis
- The AVO system may be a cooperative system, incorporating vehicle-infrastructure and vehicle-vehicle communications for a number of functions including vehicle check in, and longitudinal and lateral vehicle control.
- Vehicles will have on-board status systems that will continually sense the condition of components of the vehicle that are critical for automated vehicle operation. Some of this assurance may come from periodic inspections at local service stations, and/or state inspection stations.

There are many different concepts for AVO systems. Below, one concept is interpreted to give the reader a sense of how the AVO system would appear to a driver of a vehicle. It is recognized that there are other concepts of automated vehicle operations; this one was selected for illustrative purposes only.

3.6.7.4.1. Acquiring a Vehicle

Drivers will choose to purchase one of three AVO classes of new or used vehicles:

- AVO-Certified Vehicles - The vehicle fully meets the AVO specifications
- AVO-Capable Vehicles - The vehicle is capable of being upgraded to fully meet the AVO performance specification
- Non-AVO Vehicles - The basic vehicle is not reasonably capable of being upgraded to meet the AVO specifications.

Drivers that acquire an AVO-certified vehicle may need to have a special electronic drivers permit that (1) shows that the driver has been trained to use the AVO system, and (2) that he or she meets other requirements, including an adequate safety and licensing record. Automated vehicles should be easy and simple to use, however, drivers may need to be aware of safety, emergency or other special procedures. Perhaps the vehicle's AVO capabilities are not enabled unless a qualified AVO electronic license is entered into the on-board system.

3.6.7.4.2. Using the System

As a driver approaches a freeway that includes one or more AVO designated lanes, he or she may choose to either drive on the non-AVO lanes or on the AVO lanes. If the driver chooses the AVO lanes, the vehicle will give the driver a GO or NO-GO indication that reflects the status of the vehicle's present ability to operate on the AVO system. This assumes that the vehicle has an on-board status system that continually senses components of the vehicle that are critical for automated vehicle operation. All of the vehicle's on-board status sensors will need to be positive to get the GO indication.

When the GO indication is given, the driver will enter his desired destination into the system by voice, if driving, or by touch-pad if the vehicle is stopped. For commuters, the destination may be pre-determined and the driver need only confirm it. In doing this, the driver may be told that there is insufficient fuel, and disallow AVO system entry. If allowed, the driver will then drive the vehicle into an AVO-only check-in lane where the vehicle's (and perhaps the driver's) AVO worthiness will be verified by the infrastructure through communications between the infrastructure and the vehicle, preferably while the vehicle is moving at normal speed. Some of this assurance may come from periodic inspections at local service stations, and/or state inspections. If the vehicle is not approved, it will be diverted back to the non-AVO lanes. The diversion may be through signing (i.e., arrows and lights) or conceivably through the use of perceived barriers that would discourage a rejected driver from proceeding onto the instrumented lane.

If approved, the AVO system assumes control of the vehicle in the check-in lane, moves the vehicle onto one of the AVO lanes, and merges it with the other traffic. Once in the AVO lane, the system will manage the vehicle individually (throttle, brakes, transmission, steering and lights) and as part of the traffic flow. Depending on how the system is designed, it may pass slower moving traffic (e.g., commercial vehicles or buses). When the destination exit is reached, the system will move the vehicle to an off-ramp where the driver's ability to resume control of the vehicle will be tested before control is returned.

While in the AVO system, the driver will have a smooth, safe ride. The driver may be able to relax, work, read a book; or may choose to act as a "supervisor". As a supervisor, the driver would receive information on traffic and on the vehicle performance, and would be able to enter data into the system such as spacing from the vehicle in front, preferred lane of travel, change of exit, and "sensed" information such as "engine running rough" or "caution, bad weather approaching." The driver does need to remain alert and be prepared to resume control when exiting the system. In extreme cases of malfunction it is conceivable that the AVO system may bring all vehicles to a stop. In that case, it is possible that the driver may need to resume manual control of the vehicle to exit from the AVO lane under police supervision.

3.6.7.4.3. Transition

A major concern in transitioning to automated vehicle operations is that there must be sufficient "market penetration"; that is, a given area must have sufficient vehicles that are instrumented, sufficient highways upon which the instrumented vehicles could operate, and sufficient number of drivers that desire to use the service. Specific transition strategies will need to be developed that address each of these areas, particularly the operational test and evaluation phase. Below, each of the three areas is discussed.

- Vehicle Transition - It is envisioned that full automated vehicle operation will be achieved progressively; that is, progressively automated collision avoidance and vehicle control services will probably be offered prior to a full AVO system so that when the first dedicated AVO lanes are installed and the first fully automated service is offered, many of the vehicles will have instrumentation that will require little or no enhancement to be AVO-compliant. For example, many vehicles may have instrumentation for services such as Advanced Cruise Control (ACC), and integrated longitudinal and lateral collision avoidance. These services require sensors, processors, and electronic actuators that should be upward-compatible to automated vehicle operations. These services will continue to have value on non-instrumented roadways. For example, as a vehicle leaves an urban AVO system, it could move onto a rural non-instrumented roadway where the ACC services resume control, and vice-versa.

  Early use of ITS technologies for transit use seems to offer benefits. In congested urban settings, tight ITS operation tolerances will allow narrow guideways and accurate positioning of terminals for buses. Inside of the city, the buses can operate on dedicated AVO transit lanes, or on non-AVO equipped roadways to service the passengers.

- Highway Transition - Infrastructure capable of supporting AVO will develop as part of our nation's highway transportation system. It is believed that initial AVO lane deployments are likely to be on heavily traveled urban highway segments where there is a high need; the AVO lanes may be separately accessed as are the High Occupancy Vehicle (HOV) lanes on some of today's highways and, in fact, may be HOV lanes themselves. Special lanes for transit vehicles could be established as an early step in transition. Similarly, separate lanes for heavy commercial vehicles may be possible. Rural AVO systems may be less complex that urban AVO systems, but can provide valuable inter-city travel links.

At some point after AVO performance specifications are established, the highway community will develop standards in coordination with the U.S. DOT and other standards bodies for instrumentation of highways required to support automated vehicle operations. Doing this early could somewhat reduce the transition costs in the future. Additionally, some roadway lanes may have passive or active instrumentation placed on them for lateral collision avoidance and lane keeping purposes. With some preplanning, these enhancements might be easily upgraded for AVO use.

AVO systems are a tool to be used by transportation planners in developing their state transportation plans. AVO has many benefits that will help the planners meet the goals of ISTEA, the Clean Air Act, and the Americans with Disability Act. Thus, the first AVO implementations will be compatible with these acts and will be an integrated part of the states' transportation plans. Phased implementations are likely. For example, it is possible that some highway lanes may be time-shared between normal traffic and AVO traffic; for example, at rush hours, the lanes could be AVO only, while during normal hours all traffic could use the lanes. It is conceivable that AVO lanes could also be reversible.

- User Transition

  User transition concerns are two-fold--user acceptance and economics. By the time AVO becomes operational, many drivers will be accustomed to other AVSS services. The next step to AVO should not seem so large to those drivers.

The economics of AVO systems is of key importance. If users must pay for the service either in purchasing an instrumented vehicle, or in tolls for the special roadway, then they must be convinced that the AVO service is cost-effective, safer and more convenient. Commercial users will quickly switch if there are savings. Transit operators may move to AVO for the improved services. The initial investment in the vehicle instrumentation will need to be reasonable enough that the user can see a rapid return on the investment or feel good about the cost of the extra service. For example, if the AVO system is in fact accident-free except when there is a malfunction, then insurance rates for the AVO equipped vehicles should be substantially less, and the driver will feel safer and more comfortable in highway travel Initial government incentives may also be considered.

3.6.7.5. References

National Highway Transportation Safety Agency, Traffic Safety Facts 2003 FARS/GES Annual Report, January 2005.

3.7. Information Management

3.7.1. Archived Data

3.7.1.1. Introduction

The Archived Data user service (ADUS) describes the need for an ITS historical data archive and expands the National ITS Architecture to encompass the needs of the stakeholder groups of this user service. ADUS requires ITS-related systems to have the capability to receive, collect, and archive ITS-generated operational data for historical, secondary, and nonreal-time uses. ADUS prescribes the need for a data source for external user interfaces and provides data products to users. The goal is the unambiguous interchange and reuse of data and information throughout all functional areas.

ITS technologies generate massive amounts of operational data that are presently used primarily in real-time to effect traffic control strategies. Examples include the adjustment of ramp meter timing based on freeway flow conditions and the use of dynamic message signs to communicate traffic incidents to travelers. These data offer great promise for uses beyond the execution of ITS control strategies, such as applications in transportation administration, policy, safety, planning, operations, and research. In most cases, ITS-generated data are similar to data traditionally collected for these applications, but are much more voluminous in quantity and geographical and temporal coverage. ITS has the potential to provide data needed for planning, performance monitoring, program assessment, policy evaluation, and other transportation activities, including multimodal and intermodal applications. This user service describes the need for the collection, manipulation, retention, and distribution of data generated by ITS for use in other transportation activities.

3.7.1.2. Needs

All ITS historical and nonreal-time data should be capable of being stored, disseminated, and/or manipulated to support users with pre-defined data products. These data include, but are not limited to the following categories: (1) freeway data, (2) toll data, (3) arterial (nonfreeway) data, (4) parking management data, (5) transit and ridesharing data, (6) incident management data, (7) safety-related data, (8) commercial vehicle operations data, (9) environmental and weather data, (10) vehicle and passenger information data, and (11) intermodal operations data.

There is a broad spectrum of users who must rely on any and all available sources of data to feed the applicable planning models, simulations, and control strategies. The users' needs for the data are outlined below:

<u>Metropolitan Planning Organization (MPO) and State Transportation Planning:</u> Short- and long-range identification of transportation improvements and policies.

<u>Transportation System Monitoring:</u> Collection and analysis of transportation data for use by policy-making at all levels of government and other customers for policy analysis, performance monitoring, and investment analysis.

Traffic Management: Day-to-day operation of deployed ITS; e.g., traffic signal control systems.

Transit Management: Day-to-day operation of a transit agency, including scheduling, route delineation, origin-destination surveys, passenger counts, fare pricing, vehicle maintenance, evaluation, and capital planning.

Air Quality Analysis: Regional air quality monitoring, and transportation plan conformity with air quality standards and goals.

MPO/State Freight and Intermodal Planning: Planning for intermodal freight transfer, goods movement, and port facilities.

Safety: Identifying countermeasures for general safety problems or hotspots; automated collision notification; delivery of emergency medical services; automated crash investigation data entry; deployment planning for incident response; hazardous site identification.

Design, Construction, & Maintenance: Planning for the rehabilitation and replacement of pavements, bridges, and roadside appurtenances and the scheduling of maintenance activities.

Transportation Research: Development of forecasting and simulation models and other analytic methods and improvements in data collection practices.

Commercial Vehicle Operations: Crash investigations; enforcement of commercial vehicle regulations, and HAZMAT response.

Emergency Management (local police, fire, and emergency medical): Response planning to transportation incidents, crash investigations, and patrol planning.

Private Sector: Provision of traffic condition data and route guidance; commercial trip planning to avoid congestion; and vehicle design.

Land Use Regulation and Growth Management: Development of land use plans and zoning regulations; establishment of growth impact policies; and community economic development.

3.7.1.3. Service Description

This user service will provide an ITS historical data archive for all relevant ITS data and will incorporate the planning, safety, operations, and research communities into ITS. It will provide the data collection, manipulation, and dissemination functions of these groups, as they relate to data generated by ITS.

An example from transportation planning will illustrate the use of this service. (Many such example applications also exist for the other stakeholder groups.) AADTs (i.e., Annual Average Daily Traffic, the daily traffic count estimates for a highway) are one of the most essential data types used by planners and engineers. Nearly all AADTs used by planners are estimates based on 24- or 48-hour short counts that have been adjusted using areawide factors for daily and seasonal variability. Facility-specific data on the temporal distribution of traffic and its variability are extremely limited. ITS roadway surveillance equipment can provide detailed data on the actual average daily traffic and its variability.

ITS data, as source data, would improve the accuracy and usefulness of the core performance measures used by transportation planners. ITS data will also allow for direct measurement of congestion and permit separation of the recurring and nonrecurring components of congestion.

More detailed data will be required as the management paradigm becomes more widespread. Travel Demand Forecasting (TDF) models for predicting long-term demand characteristics (20-years into the future) use average values -- basically, one wants to make decisions about adding capacity to the nearest additional lane of accuracy (i.e., 2,200-2,300 vehicles per hour). Average peak hour traffic counts are precise enough for this purpose. However, for meeting the newer planning requirements which tend to be more short-range in nature -- such as congestion monitoring and microscale air quality modeling -- information on extreme events is important. ITS roadway surveillance data would directly measure congestion, including days with abnormally high volumes and incidents.

The information obtained from ITS sources in the above example is also valuable in a multimodal context. In addition to the highway surveillance data mentioned above, ITS technologies can also capture information about the movements of transit passengers and the performance of transit systems. When the highway and transit data are fused, effective multimodal planning, such as designing transportation strategies for key corridors, can be achieved. Further, because the data are collected constantly, a continuous multimodal performance evaluation program can be implemented. Such an effort would greatly aid transportation and transit planners in fulfilling Federal requirements and meeting local needs.

It is also possible to extend this example into the realm of traffic operations. Although ITS generally uses real-time data to implement control patterns, nonreal-time data can also be of use. Consider that ramp metering is also present for the hypothetical freeway segment mentioned above. The metering rates are generally pre-timed, actuated by mainline traffic flow, or a combination of the two. In the pre-timed case, data on historical volume and congestion patterns can be used to set metering rates by time of day. In advanced systems that are proactive (i.e., they predict traffic conditions in the very near future), historical patterns can be used in predictive algorithms. Finally, historical ramp metering rates and freeway traffic conditions are valuable to operators of traffic signal control systems in that pre-timed or proactive timing plans can be developed with that data. From an archival viewpoint, the needs of operators would tend to be more short-term (what happened yesterday or last week) than those of transportation planners.

The functionality of ADUS will be increased if opportunities for data fusion are pursued. The value of certain ITS-generated data is enhanced if additional information is added from other sources. One example is in the safety area. While locations of crashes (in terms of geo-coordinates) can be provided with high precision, safety agencies are concerned with matching crash locations with highway geometric features. This matching involves fusing the crash location data with other data (e.g., roadway characteristics inventories) and requires a common referencing system. Another example of data fusion potential is the collection of travel activity data. Traveler location data (such as those from automatic vehicle identification technologies) can identify where travelers are in time and space, again in terms of geo-coordinates. However, transportation planning agencies need to identify the origins, destinations, and lengths of trips by purpose of the trip. As the sophistication of systems and level of ITS deployment expands in the future, it may be possible to merge the location data with land use data, thereby inferring the type of trip without encumbering the traveler with an extra task.

3.7.1.4. Operational Concepts

The basic function for ADUS is to provide an ITS historical data archive and to integrate user functional needs for data.

The systems to support ADUS should be based on, but not limited to, existing data flows within the National ITS Architecture. As new data flows are added to the National ITS Architecture -- and as additional uses of existing data flows are identified -- they should be examined for their inclusion within the systems to support ADUS. The systems should also be flexible enough to accommodate data flows unique to individual ITS deployments that may not warrant a change to the National ITS Architecture. They should also be capable of handling data from existing data collection programs that may not be deemed as being in the ITS realm.

To accommodate both existing (legacy) transportation systems and the incremental deployment of new ITS, the information management systems which support data archiving may utilize one of two concepts, or a hybrid of these:

a. Decentralized - Each ITS facility possesses its own archiving function with a minimum of interconnects with other ITS facilities but utilizing standardized data definitions.

b. Centralized - Relevant data from each ITS subsystem may be captured in a central repository either directly or "virtually" through the use of appropriate distributed technologies and standards.

The following functions should be implemented to support ADUS system deployment:

a. Data Processing: the receipt and processing of incoming data from other ITS functions. ADUS should have the ability to store data, accommodate levels of aggregation and reduction, sample raw data for permanent storage, apply quality control procedures, distinguish between unprocessed, edited, aggregated and transformed data. Data processing functions may be assigned to different personnel. For example, data quality control and editing may be assigned to the group or agency responsible for the initial data collection. Subsequent data reduction may be assigned to personnel other than the original collectors of the data.

b. Data Storage: both online and offline storage of raw and processed data. Original, unaltered data must always be preserved in the master archive for some minimum amount of time. User-defined data manipulation should only be processed from copies of the master archives (e.g., editing, formatting, aggregation, reduction, or fusion of data) and preparation of data will be processed and archived for designated users separately from the master archives. ADUS should include specifications of detailed metadata and meta-attributes about the data stored in the archive. Metadata and meta-attributes should provide a complete description of the data in terms of standard data dictionary characteristics as well as providing analysts an indication of collection and sampling conditions, variability, quality control procedures, edits, and transformations. ADUS should encompass a common location referencing system for linking data elements in the archive.

c. Data Retrieval: provides the interface between the data repository and users.

Permanent or temporary storage of data within the systems to support ADUS should preclude the possibility of identifying or tracking either individual citizens or private firms and should follow the ITS Privacy Principles developed by ITS America ("Fair Information and Privacy Principles"). This means that even in the case where unprocessed data (i.e., data received directly from collection sources) are archived, privacy principles should be strictly followed. Identifiers of individual citizens or private firms should be stripped from all data before archiving unless full disclosure of the intended use is made and informed consent is obtained. Unique system-developed identifiers that do not allow identification of individual citizens or private firms may be assigned to stored data.

3.8. Maintenance and Construction Management

3.8.1. Maintenance and Construction Operations

3.8.1.1. Introduction

The key Maintenance and Construction Operations (MCO) activities include monitoring, operating, maintaining, improving, and managing the physical condition of the roadway, associated infrastructure equipment on the roadway, and the available resources necessary to conduct these activities. The functional areas addressed in the MCO user service are those that involve ITS technologies, integration with other transportation systems that are represented in the National ITS Architecture, and those that will benefit surface transportation efficiency and safety.

The MCO user service seeks to address selected maintenance and construction operations, particularly as the use of various ITS and technologies (e.g., graphical information systems, automation, robotics, computer-aided dispatching, etc.) become more commonplace. As ITS and other sensing and information systems are added to current maintenance and construction procedures, they can also provide detailed data of value to enhance traffic management, traveler information, fleet management, and planning activities.

The MCO user service requires ITS-related systems and processes to have the capability to monitor, analyze, and disseminate roadway/infrastructure data for operational, maintenance, and managerial uses. It prescribes the need to coordinate and integrate MCO activities within diverse organizations in order to reduce costs, maintain or improve the efficiency and effectiveness of these activities, and increase the level of reusability of systems and technologies. The MCO user service may be considered applicable to both urban and rural environments.

The focus for the MCO user service is in the following four (4) functional areas:

Maintenance Vehicle Fleet Management: Systems that monitor/track vehicle location, support enhanced routing, scheduling, and dispatching functions, and use on-board diagnostic systems to assist in vehicle operations and maintenance (O&M) activities.

Roadway Management: Systems that provide automated monitoring of traffic, road surface, and weather conditions (from both roadside components and vehicles), contain coordinated dispatching, perform hazardous road conditions remediation, and have the ability to alert public operating agencies of changes in these conditions.

Work Zone Management and Safety: Systems that ensure safe roadway operations during construction and other work zone activities and communicate with the traveler.

Roadway Maintenance Conditions and Work Plan Dissemination: Systems that disseminate/coordinate MCO work plans to affected personnel/staff within/between public agencies and private sector firms.

Since the MCO user service includes several different functional areas, it suggests coordination with a number of other user services. The areas for coordination are discussed in the operational concepts for the functional areas.

3.8.1.2. Needs

Typically, responsibilities for MCO activities are divided between multiple public agencies at various levels of government (e.g., state, county, city, local municipalities, etc.). Consequently, there are disparities in the type and scale of resources and equipment available to provide the necessary level-of-service. The user needs listed below represent a sampling of needs identified by MCO stakeholders.

Transportation Agencies include staff within Traffic, Transit, and Emergency Services divisions /departments:

- Maintenance and Construction Field Crews perform routine, as-needed, and emergency maintenance activities on the transportation system as well as construction activities on the roadway (e.g., rehabilitation and replacement of pavements, bridges, and roadside infrastructure, etc.). ITS should be used to improve their ability to perform the operations, reduce the amount of time and cost that it takes to respond to a MCO request/ incident, and to be better prepared to assess a MCO situation (e.g., type of problem encountered, correct tools in hand, etc.). Systems to improve work zone safety and work zone performance are also needed.

- Maintenance and Construction fleet vehicle drivers/operators perform MCO activities on/with maintenance, construction, and special service vehicles (e.g., snowplows, Freeway Service Patrols, mowers, etc.). They communicate with dispatchers, and need access to operational/surveillance data. The vehicle operators also need systems that improve vehicle and personal safety (e.g., collision warning, personal security button, individual crew location system, etc.) and that reduce stress, workload, and decision-making by automating the transmission of work data activity (e.g., plow up/down, location, herbicides, etc.)

- Dispatchers monitor, schedule, and dispatch maintenance, construction, special service, or other public/community transportation fleet vehicles;

- Vehicle Maintenance Crews maintain/repair vehicles and associated equipment, including on-board sensors, actuators, and electronics. This includes systems to collect/maintain location, type, and physical condition of the entire vehicle fleet and reduce the amount of time that it takes to respond to a vehicle/equipment request/situation

- Equipment Maintenance Crews maintain/repair roadway physical infrastructure equipment; including ITS and non-ITS components.

- Maintenance and Construction Supervisors monitor roadway conditions and/or events on the transportation system; and enhance efficiency of operations when planning, scheduling, and allocating the necessary resources or responses [e.g., driver/vehicle status, assignments, resource availability (field and depot facilities), etc.]. This includes information collection, monitoring, tracking, and dissemination.

- Asset Managers perform capital planning, manage equipment usage, and allocate other tangible resources (e.g., staff, funds, etc.).
- Traffic Managers manage highway traffic, especially during incidents, road/lane closures, work zone activities, special events, and other situations. They coordinate operational activities with maintenance and construction efforts, pass-along equipment status/failure reports, and use maintenance crews, vehicle drivers, and other fleet operators as surveillance inputs/probes. They also disseminate information on traffic, roadway, and weather conditions, roadway closures and restrictions, and other severe or unusual roadway conditions.

Other Stakeholders with an interest in MCO include those from both public and private sectors such as travelers, planners, private construction companies, and traveler information providers:

- Travelers are interested in reliable, accurate, and timely information on traffic (e.g., travel time estimates, expected delays, etc.), roadway and weather conditions, roadway closures and restrictions, work zones, snowplow activity, and other severe or unusual roadway conditions
- Private Construction Crews have similar needs as public sector agency crews including the ability to perform construction activities on the roadway (e.g., rehabilitation and replacement of pavements, bridges, and roadside infrastructure, know when and where to conduct and coordinate maintenance as per the request of the public agency). This might include access to systems that collect/maintain/report work zone location, delay, and alternate route information and improve work zone safety.
- Statewide and Metropolitan Planning Agencies identify short- and long-range MCO resources, equipment, and policies to enhance operational efficiency and operator and personnel safety; as well as provide data/information for on-going MCO initiatives to justify their incorporation as an integral component of the statewide and regional transportation planning and budgeting processes.
- Traveler Information Service Providers provide "value-added" information to roadway data obtained from internal and external resources and disseminate reliable, accurate, and timely information on traffic, roadway, and weather conditions, roadway closures and restrictions, and other severe or unusual roadway conditions
- Public Safety Agencies enforce, advise, and coordinate road/lane closures, work zone activities, incident management activities, and disaster response and recovery activities
- Equipment Providers develop equipment that allow maintenance and construction crews to perform their job better
- Weather Services and Environmental Organizations provide weather/environmental conditions data/information to transportation agencies to

enhance scheduling/routing of MCO activities. They also coordinate data collection and dissemination efforts with those of transportation agencies operating roadway/weather information systems (RWIS).

3.8.1.3. Service Description

The MCO user service will integrate key activities to ensure that roadways, associated infrastructure, and available resources are coordinated in the best possible manner. Generally, key MCO activities include monitoring, operating, maintaining, improving, and managing the physical condition of the roadway. The focus for the MCO user service will be on the four (4) functional areas that follow:

- Maintenance Vehicle Fleet Management
- Roadway Management
- Work Zone Management and Safety
- Roadway Maintenance Conditions and Work Plan Dissemination

In the sections that follow, an initial indication of the services and/or functionalities that each of these MCO functional areas provides/contains are described.

3.8.1.3.1. Maintenance Vehicle Fleet Management

Fleet operations, management, and maintenance is important to roadway operating agencies with fleets of maintenance, construction, and specialized service vehicles (e.g., snowplows, freeway service patrols, bucket trucks, etc.). These vehicles are currently monitored, scheduled, routed, located, and maintained in an environment that generally creates high unit cost of operations. The Maintenance Vehicle Fleet Management functional area entails real-time tracking of all vehicle properties owned by a public agency along with the tracking of vehicles owned by organizations contracted by the public agency. The tracking of the rolling property may include monitoring of the on-board equipment and materials. The rolling property is observed to measure the effectiveness for remediating impediments to travel (e.g., snow/ice, rocks, dead animals).

3.8.1.3.2. Roadway Management

Roadway management systems typically provide automated monitoring and forecasting of traffic, road surface, and weather conditions (from both roadside components and vehicles), contain coordinated dispatching, perform hazardous road conditions remediation (e.g., sand, salt, and de-icing chemical application, snowplowing, etc.), and have the ability to alert public operating agencies of changes in these conditions. This functional area therefore entails real-time observations of the roadway network to determine or infer the presence of materials that could obstruct the path of vehicles and that pose a threat for vehicle crashes. The Roadway Management functional area also accommodates the remediation of potential hazards through automated crew dispatch or devices that can remove the hazard without human intervention, and/or by coordinating with mobile crews already in the field. The hazard observations themselves may come from deployed sensors such as RWIS stations. For example, a rockslide occurs and obstructs several lanes. Because this area is prone to rockslides the public agency responsible for the roadway has deployed a video detection system to detect the presence of rocks in the roadway and automatically alert the local operations center and maintenance yard. Roadway Management supports a number of different services, operations, staff, and vehicle fleets as follows:

- Winter Road Maintenance: Activities include but are not limited to snowplowing, salt and sanding, application of deicing chemicals, and storm clean up. Winter road maintenance and weather information needs are documented in FHWA's "Surface Transportation Weather Decision Support Requirements (STWDSR)", Version 2.0.
- Hazard Removal: Activities include removal of animals, objects, trash, washouts, sinks, slides, disabled vehicles, etc., and storm clean up.
- Emergency Preparedness: Activities include alternate routing, communications planning, preplanning routes, and coordination with local public safety and law enforcement agencies.

All of these activities are performed in a coordinated manner in order to ensure safe roadway operations during normal and severe weather or adverse travel conditions. Successfully meeting this functional aspect of the MCO user service with ITS solutions has the potential to provide roadway management with the following services/functionalities:

- Plan and forecast roadway management activities in proactive and reactive response situations (winter and summer)
- Determine the need for roadway treatment, both scheduled and forecasted (e.g., short-term weather prediction for winter maintenance, friction monitors, etc.)
- Perform hazardous road conditions remediation (e.g., sand, salt, snowplows, etc.)
- Monitor the level of chemicals on the roadway (e.g., salt, sand, de-icing chemicals, etc.)
- Monitor the amount and availability of chemicals on snowplows/spreader vehicles and at the maintenance shop facility (e.g., salt, sand, de-icing chemicals, etc.)
- Manage maintenance crew dispatching during road maintenance operations, hazard removal, and emergency preparedness activities
- Monitor, manage, and control, automated systems operating at remote locations that affect the roadway surface through treatment applications (e.g., de-icing applications underneath an overpass, etc.)
- Archive data for use in performance monitoring activities to track out-sourced contracting (private sector or to other public agencies)

3.8.1.3.3. Work Zone Management and Safety

The services and/or functionalities that this MCO functional area provides are intended to ensure safe roadway operations and improve operational efficiencies during construction and other work zone activities. These services include the following at a minimum:

Enact procedures and systems that cost-effectively manage work zone activities and communicate with the traveler

Predict "when" a work zone/lane closure may be necessary (e.g., flooding, landslide, etc.)

Collect/maintain/report work zone location, delay, and alternate route information

Provide automated systems that enforce speed limits, provide vehicle intrusion warnings, and track individual crew movements

Provide reliable, accurate, and timely information to the motorists regarding the upcoming work zone and how best to navigate safely through the area

3.8.1.3.4. Roadway Maintenance Conditions and Work Plan Dissemination

Roadway maintenance conditions and work plan dissemination systems are intended to disseminate/coordinate MCO assignments and work plans (e.g., type, routing, scheduling, resource allocation, etc.) to affected personnel/staff within and between public agencies (e.g., transportation, public safety, law enforcement, transit, construction, emergency service, etc.). They are meant to support resource allocation, routing, and scheduling, including the ability to provide this information in a real-time, accurate, and secure manner.

3.8.1.4. Operational Concept

In the sections that follow, the operational concepts for the MCO user service will be further described for each functional area supporting the MCO user service. Operational concept should be thought of in terms of "…what do we want the MCO user service to accomplish…" and "…how will the MCO user service actually accomplish/provide the functionality…". Multiple listings of a specific functionality under different MCO user service functional areas points out the potential for integration and cost-savings through delivery of the "same" function by a system/technology that can perform multiple jobs/tasks.

3.8.1.4.1. Maintenance Vehicle Fleet Management

The operational concepts and/or functionalities that this MCO functional area provides/contains includes the following at a minimum:

Vehicle Location and Operating Status

- Systems that provide information on vehicle location in order to track movements, enhance route scheduling, and improve dispatch functions
- Systems that provide/monitor information on vehicle conditions/status and on-board materials in order to enhance vehicle maintenance scheduling and improve vehicle operating performance
- Systems should be capable of operating in various types of terrain such as mountains, valleys, canyons, etc.

- Other user services to coordinate with include Route Guidance, Public Transportation Management, Emergency Vehicle Management, Archived Data, and the entire Advanced Vehicle Safety Systems bundle

Contractor Monitoring (Private Sector and Public Agency)

- Systems that facilitate monitoring of the location, actions, and availability of private sector MCO services, equipment assets, and resources in order to optimize/manage scheduling, dispatching, and operations

Traveler Information

- Systems that provide vehicle operators and dispatchers with routing information in order to direct vehicles around potential roadway problem spots
- Other user services to coordinate with include Route Guidance, En-Route Driver Information, En-Route Transit Information, Incident Management, Archived Data, Hazardous Materials Security and Incident Response, and Disaster Response And Evacuation

Computer-Aided Dispatching

- Systems that support route planning, scheduling and dispatching of vehicles in public fleets in order to optimize operations and provide enhanced communications between vehicle and dispatch facility
- Systems may be agency-specific or include inter-agency communications (e.g., highway patrol, EMS, maintenance vehicles, etc.)
- Other user services to coordinate with include Route Guidance, Archived Data, En- Route Driver Information, and En-Route Transit Information

3.8.1.4.2. Roadway Management

The operational concepts and/or functionalities that this MCO functional area provides/contains include the following (at a minimum):

Roadway Surface and Atmospheric Conditions

- Systems that monitor, detect, and forecast changes in roadway surface conditions and other weather and atmospheric conditions affecting travel in order to have a more up-to-date/accurate picture of roadway conditions so that dispatching of maintenance vehicles and use of salt/chemicals is optimized
- Systems that disseminate information/alerts to public agencies (potentially located in separate facility locations) via computer networks (or telephone), self-actuated components (e.g., DMS, HAR, etc.) that provide traveler warnings at spot-specific hazardous condition locations
- Other user services to coordinate with include Pre-Trip Travel Information, En-Route Driver Information, and Archived Data

Winter Maintenance

- Systems to enhance the efficiency and safety of roadway treatment and plowing operations before, during, and after winter storms using information on weather and roadway surface conditions, location of nearest maintenance vehicle, time of last treatment per segment, type of treatment or chemicals applied, or last plowing per segment, environmental recordings, vehicle operational data (e.g., spreader on/off, plow up/down, etc.), vehicle position on roadway, automated roadway treatment system status (e.g., on-line, chemical levels, roadway conditions, etc.), bridge-related hazards such as surface conditions, chemical and icing reports, etc.
- Other user services to coordinate with include Public Transportation Management, Emergency Vehicle Management, Traffic Control, Incident Management, Hazardous Materials Security and Incident Response, Disaster Response and Evacuation, and the entire Advanced Vehicle Safety Systems bundle

Non-Winter Maintenance

- Systems to enhance the efficiency and safety of other (non-winter) maintenance activities including hazard removal and emergency preparedness activities using information on roadway conditions, location of nearest maintenance vehicle, time of last maintenance/treatment per segment, type of activity performed, automated environmental recordings (e.g., water levels), vehicle position on roadway, etc.
- Other user services to coordinate with include Public Transportation Management, Emergency Vehicle Management, Traffic Control, Incident Management, Hazardous Materials Security and Incident Response, and the entire Advanced Vehicle Safety Systems bundle

3.8.1.4.3. Work Zone Management and Safety

The operational concepts and/or functionalities that this MCO functional area provides/contains includes the following at a minimum:

Work Zone Information

- Systems that gather, store, and disseminate information about work zones and construction activities (both short- and long-term activities, including location, nature/type, duration, lane shifts, staging areas, length, scheduled phases of work zone configuration, alternate route(s)) in order reduce the length of time that work zones are in place, reduce the frequency that work zones are established, and establish a more accurate picture of "where" activities are occurring and/or are planned in order to support internal MCO needs, commercial and emergency vehicle routing activities, and traveler information systems
- Other user services to coordinate with include En-Route Driver Information, Traffic Control, Route Guidance, Pre-Trip Travel Information, Archived Data, and Incident Management

Smart Work Zones

- Systems that monitor, control, and direct traffic activity in the vicinity of work zones in order to enhance operator (e.g., maintenance and construction crews) and public safety, minimize congestion delays, and provide relevant traveler information to motorists
- Systems that divert vehicles around work zones via automatic lane changing/merging techniques
- Other user services to coordinate with include En-Route Driver Information, Traffic Control, Incident Management, Archived Data, and the entire Advanced Vehicle Safety Systems bundle.

3.8.1.4.5. Roadway Maintenance Conditions and Work Plan Dissemination

The operational concepts and/or functionalities that this MCO functional area provides/contains includes the following at a minimum:

MCO Information Dissemination

- Systems to facilitate coordination of MCO activities within/between agencies in order to provide the ability to share information about affected roadways, anticipated duration, and sharing resources (see above for more details) as well as potential impacts caused by natural disasters such as hurricanes or blizzards
- Other user services to coordinate with include Archived Data, En-Route Driver Information, and Pre-Trip Travel Information

4. Procedure for New User Services

4.1. General

The following paragraphs describe a procedure for the development of a new user service and the introduction and integration of this new user service into the National ITS Architecture. It may also be used for a significant change cutting across a number of existing user services that does not call for the specific addition of a new user service. The procedure is not intended to be all encompassing, nor is it intended to be restrictive. It should serve only as a guide to stakeholders who are interested in adding their needs to the National ITS Architecture.

It consists of two phases. Phase one of the procedure is the principle responsibility of the stakeholder community and involves addressing its transportation system needs, formalizing them in an acceptable user service, and securing acceptance for integration into the National ITS Architecture. Phase two of the procedure is the principle responsibility of the ITS Joint Program Office (JPO) and involves its actions to integrate the user service into the National ITS Architecture, coordinate its activities with the stakeholders, and ensure that the final product has stakeholder consensus and support. In both phases, it is necessary to engage in public outreach activities to ensure adequate awareness among the stakeholder and ITS communities and to offer the opportunity for them to participate.

4.2. Phase 1

a. The first step is for the interested group of stakeholders to determine their collective concerns. Although it is not required, there are three sources of advocacy where the stakeholders may go for advice before proceeding. They are the ITS JPO, the applicable office or modal administration in the U.S. DOT, and ITS America. In the case of Highway Rail Intersection (HRI), the advocacy came from the Federal Railroad Administration. In the case of Archived Data (ADUS), the advocacy was shared between the Federal Highway Administration Policy Office and the JPO. Voicing stakeholder concerns to an advocate should lead to a partnership and understanding of these concerns, and a better stakeholder understanding of the process to cause the National ITS Architecture to be modified.

b. The second step is for the stakeholders to review the existing user services contained in this document. Originally, Volume II of the “National ITS Program Plan, Intelligent Transportation Systems”, dated March 1995, described each of the 29 original user services. The 30th and 31st user services, addressing HRI and ADUS, have been separately developed and approved, and were added to an appendix of the “National Intelligent Transportation Systems Program Plan, Five-Year Horizon”, dated August 2000. The Maintenance and Construction Operations (MCO) user service and the Disaster Response and Evacuation (DRE) user service representing the 32nd and 33rd user services, respectively; were published separately by the ITS JPO. The review of this document enables the stakeholders to better understand the user needs currently addressed by the National ITS Architecture and how they are described. If their current needs are not satisfied in the three documents, then the stakeholders may choose to propose actions to add a newly defined user service to the National ITS Architecture.

At this point, the ITS JPO, in conjunction with other modal administrations as appropriate, will make a decision regarding the appropriateness and viability of the proposed new user service. This decision enables the stakeholders to know whether or not the ITS JPO will support their effort, and then to begin developing the user service with good guidance and direction. If the decision is to proceed, there will be a notification to the broader transportation community of the intent to expand upon the existing set of user services in response to stakeholder concerns. This can be accomplished through a notice in the Federal Register; press releases to other print media; notices posted on the ITS JPO, National ITS Architecture, and ITS America websites; notification to specific transportation committees including those of the Transportation Research Board (TRB), the Institute of Transportation Engineers (ITE), the American Association of State Highway Transportation Officials (AASHTO), and the American Public Transportation Association (APTA); and notification to appropriate ITS America technical committees and task forces.

After reviewing the proposal for a new user service, the ITS JPO may determine that a new user service is not needed as the problem may be addressed by amending and/or modifying the existing user services. If they are not significant, recommendations in these areas should be forwarded to the ITS JPO Architecture Program Manager for subsequent disposition and National ITS Architecture modification. If they are significant and cut across a number of existing user services, the same steps outlined below may be followed.

c. The third step is for the stakeholders to identify their specific transportation needs. This is not trivial, and may require workshops and other forums to clearly define and articulate the consensus-based needs of the stakeholder group. It should be noted that the National ITS Architecture is a consensus architecture, and no individual or small group of persons will be able to change it without the full consent of the larger stakeholder community. Development of the needs document/paper lends focus to the effort, gets the important issues addressed, and highlights consensus.

d. The fourth step is the development of the user service which will become an addendum to Volume II of the “National ITS Program Plan, Intelligent Transportation Systems” or an appendix to the “National Intelligent Transportation Systems Program Plan, Five-Year Horizon”. The definition of the new user service follows the general format shown in Volume II of the “National ITS Program Plan, Intelligent Transportation Systems”, and thus may require assistance from one of the advocacy sources.

Prior to completing development, it is suggested that public outreach similar to the second step of Phase 1 be used again to invite reviews of the draft user service from within the known stakeholder community as well as from the broader ITS community. In addition, since it is probable that the user service is going to be accepted by the JPO for addition to the National ITS Architecture, it is advisable to invite the Architecture Team to monitor the later development stages of the user service.

e. The fifth step is an ITS screening process used by the ITS JPO, working in conjunction with other modal administrations as appropriate. This entails a review of the definition of

ITS to ensure that the user service improves the availability, efficiency, and safety of operations of the transportation system. The screening process also ensures that the user service is consistent with the goals of integration and standardization. The ITS JPO will make the appropriate changes to the draft user service to ensure that its scope is consistent with the other user services.

f. The final step in Phase 1 is for the ITS JPO, with formal advice from ITS America, to determine whether or not to accept and include the completed user service into the "National ITS Program Plan, Intelligent Transportation Systems" or into the "National Intelligent Transportation Systems Program Plan, Five-Year Horizon". The Director, JPO, may accept the user service immediately or take it to the Strategic Planning Group for discussion and concurrence before it is accepted. Once accepted by the ITS JPO, the user service will be forwarded to the JPO Architecture Program Manager who will be directed to determine the resources and begin incorporation of the new user service into the National ITS Architecture.

4.3. Phase 2

a. The first step is for the JPO Architecture Program Manager to task the headquarters team to develop user service requirements that trace to the user service, satisfy the intent of the stakeholder community, and subsequently offer clear tasking requirements to the Architecture Team. This tasking may be informally done following the ITS screening process when it is known that the user service is going to be accepted, and enable the requirements to be developed in coordination with the final development of the user service.

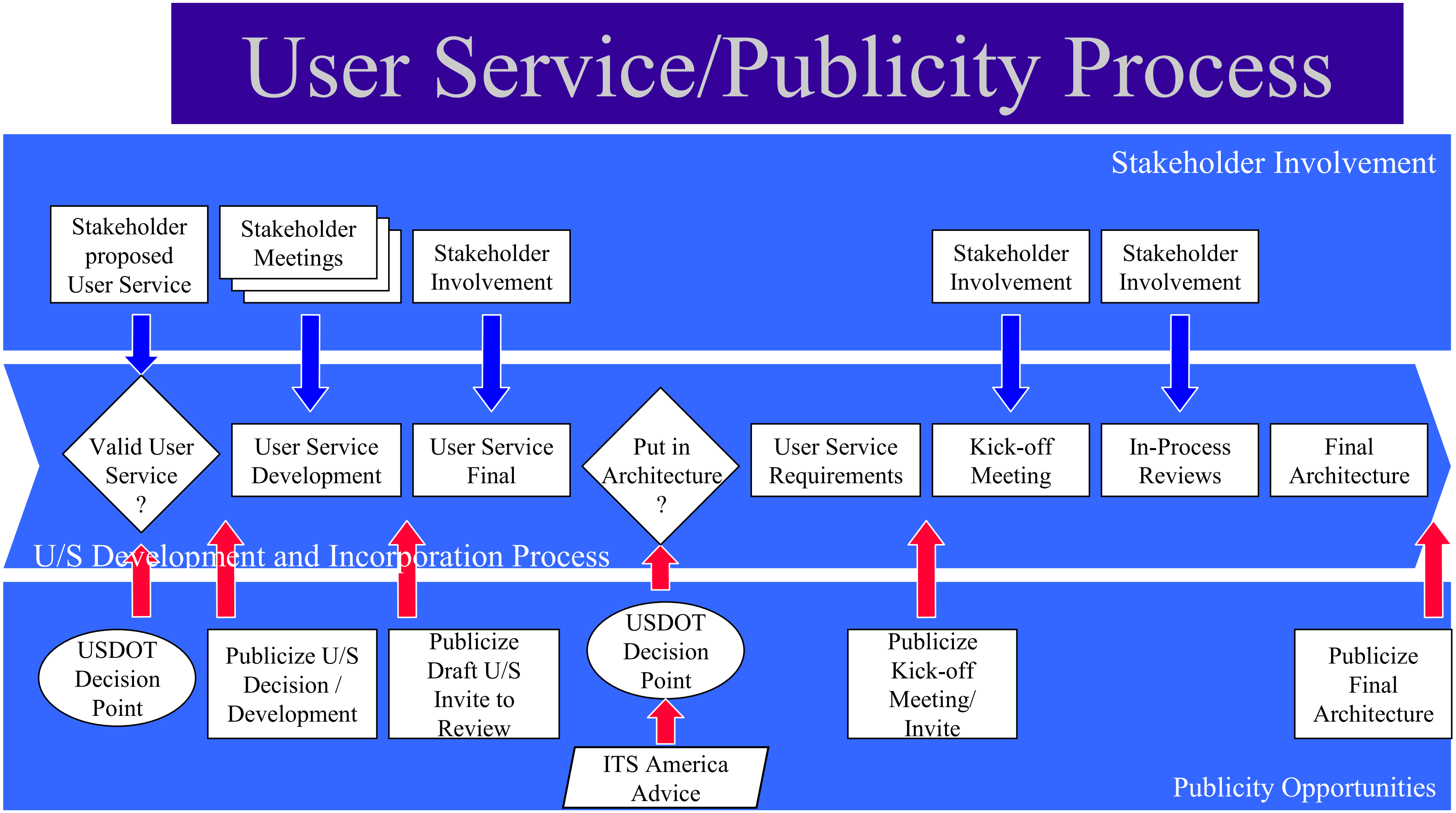
b. The second step is for the JPO Architecture Program Manager to forward the user service requirements with a tasking document to the Architecture Team for their integration proposal and response. They will then be placed under contract for this task to modify the National ITS Architecture. The Architecture Team must develop a milestone schedule that includes a kickoff meeting and interim program review(s) to engage representatives of the stakeholder community, address the user service requirements, and begin their formal National ITS Architecture integration effort.

At this stage, it is appropriate to invite a group of stakeholders who, where possible, will be involved in the kickoff meeting and each of the reviews to lend continuity and understanding to the overall effort and to ensure stakeholder concerns and needs are met. This will require an outreach effort prior to the kickoff meeting, again similar to the second step in Phase 1.

c. The third step is the effort of the Architecture Team, in concert with the stakeholders, to integrate the new user service into the National ITS Architecture. In addition to the technical work, the effort involves one or more interim program reviews and the possibility of outreach meetings with selected members of the stakeholder community.

d. The fourth step is to render a final report to the stakeholder community representatives by the ITS JPO and the Architecture Team. This is a brief oral report highlighting the changes and indicating that the integration effort is complete.

e. The final step is to post the changed National ITS Architecture on the ITS JPO and National ITS Architecture websites and to release the next version of the National ITS Architecture on CD-ROM, if appropriate. There will be an outreach effort to announce the change and new version of the National ITS Architecture through the same media used previously: a notice in the Federal Register; notices in newsletters; notices in the Architecture, ITS JPO, and ITS America websites; press releases in other print media; and through notification to appropriate ITS America technical committees and task forces. Phase 2 of the ITS JPO integration activities should be accomplished within 6 to 9 months, depending upon the detail and complexity of the new user service.


User Service/Publicity Process
Stakeholder Involvement
Stakeholder proposed User Service
Stakeholder Meetings
Stakeholder Involvement
Stakeholder Involvement
Stakeholder Involvement
Valid User Service ?
User Service Development
User Service Final
Put in Architecture ?
User Service Requirements
Kick-off Meeting
In-Process Reviews
Final Architecture
U/S Development and Incorporation Process
USDOT Decision Point
Publicize U/S Decision / Development
Publicize Draft U/S Invite to Review
USDOT Decision Point
ITS America Advice
Publicize Kick-off Meeting/ Invite
Publicize Final Architecture
Publicity Opportunities