

ITS

NATIONAL INTELLIGENT TRANSPORTATION SYSTEMS PROGRAM PLAN FIVE-YEAR HORIZON

AUGUST 2000



USER SERVICE DEVELOPMENT PLANS

A development plan has been generated for each user service. The plans identify the needs that the user service is designed to meet, present an operational concept for how the service might function in its fully deployed state, describe the technologies that the service might use, discuss potential costs and benefits, and provide an assessment of the public and private sector roles in developing and deploying the systems that will provide the service. The user service development plans for the first 29 services are contained in Volume II of the 1995 National ITS Program Plan. Detailed user service development plans for the two new user services appear below. The plans follow the format used in the 1995 National ITS Program Plan. The numbering is according to their placement within the bundles shown in Table C-1. For example, the Highway Rail Intersection user service is the tenth service listed under Travel and Traffic Management. Thus, the numbering for this user service begins 1.10.

Highway-Rail Intersection User Service

1.10 HIGHWAY-RAIL INTERSECTION USER SERVICE

1.10.1 Introduction

Highway-Rail Intersections, where highways cross rail lines at-grade, are a special case of Highway-Highway Intersections (HHI). HRI user service systems 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 and emergency vehicle operators, as well as motorcyclists, bicyclists, and pedestrians.

The HRI user service directly supports the national transportation policy and safety goals as specified in Sections 1010, 1036, and 1072 of the Intermodal Surface Transportation Efficiency Act of 1991, and the National Highway System Designation Act of 1995. The HRI user service addresses the National Intelligent Transportation System's overall goal of improving transportation safety and the specific objectives of reducing the number and severity of transportation accidents, as well as the resulting fatalities and injuries. This service also indirectly supports the goals of enhancing productivity by reducing costs incurred by fleet and rail system operators and reducing costs to transportation dependent industries.

The HRI user service provides two major subservices: (1) the Standard Speed Rail (SSR) subservice, which applies to all trains operating at speeds of 79 miles per hour or less; and (2) the High-Speed Rail (HSR) subservice, which applies to trains operating at speeds greater than 79 miles per hour. The SSR subservice applies to traditional types of rail service including freight, intercity passenger, light rail, and commuter rail. The HSR subservice is intended to address the unique safety requirements imposed by high-speed passenger rail service operating on high-speed corridors.

The HRI user service will reduce the frequency and resulting fatalities and injuries of collisions at HRIs through improved control of train and highway traffic. Improved train control could be accomplished by two basic functions: (1) advisories and alarms to train crews of the operational status of an HRI warning device and of highway vehicle intrusions onto HRIs; and (2) automated stopping of high-speed (greater than 79 miles per hour) 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. Improved highway traffic control could be accomplished through the integration of ITS technologies into a variety of functions including: (1) improved HRI warning devices; (2) roadside variable message signs; (3) in-vehicle motorist advisory, warning, and automatic vehicle stopping; and (4) automated collision notification.

The HRI user service will be accomplished by the integration of ITS technologies and other ITS user services with the national network of railroad and highway operations. The Federal Railroad Administration (FRA) will assist in the development of HRI user services in close cooperation with FHWA, FTA, and the other participants in the National ITS Program.

1.10.2 Needs

HRI accidents are one of the most significant safety concerns of railroads and the FRA. In 1994, there were approximately 273,000 HRIs in the United States; 166,000 are public at-grade and 107,000 are private at-grade. Accidents at HRIs occur at a rate of about 4,900 each year, resulting in about 600 fatalities and 1,900 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 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 Transportation 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 HRI user services.

The National Highway System Designation Act of 1995 also recognized the importance of improving HRI safety through ITS technology and required the National ITS Program to address, in a comprehensive and coordinated manner, HRI safety needs.

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; and 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 1 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 a HRI 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.

Standards for design, installation, and operation of current HRI warning devices are covered in FHWA's "Manual on Uniform Traffic Control Devices," and in "A Policy on Geometric Design of Highways and Streets" published by the American Association of State Highway and Transportation Officials. However, there are no FRA regulations that mandate the type of warning devices to be provided at HRIs. There are presently two general categories of warning devices at HRIs: passive and active.

Passive warning devices are used at approximately 212,000 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 or pavement markings 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 60,000 public and 1,000 private HRIs that have active warning devices. Factors considered in determining the need for active warning devices include type of roadway, type and volume of vehicular and railroad traffic, hazardous material traffic, maximum speeds of trains and vehicular traffic, pedestrian traffic, accident record, sight distance, and geometry of the HRI. Active warning devices usually include two flashing red lights mounted horizontally below the crossbuck. This traffic control and regulatory device is referred to as "Flashing Lights."

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. Recently, research and limited deployment of "Four-Quadrant"

gates and “Median Barriers” have been made to improve safety at HRIs. Median barriers are placed along the centerline of the highway 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. These concepts are discussed in more detail in Section 1.10.4.3.

Some HRIs are located near HHIs that are controlled with standard highway traffic signals. To ensure safe movement of traffic through these intersections and the adjacent HRI, active warning devices at the HRI often include the capability of engaging nearby highway traffic signals to prevent the progress of motorists across the tracks.

The HSR subservice will address the special needs of trains with operating speeds in excess of 79 miles per hour. Because collisions between high-speed passenger trains and highway vehicles are 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 HSR 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) that provide constant warning time. Automatic four-quadrant gates should be considered. Train-activated advance warning systems also should be considered, especially where sight distance is restricted.
- For train operations from 111 to 125 miles per hour, the FRA must be notified and approval granted for a waiver from current FRA Track Regulations. The HRI must be either grade separated or blocked during train passage. 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 permanent, blocked, or grade separated.

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 (per 49 CFR 229.125).

Railroads control the movement of trains by train orders, time tables, manual block systems, and provide 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 so as to preclude the entry of two trains into the same controlled section of track. Central dispatchers who are in voice contact with train crews may also control the signal. The railroads are conducting research and limited deployment of advanced train control systems that respond to electronic signals and have the ability to provide automated control of the train speed and braking. 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.

HRI user services are 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 factors influencing safety at HRIs that must be dealt with by HRI user service systems include risk-taking behavior of drivers, train operations, track and highway characteristics, and current HRI and highway traffic control systems. The new technologies that emerge to provide HRI user services must be proven cost effective and highly reliable before their wide-scale implementation in the highway and rail system environments. It is also critical for the improvement of HRI safety that the control and signal systems of the distinctly different highway and railroad modes are interoperable and communicate precisely with each other. 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. It is very important, therefore, to include HRI user services in the overall national plan for deploying ITS in both the near and long term.

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 HRI subservice and (2) the high-speed rail HRI subservice. The HRI user service also 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 two basic functions: (1) providing advisories and alarms to train crews of the operational status of an HRI warning device and of highway vehicle intrusions onto HRIs; and (2) automated stopping of high-speed (greater than 79 miles per hour) 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. The first function, crew advisories and alarms, are incorporated into the SSR subservice. The second function of automated stopping of the train is the basis of the HSR subservice and is intended primarily to address the additional safety demands of high-speed passenger trains.

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 of 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 also will 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 variable message signs for motorists. These message signs will effectively inform motorists and pedestrians of an HRI ahead and the need to exercise caution. These signs also will 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 provided 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, in essence, can be made active without the expense of providing them with active warning devices. In its most extended form, the in-vehicle HRI user service can provide automatic stopping of vehicles to avoid an HRI collision.

The HRI user service also will 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). The capability, if highway vehicle based, would most likely be provided by the emergency notification user service.

1.10.4 Operational Concept

1.10.4.1 Overview

Long-term implementation of HRI user services could be supported through establishment of Train Control Centers (TCC) and Traffic Management Centers (TMC). In this fully deployed concept of operation (circa 2012), the HRI user service provides real-time information on train position and estimated time of arrival at HRIs, HRI status, and roadway traffic conditions at HRIs.

The HRI user service could interface with the TCC and the train to provide HRI status to train crews and automated stopping of high-speed (greater than 79 miles per hour) 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 new Positive Train Control systems. These technologies are described in more detail in Section 1.10.5.

The HRI user service also will interface with TMCs to control highway vehicle access to the HRI, to provide motorists with warnings of train arrival times as a collision prevention service, and to permit travelers to select alternative routes to avoid delays and minimize traffic at the HRI. Improved HRI warning devices could 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 could include features that allow them to be integrated effectively with nearby highway traffic signals to maintain safe traffic patterns at HRIs. HRI warning devices could be augmented with roadside variable message signs that provide additional warnings of a train arrival at the HRI. The HRI user service also will provide in-vehicle visual and audible advisory and warning functions to assist motorists in avoiding collisions at HRIs. The HRI user service could help to reduce the severity of HRI collisions by providing collision notification functions.

While this conceptual description is based on central control functions resident at TCCs and TMCs, implementation of some HRI user services, especially early capabilities, could be accomplished with more distributed intelligence. For example, sensing, communication, processing, and control can take place directly between trains, HRIs, and highway vehicles to provide many HRI user services.

1.10.4.2 Train Control Functions

The HRI user service will provide for two levels of train control to prevent HRI collisions: (1) advisories and alarms to train crews of the operational status of an HRI warning device and of highway vehicle intrusions onto HRIs; and (2) automated stopping of high-speed (greater than 79 miles per hour) 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. The first function, crew advisories and alarms, applies to traditional types of rail service including freight, intercity passenger, light rail, and commuter rail, and are incorporated into the SSR subservice. The second function of automated stopping of the train is the basis of the HSR subservice and is intended primarily to address the additional safety demands of high-speed passenger trains. It is not envisioned that routine freight service trains would be stopped under this user service.

The SSR and the HSR user subservices will both require information on the operational status of traffic control systems at the HRI (such as whether the device is operational, fully deployed, etc.) and whether a highway vehicle has intruded onto the HRI. 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 TCC and TMC. Similarly, vehicle intrusions can be detected using sensors incorporating inductive loop, radar, and video technologies. Intrusion detection systems are intended for use with HRI barrier systems, such as four-quadrant gates, where a highway vehicle could become entrapped between the barriers. Intrusion detection systems employing video technologies also can be particularly effective in supporting efforts to enforce HRI traffic regulations by law enforcement officials.

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 communications can be established readily by existing technologies such as cellular phone. Later stages of implementation of the SSR subservice could be accomplished by communication of these data to the train crew through the TCC. In addition to notifying train crews for collision avoidance actions, notification of signal malfunctions also can be sent to the railroad dispatcher, signal maintainer, local police, and roadway authorities for purposes of corrective action to prevent future incidents.

The HSR subservice will provide for automated stopping of high-speed 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 communications with the TCC and the capabilities of technologies such as new Positive Train Control systems. The HSR subservice will verify proper operation of HRI warning devices and will detect intrusions into HRIs employing barrier systems (e.g., four-quadrant gates) to ensure 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. As each HRI is approached, the critical train stopping distance will be calculated based upon train operating and track approach characteristics and other factors. If the distance from the passenger train to an intruding vehicle or malfunctioning warning device exceeds the critical stopping distance, automatic stopping will halt the train before an accident occurs. If the distance from the passenger train to the vehicle is less than this critical stopping distance, a collision cannot be avoided, although intervention may reduce collision severity and help protect train passengers and crew.

The HSR HRI 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 also will 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.

1.10.4.3 Highway Control Functions - Warning Devices

Improved highway traffic control at HRIs will be accomplished through a variety of functions available under the SSR subservice. The HRI active warning system's ability to control highway traffic will be improved through the use of ITS technologies that will enhance alerting capabilities, reduce costs, and increase performance in terms of 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. A significant design challenge for these systems is to develop appropriate sequencing of the entrance and exit gates, and to provide for other features to prevent or minimize the risk of possible entrapment of highway vehicles. Four-quadrant 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 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 also may 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. However, these barriers also could pose an additional hazard to motorists if not properly designed.

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 also may 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; motorists may not always properly interpret these messages. The use of standard highway traffic control signals also may be more cost effective than traditional HRI warning systems.

1.10.4.4 Highway Control Functions - Variable Message Signs

Highway traffic control devices at the HRI will be supplemented with roadside variable message signs. These messages will provide the minimum amount of 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. An example of the sequence of messages that could be displayed to a motorist approaching an HRI is the following:

1. "PROCEED" (HRI clear)
2. "TRAIN(S) ARRIVING, CLEAR THE INTERSECTION" (30-60 seconds prior to arrival of train)
3. "STOP - DO NOT ENTER - WAIT FOR TRAIN(S) TO CLEAR CROSSING" (20-30 seconds prior to arrival of a train; other tracks verified clear if at a multiple-track crossing)
4. "TRAIN(S) WILL CLEAR CROSSING IN # # SECONDS and/or WATCH FOR OTHER TRAIN"
5. "CAUTION" (after the train(s) clears the HRI)
6. "WAIT FOR PROCEED SIGNAL"
7. "PROCEED"

Traffic operations at intersections on adjacent roadways will be significantly improved with variable message signs that interact with the TMC and TCC. These signs can be provided with real-time information about the location and arrival time of trains so that traffic can be redirected and controlled to minimize delay times that may result, for example, from signal malfunctions or unusually long or slow trains.

Information on train movements relative to HRI can be provided to the TMC via remote systems that monitor the operational status of HRI signal 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 variable message signs. The information also could be relayed to emergency services personnel, police, fire, and ambulance services, to facilitate routings that avoid blocked HRIs and thereby optimize emergency response time. Similar actions could be implemented by the TMC in the event of HRI signal malfunctions.

1.10.4.5 Highway Control Functions - In-Vehicle Services

HRI user services 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.

In-vehicle driver advisories are the most basic service and can be accomplished without information about train operations. This service is intended to take advantage of other in-vehicle ITS user services such as En-Route Driver Information and Route Guidance. These services will basically advise the driver that an HRI is ahead and caution should be exercised. These services will require that the location of HRIs be included in their geographic data bases and that the necessary software is included to provide the advisory messages. The advisories most likely would 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. These 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, TCC, and TMC. 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 also will 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.

1.10.4.6 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 Emergency Notification and Personal Security user service. The TMCs and TCCs will require integration with control centers for emergency response teams.

1.10.5 Technology

Implementation of HRI user services will require the application of supporting technologies such as those described below.

1.10.5.1 New Positive Train Control Systems

New Positive Train Control systems are made up of the same technologies used in ITS: digital data links connecting locomotives, maintenance-of-way equipment, wayside base radios, and control centers; on-board computers, positioning systems, data radios, and display screens on locomotives and maintenance-of-way equipment; and control center computers. Positive Train Control systems can reduce the probability of collisions and over-speed accidents by two orders of magnitude, and can also improve running time, service reliability, capacity, and rolling stock and crew utilization.

1.10.5.2 Vehicle Proximity Alerting System (VPAS)

Section 1072 of ISTEA required field testing of a Vehicle Proximity Alerting System (VPAS) and comparable systems to determine their effectiveness as a safety warning device for "priority" vehicles approaching HRIs. As envisioned, the VPAS would be installed only on priority vehicles – school buses, large trucks, hazardous materials haulers, and emergency vehicles. VPAS provides an in-vehicle warning (visual and audible) to motorists at both passive and active crossings. VPAS benefits would be greatest at passive crossings where motorists currently receive no indication of an approaching train.

In July 1993, FHWA issued a request for proposals for VPAS devices to be evaluated for effectiveness as a means of improving HRI safety. Prototype testing by the FRA of promising devices identified by FHWA occurred in 1994 and 1995 at the Transportation Technology Center in Pueblo, Colorado. The VPAS concepts evaluated employ a variety of techniques to accomplish communication from an approaching train to a highway vehicle near the HRI. The communication systems typically use radio frequency devices. Basic systems would only inform the driver that a train is approaching, or that the crossing ahead is blocked by a train, but provide no further information. Enhanced systems would inform the driver of the train's approach, direction, and estimated time of arrival at the HRI, based on train position, speed, and direction of travel data.

1.10.5.3 Geographical Mapping Systems

Many of the HRI user services discussed require data bases of accurate information on the location of HRIs relative to highways and other related highway and rail system structures. Systems are available and are being developed for automated surveying of track and wayside infrastructure. One such system uses Global Positioning System (GPS) equipment and digital video imaging recording devices to video survey railroad facilities, including intersections of track and roadways, and to provide a longitudinal-latitude data base.

1.10.5.4 Other Supporting Technologies

A number of technology developments and applications need to be developed and/or enhanced and integrated to support implementation of HRI user services in addition to those discussed above. These technologies are briefly discussed below.

- Location technologies are required to accurately position trains and highway vehicles relative to each other as well as to HRIs and other rail and highway system structures. These technologies include GPS and inertial navigation systems as well as various other systems for dead reckoning.
- Train detection systems are required to determine train position relative to HRIs for purposes such as activating HRI warning and control systems. Those systems that also detect train speed and direction will have more potential applications. These systems may be either train based or infrastructure based.
- Highway vehicle detection systems are required to determine vehicle location relative to HRIs and to determine vehicle intrusions onto HRIs. These systems, especially those employing video technologies, can support efforts to enforce traffic regulations at HRIs.
- Communication systems are required for exchanging information between trains, highway vehicles, TCC, TMC, and various rail and highway system infrastructure elements.
- Remote sensor systems are required to monitor the operational status of HRI warning and traffic control systems.
- Motorist warning and control system technologies need to be enhanced by improving their safety effectiveness, operational efficiency, and costs.

1.10.6 **Potential Costs and Benefits**

1.10.6.1 Potential Costs

There are about 100,000 public HRIs with passive warning devices that are candidates for warning device improvements. These improvements would be of the type included in SSR HRI user services such as enhanced warning devices and variable message signs. Traditional active warning devices typically cost in the range of \$50,000 to \$150,000 per HRI. The national cost of upgrading all passive crossings with active warning devices would be prohibitive. Advances in warning device design using ITS technologies could reduce these costs. The capital and installation costs of installing active warning devices have typically been funded, since 1973, under continuing Highway Safety Acts. Since 1973, about \$3 billion have been spent on upgrading about 60,000 HRIs. Railroads have typically accepted the responsibility for maintaining these new devices at a cost of about \$1,300 to \$2,200

per HRI per year. Since it is unrealistic to assume that all passive HRIs can be upgraded, U.S. DOT, working with state and local agencies, will continue to prioritize HRIs for upgrading on the basis of criteria such as the level of train and highway traffic, train speeds, hazardous materials traffic, etc.

A small subset of all HRIs includes the 2,800 HRIs on the designated high-speed rail corridors. These HRIs are candidates for improvement under the HSR HRI user service. There is little precedent for Federal funding of the types of improvements envisioned under this service. However, it is the established policy of the Federal government, as expressed in Section 1010 of ISTEA, to promote high-speed rail service, and to fund demonstration projects for improving HRI safety on the designated corridors. States, local public agencies, and railroads may be expected to share in the capital, installation, operation, and maintenance costs of HRI improvements. Costs for advanced warning and protection devices under the HSR subservice are not well established but could range from about \$200,000 for a four-quadrant gate installation to about \$1,000,000 for an energy absorbing barrier system or a low-cost grade separation. The HSR subservice also will require extensive infrastructure investments on railroads to implement automatic train control systems and TCCs as well as highway system investments for TMCs. Federal subsidies for these investments might be required to achieve high-speed rail passenger service on designated corridors. Much of the highway investment could be accomplished as part of a larger integrated ITS Traffic Control user service.

In-vehicle warning systems can address the needs of both the SSR and HSR HRI user subservices. In 1993, there were nearly 198 million registered motor vehicles in the United States, of which 146 million were automobiles. If all or a substantial portion of these vehicles included HRI collision avoidance systems, the total monetary costs could be substantial. The capabilities required of these in-vehicle systems, however, could be obtained as minor added functions to systems installed as part of other ITS user services such as En-Route Driver Information and Route Guidance. The actual cost of these systems has not yet been determined.

1.10.6.2 Potential Benefits

The primary benefit from the HRI user service will be a reduction in the number and severity of the 4,900 HRI collisions that occur annually. Also, the safety risk to large numbers of passengers on future high-speed rail trains will be significantly reduced. Secondary benefits will result from reductions in motorist delays and improved operational efficiency of railroad and highway operations. Higher train speeds along the designated corridors will be possible creating economic and social benefits for travelers and users of rail freight transportation. These benefits will increase as ITS technologies mature, promoting the exchange of information between TMCs, TCCs, trains, and highway vehicles. Improved information exchange will support user services such as En-Route Driver Information, Pre-Trip Travel Information, Route Guidance, Public Transportation Management, Emergency Vehicle Management, and Commercial Fleet Management.

1.10.7 **Assessment of Roles**

The public safety benefits and other potential public and commercial benefits of the HRI user service are expected to be high. Therefore, U.S. DOT will encourage joint public/private development efforts for enabling technologies. This approach, which underlies the U.S. DOT strategy for investment in ITS technologies and systems, is used to assess the appropriate role for U.S. DOT in developing the HRI user service.

The development of low-speed light rail and commuter rail service as well as high-speed rail service will need to be a cooperative effort between FRA, FHWA, FTA, and the relevant states and local agencies. The parallel development of ITS and HRI technologies provides a unique opportunity to integrate current and future highway and railroad traffic control systems. Due to the involvement of two significantly different modes of surface transportation, the design will be subject to regulation by highway, transit, and rail regulatory bodies.

1.10.7.1 Public Benefit

This user service addresses the most common and severe type of collision that affects railroad operations as well as the motoring public. This service therefore has high potential for public benefit. There also will be significant benefits in improving the efficiency of railroad operations as well as reducing unnecessary travel time delays, accidents, air pollution, and traveler frustration.

1.10.7.2 Potential for Private Investment in Development

This service will require significant infrastructure investment on both the highway and railroad systems. Provision of highway-based motorist warning and traffic control systems will primarily be the responsibility of public transportation entities. Private industry, however, will have primary responsibility for development of train control systems. Several railroads are currently involved in joint programs with the FRA to develop and demonstrate advanced train control systems. In addition, private industry has traditionally developed HRI motorist warning devices. Companies other than traditional railroad suppliers may develop new technologies to address HRI user service requirements. Additionally, the service may need to be designed as a capability that is integrated with other vehicle-warning devices and perhaps other ITS services as well. The market for highway infrastructure equipment will be state and local governments responsible for traffic management, while private railroad companies will develop train control systems and equipment.

1.10.7.3 Public and Private Sector Roles in HRI Deployment

The public sector role for installing, supporting, operating, and maintaining highway traffic control systems is high, since this service directly affects overall public safety and the publicly owned roadway network. State DOTs and local highway authorities have the primary role in the day-to-day operation and maintenance of traffic monitoring and control systems. The railroad industry has traditionally assumed the responsibility for maintaining HRI warning devices. In many cases, private sector firms will have roles as contractors executing the actual design, development, and integration of the technologies and equipment to perform HRI user services. The use of new technologies for these functions will broaden the market potential for private sector suppliers. Potential new markets for vendors of surveillance, communications, and control systems exist, and the public and private sectors may share rights-of-way for communications or other networks. In addition, private firms may also operate and maintain traffic control systems under contract to public agencies. Section 1010 of ISTEA permits public and private cooperative roles in the improvement of safety at HRIs to promote the implementation of high-speed rail corridors. State DOTs have taken a lead role in planning the implementation of high-speed rail service in their respective states.

1.10.7.4 Role of the U.S. DOT in Developing Service

The HRI user service will be incorporated into U.S. DOT's National ITS Program and the National ITS Architecture. The Architecture will provide the framework for implementing the HRI user service. The role of U.S. DOT in developing the HRI user service will be significant.

1.10.7.4.1 Research and Development

The role of the U.S. DOT in research and development activities is to address deployment issues associated with the use of advanced system components, and to develop operational concepts and support systems for advanced motorist warning and highway traffic management and train control systems. U.S. DOT will encourage private industry involvement in the development of the necessary technology and equipment to be compatible with the functional specifications of these systems. U.S. DOT also will work with private industry to develop functional specifications for highway and railroad traffic surveillance and control systems such that system components may be fully integrated in an effective and efficient manner. Section 1036(e) of ISTEA and the Swift Rail Development Act of 1994 provide funding for demonstrations of new technology in the high-speed rail corridors.

1.10.7.4.2 Operational Tests

The role of U.S. DOT in operational tests of HRI user service systems is high. A number of current field-test activities supported by U.S. DOT that relate to HRI user services are currently underway. These activities include:

- Prototype assessment and field testing of VPAS concepts;
- Broad agency announcements for innovative new technologies to address high-speed rail HRI safety issues;
- Requests for proposals on Advanced Rail Technologies through the Transportation Research Board's Innovations Deserving Exploratory Analysis Program;
- Next Generation High-Speed Rail Program rail highway crossing hazard elimination demonstration projects;
- Four-quadrant gates with intrusion detection demonstration project in Connecticut;
- Vehicle arrestor net demonstration project in Illinois;
- Friendly Mobile Barrier energy absorbing barrier system development;
- Automated wayside horn demonstration in Nebraska;
- High-Speed Rail automatic train control demonstration projects in Michigan and Washington; and
- Obstacle detection research and low-cost grade separation demonstration in Florida.

1.10.7.4.3 Institutional and Legal

U.S. DOT will take an active role in fostering the necessary institutional arrangements required for deployment of the HRI user services. Liability issues have historically played an important role in influencing safety improvement decisions at HRI. Highway traffic regulations generally require motorists to comply with HRI warning devices and to yield to train traffic. However, railroads and railroad signal suppliers are often found at fault in litigation resulting from HRI collisions. Railroads and local public authorities are therefore encouraged to improve safety at HRI to minimize collisions and resulting litigation, but are also cautious in employing new concepts to accomplish this, as innovation may be construed as imprudent. These and other complex legal issues must be addressed within any comprehensive program to improve the safety of HRI, in general, and, in particular, at HRI on high-speed passenger train corridors.

1.10.7.4.4 Deployment

The role of the U.S. DOT in deployment of this service is to encourage adoption of advanced systems by states, local government agencies, and the railroad industry.

Archived Data User Service

7.1 ARCHIVED DATA USER SERVICE

7.1.1 Introduction

The Archived Data User Service (ADUS) describes the need for an Intelligent Transportation Systems Historical Data Archive and expands the National ITS Architecture to encompass the needs of the stakeholder groups of this user service. Many of these stakeholder groups previously had little or no involvement in the National ITS Architecture. ADUS requires ITS-related systems to have the capability to receive, collect, and archive ITS-generated operational data for historical, secondary, and non-real-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.

AADT	Annual Average Daily Traffic
ACN	Automated Collision Notification
ACS	Adaptive Signal Control Systems
ADUS	Archived Data User Services
API	Application Program Interface
ARTS	Advanced Rural Transportation System
ASPEN	A roadside inspection tool used for CVISN safety information exchange
ATC	Advanced Transportation Controller
ATIS	Advanced Traveler Information System
CAT	Carrier Automated Transaction
CC	Control Center
CCTV	Closed Circuit Television
CFR	Code of Federal Regulations
CI	Credentialing Interface
CORBA	Common Object Request Broker Architecture
CORSIM	Corridor Simulation
CPT	Common Public Transportation
CVIEW	Commercial Vehicle Information Exchange Window
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial Vehicle Operations
DARC	Data Radio Channel
DATEX	Data Exchange
DOT	Department of Transportation
DSRC	Dedicated Short Range Communication
EDI	Electronic Data Interchange
EMC	Emergency Management Center
EMS	Emergency Management Systems
ETTM	Electronic Toll Collection and Traffic Management
FC	Fare Collection
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FOT	Field Operational Test
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FTP	File Transfer Protocol
FY	Fiscal Year(s)
GHz	Gigahertz
GPRA	Government Performance and Results Act
GPS	Global Positioning Systems
HHI	Highway-Highway Intersection
HQ	Headquarters
HRI	Highway-Rail Intersection
HSR	High-Speed Rail
IDAS	ITS Deployment Analysis System
IFTA	International Fuel Tax Agreement
IM	Incident Management
IMMS	Incident Management Message Sets

IRP	International Registration Plan
ISP	Internet Service Provider
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	Intelligent Transportation System(s)
ITS/CVO	Intelligent Transportation Systems for Commercial Vehicle Operations
ITS JPO	ITS Joint Program Office
ITS America	Intelligent Transportation Society of America
IVI	Intelligent Vehicle Initiative
JPL	Jet Propulsion Laboratory
MCMIS	Motor Carrier Management Information System
MHz	Megahertz
MS/ETMCC	Message Set for External TMC Communication
NAFTA	North American Free Trade Agreement
NHTSA	National Highway Traffic Safety Administration
NTCIP	National Transportation Communications for ITS Protocol
O&M	Operations and Maintenance
OB	Onboard
OER	Octet Encoding Rules
PI	Passenger Information
R&D	Research and Development
RSPA	Research and Special Programs Administration
RTTRACS	Real-Time Traffic-Adaptive Control System
SAFER	Safety and Fitness Electronic Records System
SCH	Scheduling/Runcutting
SDO	Standards Development Organization
SP	Spatial Representation
SSR	Standard Speed Rail
STMF	Simple Transportation Management Framework
STIC	Subcarrier Traffic Information Channel
TCC	Train Control Center
TCIP	Transit Communications Interface Profiles
TCP/IP	Transmission Control Protocol/Internet Protocol
TEA-21	Transportation Equity Act for the 21st Century
TM	Traffic Management
TMC	Traffic Management Center
TRANSIMS	Transportation Analysis and Simulation
TSIS	Traffic Software Integrated Systems
UCR	Unified Carrier Register
UDP/IP	User Datagram Protocol/Internet Protocol
U.S. DOT	United States Department of Transportation
VPAS	Vehicle Proximity Alerting System
XML	Extensible Markup Language

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PUBLICATION NUMBER: FHWA-OP-00-008