Standards Requirements Package 12: Highway Rail Intersections (HRI)

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1 Introduction to Standards Requirements Documentation

The Standards Requirements Packages are intended to be used in conjunction with the other architecture documents. In particular, the introductory chapters of the Standards Requirements Document provide contextual material and explanations/justifications of some of the methods used to evaluate and rate architecture flows. However, it is recognized that many people may initially only receive a given Standards Requirements Package, without the associated supporting material. To aid these individuals, we offer some generic introductory material to promote understanding of the context and approach used to create a Standards Requirements Package. Ultimately, any standards development organization pursuing an ITS-related standard should ensure that they have access to a complete set of the architecture documents as a reference source.

1.1. Standards Requirements Document Executive Summary

The executive summary of the Standards Requirements Document is reproduced here, to provide a sense of the overall goals and content of the document.

The Standards Requirements Document ("SRD") collects information from the other National ITS Architecture program documents and reorganizes it in a manner intended to support the development of critical ITS standards. The key results in the SRD are a reference model for the National ITS Architecture, a rating scheme for evaluating the standardization issues associated with individual data flows that make up the architecture interfaces, and then a set of priority groupings of interfaces into standards requirements "packages". These results and the major conclusions are summarized below.

The introductory section explains the structure of the SRD and its intended usage. The strategy is that the reference model provides the overall context for a standards development organization ("SDO"). A given SDO can pull a particular package of standards requirements out of the document and then use the reference model as a quick reference to the overall architecture. More detailed needs will require going to the original source documents, such as the Logical or Physical Architectures.

The next section provides the rationale for several different ratings schemes applied to the architecture interconnects and flows. These include interoperability requirements, technology maturity assessments, stakeholder interest. All architecture interconnects were examined with respect to these measures. The stakeholder interest and interoperability requirements in particular were then used as the basis for selecting the standards requirements packages. In general, interfaces associated with mobile systems had both the greatest stakeholder interest and the most stringent interoperability requirements. Following close behind were interfaces associated with Traffic Management and Information Service Provider subsystems.

The Architecture Reference Model is provided next as a high level definition of the components that form the National ITS Architecture. It depicts the interconnectivity of the subsystems and terminators, their definitions, and suitable types of communications strategies. This reference model is an important tool for communicating the full breadth of the architecture at an abstracted level. In the SRD it is intended as a contextual reference, but, as a separate document, the reference model has received international circulation through the International Standards Organization (ISO) as a basis for documenting and comparing ITS architectures.

The "meat" of the SRD is the set of standards requirements packages. Each package is a special grouping of standards requirements and contextual information intended to be used in a nearly standalone fashion by an SDO. Thus, packages have been selected that cover the key ITS priorities, maintain the integrity and vision of the National ITS Architecture, and also are perceived as having an interested stakeholder constituency that will help drive standardization. This is a difficult balancing act, but the following 13 packages were identified as covering the high priority standardization needs for the architecture program:

1. Dedicated Short Range Communications (DSRC, formerly "VRC")
2. Digital Map Data Exchange and Location Referencing Formats
3. Information Service Provider Wireless Interfaces
4. Inter-Center Data Exchange for Commercial Vehicle Operations
5. Personal, Transit, and HAZMAT Maydays
6. Traffic Management Subsystem to Other Centers (except EMS)
7. Traffic Management Subsystem to Roadside Devices and Emissions Monitoring
8. Signal Priority for Transit and Emergency Vehicles
9. Emergency Management Subsystem to Other Centers
10. Information Service Provider Subsystem to Other Centers (except EMS and TMS)
11. Transit Management Subsystem Interfaces
12. Highway Rail Intersections (HRI)
13. Archived Data Management Subsystem Interfaces

These 13 areas cover much of the National ITS Architecture and represent the distillation of stakeholder interests and architecture interoperability requirements. If standardization can be achieved in the near term for all or most of these packages, then ITS will be a long ways towards achieving the original vision captured in the user service requirements.

1.2. Constructing a Standards Requirements Package

The intent of creating a Standards Requirements Package is to facilitate efforts to standardize some subset of the National ITS Architecture. The "packaging" process involves abstracting and reorganizing information from other documents, primarily the Logical and Physical Architectures. We have gone through a number of iterations to try and achieve a format that is understandable and useful for SDO's; in the end, while there is not a universal consensus, we have tried to address the substance of most of the comments received.

This Standards Requirements Package has the following main components:

- General introduction to the scope and intent of this package
- Message transaction sets
- Decomposition of the interfaces
- Communications Considerations
- Constraints
- Leveled Data Item definitions

The general introduction is self-explanatory, but the other items require some explanation. We will address them one at a time:

Message Transaction Sets: In order to accomplish a given activity, a series of messages usually have to be exchanged between two or more subsystems. These messages, as a group, constitute a message transaction set. The sequencing of the messages is shown via an ISO-style message sequence chart. Typically the physical architecture flow or highest level logical architecture data flows represent individual messages.

Interface Decomposition: This is the hierarchy of items that constitute an interface. It starts with the interface between two subsystems itself, which is then decomposed into physical architecture flows. Each of the physical architecture flows is then decomposed into a set of Leveled Architecture Flows. These sets of flows have been created in order to capture the essential information described by the National ITS Architecture on each Subsystem interface of interest. The Leveled Architecture Flows can be thought of as a simplified view of the logical architecture information, removing aggregation of data which does not add value to describing the essential information on the interface, and removing some of the lower level details in the existing data flows. These leveled architecture flows are traceable to flows in the logical architecture. The physical architecture data flows are labeled with the type of communications technology appropriate for that flow. Figure 1 shows an example of an interface decomposition. The leveled data items represent a simplification of the logical architecture information to focus on the essential data on each subsystem interface. They have been developed in order to provide traceability between the ITS standards being developed and the National ITS Architecture. Once a draft standard has been developed, the question that must be addressed is whether the standard addresses completely all elements of the National ITS Architecture interface. Due to the complex hierarchical nature of the Logical Architecture data flows, comparison with standards outputs is very difficult. By creating a simplified view of each interface, it is possible to more effectively trace the standards outputs to the National ITS Architecture.

Communications Considerations provides a discussion of the basic nature of the communications modalities that are suitable for supporting the interfaces in the particular standards requirements package. This section identifies some high level requirements, but the primary focus is to provide information that is viewed as useful to the initiation of the standardization process.

Constraints lists the architecture flows and any constraints placed upon them.

Leveled Data Items: This section provides a set of definitions for each of the leveled data elements included in the Interface Decomposition section. These definitions are simplified versions of the definitions contained in the Logical Architecture Data Dictionary, providing just the essential information to define the key elements of a subsystem interface.

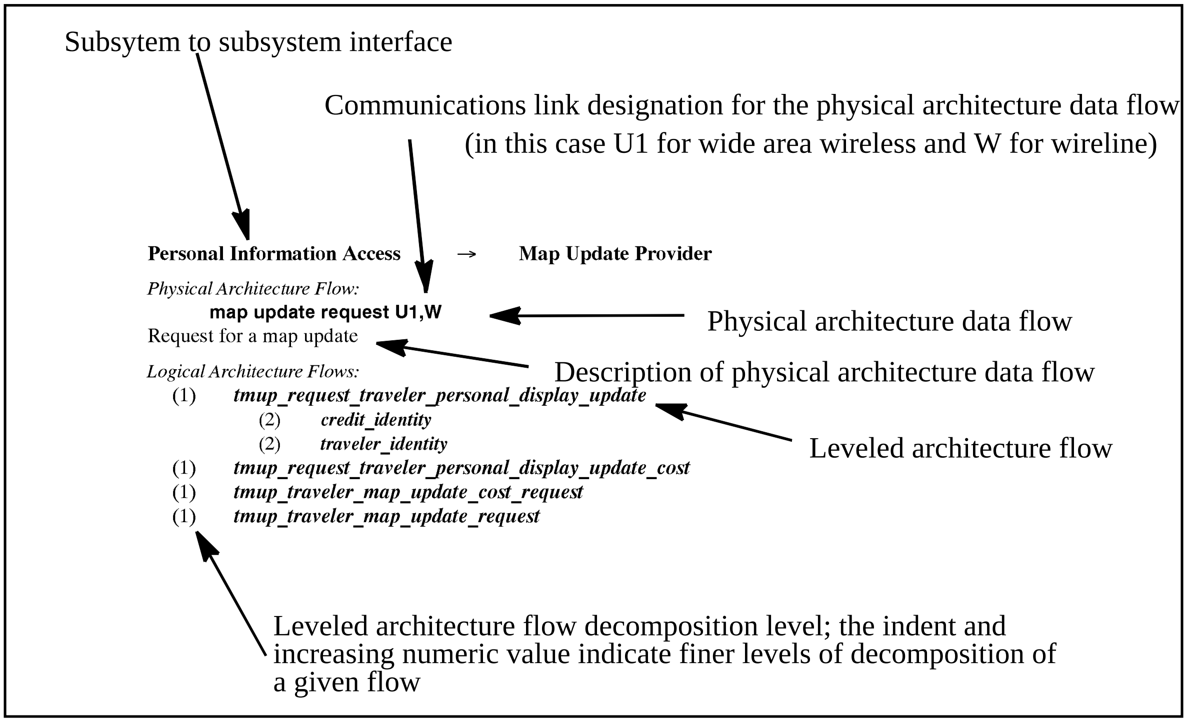

Figure 1 - Example of the parts of an interface decomposition

As a final clarification, it is useful to remind readers of the distinction between the layers in the ISO OSI communications reference model and the layers in the National ITS Architecture. For purposes of analysis and discussion, the National ITS Architecture has been portrayed as having three layers: *the transportation, the communications, and the institutional layer*. The first two are of concern here. The transportation layer contains all the functionality of the National ITS Architecture. As a consequence, any discussion of interfaces, messages, data dictionary entries, etc., is drawn from the information in the transportation layer. The communications layer describes the technology required to support the information exchange needs of the transportation layer. These National ITS Architecture layers can be roughly mapped to the ISO OSI reference model; the transportation layer is typically at or above the application layer and the communications layer is most often concerned with the lowest four layers of the ISO OSI reference model. The interested reader is directed to the Communications Analysis Document for a more substantial explanation of this relationship.

This explanation of the layers is offered here because the terminology can be confusing. Every effort has been made to clarify when the “layered model” is the National ITS Architecture and when it is the OSI reference model. In general, when the term “communications layer” is used in the Standards Requirements Document, it refers to the National ITS Architecture ”layer”.

2 Introduction: Highway Rail Intersections (HRI)

A highway-rail intersection (HRI) is an at-grade crossing between a roadway and a rail system. These occur widely in the U.S. for passenger, freight, and mixed-use tracks. In all normal operating scenarios the train has the right-of-way at these intersections. The issue is then how to manage roadway vehicle traffic so as to maximize safety while minimizing delays. This involves the coordination of rail signals with traffic signals, as well as dissemination of crossing status information to aid in route planning.

This package is primarily concerned with two new interfaces, between the Roadway Subsystem and the Wayside Equipment terminator and between the Traffic Management Subsystem and the Rail Operations terminator, and with one interface that is augmented to carry HRI data, Traffic Management to Roadway.

The subsystems and the physical architecture data flows that are applicable to the Highway Rail Intersections standards package are shown in Figure 2.

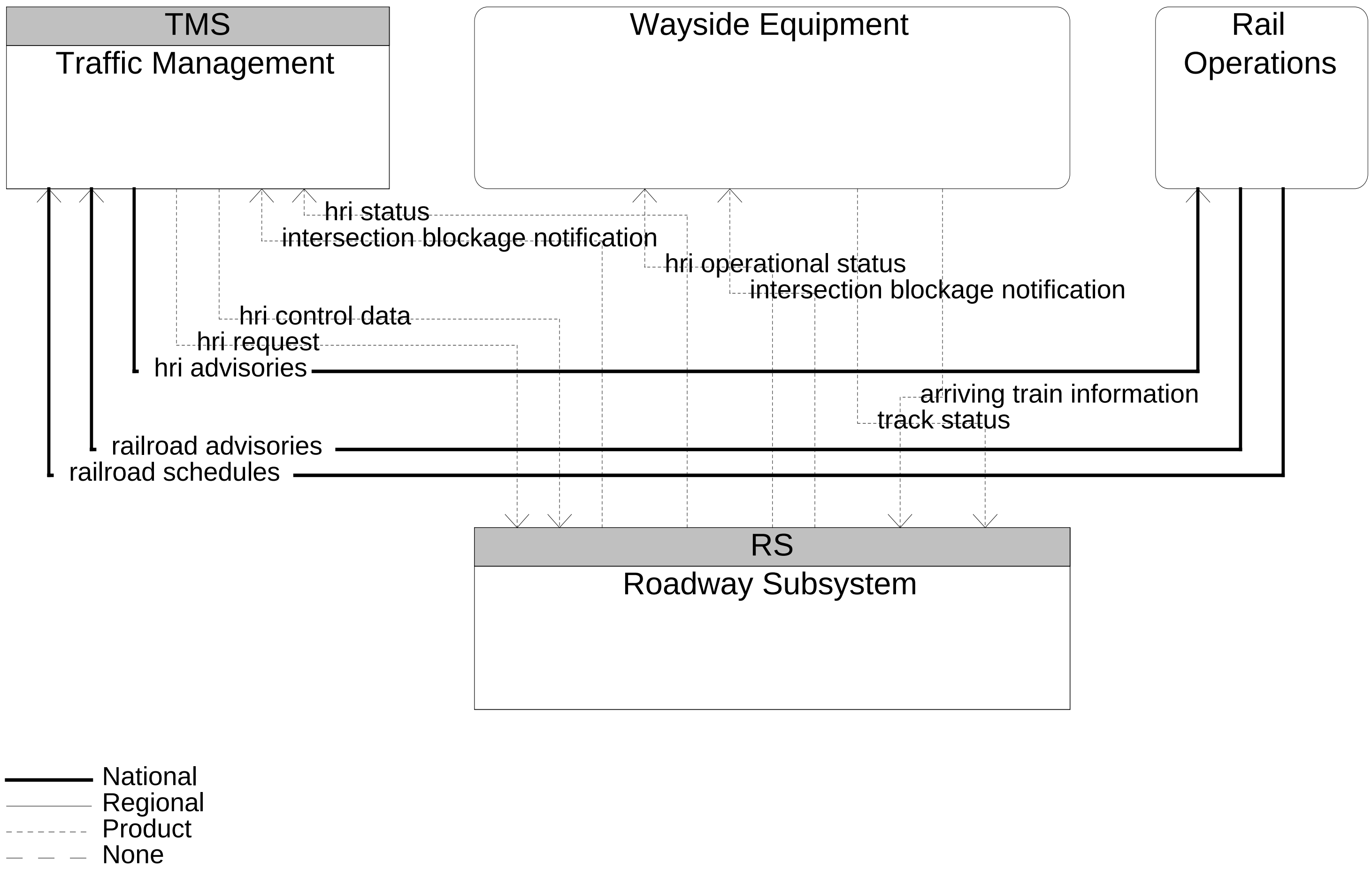

Figure 2 - Interfaces for Highway Rail Intersections

3 Transaction Sets for Highway Rail Intersection Interfaces

In this section we define the transaction sets needed to accomplish different ITS tasks. A message sequence chart format along the lines of those defined under ISO standardization is used for clarity of presentation. The following subsections each discuss the interactions between the Roadside and Traffic Management Subsystems as related to HRI, and also the interactions between the HRI terminators and the same subsystems. Finally the in-vehicle signing interface is also included. The transaction set figures used in this chapter identify the messages that go between the subsystems or between subsystem and terminator. Where messages follow each other top to bottom, they represent a transaction sequence or protocol. Where messages are separated by a horizontal dotted line, the messages are distinct, and not related in any particular sequence. Notes to the right of the messages, or in some cases groups of messages, amplify on details of the message protocols. Sometimes a number in a circle identifies a following numbered section in the text which also describes the particular message or message sequence function.

3.1 Rail Operations and Traffic Management Subsystem

The interface between the Rail Operations terminator and the Traffic Management Subsystem (TMS) provides for the exchange of management or near real time data between these two key functions. The message transaction set for this service is shown in Figure 3.

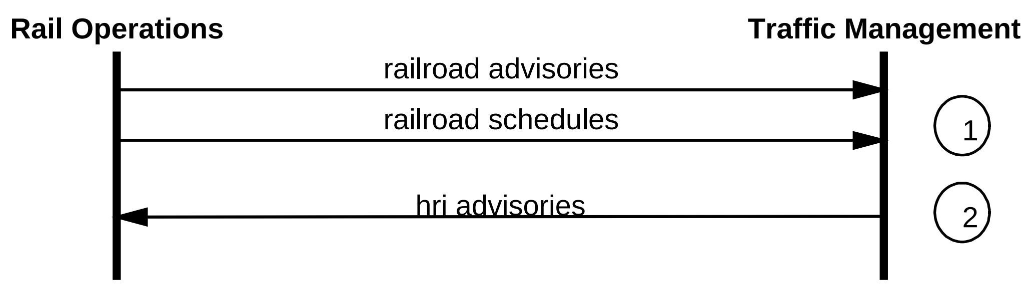

Figure 3 - Rail Operations and Traffic Management Transaction Set

1. The Rail Operations function will send information to the TMS to support forecasting of HRI closures. This includes train schedules (that would be pertinent to HRI's) and maintenance schedules (that would affect HRI's). In addition the RO will send to the TMS information about rail incidents which may impact vehicle traffic. This latter information would be in near real time, while the other schedule information would be provided on a periodic basis (e.g., daily).

2. The TMS would notify the RO in near real time about equipment failure, intersection blockage, or other incident information (e.g., nearby HAZMAT spill). The TMS would also send information about planned maintenance activities that are occurring at or near the grade crossing and which could impact the railroad right of way.

3.2 Roadway Subsystem and Traffic Management Subsystem

The addition of HRI to the National Architecture will add several flows between the Roadside and TMS. The transaction set for these additional flows is shown in Figure 4.

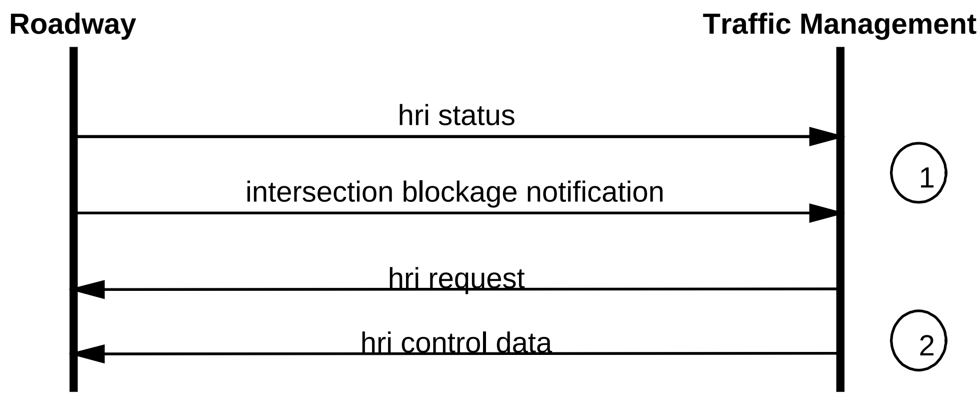

Figure 4 - Roadway and Traffic Management Subsystems Transaction Set

1. The Standard Rail Crossing Equipment Package in the Roadway Subsystem determines the status of the HRI and transmits this to the TMS. This status is made up of several components: information about the crossing itself, information about the traffic in the neighborhood of the crossing, information about the expected closure time and duration (obtained from the wayside equipment), and information that should be displayed via VMS or beacon (for in-vehicle signing). This same information is applicable to the Advanced Rail Crossing Equipment Package. In addition, an intersection blockage notification message is included to provide an indication if a blockage in the HRI exists.

2. The TMS will communicate with the Roadway with two types of HRI related messages: the first are control messages (the HRI control data flow) sent directly to the HRI equipment (such as the intelligent intersection controller, VMS, etc.), the second are status request messages. The control messages can also include rail advisory information obtained from the Rail Operations and forwarded by the TMS.

3.3 Roadway Subsystem and Wayside Equipment Terminator

The Roadway Subsystem interfaces with Wayside Equipment will provide status and blockage notification. The Wayside Equipment interfaces to the Roadway to provide real time information about the approach (actual or predicted) of a train. The transaction set for these interactions is shown in Figure 5.

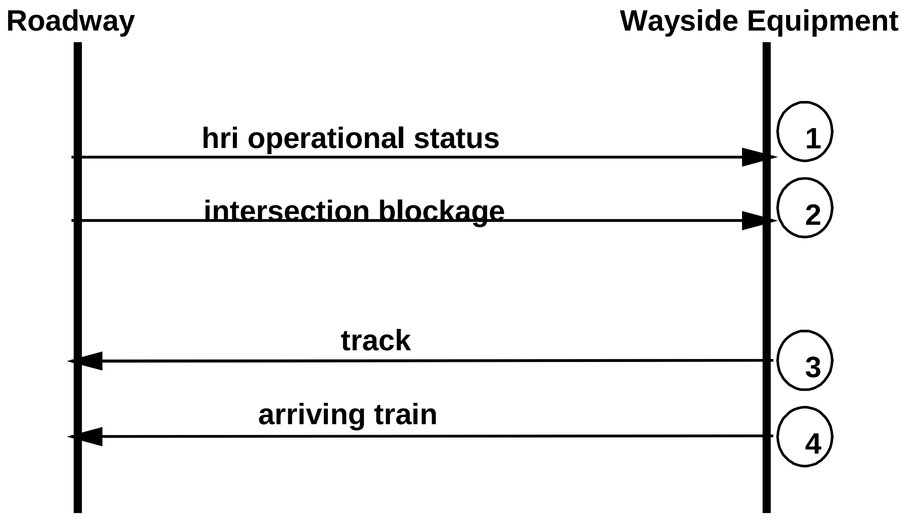

Figure 5 - Roadway Subsystem and Wayside Equipment Transaction Set

1. The Roadway sends a real time HRI status to the Wayside Equipment. This includes a confirmation that the highway grade crossing is closed and that trains may proceed at full authorized speed.
2. The Roadway also sends a real time indication of intersection blockage. This message would be used in the Advanced Rail Equipment Package to provide the information needed by the wayside equipment in order to alert the train to slow down or stop.
3. The Wayside Equipment provides a real time indication of its operational status via the track status message. This would alert the roadside equipment to possible failures or problems in the wayside equipment. The track status message also includes the simple binary indication of a train approaching which is currently used when signal controllers are interconnected with the wayside equipment.
4. In future implementations, the wayside equipment would provide expected time of arrival and length of closure via the arriving train information flow.

4 Interface Decomposition

This section shows the interface decomposition for the interfaces covered in this package. The format shows the interface followed by the first physical architecture data flow in the interface and its description. Each of the physical architecture flows is then decomposed into its constituent leveled data items, which in turn are decomposed hierarchically into more basic leveled architecture flows. The leveled data items are numbered and indented to indicate which are top level flows (1) and which are constituent data flows (numbered 2 and lower). The description of the top level leveled data item is given. The full leveled data item definition for the top level flows and for all the constituent flows is given in Section 7. That section contains the leveled data item entries, listed in alphabetical order, for all of the leveled data items contained in this package. The leveled data items represent a simplification of the logical architecture information to focus on the essential data on each subsystem interface. They are traceable to the original logical architecture data elements, and have been developed in order to provide traceability between the ITS standards being developed and the National ITS Architecture. Once a draft standard has been developed the question that must be addressed is whether the standard completely addresses all elements of the National ITS Architecture interface. Due to the complex hierarchical nature of the Logical Architecture data flows, comparison with standards outputs is very difficult. By creating a simplified view of each interface, it is possible to more effectively trace the standards outputs to the National ITS Architecture.

4.1 Traffic Management -> Rail Operations

Physical Architecture Flow: hri advisories W

Notification of Highway-Rail Intersection equipment failure, intersection blockage, or other condition requiring attention, and maintenance activities at or near highway rail intersections.

Leveled Data Items:

(1) ***to_rail_operations_equipment_status***

This data item contains information about the status of the wayside equipment and the intelligent intersection controller. It is used to pass information to rail operations about the overall health and status of the HRI.

(1) ***to_rail_operations_event_schedules***

This data item contains highway event schedules for use by a rail operator. Typically the rail operator would be interested in highway maintenance at or near grade crossings that may interfere with the rail right-of-way.

(1) ***to_rail_operations_incident_notification***

This data item contains a highway incident notification relevant to a rail operator. Typically the rail operator would be interested in highway incidents at or near railroads that may interfere with the safe operation of passing trains (e.g. a HAZMAT spill, equipment failure, or an intersection blockage).

4.2 Traffic Management -> Roadway Subsystem

Physical Architecture Flow: hri control data W

Data required for HRI information transmitted at railroad grade crossings and within railroad operations.

Leveled Data Items:

(1) ***hri_traffic_surveillance***

This data item represents the various traffic sensor inputs to HRI from the Traffic Surveillance processes .

(1) ***indicator_sign_control_data_for_hri***
This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators, dynamic message (dms), advisory beacons, and other types of signs on the roads (surface streets) in the vicinity of railroad grade crossings.

(1) ***rail_operations_advisories***
This data item contains advisory information for HRI vehicular traffic that has been derived from information received from rail operations.

(1) ***rail_operations_device_command***
This data item contains HRI device commands that have been derived from information received from rail operations and provides for rail operations preemption capability.

Physical Architecture Flow: hri request W
A request for highway-rail intersection status or a specific control request intended to modify HRI operation.

Leveled Data Items:
(1) ***request_hri_status***
This data item defines a request for HRI status (status of the intersection controller and/or wayside equipment).

4.3 Wayside Equipment -> Roadway Subsystem

Physical Architecture Flow: arriving train information W
Information for a train approaching a highway-rail intersection that may include direction and allow calculation of approximate arrival time and closure duration.

Leveled Data Items:
(1) ***from_wayside_equipment_train_data***
This data item contains time critical data about an approaching train and is provided to the HRI at the roadside by railroad owned and maintained equipment and/or communications networks. This data, if available, will be provided concurrently with the approaching train announcement and must include data sufficient for the HRI to determine crossing close time, and the anticipated closing duration.

Physical Architecture Flow: track status W
Current status of the wayside equipment and notification of an arriving train.

Leveled Data Items:
(1) ***data_from_wayside_equipment_status***
This data item allows the railroad operated and maintained equipment to verify its operational status to dependent HRI processes. This can be as simple as a binary indication of status, to a full maintenance report.

4.4 Rail Operations -> Traffic Management

Physical Architecture Flow: railroad advisories W
Real-time notification of railway-related incident or advisory.

Leveled Data Items:
(1) ***from_rail_operator_incident_notification***
This data item is used by a rail operator to notify an ITS traffic management function that a rail incident has been detected that will impact vehicle traffic. This could be an HRI collision incident or merely a stalled train that is blocking an HRI. It could also be a rail incident NOT associated with an HRI, but that may cause abnormal traffic patterns, or blockage of a non-crossing or grade separated roadway. .

Physical Architecture Flow: railroad schedules W
Train schedules, maintenance schedules, and other information from the railroad that supports forecast of HRI closures.

Leveled Data Items:
(1) ***from_rail_operator_maintenance_schedules***
This data item provides the information traffic management needs to plan around scheduled maintenance by railroad crews at highway grade crossings that may affect highway traffic.

(1) ***from_rail_operator_train_schedules***
This data item is used by railroads to provide ITS traffic management functions of train movement schedules that may be pertinent to traffic and route planning, highway maintenance planning, etc. As scheduled information, it may be used to determine the probability of grade crossing blockage by trains and therefore the expected traffic flow rates on specific vehicle routes.

4.5 Roadway Subsystem -> Traffic Management

Physical Architecture Flow: hri status W
Status of the highway-rail intersection equipment including both the current state or mode of operation and the current equipment condition.

Leveled Data Items:
(1) ***hri_guidance_for_beacon_message***
This data item is used to control which message is to be broadcast to drivers approaching an HRI.

(1) ***hri_guidance_for_dms***
This data item is used to control which message is to be displayed on a dynamic message sign (dms) as drivers approach an HRI.

(2) ***hri_closure_data_response***

(2) ***hri_state***

(1) ***hri_traffic_data***
This data item contains data to be used by traffic management to coordinate its overall operations with the HRI activity.

(1) ***rail_operations_message***
This data item contains advanced (predictive) data about an HRI operational status to be passed to rail operations. It is generated by the Manage HRI Traffic process for use by the Interact with Rail Operations process.

(1) ***traffic_management_request***
This data item is used by HRI to request services or data from other traffic management functions .

Physical Architecture Flow: intersection blockage notification W
Notification that a highway-rail intersection is obstructed and supporting information.

Leveled Data Items:
(1) ***hri_blockage***
This data item contains information, obtained from sensors in the intersection, regarding blockage of the HRI by a vehicle or other object. This data will be passed to Rail Operations.

(1) ***intersection_blocked***
This data item contains information, obtained from sensors in the intersection, regarding blockage of the HRI by a vehicle or other object. This data will be used by the traffic management functions to begin incident management procedures.

4.6 Roadway Subsystem -> Wayside Equipment

Physical Architecture Flow: hri operational status W
Status of the highway-rail grade crossing equipment including both the current state or mode of operation and the current equipment condition.

Leveled Data Items:
(1) ***to_wayside_equipment_hri_status***
This data item provides a real-time indication of the status at a highway grade crossing (e.g. operational, not-operational, obstructed, etc.).

Physical Architecture Flow: intersection blockage notification W
Notification that a highway-rail intersection is obstructed and supporting information.

Leveled Data Items:
(1) ***to_wayside_equipment_stop_highway_indication***
This data item provides a real-time confirmation that a highway grade crossing is closed to highway non-rail traffic and all trains may proceed at full authorized speed. Alternative indications are possible, i.e. proceed at reduced speed - prepared to stop.

(1) ***to_wayside_equipment_stop_train_indication***
This data item provides a real-time indication that a highway grade crossing is obstructed or otherwise closed and all trains must stop prior to entering it. Alternative indications to full stop are possible, i.e. proceed at reduced speed - prepared to stop.

5 Communications Layer Requirements

This chapter describes relevant requirements regarding the Communications Layer for the portion of the ITS National Architecture covered by this package. In general the Communications Layer supports the four lower layers of the OSI model (transport, network, data link, and physical layer). A complete description of the Communications Layer is contained in the ITS National Architecture Communications Analysis Document. In addition to actual requirements the section contains some informational notes which are included in brackets.

5.1 Communications Services: Wireline and Wireless

The communication services define the exchange of information between two points and are independent of media and application (i.e., ITS user service). In essence, they are a specified set of user-information transfer capabilities provided by the communication layer to a user in the transportation layer.

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

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

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

An additional class of communication services is location services. These fall in two categories: (1) the services that do not use the communication network (i.e., GPS, and stand alone terrestrial systems); (2) location services that use the network for providing the service (e.g., cellular based systems). In the latter case, the location services fall under the interactive services. The service will be rendered by a service provider in response to a request for information or help.

The class of communications service for each Architecture Flow in this standards package is defined in a table in the following section.

5.2 Wireline Communication Elements (w)

The interfaces of this standards package are entirely wireline interfaces. The primary requirements of the wireline communication layers include the utilization of open standards for the communications protocols. The following paragraphs provide a discussion of wireline considerations for ITS.

The wireline links represent wide area network communications elements, which can take a number of forms. Typically, it will be a data network of some kind. Physically the network can be fiber, coaxial, twisted pair, or even microwave. It can be an ITS dedicated network, such as a communication system installed by a public agency to pass messages between a Traffic Management subsystem and associated Roadway subsystems distributed across a region. Alternatively it can be a privately deployed network owned and operated by a communication service provider, where operators of ITS subsystems pay a service fee for connection to and use of the network for ITS functions. More than one network used for ITS may coexist within a region, and these networks will be connected (or internetworked) to support ITS message communication between subsystems that are attached to different networks.

It is expected that the current trend toward ubiquitous internetworking of public and private data networks, as currently embodied in the ‘‘Internet”, for example, will continue. This will enable inter-subsystem messaging across local, regional, and national distances. What the Internet is rapidly evolving to (as security and reliability issues of today’s Internet are addressed) has been referred to as the ‘‘National Information Infrastructure”or ‘‘NII”.

In the near term, we expect that many communication elements will be dedicated, as they primarily are today. As commercial data networks are deployed, interconnected, and mature, and the cost of access and use of these private data networks drops, we expect more and more wireline networks for ITS to be supplied from Communication Service Providers (CSP's). The time when the transition from private data networks to commercial data networks becomes practical and economical will vary by region. We expect this transition to be analogous to the transition that was made early in this century from private phone networks to the Public Switched Telephone Network (PSTN). Our expectation is that in the 20-year time frame most ITS communications will be provided by CSP's.

For the links to the TMS, the evolving ITS standard is the National Transportation Communications for ITS Protocol (NTCIP). This standard is being developed for the transmission of data and messages between ITS elements. The NTCIP constitutes a set of standards that define common methods of physically interconnecting ITS control equipment, establishes the protocol and procedures for establishing communications between the components, and defines procedures to develop and register common sets of manageable objects related to controlling and managing the components. The standards are being developed by National Electrical Manufacturers Association (NEMA) with support from the US DOT. NTCIP contains a suite of communications protocols, divided into several class profiles, for integrating the various components that may be included in an ITS. The standard defines the elements that allow transportation control equipment to be interchanged by a manufacturer. Also, a complete end-to-end data handling procedure is defined allowing devices to perform tasks associated with communications between traffic management centers and other field equipment. The initial version of the NTCIP is being developed to support the interface from the TMS to traffic controllers and VMS signs. Work is underway to extend this to other roadside equipment. Plans are also in place to extend the protocol for center to center communications. In the area of center to center communications, there are several existing and developing communications standards to choose from for the physical (and data link) layers. These include ATM, Frame Relay, MAN (IEEE 803.6), and FDDI. At the network layers, TCP/IP is a widespread standardized protocol (and is being used in the NTCIP efforts). The key is that by using standard communication protocol suites the regional integration of the wireline data will most readily be accomplished.

5.3 Wireless Communication Elements (u1 and u2)

There are no wireless interfaces in this standards requirements package.

6 Constraints

This chapter identifies constraints placed upon Physical Architecture flows.

6.1 Assessment Categories

The following categories have been used in rating the constraints that exist on the physical data flows.

1. Performance

   a. Emergency Priority (E)

      Essentially "real-time" requirements. Emergency data that is time critical must be received by a certain absolute time, or it is useless. For these flows the communication channel may require priority in emergencies. The data channels required must be operational even when there is an emergency that might place other loads on the interface. A private communication channel or frequency may be required to satisfy the requirement.

   b. Reliability(R)

      This category encompasses both the concepts of reliability and availability. Data must be delivered reliably. Loss can not be tolerated. The communications link must also have high availability. Failure of the communication medium may result in severe accident. This communication channel may require redundant paths or require extra attention paid to potential failure modes. For wireline cases, this may indicate that alternate phone or other connections are required. For wireless cases (e.g., for AHS applications), special attention will be paid to the transmitters, receivers, and potential interference for these connections.

   c. Timing (T)

      The timing constraints are critical. If communication does not occur within set limits system failures can occur. Timing for most ITS communication services is based on the response to a request for data. Because of this, common communication media designed to handle voice data will likely support these requirements. The beacon interface has special requirements for identifying the vehicle as well as exchanging information before the vehicle gets out of range. This problem becomes greater with vehicles traveling at speed. The architecture constrains time critical access to data such that the data is available at the beacon site. This obviates the need for explicit specification of other timing information to support data transfer over a short range beacon.

      This timing constraint is related to (but not the same as) another attribute often discussed in specifying systems: latency. Latency is used to quantify end-to-end processing and transmission time (round trip delays). Data with a latency requirement must be handled within a certain time interval. This differs from "time criticality" in that it is a relative rather than absolute time requirement (i.e., latency: interface screen must update every 2 seconds; time criticality: route instructions must be received 30 seconds prior to first turning action). Because latency requirements are greatly affected by the implementation of the subsystem elements, it cannot be specified directly when discussing only the interface between two subsystems.

2. Data Sensitivity

   a. Security (S)

      Access to the data must be restricted. Data itself must be secure during transmission. This is typically used for financial information, but could also include data of a sensitive nature (e.g., notice of movements of certain cargoes, or certain important persons).

b. Privacy(P)

Anonymity of the data source or recipient must be protected. This is typically used for personal information.

6.2 Architecture Flow Constraints

Table 1. Architecture Flow Constraints

Source	Destination	Architecture Flow	Interconnects	Communication Service	Special Constraints
Roadway Subsystem	Traffic Management	hri status	W	Conversational data, Messaging data	R
Roadway Subsystem	Traffic Management	intersection blockage notification	W	Messaging data	T, R
Roadway Subsystem	Wayside Equipment	hri operational status	W	Conversational data, Messaging data	R
Roadway Subsystem	Wayside Equipment	intersection blockage notification	W	Messaging data	T, R
Traffic Management	Rail Operations	hri advisories	W	Conversational Data, Messaging data	T,R
Traffic Management	Roadway Subsystem	hri control data	W	Messaging data	R
Traffic Management	Roadway Subsystem	hri request	W	Conversational data, Messaging data	R
Wayside Equipment	Roadway Subsystem	arriving train information	W	Messaging data	T, R
Wayside Equipment	Roadway Subsystem	track status	W	Messaging data	T,R

7 Data Dictionary Elements

This section contains the leveled data item (LDI) definitions for all the leveled data item elements listed in this standards requirements package.

The LDI's are given in alphabetical order.

data_from_wayside_equipment_status
: This data item allows the railroad operated and maintained equipment to verify its operational status to dependent HRI processes. This can be as simple as a binary indication of status, to a full maintenance report.

from_rail_operator_incident_notification
: This data item is used by a rail operator to notify an ITS traffic management function that a rail incident has been detected that will impact vehicle traffic. This could be an HRI collision incident or merely a stalled train that is blocking an HRI. It could also be a rail incident NOT associated with an HRI, but that may cause abnormal traffic patterns, or blockage of a non-crossing or grade separated roadway.

from_rail_operator_maintenance_schedules
: This data item provides the information traffic management needs to plan around scheduled maintenance by railroad crews at highway grade crossings that may affect highway traffic.

from_rail_operator_train_schedules
: This data item is used by railroads to provide ITS traffic management functions of train movement schedules that may be pertinent to traffic and route planning, highway maintenance planning, etc. As scheduled information, it may be used to determine the probability of grade crossing blockage by trains and therefore the expected traffic flow rates on specific vehicle routes.

from_wayside_equipment_train_data
: This data item contains time critical data about an approaching train and is provided to the HRI at the roadside by railroad owned and maintained equipment and/or communications networks. This data, if available, will be provided concurrently with the approaching train announcement and must include data sufficient for the HRI to determine crossing close time, and the anticipated closing duration.

hri_blockage
: This data item contains information, obtained from sensors in the intersection, regarding blockage of the HRI by a vehicle or other object. This data will be passed to Rail Operations.

hri_closure_data_response
: This data item represents an historical log of HRI closure data.

hri_guidance_for_beacon_message
: This data item is used to control which message is to be broadcast to drivers approaching an HRI.

hri_guidance_for_dms
: This data item is used to control which message is to be displayed on a dynamic message sign (dms) as drivers approach an HRI.

hri_state
: This data item represents the complete state of an HRI as determined by monitoring the status of the track, traffic and equipment.

hri_traffic_data
: This data item contains data to be used by traffic management to coordinate its overall operations with the HRI activity.

hri_traffic_surveillance
: This data item represents the various traffic sensor inputs to HRI from the Traffic Surveillance processes .

indicator_sign_control_data_for_hri
This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators, dynamic message (dms), advisory beacons, and other types of signs on the roads (surface streets) in the vicinity of railroad grade crossings.

intersection_blocked
This data item contains information, obtained from sensors in the intersection, regarding blockage of the HRI by a vehicle or other object. This data will be used by the traffic management functions to begin incident management procedures.

rail_operations_advisories
This data item contains advisory information for HRI vehicular traffic that has been derived from information received from rail operations.

rail_operations_device_command
This data item contains HRI device commands that have been derived from information received from rail operations and provides for rail operations preemption capability.

rail_operations_message
This data item contains advanced (predictive) data about an HRI operational status to be passed to rail operations. It is generated by the Manage HRI Traffic process for use by the Interact with Rail Operations process.

request_hri_status
This data item defines a request for HRI status (status of the intersection controller and/or wayside equipment).

to_rail_operations_equipment_status
This data item contains information about the status of the wayside equipment and the intelligent intersection controller. It is used to pass information to rail operations about the overall health and status of the HRI.

to_rail_operations_event_schedules
This data item contains highway event schedules for use by a rail operator. Typically the rail operator would be interested in highway maintenance at or near grade crossings that may interfere with the rail right-of-way.

to_rail_operations_incident_notification
This data item contains a highway incident notification relevant to a rail operator. Typically the rail operator would be interested in highway incidents at or near railroads that may interfere with the safe operation of passing trains (e.g. a HAZMAT spill, equipment failure, or an intersection blockage).

to_wayside_equipment_hri_status
This data item provides a real-time indication of the status at a highway grade crossing (e.g. operational, not-operational, obstructed, etc.).

to_wayside_equipment_stop_highway_indication
This data item provides a real-time confirmation that a highway grade crossing is closed to highway non-rail traffic and all trains may proceed at full authorized speed. Alternative indications are possible, i.e. proceed at reduced speed - prepared to stop.

to_wayside_equipment_stop_train_indication
This data item provides a real-time indication that a highway grade crossing is obstructed or otherwise closed and all trains must stop prior to entering it. Alternative indications to full stop are possible, i.e. proceed at reduced speed - prepared to stop.

traffic_management_request
This data item is used by HRI to request services or data from other traffic management functions .