Standards Requirements Package 2: Digital Map Data Exchange and Location Referencing

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Table of Contents

Table of Figures

Table of Tables

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.

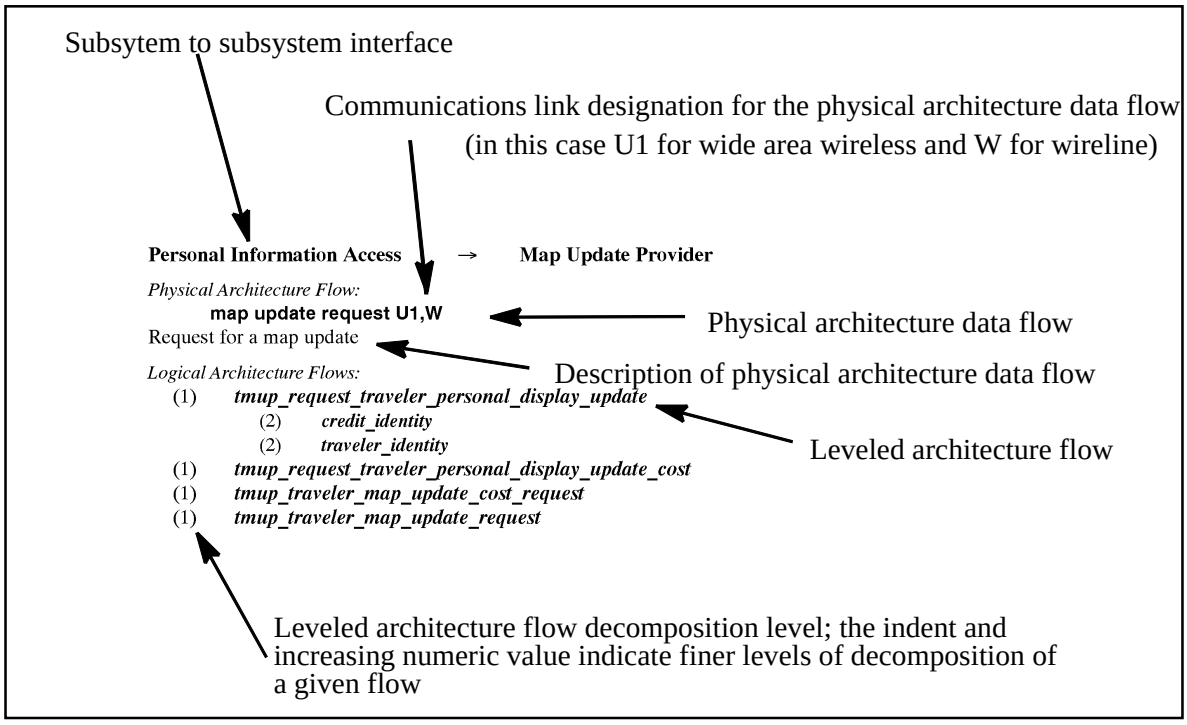

Figure 1. Example of the parts of an interface decomposition

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 to this Standards Package

The exchange of spatial information is critical to many aspects of ITS. Obvious uses are vehicle position reporting for Maydays or guidance, or map data furnished to an ISP. Less obvious uses include the exchange of databases that are linked to spatial coordinates. An example of this would be a Metropolitan Planning Organization (MPO) that requires data from traffic, safety, and public works departments, in order to make long range planning decisions. As illustrated in this standards package, both mobile and stationary subsystems need to use spatial data.

Currently there is a rapid proliferation of both digital map suppliers and devices that provide location (primarily GPS based). While these providers may gain market advantage through proprietary technologies within their products, creating open interfaces and exchange formats will benefit all, by creating larger markets and increasing consumer confidence.

This package actually addresses two types of spatial information. The first is the digital map information. A digital map is the equivalent of an electronic version of a paper map. It typically depicts the navigable roadways and may also include points of interest, speed limit, and special traffic control information. Typically we are concerned with digital maps that are machine readable; that is, that can be used by algorithms that calculate routes or do other analysis. In some cases we are also interested in graphical digital maps for display to humans. Both are valid forms of this first type of spatial information.

The second type of spatial information in this package is position information. Typically, this is provided by a mobile platform as a specification of location. The position, referred to as "location reference" or "location identity", is typically interpreted relative to a digital map of the surface transportation network. Thus the digital map information and the location identity information are interdependent. For this reason, both types of spatial information are addressed in this package.

As noted previously, the format of this package deviates slightly from what we have used previously. We examine the digital map data standards requirements using the usual format of defining an entire interface. However, location identity is a component data item in virtually every system interface. To make this tractable, we try to tersely define for what purpose each interface uses the location identity. We then summarize this to give an overall picture of the set of requirements that location identity must address across the Architecture.

This package will need to be coordinated with the Mayday package. Clearly Mayday messages will require a location reference component; the standards developed to meet the requirements in this package should also meet the location referencing needs for Mayday.

2.1 Subsystems Involved in Map Data Exchange

It is expected that suppliers will provide digital maps, as well as periodic updates to these maps, to the entities that utilize them. The terminator "Map Update Provider" is intended to capture this vendor function. The following figure depicts the physical architecture subsystems and flows involved in digital map data exchange.

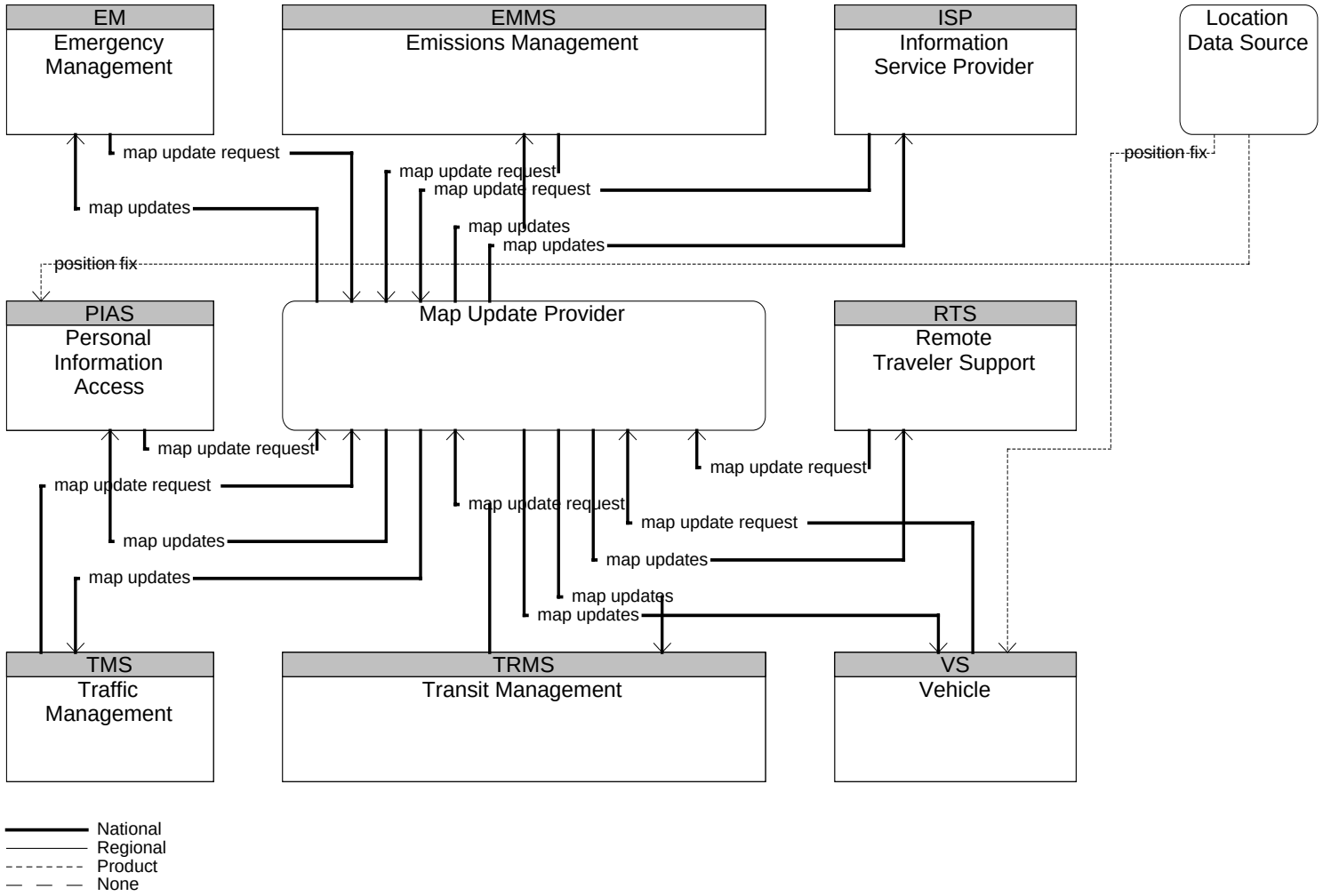

Figure 2 - Subsystems that receive map data

Figure 2 indicates that the nature of the interactions is quite straightforward; nine different subsystems request and receive digital map data from the Map Update Provider terminator. The next section, Section 3, will illustrate the types of updates that these different entities are likely to need.

Figure 2 also shows the "Location Data Source" terminator. This terminator provides a position fix to the vehicle platform (as well as to PIAS) and is a fundamental part of many ITS services. The ITS instrumentation on the vehicle turns this data into an actual location, perhaps by combining a latitude-longitude measurement with a compass heading, and then matching this information to a digital map. This is included in Figure 2 to show how position is determined. It also shows an example of mobile subsystems obtaining map data and fixing their own positions, to emphasize the synergy of digital map data and location referencing.

One final point on Figure 2 is that all flows related to the map data require national interoperability. This is to support mobile platforms and to allow inter-jurisdictional information exchange. The "position fix" and "vehicle location" architecture flows are all internal to a single vehicle; as a result they only require product interoperability.

2.2 Usage of the "*Location_Identity*" Primitive Element

The second type of spatial information -- that specifying position -- is captured in the National ITS Architecture in the primitive element ("pel") of the Logical Architecture called *location_identity*. Wherever a position specification is required for a data flow, the pel location_identity is used. This item is currently sized at 22 bytes, based on the LRMS (Location Reference Messaging Standard) proposal from the University of Tennessee/Oak Ridge National Laboratory. The LRMS has been developed as a flexible and unambiguous way to specify position for transportation needs.

The pel location_identity is used by 85 interfaces in the physical architecture. Digging down into the logical architecture, we find that there are 521 instances of location_identity used in the flow hierarchy. This is the most frequently used pel by a significant margin; location_identity's frequent use attests to the pivotal importance of specifying and reporting locations for satisfying the ITS user services requirements.

Section 3 of this package will examine the types of uses that are made of location_identity. By looking at the fundamental types of messages that include this pel, it is hoped that proposed standards such as LRMS can be evaluated. If necessary, variants or extensions may need to be specified, but by looking at the full set of needs from the start, it should be possible to conceive of these in a coherent framework.

3 Transportation Layer Message Sets and Theory of Operation

This section contains two main subsections. The first covers the transaction sets required for the exchange of map data, as depicted in Figure 2. The second subsection, Section 3.2, covers the use of "location_identity" in the architecture.

Based on the top level logical architecture data flows, we can 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.

3.1 Digital Map Data

The basic mechanism for obtaining map data is to send a request to the Map Update Provider, who then provides the map or update:

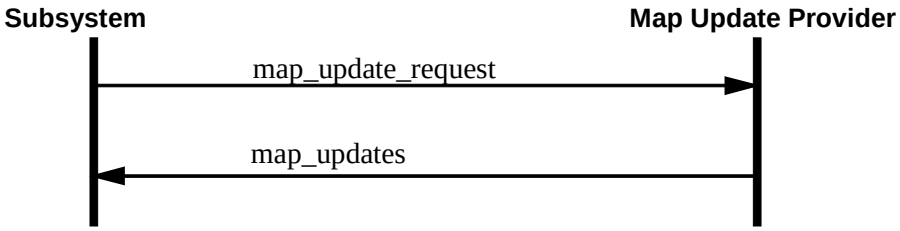

Figure 3 - Generic Example Map Request Transaction Set

The specifics of this vary for the particular subsystems, and will be addressed in the following subsections. In general, the Architecture does not distinguish between different types of "map_update". So there is not a "full map initialization" and an "incremental map refresh". In a deployment scenario, these different types of updates might arise, depending on the nature of the particular situation. Hopefully, as standardization moves forward and implementers become involved, this additional level of detail can be added.

The messages of the general form "map_update_request" are sized at 2 bytes in the data dictionary. This was an estimate that assumed a standard grid-based (e.g., zip-code) or hierarchical (e.g., state-county) regional specification. If this specification is internationalized, and country is not felt to be obvious from the request context, then this sizing will need review.

3.1.1 Emergency Management Subsystem

The Emergency Management Subsystem monitors incidents in the transportation network and the progress of emergency responses to those incidents. Information may also be communicated to Traffic Management to support signal priority for emergency vehicles; this suggests it may be important for EMS and TMS to work from similar maps.

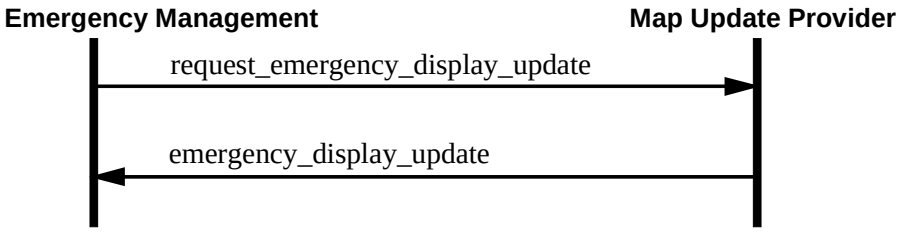

Figure 4 - Emergency Management Map Request Transaction Set

A request is sent "to map update provider" for the digital map data used to display emergency related activities to the EMS operator. In response, a digital display map is returned "from map update provider".

In general the map data required by the EMS operator will need to support precise geolocation, visualization of the transportation network, and probably also vehicle route tracking and planning. This creates a requirement for map data that can support geolocation relative to map entities (roads, intersections, points-of-interest) and the generation of operator displays that can be updated in real-time to show the emergency response situation.

3.1.2 Emissions Management Subsystem

Emissions Management monitors pollution levels in the transportation network, via sensors located at the roadside. This information is communicated to the public and to decision makers, such as Traffic Management which sets short term traffic policy, and Planning which makes longer term infrastructure decisions. Emissions Management utilizes digital maps to produce reports of regional pollution levels (pollution maps) and to communicate this information with other entities.

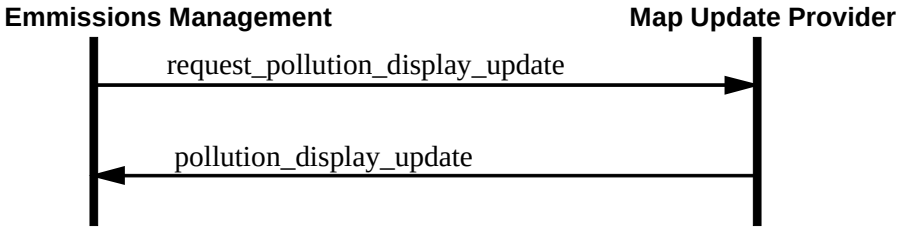

Figure 5 - Emissions Management Map Request Transaction Set

A request is sent "to map update provider" for the digital map data used to display pollution information. In response, a digital display map is returned "from map update provider".

In general, the map data required by Emissions Management will need to support visualization of the transportation network. Depending on the nature of the emissions sensing technology, pollution information may be available from wide-area sensing devices (lidar sensors, satellite data, etc.) or from sampling stations located at specific points on the roadway. This creates requirements for map data, in the first case, that can support geolocation at the latitude-longitude specification of regions. In the second case, the specification will more likely be made relative to the transportation network ("I-5 has unacceptable levels of ozone at the exit 12 sensor"). In both cases the map data will need to support the generation of operator displays that show the pollution status.

3.1.3 Information Service Provider Subsystem

The Information Service Provider is responsible for all routing and traveler information functionality in the architecture. Because of this general role, digital map data depicting several different kinds of data is required. Shown below are requests for map data to support vehicle routing requests and to support non-vehicle traveler needs.

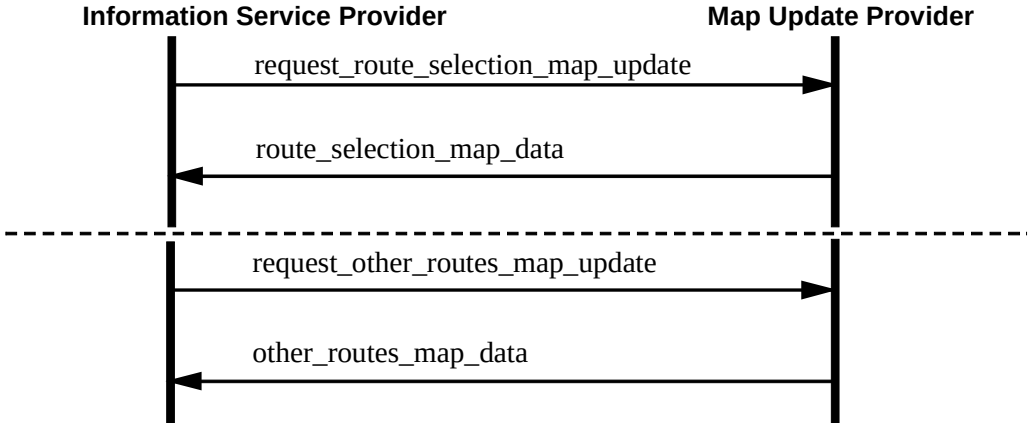

Figure 6 - Information Service Provider Map Request Transaction Set

In the above figure we see the two types of map data requests and responses. The top is for data to support vehicle routing. The other is to provide non-vehicle/non-transit routes for travelers.

In general, the map data required by the ISP will need to support precise geolocation of the ISP clientele, so that dynamic travel services can be furnished and probably also vehicle route tracking and planning. This creates a requirement for map data that can support geolocation relative to map entities (roads, intersections, points-of-interest) that, in this case, must include non-private transportation options (trains, buses, paratransit, etc.). Depending on the mode of operation of the ISP, they may also require visualization of the transportation network to support operator activities, such as non-automated responses to customers.

3.1.4 Personal Information Access Subsystem

The PIAS systems, which are mobile systems that provide access to ISP services, TMS traffic information, and other services, are likely to have map needs very similar to the vehicle subsystem. This would include transit options and pedestrian-relevant information in addition to the standard navigable roadway information. Since this device is mobile, an unambiguous location reference is required that corresponds to the map data. Also, because this system is mobile, it may move between different map update providers much more frequently than the fixed “center”-type subsystems. To make this mobility more convenient, the payment aspect is integrated with the map update request process. This is depicted in the following figure.

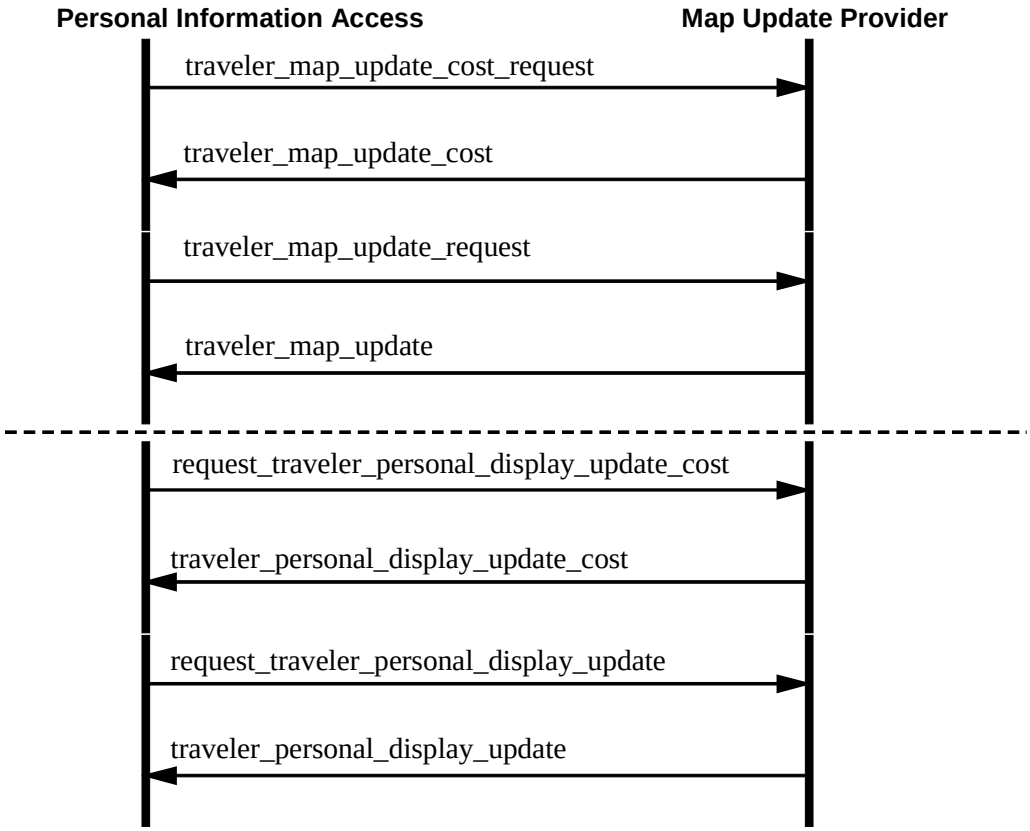

Figure 7 - Personal Information Access Map Request Transaction Set

The top set of 4 messages in the figure accomplishes the update of a navigable map in a PIAS. This includes an initial query on map pricing followed by the actual request and receipt of the map. The lower transaction set of 4 messages follows the same basic pattern for the request of the cost and then the data. In this latter case, the map data is used as a visual display background; that is, it is for the human interface, rather than for machine interpretation. It is likely that, to be a marketable product/service, the PIAS will need to support both functions: route planning, either autonomously or by request to an ISP, and presentation of the routing information to the human user in an accessible form.

3.1.5 Remote Traveler Support Subsystem

The RTS kiosk system provides access to ISP services, TMS traffic information, and other services. This device is at a fixed location, making its position specification hopefully unambiguous.

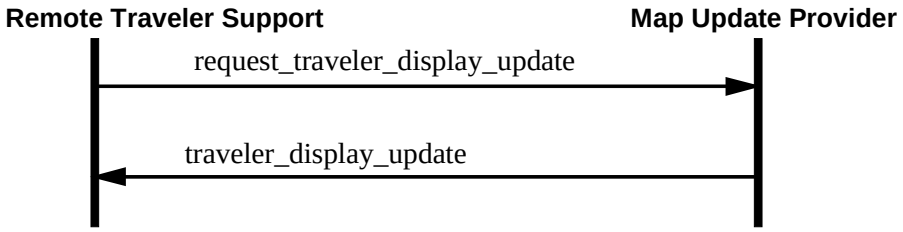

Figure 8 - Remote Traveler Support Map Request Transaction Set

In the figure, we see display data as the expected type of data to be exchanged. This reflects the expectation that kiosks will principally function as user friendly human interfaces to the available transportation information. Thus the map data will provide backgrounds for traffic, transit, and pollution statuses, as examples. Kiosks may also provide printed routing or trip information, but this will likely be provided by an ISP, so there is not a clear need for digital maps for other than visualization purposes.

3.1.6 Traffic Management Subsystem

The Traffic Management subsystem has responsibility for the monitoring of traffic conditions, the management of incidents (performed jointly with a number of subsystems), and the implementation of travel demand management policy. Map data is used to support operator displays that provide quick understanding for the humans running the TMS, who must implement the control decisions.

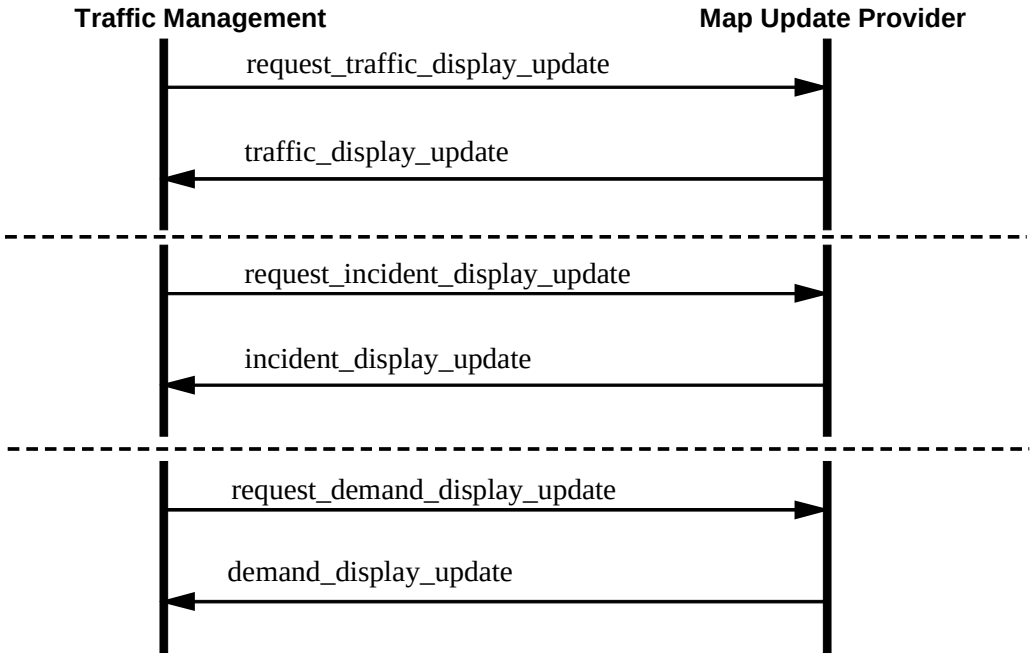

Figure 9 - Traffic Management Map Request Transaction Set

We see the 3 pairs of request-reply message sets in the above figure. All are doing essentially the same activity: requesting data to support human operator display and analysis. The names indicate the different types of activities that are supported, specifically current and predicted traffic conditions monitoring, incident management, and travel demand monitoring and planning. Since not all TMS will support all

these functions, the data requests are distinguished, even though ultimately the same type of data might be usable in all three cases.

In general, the map data required by the TMS will need to support precise geolocation, visualization of the transportation network (including time-varying and static attributes of map entities), and probably also vehicle route tracking and planning, particularly to support incident management strategies and signal priority. This creates a requirement for map data that can support geolocation relative to map entities (roads, intersections, points-of-interest) and the generation of operator displays that can be updated in real-time to show the traffic situation.

3.1.7 Transit Management Subsystem

The Transit Management Subsystem monitors transit fleet activities and positions, and plans routing and responses to customer requests. The Americans with Disabilities Act (ADA) also dictates certain services and levels of responsiveness that require adaptive planning of routes and schedules. All these functions are facilitated with digital maps and automated scheduling tools. Information may also be communicated to Traffic Management to support signal priority for transit vehicles to improve their ability to adhere to schedules; this suggests it may be important for TRMS and TMS to work from similar maps.

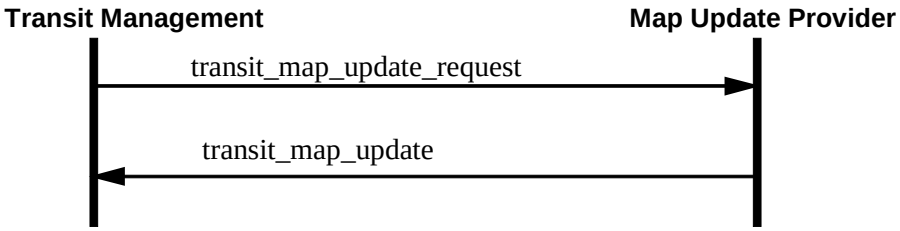

Figure 10 - Transit Management Map Request Transaction Set

A request is sent for the digital map data used for route planning and to display transit related activities to the transit management operator. In response, a digital display map is returned “from map update provider”.

In general, the map data required by the TRMS operator will need to support precise geolocation, visualization of the transportation network, and probably also vehicle route tracking and planning. In particular, the ADA requirements create some unique map needs for paratransit, both for determining eligibility and providing timely service. Overall, TRMS has a requirement for map data that can support geolocation relative to map entities (roads, intersections, points-of-interest) and the generation of operator displays that can be updated in real-time to show the status of the transit system.

3.1.8 Vehicle Subsystem

The Vehicle subsystem is a mobile platform like the Personal Information Access subsystem, and shares much of its functionality and requirements. The map requirements for the VS include a digital map to support navigation tasks, that is, route planning.

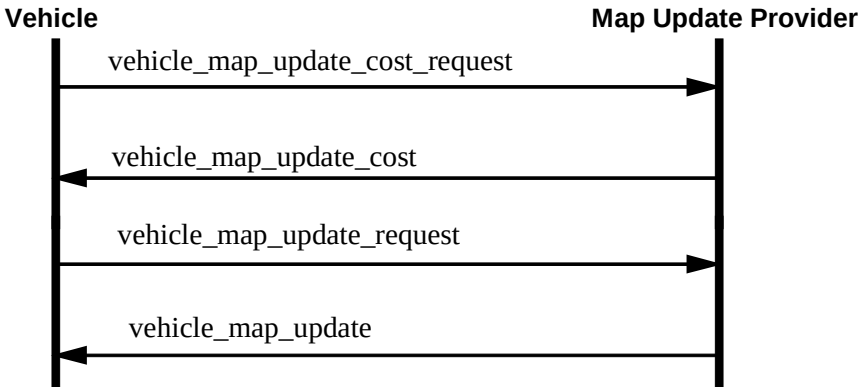

Figure 11 - Vehicle Map Request Transaction Set

The set of 4 messages in the figure accomplishes the update of a navigable map in the navigation portion of the Vehicle subsystem. This includes an initial query on map pricing followed by the actual request and receipt of the map. It should be noted that map updates will be required for situations where the vehicle has moved to a new location not covered by its current database, as well as for situations where the current data is no longer accurate, due to construction, road closings, etc.

The nature of the map data that the vehicle subsystem requires can be quite varied, depending on the type of route guidance option in use. The available options are covered in detail in the Theory of Operations Document. These range from fully autonomous, where the vehicle calculates the routing based on on-board map data, to fully infrastructure-based, where the vehicle is furnished a route by an ISP. In this latter case, the only map data on the vehicle may be the actual route (or route segment) itself. In all cases, the map data must be useful for navigation and it must be possible to present the navigation instructions to the driver in a useful and safe manner.

3.2 Usage of *Location_Identity* for Spatial Position Specifications

The first part of the logical grouping of two items in this Standards Requirement Package was the map data component. The second item, position specification, is discussed in this section. The two items form a natural pair as they will often be used in conjunction with each other. This is particularly true for the pairing of location data for mobile subsystems and digital navigation maps.

Although leveled architecture flows are used throughout this document to describe the ITS National Architecture as it applies to Digital Map Data Exchange, this section describing location referencing will utilize the data elements of the ITS Logical Architecture, particularly the primitive data element (or “pel”) called *location_identity*.

In the National ITS Architecture, the *location_identity* pel is the lowest level data item used to provide a spatial position. This pel is used throughout the architecture wherever it is necessary to provide the location of some item, be it a vehicle, road, or piece of equipment. The location_identity pel is used 521 times, which makes it quite pervasive. It also makes the type of analysis used elsewhere in this and other Standards Requirements Packages inappropriate.

Instead, this section will catalog the specific types of data structures that use location_identity, propose a strawman set of standard requirements for location_identity, and then summarize the interfaces that use location_identity and the type of usage it is. This is intended to allow an examination of the different

types of position specifications in the architecture and to support analysis to determine whether a single format can be used to meet all needs, or if it is more appropriate to design a family of specifications.

One final note: the data dictionary sizing of *location_identity* is 22 bytes. This was based on a preliminary version of LRMS (see the following discussion in Section 3.2.2.). Subsequent modifications to LRMS have led to changes in the sizing of some elements; in particular, there is now no 22 byte option. Readers should not be disturbed by this. As with all data dictionary sizes, the 22 byte sizing should be viewed as "typical" rather than a prescriptive specification.

3.2.1 Interface Structures that Use Location_Identity

There are a number of possible groupings that can be adopted to summarize the uses of location_identity. We will use the following three high level categories here:

- *Transportation network descriptions*

  Location_identity is used to specify the locations of parts of the transportation network, such as roads and intersections.

- *Locations of permanently stationary objects*

  Location_identity is used to give the position of stationary entities such as parking lots and pieces of equipment. In some cases, the location forms part of the unique identification of a particular object.

- *Locations of moving objects*

  This covers the use of location_identity to provide the position of mobile subsystems, such as vehicles, where the location data is transient and must be continually refreshed.

The distinctions between these cases are somewhat arbitrary, but the classification works for most of the architecture interfaces. There are some problematic types of data; for example, "pollution conditions reporting" uses location and is mobile/ephemeral. But pollution data clearly does not need to be reported with the same precision as vehicle position. For the purposes of this taxonomy pollution conditions are grouped into the first category, as an attribute of the transportation network. Any similar arbitrary assignments will be discussed below.

It is very possible that during the standardization process the current generic "*location_identity*" may be subdivided into multiple specialized versions that are optimized for the different applications. We view this as appropriate, but encourage the standards developers to try to identify and specify fundamental types of position specifications, like the brief taxonomy offered above.

3.2.1.1 Transportation Network Description Interface Data Items

The following types of data items are considered to be in this category:

- Route segments and routes
- Links and lists of links
- Attributes associated with route segments, links, or locations

We will present examples below of typical message structures that provide this type of information. This will demonstrate how location_identity is utilized in these different cases. The same notation is used as in

the hierarchical interface decompositions in Section 4, except that letters are used instead of numbers for the indenture level of the logical data flows. This is done to emphasize that these are, in some cases, extracted from larger data flows and could be embedded at any level.

The basic unit in a *route* is the *route_segment*. A route_segment represents the portion of a transportation system, typically a road, between two actions of some sort. The actions could be as simple as a turn or as complex as a modal change. An example of a route_segment data flow structure is shown below:

(a) ***route_segment***
  (b) ***route_segment_data***
    (c) ***route_segment_description***
    (c) ***route_segment_end_point***
      (d) ***location_identity***
    (c) ***route_segment_start_point***
      (d) ***location_identity***
  (b) ***route_segment_identity***
    (c) ***location_identity***
    (c) ***route_segment_type***
    (c) ***unit_number***
  (b) ***route_segment_mode***

The *route_segment_data* portion can also be augmented with attributes, such as the following that provide information relevant to trip planning:

(d) ***route_segment_estimated_arrival_time***
(d) ***route_segment_estimated_condition***
(d) ***route_segment_estimated_travel_time***
(d) ***route_segment_predicted_weather***

Also within the *route_segment_data* portion can be a series of way points, such as the following that indicate a location for providing a status report:

(d) ***route_segment_report_position_points***
  (e) ***list_size***
  (e) ***route_segment_way_point***
    (f) ***location_identity***

To construct an actual *route*, a set of *route_segments* that describe the sequence of maneuvers is combined, along with any additional attributes associated with the overall route itself into a route message. An example is:

(a) ***route***
  (b) ***route_cost***
  (b) ***route_list***
    (c) ***route_segment_number***
  (b) ***route_segment***
    (c) ***route_segment_data***
      (d) ***route_segment_description***
      (d) ***route_segment_end_point***
        (e) ***location_identity***
      (d) ***route_segment_estimated_arrival_time***
      (d) ***route_segment_estimated_condition***
      (d) ***route_segment_estimated_travel_time***

(d) ***route_segment_predicted_weather***
(d) ***route_segment_report_position_points***
(e) ***list_size***
(e) ***route_segment_way_point***
(d) ***route_segment_start_point***
(e) ***location_identity***
(c) ***route_segment_identity***
(d) ***location_identity***
(d) ***route_segment_type***
(d) ***unit_number***
(c) ***route_segment_mode***
(b) ***route_start_time***
(c) ***date***
(c) ***time***
(b) ***route_statistics***

A slightly different concept from a route_segment is the *link.* While the actions of the traveler determine the end points of the route_segment, a link is the piece of transportation infrastructure between possible changes. For roads, a link would typically correspond to a block. A route_segment, then, is at least as long as a link and may often be many links long.

The analogous structure to routes for links is the *link_list*. This is literally a list of links. This is particularly appropriate for updating things like traffic status databases. The following is an example of a *link_list* composed of *links*. It should be recognized that the *link_identity* portion would be repeated in an actual message *list_size* number of times.

(a) ***link_list***
(b) ***link_identity***
(c) ***link_type***
(c) ***location_identity***
(c) ***unit_number***
(b) ***list_size***

As with route segments, the links can have attributes that provide information about the underlying transportation network. This is, in fact, the primary use of links; for providing a location basis for this type of data. Examples are:

(c) ***link_journey_time***
(c) ***link_queue_time***

Location_identity is also used to provide position fixes for information or attributes that are associated with the transportation network. These types of attributes may be associated with links or route segments, as described above, or they may be independently positioned. Below are two examples. The first is for a predictive model that tries to anticipate where high risk for traffic incidents exist:

(a) ***planned_events_for_broadcast***
(b) ***incident_description***
(b) ***incident_location***
(c) ***location_identity***
(b) ***incident_severity***

(b) ***incident_traffic_impact***
(b) ***incident_type***
(b) ***list_size***

The second example is for pollution results:

(a) ***pollution_state_area_collection***
(b) ***area_air_quality_index***
(b) ***current_carbon_monoxide_pollution***
(b) ***current_hydrocarbon_pollution***
(b) ***current_nitrous_oxide_pollution***
(b) ***current_ozone_pollution***
(b) ***current_particulate_pollution***
(b) ***current_pollution_location***
(c) ***location_identity***
(b) ***current_sulfur_dioxide_pollution***

The above example could arguably go into the next section, if the location of the pollution is just the location of the fixed sensing system. However, it is assumed that the above may be based on remote sensing technology, so it is more likely that we are considering a variable position that will be correlated to the transportation network.

3.2.1.2 Specification of Stationary Objects Interface Data Items

The following types of data items are considered to be in this category:

- • Location of places (like parking lots)
- • Location of equipment (like dynamic message signs) or signage
- • Identification of the above items

An example of describing a parking lot follows. The data flow fragment below shows the identification of a parking lot by a *unit_number* and a *location_identity*:

(a) ***parking_lot_identity***
(b) ***location_identity***
(b) ***unit_number***

A traveler utilizing a yellow pages service through a kiosk or personal information access device might ask for information on a point of interest (POI) or list of POIs, such as restaurants. This type of data flow structure is shown below; again, *list_size* indicates the number of actual items in a message.

(a) ***traveler_personal_yellow_pages_data***
(b) ***traveler_identity***
(b) ***yellow_pages_general_information***
(c) ***yellow_pages_history***
(d) ***list_size***
(d) ***yellow_pages_service_contact***
(d) ***yellow_pages_service_description***
(d) ***yellow_pages_service_location***

(e) ***location_identity***
(d) ***yellow_pages_service_time***
(e) ***time***
(d) ***yellow_pages_service_type***
…
(b) ***yellow_pages_specific_information***
(c) ***yellow_pages_food***
(d) ***list_size***
(d) ***yellow_pages_service_contact***
(d) ***yellow_pages_service_description***
(d) ***yellow_pages_service_location***
(e) ***location_identity***
(d) ***yellow_pages_service_type***
(c) ***yellow_pages_gas_stations***
(d) ***list_size***
(d) ***yellow_pages_service_contact***
(d) ***yellow_pages_service_description***
(d) ***yellow_pages_service_location***
(e) ***location_identity***
(d) ***yellow_pages_service_type***
(c) ***yellow_pages_hospitals***
(d) ***list_size***
(d) ***yellow_pages_service_contact***
(d) ***yellow_pages_service_description***
(d) ***yellow_pages_service_location***
(e) ***location_identity***
(d) ***yellow_pages_service_type***
(c) ***yellow_pages_lodging***
(d) ***list_size***
(d) ***yellow_pages_service_contact***
(d) ***yellow_pages_service_description***
(d) ***yellow_pages_service_location***
(e) ***location_identity***
(d) ***yellow_pages_service_type***
(c) ***yellow_pages_parking***
(d) ***list_size***
(d) ***yellow_pages_service_contact***
(d) ***yellow_pages_service_description***
(d) ***yellow_pages_service_location***
(e) ***location_identity***
(d) ***yellow_pages_service_type***
…

The two examples above showed “places”. We now show two examples of the use of location_identity for equipment. The first example is an unusual one, the data used for beacon-based in-vehicle signage:

(a) ***vehicle_sign_data***
(b) ***list_size***
(b) ***vehicle_signage_output_data***
(c) ***vehicle_signage_current_data***

(c) ***vehicle_signage_fixed_data***
(c) ***vehicle_signage_incident_details***
(c) ***vehicle_signage_vms_data***
(b) ***vehicle_signage_output_identity***
(c) ***location_identity***
(c) ***unit_number***
(b) ***vehicle_signage_traffic_data***
(c) ***link_identity***
(d) ***link_type***
(d) ***location_identity***
(d) ***unit_number***
(c) ***vehicle_occupancy***
(c) ***vehicle_speed***

The second example is a more conventional traffic indicator device, used at multimodal crossings on roadways. The crossing control is one element of a larger class of control devices that would include pedestrian crossings, dynamic message signs, intersection signals, and the like. We only show the crossing control case, but the basic structure and the way location_identity is used is very similar in all cases.

(a) ***indicator_control_data_for_roads***
(b) ***indicator_crossing_control_data_for_roads***
(c) ***indicator_crossing_controls***
(c) ***indicator_identity***
(d) ***indicator_type***
(d) ***location_identity***
(d) ***unit_number***
(c) ***list_size***
…

3.2.1.3 Location of Moving Objects Interface Data Items

The following data items are considered to be in this category:

- • Vehicle location
- • Traveler location

An example of the way vehicles communicate location is shown below:

(a) ***vehicle_route_request***
…
(b) ***departure_time***
(c) ***time***
(b) ***desired_arrival_time***
(c) ***time***
(b) ***destination***
(c) ***route_point***
(b) ***origin***
(c) ***route_point***
(b) ***preferred_alternate_routes***

(b) ***preferred_route_segments***
(b) ***preferred_routes***
(b) ***vehicle_identity***
(b) ***vehicle_location_for_dynamic_guidance***
(c) ***location_identity***

This example is a data flow to the Information Service Provider to support dynamic route guidance. Another similar use is to the Emergency Management subsystem for the case of a driver or traveler emergency. As an example of traveler location data, we show the traveler emergency request data flow:

(a) ***emergency_request_personal_traveler_details***
(b) ***date***
(b) ***time***
(b) ***traveler_personal_emergency_request***
(c) ***traveler_identity***
(c) ***traveler_location_for_emergencies***
(d) ***location_identity***

These three categories cover the majority of the types of uses of *location_identity* in the architecture. As a part of the standardization process, it will be necessary to evaluate further whether a single method for providing *location_identity* can be used in all cases or whether it will be necessary to come up with specialized versions to support the different applications.

3.2.2 Standardization for Location Identity

A proposed mechanism for standard link and node referencing in ITS, the Location Reference Message Specification (LRMS), has been developed by Oak Ridge National Laboratory under contract to the FHWA. The original drafts of the LRMS have been updated under the auspices of the Society of Automotive Engineers (SAE) Map Database Committee as Information Report J2374, which provides a set of message location reference format specifications for the transfer of location data. The LRMS is now endorsed by SAE. The following descriptive information about the specification is taken directly from the standard.

> "The LRMS is intended to provide a practical approach to standardization for location referencing within a mixed data set environment, i.e., where more than one kind of spatial data set exists, and where spatial references between these data sets must be made. Although some ITS applications in local areas may be satisfied by having one common data set -- for which location references may be implemented in any number of ways -- many ITS applications will have broad interoperability requirements within the nation or a region. For example, a vehicle driven from California to Florida in the U.S. should be able to receive and understand spatial references for traffic information or routing instructions throughout the trip. Similarly, information sent from a vehicle to a central site should be understood in any city regardless of the kinds of data sets in use, whether they are public or private, or how locations are referenced internally to particular data sets.
>
> "The LRMS can be applied to ITS systems involving mobile vehicles on roads, rails, and waterways. It can also be applied to location references to and from central sites to non-mobile sites such as kiosks, other central sites, or pedestrians. The broadest scope of the LRMS is therefore intermodal spatial data set interoperability at the national level and across all of ITS.

Given the great variety of ITS systems, it is expected that individual LRMS profiles will generate location referencing standards for subsets of ITS applications, such as ISP-Vehicle-ISP, or center-to-center."

Since multiple kinds of location references (multiple location reference methods) must be supported for ITS applications, multiple message formats are provided within the LRMS. We call the set of useful generic formats based on a given location reference method a *profile*. Each profile contains multiple individual *format records* constituting the set of useful formats. Over time, user application experience will drive further profile and format record evolution within the open LRMS specification.

The LRMS profiles described in the specification include:

- The Geometry Profile
- The Geographic Coordinate Profile
- The Grid Profile
- The Linear Referencing Profile
- The Cross-Streets Profile
- The Address Profile
- The MDI (Model Deployment Initiative) Profile

The LRM Specification covers most of the options for locating a transportation-relevant entity. It assumes that there is a set of locations (nodes) with precisely specified positions that can be used as reference points (a national datum). A road segment (link) that had a national datum node at each end could be specified very compactly: 6 bytes, for example. Other links that do not contain a national datum node would require a longer specification: 28 bytes, for example, where the start and end points of the link are georeferenced back to a datum node. The datum nodes themselves are given an ID and are described by a longitude, latitude, and an elevation.

3.2.3 Summary of Interfaces Using Location_Identity

Based on the discussion of the types of uses of location_identity in the architecture, the 85 interfaces that use this pel can be categorized. Using the three categories discussed above, we will use the following abbreviation letters for the different classes of use, with routes as an additional class extracted out of the transportation network descriptions:

T - ***Transportation network descriptions***

R **- *Routes or route segments***

S - ***Locations of permanently stationary objects***

M - ***Locations of moving objects***

The results of this are shown in Table 1. For each interface that passes location_identity we categorize the data flows as one or more of the above categories. For example, VS to EM (vehicle subsystem to emergency management) passes a vehicle location as part of an emergency message; this table location receives an "***M***" to indicate that *location_identity* passes across this interface as part of the specification of a mobile platform's position.

For the purposes of fitting Table 1 onto a single page, the following "X code" abbreviations for the terminators are used in the table. While these are explained in the introductory sections of the Standards Requirements Document, the relevant ones are repeated here for the reader's convenience:

X13 - ***Emergency Telecommunications System***

X22 - ***Government Agencies***

X27 - ***Media***

X30 - ***Other Emergency Management***

X35 - ***Other Traffic Management***

Hopefully Table 1 provides a good overview when coupled with the examples in the previous sections. The source subsystems/terminators are on the left and the destinations are on top. The letters T, R, S, and M indicate the type of use made of *location_identity*.

Table 1. The interfaces that use location_identity.

	ADMS	CVAS	CVS	EM	EMMS	EVS	FMS	ISP	PIAS	PMS	RS	RTS	TMS	TRMS	TRVS	VS	X30	X35	X27
CVAS							R												
CVS							M												
EM								T					T R	T			T		T
EMMS	T												T						
FMS		R	R	R															
ISP	R			R			R		T R S	S		T R S	T R			TRS			T
PIAS				M				RSM											
PMS	S							S					S	S					
RS					T								T S			S			
RTS								S											
TAS								R											
TMS	TRS			T				TRS		S	S			RT				T R	T
TRMS	S			T				TSM					SMR						T
TRVS														S M					
VS			M	M		M		RSM		S	R				T R S				
X13				T															
X22		S																	
X27								T					T						
X30				T															
X35													T R S						

The intent of Table 2 is to illustrate when we are talking about a mobile platform position and when we are talking about large static entities such as parking lots, for example. These types of distinctions carry a number of secondary considerations, including the fact that some interfaces are wireless and may benefit from compact location_identity formats. This type of information should be clear from examining the reference material in the introductory sections of the Standards Requirements Document.

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 Map Update Provider -> Emergency Management

Physical Architecture Flow: map updates W
Map update which could include a new underlying static or real-time map or map layer(s) update.

Leveled Data Item(s):

(1) ***emergency_display_update***
This data item contains the digitized map data for displays that can be used as the background for the output of data on incidents and emergencies to the emergency system operator.

4.2 Map Update Provider -> Emissions Management

Physical Architecture Flow: map updates W
Map update which could include a new underlying static or real-time map or map layer(s) update.

Leveled Data Item(s):

(1) ***pollution_display_update***
This data item contains the digitized map data for displays that can be used as background for the output of data on the levels of various atmospheric pollutants.

4.3 Map Update Provider -> Information Service Provider

Physical Architecture Flow: map updates W
Map update which could include a new underlying static or real-time map or map layer(s) update.

Leveled Data Item(s):

(1) ***other_routes_map_data***

This data item contains a new copy of the digitized map data used by the process that selects other, i.e. non-vehicle and non-transit, routes.

(1) ***route_selection_map_data***

This data item contains an update of the digitized map data used by the route selection facility to produce vehicle based routes for trip planning and on-line guidance purposes.

4.4 Emergency Management -> Map Update Provider

Physical Architecture Flow: map update request W

Request for a map update which could include a new underlying map or map layer updates.

Leveled Data Item(s):

(1) ***request_emergency_display_update***

This data item contains a request for an update to the digitized map data for displays that can be used as the background for the output of data incidents and emergencies to the emergency system operator.

4.5 Emissions Management -> Map Update Provider

Physical Architecture Flow: map update request W

Request for a map update which could include a new underlying map or map layer updates.

Leveled Data Item(s):

(1) ***request_pollution_display_update***

This data item contains a request for an update to the digitized map data for displays that can be used as background for the output of data on the levels of various atmospheric pollutants.

4.6 Information Service Provider -> Map Update Provider

Physical Architecture Flow: map update request W

Request for a map update which could include a new underlying map or map layer updates.

Leveled Data Item(s):

(1) ***request_other_routes_map_update***

This data item contains a request for a new copy of the digitized map data used by the process that selects other, i.e. non-vehicle and non-transit, routes for travelers.

(1) ***request_route_selection_map_update***

This data item contains a request for a new copy of the digitized map data used by the process that selects vehicle based routes for travelers and drivers.

4.7 Personal Information Access -> Map Update Provider

Physical Architecture Flow: map update request W,U1t

Request for a map update which could include a new underlying map or map layer updates.

Leveled Data Item(s):

(1) ***request_traveler_personal_display_update***

This data item contains a request for an update to the digitized map data used for displays that can be output as background for traffic, trip and travel information for use by a traveler at a personal device.

(2) ***credit_identity***

(2) ***traveler_identity***

(1) ***request_traveler_personal_display_update_cost***

This data item contains a request for the cost of an update to the digitized map data used for providing the

background to displays of traffic and travel information on a traveler personal device.
(1) ***traveler_map_update_cost_request***
This data item contains a request for the cost of an update to the navigable map database used for providing traveler personal on-line guidance.
(1) ***traveler_map_update_request***
This data item contains a request for an update of the digitized map database used for guiding travelers on their selected routes.

4.8 Remote Traveler Support-> Map Update Provider

Physical Architecture Flow: map update request W
Request for a map update which could include a new underlying map or map layer updates.

Leveled Data Item(s):

(1) ***request_traveler_display_update***
This data item contains a request for an update to the digitized map data used for displays that can be output as background for traffic, trip and travel information for use by travelers at kiosks.

4.9 Traffic Management -> Map Update Provider

Physical Architecture Flow: map update request W
Request for a map update which could include a new underlying map or map layer updates.

Leveled Data Item(s):

(1) ***request_demand_display_update***
This data item contains a request for an update to the digitized map data for displays that can be used as background for the output of data on traffic and travel demand levels.
(1) ***request_incident_display_update***
This data item contains a request for an update to the digitized map data for displays that can be used as background for the output of data on current incidents and planned events.
(1) ***request_traffic_display_update***
This data item contains a request for an update to the digitized map data for displays that can be used as background for the output of data on current and predicted traffic levels.

4.10 Transit Management -> Map Update Provider

Physical Architecture Flow: map update request W
Request for a map update which could include a new underlying map or map layer updates.

Leveled Data Item(s):

(1) ***transit_map_update_request***
This data item contains a request for an update of the map database used for generating new transit routes and as a background to displays of transit services.

4.11 Vehicle -> Map Update Provider

Physical Architecture Flow: map update request U1t
Request for a map update which could include a new underlying map or map layer updates.

Leveled Data Item(s):

(1) ***vehicle_map_update_cost_request***
This data item contains a request for the cost of an update to the navigable map database used for

providing in-vehicle on-line guidance.

(1) ***vehicle_map_update_request***
This data item contains a request for an update of the navigable map database used for providing in-vehicle on-line guidance.

4.12 Location Data Source -> Personal Information Access

Physical Architecture Flow: position fix L
Information which provides a traveler or vehicles geographical position.

Leveled Data Item(s):

(1) ***location***
This data item contains the position fix of the transportation object.

4.13 Map Update Provider -> Personal Information Access

Physical Architecture Flow: map updates W,U1t
Map update which could include a new underlying static or real-time map or map layer(s) update.

Leveled Data Item(s):

(1) ***traveler_map_update***
This data item contains data for a new guidance map to be used by the on-line traveler guidance facility.
(1) ***traveler_map_update_cost***
This data item contains the cost for a new navigable map database to be used by the traveler personal on-line guidance facility.
(1) ***traveler_personal_display_update***
This data item contains the digitized map data that can be used as background to displays of traffic, trip and travel information that are output to a personal device for use by travelers.
(1) ***traveler_personal_display_update_cost***
This data item contains the cost for a new set of digitized map data to be used as the background to displays of traffic and travel information being output by a traveler's personal device.

4.14 Map Update Provider -> Remote Traveler Support

Physical Architecture Flow: map updates W
Map update which could include a new underlying static or real-time map or map layer(s) update.

Leveled Data Item(s):

(1) ***traveler_display_update***
This data item contains the digitized map data that can be used as background to displays of traffic, trip and travel information that are output to a kiosk for use by travelers.

4.15 Map Update Provider -> Traffic Management

Physical Architecture Flow: map updates W
Map update which could include a new underlying static or real-time map or map layer(s) update.

Leveled Data Item(s):

(1) ***demand_display_update***
This data item contains the digitized map data for displays that can be used as background for the output

of data on traffic and travel demand levels.
(1) ***incident_display_update***
This data item contains the digitized map data for displays that can be used as background for the output of data on current incidents and planned events.
(1) ***traffic_display_update***
This data item contains the digitized map data for displays that can be used as background for the output of data on current or predicted traffic levels.

4.16 Map Update Provider -> Transit Management

Physical Architecture Flow: map updates W
Map update which could include a new underlying static or real-time map or map layer(s) update.

Leveled Data Item(s):

(1) ***transit_map_update***
This data item contains digitized map data to be used for route generation and as a background to displays of services requested by the transit fleet manager.

4.17 Location Data Source -> Vehicle

Physical Architecture Flow: position fix L
Information which provides a traveler or vehicles geographical position.

Leveled Data Item(s):

(1) ***location***
This data item contains the position fix of the transportation object.

4.18 Map Update Provider -> Vehicle

Physical Architecture Flow: map updates U1t
Map update which could include a new underlying static or real-time map or map layer(s) update.

Leveled Data Item(s):

(1) ***vehicle_map_update***
This data item contains data for a new navigable map database to be used by the on-line vehicle guidance facility.
(1) ***vehicle_map_update_cost***
This data item contains the cost for a new navigable map database to be used by the on-line vehicle guidance facility.

5 Communications Layer Considerations

This chapter describes relevant requirements and information regarding the portion of the Communications Layer 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.

Because of the ubiquitous usage of *location_identity* in the architecture, it is difficult to succinctly capture its communications needs. However, both map data exchange and position data use two types of communications media, the wide area wireless and the wireline. We can exhaustively discuss map data because of its limited scope, and then we can discuss the interfaces and physical data flows that use *location_identity*.

5.1 Communications Services

Category terms are used for the type of communications service appropriate for an architecture flow in Table 2 through Table 6. A brief explanation is offered here for the meanings of these abbreviations. More information is offered in the introductory parts of the SRD and in the Communications document.

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.)

5.2 Wireline Communication Elements (w)

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.

The primary requirements regarding the wireline communications layers include the utilization of open standards for the communication protocols. For the links to the TMS, the evolving ITS standard protocol 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 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. These include ATM, Frame Relay, MAN (IEEE 803.6), and FDDI. At the network layers, TCP/IP is a widespread standardized protocol. The key is that by using standard communication protocol suites the regional integration of the wireline data shown above will most readily be accomplished.

5.2.1 Wireline for Digital Map Data

Table 2 shows the wireline architecture flows for digital map data exchange in this standards package.

Table 2. Wireline Data Flows for Digital Map Data Exchange

Source	Destination	Architecture Flow	Communication Service
Emergency Management	Map Update Provider	map update request	Messaging data
Emissions Management	Map Update Provider	map update request	Messaging data
Information Service Provider	Map Update Provider	map update request	Messaging data
Map Update Provider	Emergency Management	map updates	Messaging data, Multicast data
Map Update Provider	Emissions Management	map updates	Messaging data
Map Update Provider	Information Service Provider	map updates	Messaging data, Multicast data

Source	Destination	Architecture Flow	Communication Service
Map Update Provider	Personal Information Access	map updates	Messaging data, Multicast data
Map Update Provider	Planning Subsystem	map updates	Messaging data,Broadcast data, Multicast
Map Update Provider	Remote Traveler Support	map updates	Messaging data
Map Update Provider	Traffic Management	map updates	Messaging data, Multicast data
Map Update Provider	Transit Management	map updates	Messaging data, Multicast data
Personal Information Access	Map Update Provider	map update request	Messaging data
Planning Subsystem	Map Update Provider	map update request	Messaging data
Remote Traveler Support	Map Update Provider	map update request	Messaging data
Traffic Management	Map Update Provider	map update request	Messaging data
Transit Management	Map Update Provider	map update request	Messaging data

5.2.2 Wireline Data Flows for location_identity

Table 3 shows the wireline architecture flows that utilize location_identity.

Table 3. Wireline Data Flow Examples for location_identity

Source	Destination	Architecture Flow	Communication Service
Commercial Vehicle Administration	Commercial Vehicle Check	CVO database update	Conversational data, Messaging data
Commercial Vehicle Administration	Commercial Vehicle Check	safety information	Conversational data, Messaging data
Commercial Vehicle Administration	Fleet and Freight Management	electronic credentials	Messaging data
Commercial Vehicle Check	Commercial Vehicle Administration	citation data	Conversational data, Messaging data
Emergency Management	Information Service Provider	incident information	Conversational speech, Messaging data
Emergency Management	Traffic Management	emergency traffic control request	Conversational data, conversational speech
Emergency Management	Traffic Management	incident information	Conversational data, Messaging data
Emergency Management	Media	incident information for media	Messaging data
Emergency Management	Other EM	incident report	Conversational data, Messaging data
Emissions Management	Archived Data Management Subsystem	emissions archive data	Messaging data
Emissions Management	Information Service Provider	air quality information	Messaging data
Emissions Management	Traffic Management	widearea statistical pollution information	Messaging data
Fleet and Freight Management	Commercial Vehicle Administration	credential application	Conversational data, Messaging data
Fleet and Freight Management	Emergency Management	Hazmat information	Conversational data, Messaging data
Information Service Provider	Archived Data Management Subsystem	traveler archive data	Messaging data

Source	Destination	Architecture Flow	Communication Service
Information Service Provider	Fleet and Freight Management	route plan	Messaging data
Information Service Provider	Personal Information Access	broadcast information	Messaging data,Broadcast data, Multicast
Information Service Provider	Personal Information Access	traveler information	Broadcast data,Multicast data
Information Service Provider	Personal Information Access	trip plan	Conversational data, Messaging data
Information Service Provider	Personal Information Access	yellow pages information	Conversational data, Messaging data
Information Service Provider	Parking Management	parking lot data request	Messaging data
Information Service Provider	Parking Management	parking reservations request	Messaging data
Information Service Provider	Remote Traveler Support	broadcast information	Messaging data,Broadcast data, Multicast
Information Service Provider	Remote Traveler Support	traveler information	Broadcast data,Multicast data
Information Service Provider	Remote Traveler Support	trip plan	Conversational Data
Information Service Provider	Remote Traveler Support	yellow pages information	Conversational data, Messaging data
Information Service Provider	Traffic Management	fare and price information	Messaging data
Information Service Provider	Traffic Management	logged special vehicle route	Conversational data, Messaging data
Information Service Provider	Traffic Management	road network use	Messaging data
Information Service Provider	Other ISP	ISP coordination	Messaging data
Personal Information Access	Information Service Provider	trip request	Conversational Data, Messaging data
Parking Management	Archived Data Management Subsystem	parking archive data	Messaging data
Parking Management	Information Service Provider	parking information	Messaging data
Parking Management	Information Service Provider	parking lot reservation confirmation	Messaging data
Parking Management	Traffic Management	parking availability	Messaging data
Parking Management	Traffic Management	parking demand management response	Messagind data
Roadway Subsystem	Archived Data Management Subsystem	roadside archive data	Messaging data
Roadway Subsystem	Emissions Management	pollution data	Messaging data
Roadway Subsystem	Traffic Management	emissions data	Messaging data
Roadway Subsystem	Traffic Management	freeway control status	Messaging data
Roadway Subsystem	Traffic Management	hov data	Messaging data
Roadway Subsystem	Traffic Management	request for right-of-way	Conversational data, Messaging data
Roadway Subsystem	Traffic Management	roadway information system status	Messaging data
Roadway Subsystem	Traffic Management	signal control status	Messaging data
Roadway Subsystem	Traffic Management	vehicle probe data	Messaging data

Source	Destination	Architecture Flow	Communication Service
Remote Traveler Support	Information Service Provider	traveler request	Messaging data
Remote Traveler Support	Transit Management	emergency notification	Conversational data, Messaging Data
Toll Administration	Information Service Provider	probe data	Messaging data
Toll Administration	Traffic Management	probe data	Messaging data
Traffic Management	Archived Data Management Subsystem	traffic archive data	Messaging data
Traffic Management	Emergency Management	current network conditions	Messaging data
Traffic Management	Emergency Management	emergency traffic control response	Conversational data, conversational speech
Traffic Management	Emergency Management	incident information	Messaging data
Traffic Management	Information Service Provider	traffic information	Messaging data
Traffic Management	Parking Management	parking demand management request	Messaging data
Traffic Management	Parking Management	parking instructions	Messaging data
Traffic Management	Roadway Subsystem	freeway control data	Messaging data
Traffic Management	Roadway Subsystem	roadway information system data	Messaging data
Traffic Management	Roadway Subsystem	signal control data	Messaging data
Traffic Management	Transit Management	traffic information for transit	Messaging data
Traffic Management	Other TM	traffic control coordination	Messaging data
Traffic Management	Other TM	traffic information coordination	Messaging data
Transit Management	Archived Data Management Subsystem	transit archive data	Messaging data
Transit Management	Emergency Management	transit emergency data	Conversational data, Messaging data
Transit Management	Information Service Provider	demand responsive transit plan	Conversational data, Messaging data
Transit Management	Information Service Provider	transit and fare schedules	Messaging data
Transit Management	Information Service Provider	transit request confirmation	Messaging data
Transit Management	Remote Traveler Support	transit fare payment responses	Conversational data, Messaging data
Transit Management	Traffic Management	transit system data	Messaging data
Emergency Telecommunications System	Emergency Management	incident notification	Conversational data, Conversational speech, Location data
Government Administrators	Commercial Vehicle Administration	regulations	Messaging data, Multicast data
Media	Information Service Provider	external reports	Messaging data, Multicast data
Media	Traffic Management	external reports	Messaging data, Multicast data
Other EM	Emergency Management	incident report	Conversational data, Messaging data

Source	Destination	Architecture Flow	Communication Service
Other ISP	Information Service Provider	ISP coordination	Messaging data
Other TM	Traffic Management	traffic control coordination	Messaging data
Other TM	Traffic Management	traffic information coordination	Messaging data

5.3 Wide Area Wireless Communication Elements (u1)

Given the ITS goal of seamless nationwide wireless services, the following three requirements can be stated for any wireless wide area network (WAN) communication elements:

1. The interfaces use open standards.

   [This guarantees that ITS subsystem equipment from many competing manufacturers can be used to connect using the communications element. The cost of the data communication module (e.g., modem, transceiver) should be small relative to the ITS subsystem.]

2. The communication element be internetworked with other communication elements.

   [The communication element provider must participate in the open internetworking standards that enable messaging between users of different communication element technologies.]

3. The communication element be nearly ubiquitous to the nation or at least a region.

   [This enables users to "roam" over a substantial area of user interest and have seamless access to ITS services. The roaming capability is supported by the communication service provider.]

Exceptions will be found for specific deployments where legacy communication systems need to be accommodated, or where some of the interoperability related benefits of ITS are not important (e.g., dedicated regional safety or transit services). It is expected in these cases that the capability to interface to open systems (through the wireline networks) to allow information exchange will still be possible.

The wide area network (WAN) wireless communication element can be dedicated to a specific user or agency (and publicly owned or privately owned), or it can be privately owned and operated by a communication service provider who sells access to this data network to many users or agencies for a fee.

A key feature of most wireless communication elements is that they are or can be internetworked to a wireline communication system of some sort. In this way, mobile units can exchange ITS messages with Center or Roadside subsystems. We assume and require that the 2-way ITS wireless communication network will have the necessary coverage for a particular user service application, and that the wireless network will be internetworked to the wireline wide area communications network. The following sections discuss various options that might be deployed.

A key concept in the ITS architecture is that communications technology is a "commodity" that can conceptually be considered separately from ITS subsystems and their architecture defined functions. The benefit of this concept is that the investment in ITS subsystem functions can be made relatively stable and secure while still allowing rapid evolution and adaptation to evolving communication technologies.

This requires that communication modules in ITS subsystems be replaceable at low cost so that the benefits of rapidly evolving communication technologies can be incorporated into ITS deployments. An essential element to this concept is communication standards so that the interface between the communication modules and the ITS modules in an ITS subsystem and across subsystems are well defined. These standards must be *open* (as opposed to *proprietary*), so that multiple vendors will be able to provide functionally equivalent communication modules, and the cost of acquiring these communication modules will be contained by competition.

Both broadcast modalities and two-way are supported in the architecture for various appropriate applications. This approach allows attractive early deployments using mature and emerging one-way data services (e.g., pager technology and FM subcarrier), yet also supports use or evolution towards more functionally rich two-way modalities.

5.3.1 Wide Area Wireless for Digital Map Data

Table 4 shows the wireless architecture flows for digital map data exchange in this standards package.

Table 4. Wide Area Wireless Data Flows for Digital Map Data Exchange

Source	Destination	Architecture Flow	Communication Service
Location Data Source	Personal Information Access	position fix	Broadcast Data
Location Data Source	Vehicle	position fix	Broadcast Data
Map Update Provider	Personal Information Access	map updates	Messaging data, Multicast data
Map Update Provider	Vehicle	map updates	Messaging data, Multicast data
Personal Information Access	Map Update Provider	map update request	Messaging data
Vehicle	Map Update Provider	map update request	Messaging data

5.3.2 Wide Area Wireless Data Flows that Use Location_Identity

Table 5 shows the wide area wireless architecture flows that utilize location_identity.

Table 5. Wide Area Wireless Data Flows Examples for Location Referencing

Source	Destination	Architecture Flow	Communication Service
Commercial Vehicle Administration	Commercial Vehicle Check	safety information	Conversational data, Messaging data
Commercial Vehicle Administration	Fleet and Freight Management	electronic credentials	Messaging data
Commercial Vehicle Subsystem	Commercial Vehicle Check	on board safety data	Conversational data
Commercial Vehicle Subsystem	Fleet and Freight Management	on board vehicle data	Messaging data
Emergency Management	Emergency Vehicle Subsystem	emergency dispatch requests	Conversational speech, Messaging data
Emergency Vehicle Subsystem	Emergency Management	emergency vehicle tracking data	Conversational speech, Messaging data
Fleet and Freight Management	Commercial Vehicle Subsystem	fleet to driver update	Messaging data
Information Service Provider	Personal Information Access	broadcast information	Messaging data,Broadcast data, Multicast
Information Service Provider	Personal Information Access	traveler information	Broadcast data,Multicast data

Source	Destination	Architecture Flow	Communication Service
Information Service Provider	Personal Information Access	trip plan	Conversational data, Messaging data
Information Service Provider	Personal Information Access	yellow pages information	Conversational data, Messaging data
Information Service Provider	Remote Traveler Support	broadcast information	Messaging data,Broadcast data, Multicast
Information Service Provider	Remote Traveler Support	traveler information	Broadcast data,Multicast data
Information Service Provider	Remote Traveler Support	trip plan	Conversational Data
Information Service Provider	Remote Traveler Support	yellow pages information	Conversational data, Messaging data
Information Service Provider	Vehicle	broadcast information	Messaging data,Broadcast data, Multicast
Information Service Provider	Vehicle	traveler information	Messaging data,Broadcast data, Multicast
Information Service Provider	Vehicle	trip plan	Conversational data, Messaging data
Information Service Provider	Vehicle	yellow pages information	Conversational data, Messaging data
Personal Information Access	Emergency Management	emergency notification	Conversational data, Messaging data
Personal Information Access	Information Service Provider	trip request	Conversational Data, Messaging data
Roadway Subsystem	Vehicle	vehicle signage data	Messaging data
Remote Traveler Support	Emergency Management	emergency notification	Conversational speech, Messaging data, location data
Transit Management	Transit Vehicle Subsystem	driver instructions	Messaging data
Transit Management	Transit Vehicle Subsystem	fare management information	Messaging data
Transit Vehicle Subsystem	Transit Management	emergency notification	Messaging data
Transit Vehicle Subsystem	Transit Management	fare and payment status	Conversational data, Messaging data
Transit Vehicle Subsystem	Transit Management	transit vehicle location data	Conversational data, Messaging data, location data
Transit Vehicle Subsystem	Transit Management	transit vehicle schedule performance	Conversational data, Messaging data
Vehicle	Emergency Management	emergency notification	Conversational speech, Messaging data, location data
Vehicle	Information Service Provider	traveler request	Conversational data, Messaging data
Vehicle	Information Service Provider	trip request	Conversational data, Messaging data
Vehicle	Information Service Provider	vehicle probe data	Messaging data, location data
Vehicle	Information Service Provider	yellow pages request	Conversational data, Messaging data
Vehicle	Roadway Subsystem	AHS vehicle data	Conversational data

6 Constraints

This chapter identifies Physical Architecture intersubsystem message performance requirements below the application layer.

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 communcations link must also have high availabiltiy. Failure of the communications medium may result in severe accident. This communication channel may require redundant paths or extra attention paid to potential failure modes. For wireline cases, this may indicate 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 of identifying the vehicle as well as exchanging information before the vehicle gets out of range. This is more of a problem with vehicles traveling at speed. The architecture constrains such 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.

   b. Privacy (P)

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

For the digital map data-related data flows, there are no special constraints currently documented in the architecture. A reasonable constraint that could be introduced for this case would be "accuracy" or perhaps more nebulously "quality". The distinction could then be made between applications such as display maps that have very low accuracy requirements, and vehicle navigation maps that have very high accuracy requirements.

For the data flows that utilize *location_identity*, there are numerous examples where the current constraint rankings apply. The data flows with constraints follow in Table 6. The following coding scheme is utilized for the constraint categories:

E - ***Emergency Priority***

R - ***Reliability***

T - ***Timing***

F - ***Financial Security***

P - ***Personal Privacy***

S - ***Security***

Table 6. Constraints on the Data Flows Containing Location_Identity

Source	Destination	Architecture Flow	Interconnects	Communication Service	Special Constraints
Commercial Vehicle Check	Commercial Vehicle Administration	citation data	W	Conversational data, Messaging data	P
Commercial Vehicle Subsystem	Commercial Vehicle Check	on board safety data	U2	Conversational data	T
Emergency Management	Emergency Vehicle Subsystem	emergency dispatch requests	U1t	Conversational speech, Messaging data	E
Emergency Management	Traffic Management	emergency traffic control request	W	Conversational data, conversational speech	E
Emergency Management	Other EM	incident report	W	Conversational data, Messaging data	E
Emergency Vehicle Subsystem	Emergency Management	emergency vehicle tracking data	U1t	Conversational speech, Messaging data	E
Information Service Provider	Fleet and Freight Management	route plan	W	Messaging data	P

Source	Destination	Architecture Flow	Interconnects	Communication Service	Special Constraints
Information Service Provider	Personal Information Access	traveler information	W,U1t	Broadcast data,Multicast data	P
Information Service Provider	Personal Information Access	trip plan	W,U1t	Conversational data, Messaging data	P
Information Service Provider	Parking Management	parking lot data request	W	Messaging data	P
Information Service Provider	Parking Management	parking reservations request	W	Messaging data	P
Information Service Provider	Remote Traveler Support	traveler information	W,U1t	Broadcast data,Multicast data	P
Information Service Provider	Remote Traveler Support	trip plan	W,U1t	Conversational Data	P
Information Service Provider	Traffic Management	logged special vehicle route	W	Conversational data, Messaging data	P
Information Service Provider	Vehicle	traveler information	U1t,U1b	Messaging data,Broadcast data, Multicast	P
Information Service Provider	Vehicle	trip plan	U1t	Conversational data, Messaging data	P
Personal Information Access	Emergency Management	emergency notification	U1t	Conversational data, Messaging data	E
Personal Information Access	Information Service Provider	trip request	W,U1t	Conversational Data, Messaging data	P
Roadway Subsystem	Archived Data Management Subsystem	roadside archive data	W	Messaging data	T
Roadway Subsystem	Traffic Management	request for right-of-way	W	Conversational data, Messaging data	R
Roadway Subsystem	Vehicle	vehicle signage data	U2	Messaging data	T
Remote Traveler Support	Emergency Management	emergency notification	W,U1t	Conversational speech, Messaging data, location data	E
Remote Traveler Support	Information Service Provider	traveler request	W	Messaging data	P
Remote Traveler Support	Transit Management	emergency notification	W	Conversational data, Messaging Data	E
Traffic Management	Emergency Management	incident information	W	Messaging data	E
Traffic Management	Roadway Subsystem	freeway control data	W	Messaging data	T
Traffic Management	Roadway Subsystem	signal control data	W	Messaging data	T
Transit Management	Emergency Management	transit emergency data	W	Conversational data, Messaging data	E

Source	Destination	Architecture Flow	Interconnects	Communication Service	Special Constraints
Transit Management	Information Service Provider	demand responsive transit plan	W	Conversational data, Messaging data	P
Transit Management	Information Service Provider	transit request confirmation	W	Messaging data	P
Transit Management	Remote Traveler Support	transit fare payment responses	W	Conversational data, Messaging data	F
Transit Vehicle Subsystem	Transit Management	emergency notification	U1t	Messaging data	E
Transit Vehicle Subsystem	Transit Management	fare and payment status	U1t,U2	Conversational data, Messaging data	F,T
Vehicle	Emergency Management	emergency notification	U1t	Conversational speech, Messaging data, location data	E
Vehicle	Information Service Provider	traveler request	U1t	Conversational data, Messaging data	P
Vehicle	Information Service Provider	trip request	U1t	Conversational data, Messaging data	P
Vehicle	Information Service Provider	vehicle probe data	U1t	Messaging data, location data	P
Vehicle	Information Service Provider	yellow pages request	U1t	Conversational data, Messaging data	P
Vehicle	Roadway Subsystem	AHS vehicle data	U2	Conversational data	T,R
Other EM	Emergency Management	incident report	W	Conversational data, Messaging data	E

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.

credit_identity
: This data item contains the identity number of a credit card which is to be used to secure preclearance from paying dues, taxes, and other commercial vehicles charges, or by a traveler or driver for payment of current or advanced tolls, fares, parking lot charges, or for yellow pages services.

demand_display_update
: This data item contains the digitized map data for displays that can be used as background for the output of data on traffic and travel demand levels.

emergency_display_update
: This data item contains the digitized map data for displays that can be used as the background for the output of data on incidents and emergencies to the emergency system operator.

incident_display_update
: This data item contains the digitized map data for displays that can be used as background for the output of data on current incidents and planned events.

location
: This data item contains the position fix of the transportation object.

other_routes_map_data
: This data item contains a new copy of the digitized map data used by the process that selects other, i.e. non-vehicle and non-transit, routes.

pollution_display_update
: This data item contains the digitized map data for displays that can be used as background for the output of data on the levels of various atmospheric pollutants.

request_demand_display_update
: This data item contains a request for an update to the digitized map data for displays that can be used as background for the output of data on traffic and travel demand levels.

request_emergency_display_update
: This data item contains a request for an update to the digitized map data for displays that can be used as the background for the output of data incidents and emergencies to the emergency system operator.

request_incident_display_update
: This data item contains a request for an update to the digitized map data for displays that can be used as background for the output of data on current incidents and planned events.

request_other_routes_map_update
: This data item contains a request for a new copy of the digitized map data used by the process that selects other, i.e. non-vehicle and non-transit, routes for travelers.

request_pollution_display_update
: This data item contains a request for an update to the digitized map data for displays that can be used as background for the output of data on the levels of various atmospheric pollutants.

request_route_selection_map_update
: This data item contains a request for a new copy of the digitized map data used by the process that selects vehicle based routes for travelers and drivers.

request_traffic_display_update
This data item contains a request for an update to the digitized map data for displays that can be used as background for the output of data on current and predicted traffic levels.

request_traveler_display_update
This data item contains a request for an update to the digitized map data used for displays that can be output as background for traffic, trip and travel information for use by travelers at kiosks.

request_traveler_personal_display_update
This data item contains a request for an update to the digitized map data used for displays that can be output as background for traffic, trip and travel information for use by a traveler at a personal device.

request_traveler_personal_display_update_cost
This data item contains a request for the cost of an update to the digitized map data used for providing the background to displays of traffic and travel information on a traveler personal device.

route_selection_map_data
This data item contains an update of the digitized map data used by the route selection facility to produce vehicle based routes for trip planning and on-line guidance purposes.

traffic_display_update
This data item contains the digitized map data for displays that can be used as background for the output of data on current or predicted traffic levels.

transit_map_update
This data item contains digitized map data to be used for route generation and as a background to displays of services requested by the transit fleet manager.

transit_map_update_request
This data item contains a request for an update of the map database used for generating new transit routes and as a background to displays of transit services.

traveler_display_update
This data item contains the digitized map data that can be used as background to displays of traffic, trip and travel information that are output to a kiosk for use by travelers.

traveler_identity
This data item contains the identity of the traveler who is making a request for information or guidance, so that the results of the request can be sent back to the originating traveler.

traveler_map_update
This data item contains data for a new guidance map to be used by the on-line traveler guidance facility.

traveler_map_update_cost
This data item contains the cost for a new navigable map database to be used by the traveler personal on-line guidance facility.

traveler_map_update_cost_request
This data item contains a request for the cost of an update to the navigable map database used for providing traveler personal on-line guidance.

traveler_map_update_request
This data item contains a request for an update of the digitized map database used for guiding travelers on their selected routes.

traveler_personal_display_update
This data item contains the digitized map data that can be used as background to displays of traffic, trip and travel information that are output to a personal device for use by travelers.

traveler_personal_display_update_cost
This data item contains the cost for a new set of digitized map data to be used as the background to displays of traffic and travel information being output by a traveler's personal device.

vehicle_map_update

This data item contains data for a new navigable map database to be used by the on-line vehicle guidance facility.

vehicle_map_update_cost

This data item contains the cost for a new navigable map database to be used by the on-line vehicle guidance facility.

vehicle_map_update_cost_request

This data item contains a request for the cost of an update to the navigable map database used for providing in-vehicle on-line guidance.

vehicle_map_update_request

This data item contains a request for an update of the navigable map database used for providing in-vehicle on-line guidance.