Standards Requirements Package 7: Traffic Management Subsystem to Roadside Devices and Emissions Sensing/Management

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Table of Contents

Figures

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 SDOs; 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.

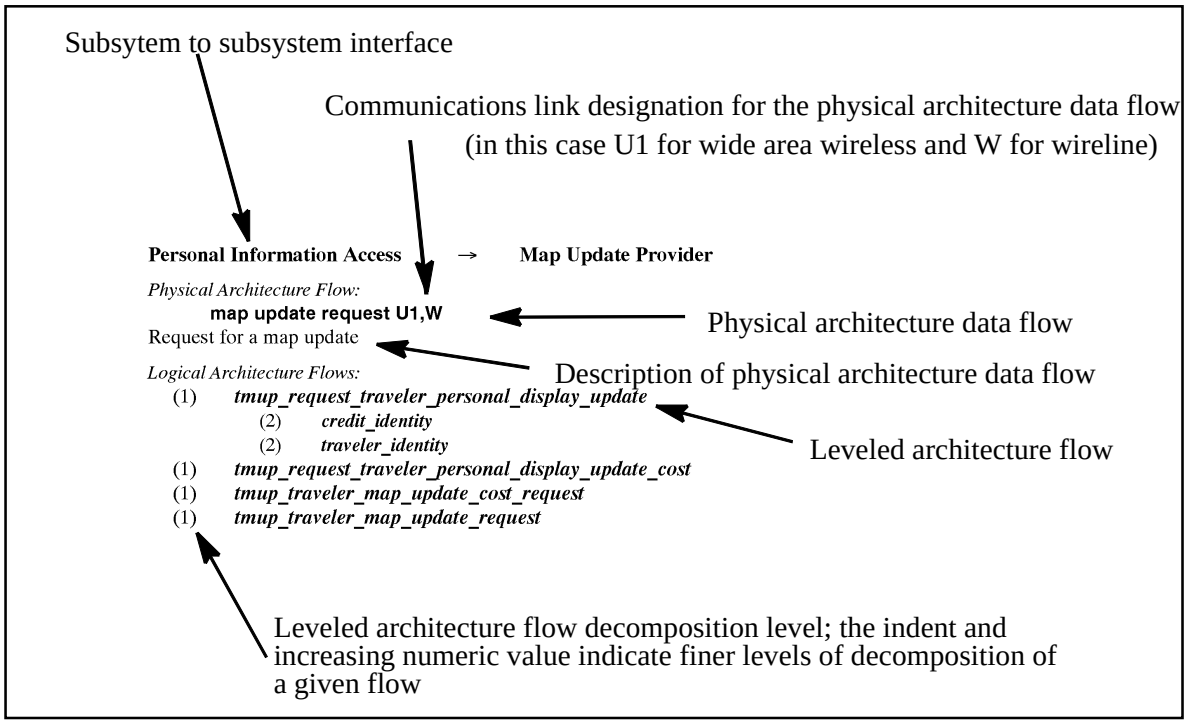

Figure 1 - Example of the parts of an interface decomposition

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 TMS to Roadside Devices and Emissions Sensing/Management Standards Package

One of the key interfaces in ITS is between the Traffic Management Subsystem and the Roadway Subsystem. The functionality directly enabled by this interface includes Traffic Control, Incident Management, and Demand Management. The information gathered at the Roadway by sensors provides network surveillance and is the starting point for the development of real time traffic information. One category of information collected at the Roadway is emissions data. Because the management of emissions monitoring and reporting is often performed by a different agency than that which performs traffic management, the National Architecture has defined a separate subsystem for Emissions Management (EMMS). The interfaces from the Roadway, Information Service Provider, and the Media terminator to this subsystem are included in this Standards Package, as well as the possible interface between the EMMS and the Traffic Management Subsystem (TMS). The current standards effort supporting National Transportation Communications for ITS Protocol (NTCIP) is addressing this Roadway to TMS interface, with plans to extend the standards applicability to center to center communications; this package will supply a direct extraction of the relevant requirements from the National Architecture.

Ultimately the TMC may implement control and pricing decisions based on congestion and emissions levels. This type of sophistication will require coordination between jurisdictions, to ensure that the control strategies do not operate at cross purposes. This means that ultimately the standardization of information in this package will interact closely with information in Package: Traffic Management to Other Centers, which contains the requirements for intercenter coordination and data exchange.

The interfaces described in this package will primarily be implemented as wireline interfaces (probably WAN or MAN-based). Figure 2 shows the key interfaces described in this standards package.

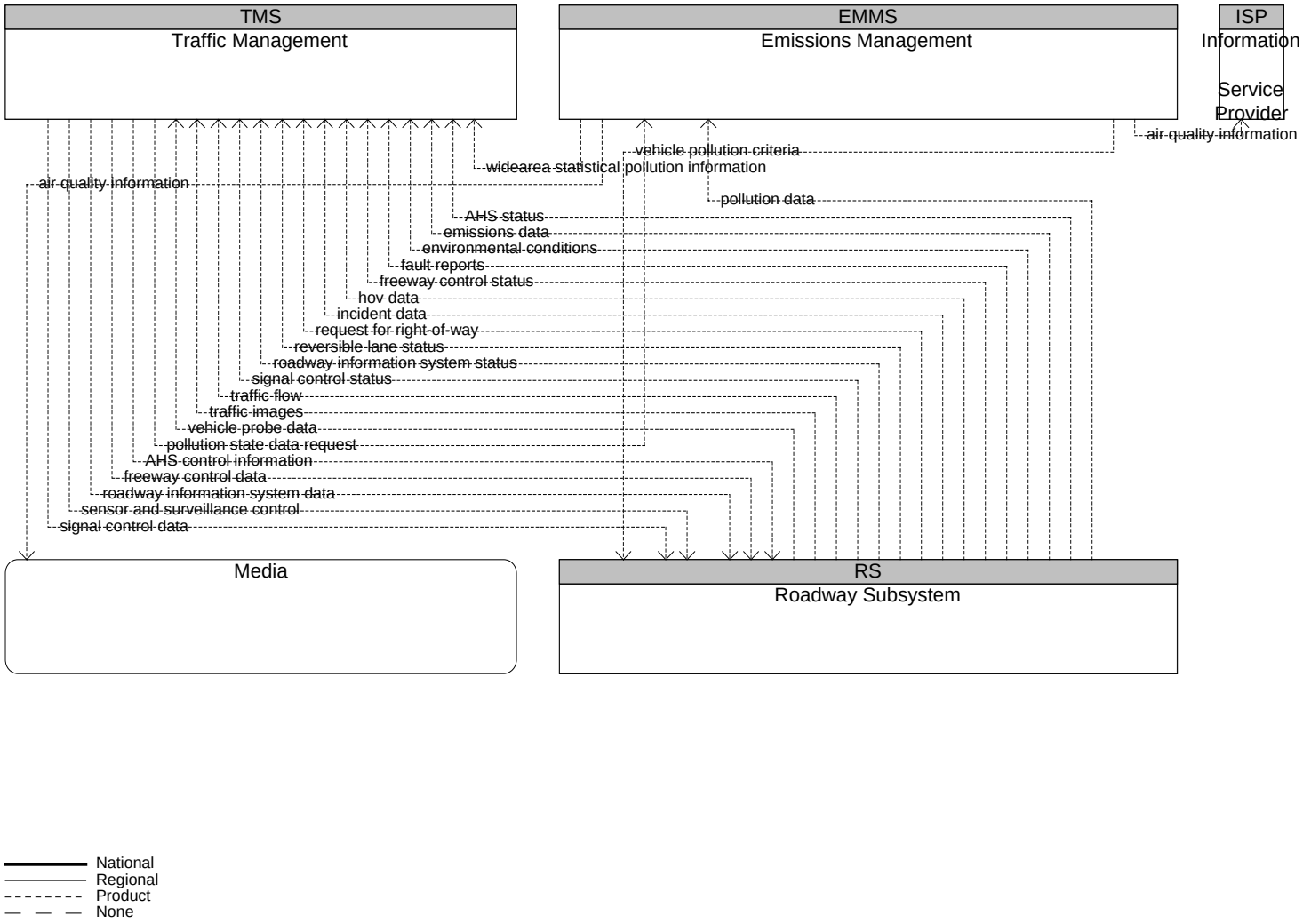

Figure 2 - Traffic Management Subsystem to Roadway Devices and Emissions Sensors/ Management

3 Transaction Sets for the TMS to Roadside and Emissions Management Subsystems

In this section we define the transaction sets needed to accomplish the interfaces between the Roadway Subsystem (RS), the Traffic Management Subsystem (TMS) and the Emission Management Subsystem (EMMS). We also define the transaction sets needed to distribute EMMS data to the Information Service Provider (ISP) and the Media. Based on the top level physical architecture data flows, a message sequence chart format along the lines of those defined under ISO standardization is used for clarity of presentation. The following subsections discuss the interactions between a set of Subsystems.

The transaction set figures used in this chapter identify the messages that go between the TMS, the EMMS and the Roadway, as well as between the EMMS to the ISP and Media terminator Where messages follow each other top to bottom, they represent a transaction sequence or protocol. Where messages are separated by a horizontal dotted line, the messages are distinct, and not related in any particular sequence. Notes to the right of the messages or in some cases groups of messages amplify on details of the message protocols and sometimes a number in a circle identifies a following numbered section in the text which also describes the particular message or message sequence function . Most of the messages shown are physical architecture flows. Occasionally, in order to better explain the functionality the logical architecture dataflows are used. These will be printed in italics to distinguish them from the physical flows.

3.1 EMMS and RS

This interface is used in providing roadside pollution assessment. The User Service requirements which are covered by this interface include the capability of detecting basic pollution levels, but also include the capability of determining (and reporting on) the levels of individual moving vehicles within the monitored area which violate the emission standard.

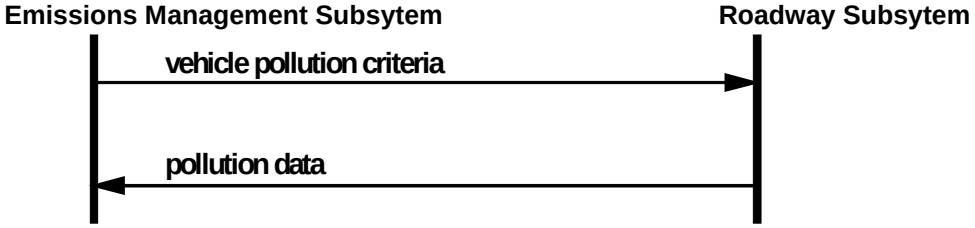

Figure 3 - EMMS and RS Transaction Set

The EMMS sets the pollution criteria for the roadside monitoring devices. The RS sends pollution data back to the EMMS. Contained within the pollution data are the following types of information (as described in the leveled data item flows):

- general roadside pollution levels
- data on individual vehicles
- a summary log of vehicle pollution data

3.2 Traffic Management Subsystem and EMMS

In support of the Emissions Testing and Mitigation User Service Requirements the architecture provides an interface between the Traffic Management Subsystem and the Emissions Management Subsystem for the exchange of wide area pollution monitoring and roadside pollution assessment. The TMS can use this information in support of its Demand Management functions.

Figure 4 shows the leveled data items associated with this interface. There are two modes of information flow. In the first the TMS makes a pollution state data request and the EMMS responds with pollution state data. In the second mode of operation the EMMS sends data such as indication of a "pollution incident" or wide area pollution data on an as required basis (not in response to a specific request).

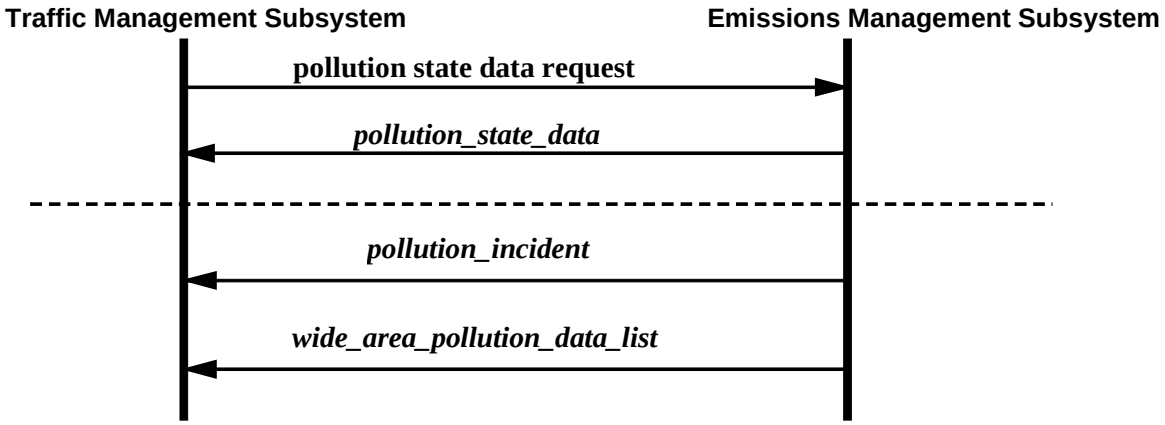

Figure 4 - TMS to EMMS Transaction Sets

3.3 Traffic Management to Roadway

The Traffic Management Subsystem to Roadway interface is one of the key interfaces in the ITS architecture. It is also an interface with considerable, diverse functionality. The following subsections will discuss the dataflows grouped into major functionality groupings.

3.3.1 AHS

The architectural definition of AHS has undergone initial development by the National AHS Consortium, but is far from finalized. Several operational concepts have been considered, with no final single concept selected. These concepts vary the amount of functionality in the vehicle versus that in the infrastructure. The National Architecture has included a general TMS to RS connection for AHS under the belief that the AHS architecture ultimately chosen will contain some degree of infrastructure functionality. This functionality will probably be provided by Roadway equipment which has some level of control from the TMS. Hence the National Architecture has included this simple model of interaction as shown in Figure 5 .

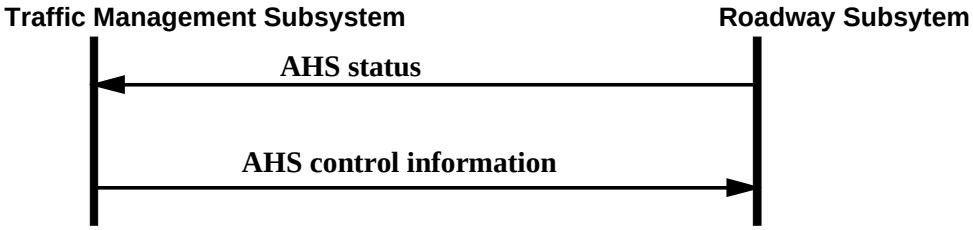

Figure 5 - TMS/ RS Interface for AHS Transaction Set

3.3.2 Freeway and Surface Street Control

The interface between the TMS and the Roadway for Freeway and Surface Street control is used to provide the major functions of Traffic Control. The basic transaction set is control data (either freeway or

surface street) sent from the TMS to the Roadway and status data is returned. (See transaction set 1 in Figure 6 .) The freeway control data flow contains logical flow elements for multimodal crossings, ramp control, and DMS control. The signal control data flow (for surface street control) contains logical flow elements for multimodal crossings, intersection control, and DMS control.

Roadway information system data is also sent to the Roadway from the TMS and then status is returned. The data obtained in the roadway information system is used to initalize, configure, and control roadside systems that provide driver information. The data included in roadway information systems include HAR (highway advisory radio) data, DMS (dynamic message sign) data, and in-vehicle sign data. (See transaction set 2 in Figure 6.) This supports the type of in-vehicle signing where real time data is sent from the TMS to the roadway (the data is then transmitted to the vehicle via a DSRC link using a beacon). As architected the message sent could be the full information, or it could be a code to provide one of a number of canned messages to the vehicle. The information sent to the roadside falls into two categories- sign data and situation data. Sign data includes permanent fixed signs (eg. STOP, YIELD, etc), temporary signs (eg. detours), and dynamic message signs. Situation data includes traffic information (including incident data) and dynamic extra-vehicle conditions (eg. weather). This definition of signage data includes the concept of location specific (or location triggered) traveler information.

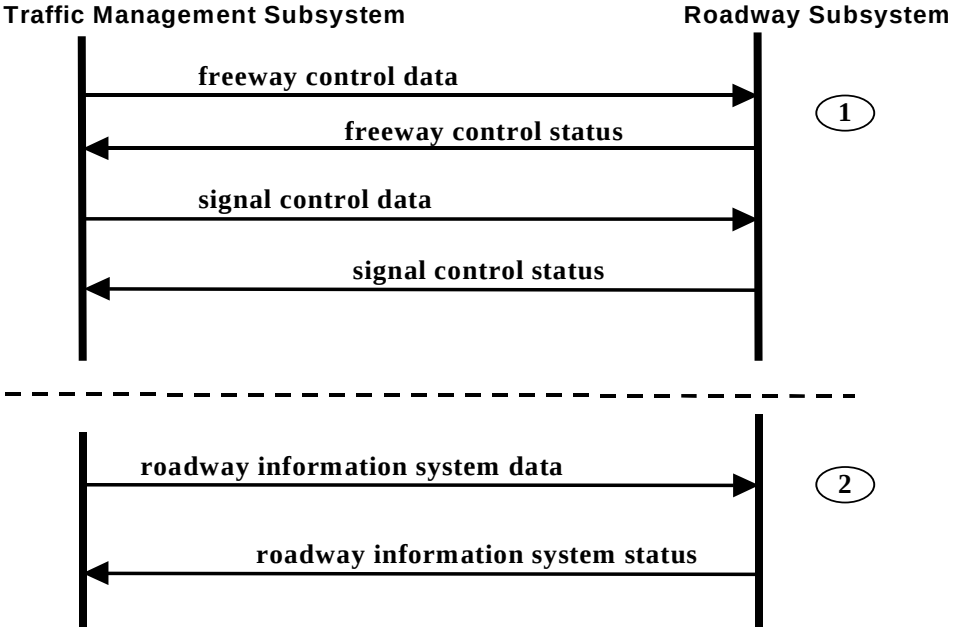

Figure 6 - Freeway and Surface Street Control and Roadway Information Transaction Sets

3.3.3 Sensor and Surveillance data

An important feature of the interface between the TMS and the Roadway is sensor and surveillance data. The sensor data obtained from the Roadway includes environmental conditions, sensor fault reports, and reversible lane status. This data is part of the Freeway and Surface Street Control data, however it primarily focuses on the control of sensors, the detection of wrong way vehicles, and environmental conditions.

Two forms of video images are present in the architecture. The first (under incident data is the standard CCTV type image). The second (under traffic images) is the machine vision type of image (used by processors to assess traffic flow, etc. The basic surveillance function (including environmental condition monitoring) is covered by the traffic flow architecture flow. Also contained within traffic flow is a vehicle

pollution input. This feature of the architecture supports the implementation where individual vehicle pollution is measured at the roadway and a Dynamic Message Sign (DMS), controlled from the TMS, displays results of the pollution test of the vehicle, or any other information deemed necessary to inform the driver of the state of this vehicle. The more normal scenario for this function would be for the pollution monitor to connect directly to a DMS without connection to the TMS. In addition to providing sensor outputs the RS will send sensor fault data to the TMS. Information passing in the opposite direction is contained in the sensor and surveillance control flow, which contains leveled data items for control of advanced sensors and video cameras.

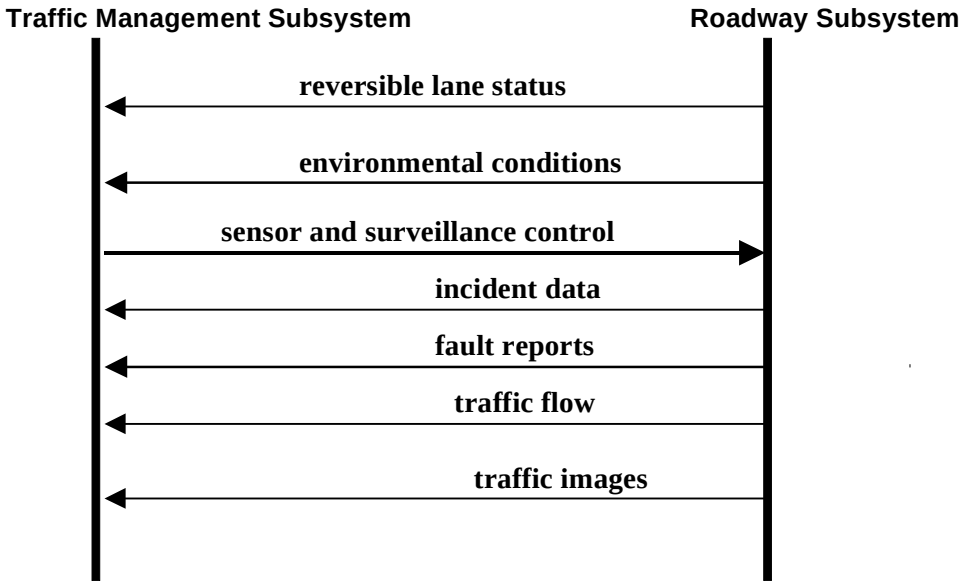

Figure 7 - Sensor and Surveillance control Set

3.3.4 HOV

The requirement to monitor HOV lane compliance is handled in the architecture through the HOV data flow going from Roadway to TMS. This flow contains data for vehicle occupancy count (the technology used to perform this reliably is not specified) as well as vehicle images.

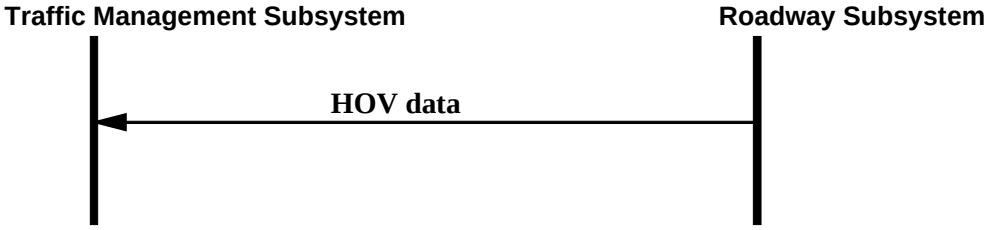

Figure 8 - HOV data Transaction

3.3.5 Signal Priority

The architecture provides support for several methods of signal priority. A complete description of the way the architecture implements signal priority is contained in the Standards Package 8: Signal Priority for Transit and Emergency Vehicles. One of the modes, shown below, is when a signal (originated in the vehicle) is forwarded to the TMS from the Roadway for inclusion in the TMS traffic control algorithms.

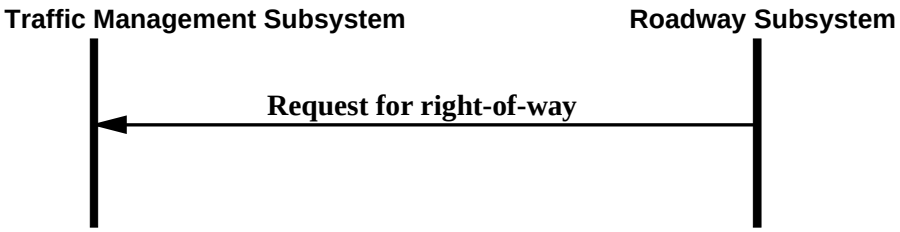

Figure 9 - Signal Priority Transaction

3.3.6 Vehicle Probe Data

The National Architecture supports the collection of vehicle probe data by beacons at the Roadway. The data is then sent to the TMS from the Roadway. When vehicles are equipped with electronic tags (eg for electronic tolls) these tags can be read by beacons put up in the infrastructure and (with processing at the TMS) the traffic flow on the links can be determined. This flow also includes smart probe information which is collected at the roadway and sent to the TMS. Smart Probes are vehicles with sensors onboard (either weather or road condition) and the ability to pass this information to the roadway via a short range tag to beacon link. The roadway processing can either directly transmit the smart probe information to other vehicles or send the information to the TMS.

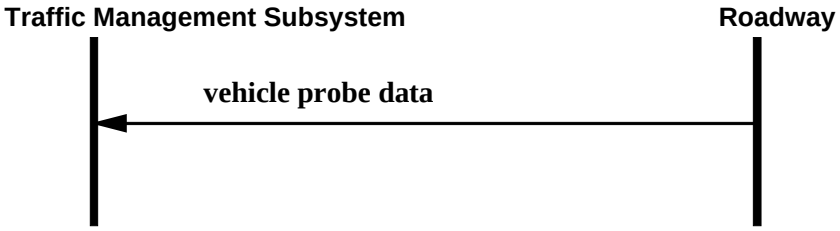

Figure 10 - Vehicle probe data Transaction

3.3.7 Emissions

The Roadway Subsystem maintains and collects emissions data and associated imagery by roadway equipment. The equipment collects current vehicle pollution data and current levels of pollution caused by vehicles.

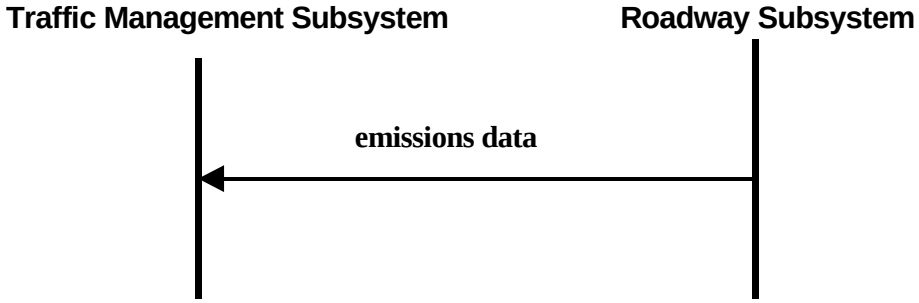

Figure 11 - TMS to Roadway Subsystem Transaction Set

3.4 Emissions Management to Information Service Provider

Emissions Management Subsystem interfaces with the Information Service Provider (ISP) to provide air quality information which includes sectors/areas exceeding safe pollution levels. The ISP collects air

quality information for distribution to travelers and businesses to aid in reducing pollution.

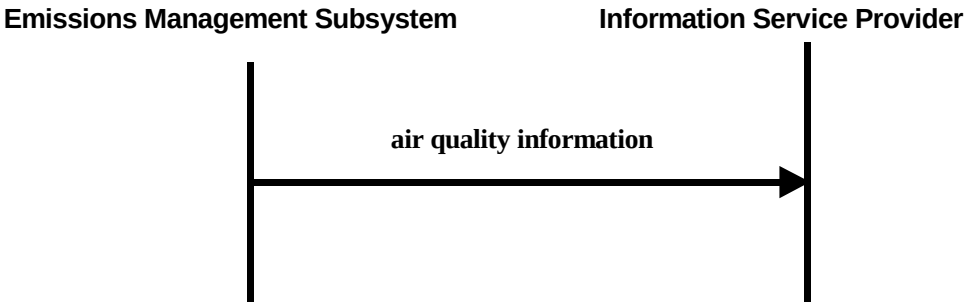

Figure 12 - EMMS to ISP Transaction Set

3.5 Emissions Management to Media Terminator

Emissions Management Subsystem interfaces with the Media terminator to provide air quality information which includes sectors/areas exceeding safe pollution levels. The information sent to the Media terminator is in a form readily understood by the media.

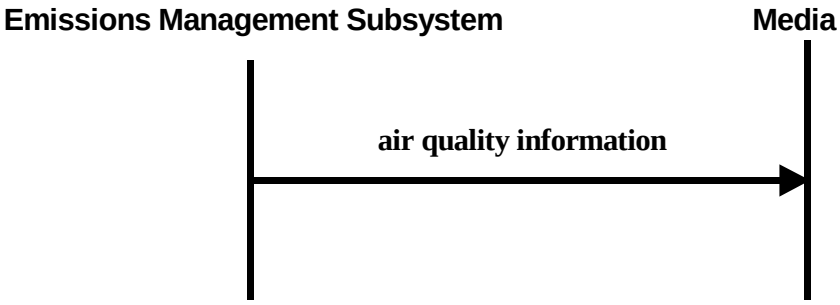

Figure 13 - EMMS to Media Transaction Set

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 Roadway Subsystem -> Emissions Management

Physical Architecture Flow: pollution data W
Measured emissions data comprised of various atmospheric pollutants.

Leveled Data Items:
(1) ***pollution_state_roadside_collection***
This data item contains the digitized values of pollution levels obtained from roadside sensors in the geographic area served by the function.

(2) ***current_pollution_data***

(2) ***current_roadside_pollution_location***

(1) ***pollution_state_vehicle_collection***
This data item contains the average levels of the various types of pollution that were being output by a particular type of violating vehicle.

(2) ***current_pollution_data***

(2) ***vehicle_type***

(1) ***pollution_state_vehicle_log_data***
This data item contains a periodic average of the pollution data measured by sensors from actual vehicles.

(2) ***pollution_state_vehicle_collection***
(3) ***current_pollution_data***

(3) ***vehicle_type***

4.2 Traffic Management ->Emissions Management

Physical Architecture Flow: pollution state data request W
Aggregated emissions data information request.

Leveled Data Items:
(1) ***pollution_state_data_request***
This data item contains request for data about current levels of pollution. This data can be requested for a roadside or wide area location.

4.3 Emissions Management -> Information Service Provider

Physical Architecture Flow: air quality information W
Aggregated region-wide measured air quality data and possible pollution incident information.

Leveled Data Items:
(1) ***current_traffic_pollution_data***
This data item provides information on current levels of pollution.

(2) ***pollution_state_area_collection***
(3) ***area_air_quality_index***
(3) ***current_pollution_data***
(3) ***current_pollution_location***
(2) ***pollution_state_roadside_collection***
(3) ***current_pollution_data***
(3) ***current_roadside_pollution_location***

4.4 Emissions Management -> Media

Physical Architecture Flow: air quality information W
Aggregated region-wide measured air quality data and possible pollution incident information.

Leveled Data Items:
(1) ***to_media_pollution_data***
This data item provides information on current pollution data in a form which will be readily understood by the Media.

4.5 Emissions Management -> Roadway Subsystem

Physical Architecture Flow: vehicle pollution criteria W
Vehicular pollution acceptance criteria.

Leveled Data Items:
(1) ***pollution_state_vehicle_acceptance_criteria***
This data item contains data on the pollution levels produced by different types of vehicle under various operating conditions.

(2) ***pollution_vehicle_acceptance_conditions***

(2) ***pollution_vehicle_acceptance_data***

4.6 Traffic Management -> Roadway Subsystem

Physical Architecture Flow: AHS control information W
Control data to AHS roadway equipment

Leveled Data Items:
(1) ***ahs_control_data_changes***
This data item contains data defining parameters to be used by vehicles participating in platoon following and running in ahs controlled lanes, which will override any already loaded into the vehicles.

(2) ***ahs_demand_accel_decel_profile***
(3) ***vehicle_accel_decel_data***
(2) ***ahs_demand_headway***
(3) ***vehicle_headway_data***

Physical Architecture Flow: freeway control data W
Control commands and operating parameters for ramp meters, dynamic message signs, mainline metering/lane controls and other systems associated with freeway operations.

Leveled Data Items:
(1) ***indicator_crossing_control_data_for_highways***
This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at multimodal crossings on freeways served by the function.

(2) ***indicator_crossing_controls***

(2) ***indicator_identity_list***

(1) ***indicator_ramp_control_data***
This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at entry ramps to highways served by the function.

(2) ***indicator_identity_list***

(2) ***ramp_controls***

Physical Architecture Flow: roadway information system data W
Information used to initialize, configure, and control roadside systems that provide driver information (e.g., dynamic message signs, highway advisory radio, beacon systems). This flow can provide message content and delivery attributes, local message store maintenance requests, control mode commands, status queries, and all other commands and associated parameters that support remote management of these systems.

Leveled Data Items:
(1) ***dms_data***
This data item contains the DMS data (e.g.. text strings of information) to be output to drivers on freeways or arterials in the geographic and/or jurisdictional area(s) served by the function.

(2) ***indicator_identity_list***

(2) ***indicator_sign_control_data***
(3) ***dms_advisory_text***
(4) ***dms_highway_open_close***
(4) ***dms_incident_warning***

(4) ***dms_weather_warning***

(3) ***hri_sign_control_data***

(3) ***lane_dms_controls***

(3) ***parking_lot_dms_controls***

(3) ***pollution_output_message***

(4) ***dms_pollution_message***

(4) ***vehicle_identity***

(1) ***har_data***

This data item contains the HAR data, both program and management, used to define the output of a Highway Advisory Radio (HAR) operating at the roadside on highways or arterials in the geographic and/or jurisdictional area(s) served by the function.

(2) ***har_identity***

(2) ***har_management_data***

(3) ***har_mode***

(3) ***har_schedule***

(2) ***har_program***

(1) ***vehicle_sign_data***

This data item is used within the Manage Traffic function and contains data for use in producing in-vehicle signage displays. The information sent can fall into two categories - sign data and situation data. Sign data includes permanent fixed signs (e.g.. STOP, YIELD, etc), temporary signs (e.g.. detours), and dynamic message signs. Situation data provides information about traffic conditions, e.g. congestion and speed, on up to eight (8) links. Up to six (6) sets of indicator data may be contained within the data item and they may be for the same or different types of indicator, or for incidents. All data is filtered so that the receiving processes only get that which is relevant to their local geographic area.

(2) ***vehicle_signage_data***

(3) ***vehicle_signage_current_data***

(3) ***vehicle_signage_dms_data***

(3) ***vehicle_signage_fixed_data***

(3) ***vehicle_signage_incident_details***

(3) ***vehicle_signage_traffic_data***

(4) ***vehicle_occupancy***

(4) ***vehicle_speed***

(2) ***vehicle_signage_output_identity***

Physical Architecture Flow: sensor and surveillance control W

Information used to configure and control sensor and surveillance systems at the roadside.

Leveled Data Items:

(1) ***environment_sensor_configuration_data***

This data item is used to provide environmental sensor control commands.

(1) ***sensor_configuration_data***

This data item provides control commands for advanced sensors, including video sensing systems .

Physical Architecture Flow: signal control data W
Information used to configure and control traffic signal systems.

Leveled Data Items:
(1) ***indicator_crossing_control_data_for_roads***
This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at multimodal crossings on roads (surface streets) served by the function.

(2) ***indicator_crossing_controls***

(2) ***indicator_identity_list***

(1) ***indicator_junction_control_data***
This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at junctions on roads served by the function.

(2) ***indicator_identity_list***

(2) ***indicator_junction_controls***

(1) ***indicator_pedestrian_control_data***
This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at pedestrian crossings on roads served by the function.

(2) ***indicator_identity_list***

(2) ***indicator_pedestrian_controls***

4.7 Emissions Management -> Traffic Management

Physical Architecture Flow: widearea statistical pollution information W
Aggregated region-wide measured emissions data and possible pollution incident information.

Leveled Data Items:
(1) ***pollution_incident***
This data item contains details of a current or predicted pollution incident. The incident type will depend on the type of pollutant that is involved.

(2) ***incident_duration***

(2) ***incident_location***

(2) ***incident_severity***

(2) ***incident_start_time***

(2) ***incident_type***

(1) ***pollution_state_data***
This data item contains data about the current levels of pollution obtained from the store of pollution data.

(2) ***current_pollution_data***

(2) ***current_pollution_location***

(2) ***vehicle_type***

(1) ***wide_area_pollution_data_list***
This data item contains data about the current levels of pollution obtained from the store of pollution data

in the area covered by the Traffic Management Center (TMC).

(2) ***pollution_state_area_collection***
(3) ***area_air_quality_index***

(3) ***current_pollution_data***

(3) ***current_pollution_location***

(2) ***pollution_state_roadside_collection***
(3) ***current_pollution_data***

(3) ***current_roadside_pollution_location***

4.8 Roadway Subsystem -> Traffic Management

Physical Architecture Flow: AHS status W
Status of AHS equipment, lane controls etc.

Leveled Data Items:
(1) ***ahs_checking_details***
This data item contains updates to the counts of successful and failed check-ins to the automatic highway system (ahs) lanes from roadside locations.

(2) ***ahs_failed_checks_count***

(2) ***ahs_successful_checks_count***

Physical Architecture Flow: emissions data W
Emissions data and associated imagery collected by roadside equipment.

Leveled Data Items:
(1) ***vehicle_pollution_alert***
This data item is used by the Manage Traffic function as a means of transferring current vehicle pollution data from the Manage Emissions facility to the Manage Emergency Services function to enable enforcement of air quality standards.

(2) ***pollution_data_violation***

(2) ***vehicle_identity***

(2) ***vehicle_license***

(1) ***vehicle_pollution_message***
This data item contains data about the current levels of pollution being output by a vehicle. It is for output to the vehicle driver who is on a freeway or arterial in the geographic and/or jurisdictional area(s) served by the function.

(2) ***pollution_output_message***
(3) ***dms_pollution_message***

(3) ***vehicle_identity***

Physical Architecture Flow: environmental conditions W
Current environment conditions (e.g., air temperature, wind speed, surface temperature) as measured by environmental sensors and communicated by supporting field equipment.

Leveled Data Items:

(1) ***environment_sensor_data***
This data item contains a set of outputs from individual environment sensors.

(2) ***environment_sensor_output***

(2) ***sensor_identity***

(2) ***station_id***

(1) ***environmental_sensor_status***
This data item reports the status of an environmental sensor. By monitoring this data item, the receiving process can monitor the health and current status of field equipment.

(2) ***sensor_identity***

(2) ***station_id***

Physical Architecture Flow: fault reports W
Reports from field equipment (sensors, signals, signs, controllers, etc.) which indicate current operational status.

Leveled Data Items:
(1) ***environment_sensor_fault_data***
This data item shows that an environment sensor has developed a fault that means it is not operating correctly. The fault will have been found by a process that is local to the sensor itself.

(1) ***sensor_fault_data***
This data item is used to show that a sensor has developed a fault that means it is not operating correctly. The fault will have been found by a process that is local to the sensor itself.

(1) ***traffic_control_device_status***
This data item is used within the Manage Traffic function to show any faults that have been found in roadside equipment. This may be in an indicator or in a traffic sensor.

(2) ***indicator_fault_data***
(3) ***indicator_fault***

(3) ***indicator_type***

(2) ***traffic_sensor_status***

(2) ***vehicle_smart_probe_data_output_fault***

(1) ***traffic_sensor_status***
This data item is used within the Manage Traffic function to report the status of a sensor. By monitoring this data item, the receiving process can monitor the health and current status of field equipment.

Physical Architecture Flow: freeway control status W
Current operational status and operating parameters for ramp meters, dynamic message signs, mainline metering/lane controls and other control equipment associated with freeway operations.

Leveled Data Items:

(1) ***indicator_input_data_from_highways***

This data item contains the actual state of operation of the roadside indicators used to pass instructions to drivers and travelers on freeways within the geographic and/or jurisdictional area(s) served by the function. It is used for centralized monitoring the operation of the indicators.

(2) ***indicator_identity_list***

(2) ***indicator_response_state***

Physical Architecture Flow: hov data W

Current HOV lane information including both standard traffic flow measures and information regarding vehicle occupancy in HOV lanes.

Leveled Data Items:

(1) ***hov_lane_data_input***

This data is used within the Manage Traffic function and contains data from which the use of High Occupancy Vehicle (HOV) lanes can be monitored.

(2) ***private_vehicle_occupants***

(2) ***traffic_video_image***

(2) ***vehicle_count***

(1) ***hov_sensor_data***

This data item contains the HOV data obtained from processing the inputs from sensors around the road network.

(2) ***hov_lane_data***

(3) ***hov_lane_vehicle_count***

(3) ***hov_lane_violation_count***

(2) ***hov_lane_identity_list***

Physical Architecture Flow: incident data W

Data and imagery from the roadside supporting incident detection and verification.

Leveled Data Items:

(1) ***incident_analysis_data***

This data item contains processed traffic sensor data that can be analyzed for the possible presence of incidents. The data is provided directly from the local traffic sensor process rather than from some regional/area based process and so must originate in sensors that are within a small geographic area.

(1) ***incident_video_image***

This data item contains a high resolution digitized image of a potential or current incident at a particular point on the road or freeway network.

Physical Architecture Flow: request for right-of-way W

Forwarded request from signal prioritization, signal preemption, pedestrian call, multimodal crossing

activation, or other source for right-of-way.

Leveled Data Items:

(1) ***indicator_input_data_from_roads***

This data item contains the actual state of operation of the roadside and grade crossing indicators used to pass instructions to drivers and travelers on roads (surface streets) within the geographic and/or jurisdictional area(s) served by the function. It is used for centralized monitoring the operation of the indicators.

(2) ***indicator_response_state***

(1) ***multimodal_crossing_sensor_data***

This data item contains the multimodal crossing data obtained from processing the other inputs from sensors around the road network.

(2) ***crossing_close_duration***

(2) ***crossing_close_time***

(2) ***crossing_identity_list***

(1) ***pedestrian_sensor_data***

This data item contains the pedestrian data obtained from processing the other inputs from sensors around the road network.

(2) ***node_identity_list***

(2) ***pedestrian_demand***

Physical Architecture Flow: reversible lane status W

Current reversible lane status including traffic sensor and surveillance data and the operational status and mode of the reversible lane control equipment.

Leveled Data Items:

(1) ***reversible_lane_video_images***

This data item contains video images of the reversible lanes.

(1) ***sensor_data_for_reversible_lanes***

This data item contains data from which a wrong way vehicle is detected in a reversible lane through the use of sensors located.

(2) ***traffic_video_image***

(2) ***vehicle_detection_data***

(3) ***sensor_identity***

(3) ***station_id***

(3) ***traffic_sensor_output***

Physical Architecture Flow: roadway information system status W

Current operating status of dynamic message signs, highway advisory radios, beacon systems, or other configurable field equipment that provides dynamic information to the driver.

Leveled Data Items:
(1) ***dms_status***
This data item contains the Dynamic Message Sign status for sign control data, operating at the roadside on
arterials or highways in the geographic and/or jurisdictional area(s) served by the function.

(2) ***dms_advisory_text***
(3) ***dms_highway_open_close***

(3) ***dms_incident_warning***

(3) ***dms_weather_warning***

(2) ***indicator_identity_list***

(1) ***har_status_data***
This data item contains the Highway Advisory Radio status for Harris, operating at the roadside on highways or arterials in the geographic and/or jurisdictional area(s) served by the function.

(2) ***har_identity***

(2) ***har_status***

(1) ***information_device_fault_status***
This data item is used to show any faults that have been found in roadside information dissemination equipment. This includes highway advisory radio, dynamic message signs, or in-vehicle signs.

(2) ***har_fault_data***
(3) ***har_fault***

(3) ***har_identity***

(2) ***vehicle_sign_data_output_fault***

Physical Architecture Flow: signal control status W
Status of surface street signal controls.

Leveled Data Items:
(1) ***indicator_input_data_from_roads***
This data item contains the actual state of operation of the roadside and grade crossing indicators used to pass instructions to drivers and travelers on roads (surface streets) within the geographic and/or jurisdictional area(s) served by the function. It is used for centralized monitoring the operation of the indicators.

(2) ***indicator_response_state***

Physical Architecture Flow: traffic flow W
Raw and/or processed traffic detector information which allows derivation of traffic flow variables (e.g., speed, volume and density measures).

Leveled Data Items:
(1) ***traffic_image_data***
This data item contains the data produced by processing image data obtained from visual detection

systems. It is analyzed and used to detect traffic conditions such as flow, occupancy, possible incidents, etc.

(1) ***traffic_sensor_data***

This data item contains the data obtained from processing the inputs from sensors around the road network.

(2) ***sensor_identity***

(2) ***station_id***

(2) ***traffic_sensor_output***

Physical Architecture Flow: traffic images W
High fidelity, real-time traffic images suitable for surveillance monitoring by the operator or for use in machine vision applications.

Leveled Data Items:
(1) ***traffic_video_image***
This data item contains a video image of sufficient fidelity to support operator monitoring applications. This image can be a by-product of a machine vision application or the end-product of a system dedicated to traffic surveillance.

Physical Architecture Flow: vehicle probe data W
Vehicle probe data indicating identity, route segment identity, link time and location.

Leveled Data Items:

(1) ***vehicle_smart_probe_data_for_storage***
This data item contains the processed vehicle smart probe data collected from a roadside unit, which in turn have received data output by suitably equipped vehicles as they pass by.

(2) ***vehicle_smart_probe_data_indication***

(2) ***vehicle_smart_probe_data_source***
(3) ***vehicle_smart_probe_data_source_identity***

(3) ***vehicle_smart_probe_data_source_location***

(1) ***vehicle_tag_data***
This data item contains the data from parking lot and toll tags on-board vehicles plus the identity of the unit which received the data.

(2) ***vehicle_tag_data_source_identity***

(2) ***vehicle_tag_input_data***

5 Communications Layer Requirements

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

5.1 Communications Services: Wireline and Wireless

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

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

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

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

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

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

5.2 Wireline Communication Elements (w)

The interfaces of this standards package are entirely wireline interfaces. The primary requirements on the wireline communications layers are that open standards be utilized for the communications protocols. The following additional requirements should be supported:

1. Support for connection-oriented and connectionless services.
2. A mechanism for acknowledged and unacknowledged data transfers.
3. An error detection algorithm scheme that insures the probability of accepting a bad frame is exceedingly small.
4. A structured approach that supports transmission media and data rate independence.
5. An addressing scheme that is extensible to cover existing and future requirements.
6. Support of a message structure that is extensible to account for variability, changeable data content, and varying length structures.

The following paragraphs provide a discussion of wireline considerations for ITS.

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

One significant ongoing standards activity in the wireline area is the development of the *National Transportation Communications for ITS Protocol(NTCIP*). This set of standards define common methods of physically interconnecting ITS control equipment, establishes the protocol and procedures for establishing communications between the components and, defines procedures to develop and register common sets of manageable objects related to controlling and managing the components. The standards are being developed by National Electrical Manufacturers Association (NEMA) with support from the US DOT. NTCIP contains a suite of communications protocols, divided into several class profiles, for integrating the various components that may be included in an ITS. The standard defines the elements that allow manufacturer inter-changeability of transportation control equipment. Also, a complete end-to-end data handling procedure is defined allowing devices to perform tasks associated with communications between traffic management centers and other field equipment.

The NTCIP is designed to support second-by-second, multi-drop, low speed modem signal system and through modularity, extensibility, and configuration expand to accommodate modern technology and signal applications. This modularity is achieved by adhering to the International Standards Organization (ISO) Open Systems Interconnect (OSI) 7-layer reference model. By following the ISO-OSI model in defining the NTCIP protocol "stack" (i.e., the layers), modularity is achieved. This permits NTCIP to be compatible with both the current installed signal system infrastructure and advanced applications and technology.

The NTCIP uses this modular approach to define several protocol stack and conformance level "profiles". Each profile is tailored to support the requirements of a particular type of communications link. For example, to support the CalTrans AB-3418 protocol, only layers 1, 2 and a limited subset of one of the layer 7 protocols are required. Full support for an advanced ITS system may require layers 1, 2, 3, 4 and full support of several layer 7 protocols.

To address the goals and topologies described above, the NTCIP uses an industry standard, generalized communications approach. This approach starts with a general model for communications and then adds specific protocols to provide the basis of information transfer. The International Standards Organization (ISO) Open Systems Interconnect (OSI) Reference Model defines a network model consisting of a stack of seven layers and associated protocols and interfaces. By following the model in defining the NTCIP protocol stack layers, modularity is achieved. The various protocols adopted by the NTCIP meet the need for reliable communications. The NTCIP supports the requirements listed above.

The current definition of NTCIP includes the physical and data link layers (common to all profiles) and the definition of application layer protocols (Simple Network Management Protocol- SNMP and Simple Transportation Management Framework - STMF). In addition the following sets of application (device) objects have been defined:

1. Global Object Definitions
2. Actuated Signal controller Objects
3. Dynamic Message Signs Objects

The following additional sets of objects will be developed in the near future:

1. Closed Circuit Television control Objects (CCTV)
2. Ramp Meter controller Objects

Work is also underway to expand the definition scope of NTCIP to cover center to center communications. Currently, a draft standard is under review by NEMA members with release expected in 1996.

In the area of center to center communications there are several existing and developing communications standards to choose from for the physical (and data link) layers. These include ATM, Frame Relay, MAN (IEEE 803.6), and FDDI. At the network layers TCP/IP is a widespread standardized protocol (and is being used in the NTCIP efforts). The key is that by using standard communication protocol suites the regional integration of the wireline data will most readily be accomplished.

5.3 Wireless Communication Elements (u1 and u2)

There are no wireless interfaces in this standards requirements package

6 Constraints

This chapter identifies constraints placed upon Physical Architecture flows.

6.1 Assessment Categories

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

1. Performance

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

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

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

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

2. Data Sensitivity

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

b. Privacy(P)
Anonymity of the data source or recipient must be protected. This is typically used for personal information.

6.2 Architecture Flow Constraints

Table 1: Architecture Flow Constraints

Source	Destination	Architecture Flow	Interconnects	Communication Service	Special Constraints
Roadway Subsystem	Traffic Management	incident data	W	Messaging data	T, R
Roadway Subsystem	Traffic Management	traffic images	W	Messaging data	T
Traffic Management	Roadway Subsystem	freeway control data	W	Messaging data	T
Traffic Management	Roadway Subsystem	sensor and surveillance control	W	Messaging data	T
Traffic Management	Roadway Subsystem	signal control data	W	Messaging data	T

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 LDIs are given in alphabetical order.

ahs_checking_details
This data item contains updates to the counts of successful and failed check-ins to the automatic highway system (ahs) lanes from roadside locations.

ahs_control_data_changes
This data item contains data defining parameters to be used by vehicles participating in platoon following and running in ahs controlled lanes, which will override any already loaded into the vehicles.

ahs_demand_accel_decel_profile
This data item contains the acceleration and deceleration characteristics profile to be used by all vehicles over their entire speed range whilst traveling along automatic highway system (ahs) lanes in automatic control mode. This data is provided by the Manage Demand facility in the Manage Traffic function and is used to override the set of data loaded into the vehicle during its manufacture.

ahs_demand_headway
This data item contains the headway to be used by a vehicle over its entire speed range whilst in automatic control mode and traveling on automatic highway system (ahs) lanes.

ahs_failed_checks_count
This data item contains a count of the number of vehicles that failed to pass through the automatic highway system (ahs) check-in procedure at a particular point.

ahs_successful_checks_count
This data item contains a count of the number of vehicles that successfully passed through the automatic highway system (ahs) check-in procedure at a particular point.

area_air_quality_index
This data item contains a code for the area wide air quality level.

crossing_close_duration
This data item contains the time duration for which a crossing must close to vehicular (roads and highway) traffic to permit the passage of the alternate item, e.g. railroad, river traffic, aircraft, etc. and is used to influence the control of signalized traffic intersections provided by the Provide Device Control facility.

crossing_close_time
This data item contains the time period before a crossing must close to vehicular (road and highway) traffic to permit the passage of the alternate item, e.g. railroad, river traffic, aircraft, etc. and is used to influence the control of signalized traffic intersections provided by the Provide Device Control facility.

crossing_identity_list
This data item contains a list of multimodal crossings to which the accompanying data applies.

current_pollution_data
This data item contains the current pollution data detected. The pollution data includes ozone pollution, nitrous oxide pollution, sulfur dioxide pollution, hydrocarbon pollution, carbon monoxide pollution, particulate pollution, and roadside pollution.

current_pollution_location
This data item gives the location coordinates from which a set of current pollution levels have been obtained.

current_roadside_pollution_location

This data item contains the location at which an associated set of current roadside atmospheric pollution values have been obtained from sensors.

current_traffic_pollution_data

This data item provides information on current levels of pollution.

dms_advisory_text

This data item contains details of the actual advisory text strings that are to be output to drivers and pedestrians using indicators that are dynamic message signs (dms). The advisory text string may be one of three types depending on the type of incident about which advice is being provided.

dms_data

This data item contains the DMS data (e.g.. text strings of information) to be output to drivers on freeways or arterials in the geographic and/or jurisdictional area(s) served by the function.

dms_highway_open_close

This data item is a DMS state which advises drivers that some or all of the highway(s) ahead is(are) closed. If the highway(s) are open no indication will be given as this is the normal state .

dms_incident_warning

This data item is the DMS state which gives warning of an incident to travelers .

dms_pollution_message

This data item is a DMS state which advises drivers that a particular vehicle is producing abnormal pollution, or that the general pollution levels are too high. If the pollution levels are not out of the ordinary, i.e. within limits, no indication will be given as this is the normal state .

dms_status

This data item contains the Dynamic Message Sign status for sign control data, operating at the roadside on arterials or highways in the geographic and/or jurisdictional area(s) served by the function.

dms_weather_warning

This data item is the DMS state which gives warning of weather conditions which are likely to be hazardous to driving.

environment_sensor_configuration_data

This data item is used to provide environmental sensor control commands.

environment_sensor_data

This data item contains a set of outputs from individual environment sensors.

environment_sensor_fault_data

This data item shows that an environment sensor has developed a fault that means it is not operating correctly. The fault will have been found by a process that is local to the sensor itself.

environment_sensor_output

This data item contains the raw data collected from a single sensor. This data item could include data pertaining to wind, temperature, humidity, precipitation, radiation (sun), visibility, and pavement sensor information .

environmental_sensor_status

This data item reports the status of an environmental sensor. By monitoring this data item, the receiving process can monitor the health and current status of field equipment.

har_data

This data item contains the HAR data, both program and management, used to define the output of a Highway Advisory Radio (HAR) operating at the roadside on highways or arterials in the geographic and/or jurisdictional area(s) served by the function.

har_fault

This data item contains an indication of a fault in the Highway Advisory Radio device. This could be a power failure, or a communications failure.

har_fault_data
This data item contains an indication of a fault in the Highway Advisory Radio device.

har_identity
This data item contains a numerical identifier of an individual Highway Advisory Radio device.

har_management_data
This data item contains the definition of a Highway Advisory Radio mode and program schedule.

har_mode
This data item contains the definition of the mode of the Highway Advisory Radio. The possible modes are idle, override current schedule with this program, run schedule, or play through.

har_program
This data item contains the definition of a Highway Advisory Radio program to be broadcast within a local area. The program can be defined by a program number or id, or by a sequence of messages (or sound bites).

har_schedule
This data item contains the definition of a Highway Advisory Radio program schedule. This schedule defines a sequence of programs and start times for the programs.

har_status
This data item contains the current status of the Highway Advisory Radio. This status included an indication of the current program being broadcast and an indication of the space available for storing messages/ programs on the device.

har_status_data
This data item contains the Highway Advisory Radio status for Harris, operating at the roadside on highways or arterials in the geographic and/or jurisdictional area(s) served by the function.

hov_lane_data
This data item contains the data obtained from processing the inputs from traffic sensors located on High Occupancy Vehicle (HOV) lanes around the road network.

hov_lane_data_input
This data is used within the Manage Traffic function and contains data from which the use of High Occupancy Vehicle (HOV) lanes can be monitored.

hov_lane_identity_list
This data item contains a list of high occupancy vehicle (HOV) lanes to which the accompanying data applies.

hov_lane_vehicle_count
This data item contains a count of the number of vehicles legitimately using High Occupancy Vehicle (HOV) lanes in the road and highway network.

hov_lane_violation_count
This data item contains the count of the number of vehicle illegally using High Occupancy Vehicle (HOV) lanes in the road and highway network.

hov_sensor_data
This data item contains the HOV data obtained from processing the inputs from sensors around the road network.

hri_sign_control_data
This data item contains the actual data for use by indicators that are dynamic message (dms) and other types of signs or indicators at railroad grade crossings served by the function.

incident_analysis_data
This data item contains processed traffic sensor data that can be analyzed for the possible presence of incidents. The data is provided directly from the local traffic sensor process rather than from some regional/area based process and so must originate in sensors that are within a small geographic area.

incident_duration

This data item contains the expected duration of an incident from its start time until the time at which it is expected that it will have no further effect on traffic conditions.

incident_location

This data item contains the location at which an incident will take place (for planned events) or is taking place (for current incidents).

incident_severity

This data item identifies the severity of an incident.

incident_start_time

This data item contains the incident start time.

incident_type

This data item uniquely defines the type of incident.

incident_video_image

This data item contains a high resolution digitized image of a potential or current incident at a particular point on the road or freeway network.

indicator_crossing_control_data_for_highways

This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at multimodal crossings on freeways served by the function.

indicator_crossing_control_data_for_roads

This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at multimodal crossings on roads (surface streets) served by the function.

indicator_crossing_controls

This data item contains the actual control data to be passed to an indicator that is a multimodal crossing. This will be either the actual indication to be seen by the driver, or a set of these instructions with duration times put together to form a fixed time signal plan, or an instruction to run using the controller's local intelligence.

indicator_fault

This data item is used within the Manage Traffic function to define the type of fault that has been found in an indicator as it is not operating correctly.

indicator_fault_data

This data item is used within the Manage Traffic function to show that an indicator has developed a fault that means it is not operating correctly. The fault will have been found by a process that is local to the indicator itself.

indicator_identity_list

This data item contains a list of indicators to which a particular traffic control strategy is to be applied. The indicators may be intersection traffic signal controllers, pedestrian signal controllers and/or dynamic message signs (dms), the latter being used for lane control or advisory message output purposes.

indicator_input_data_from_highways

This data item contains the actual state of operation of the roadside indicators used to pass instructions to drivers and travelers on freeways within the geographic and/or jurisdictional area(s) served by the function. It is used for centralized monitoring the operation of the indicators.

indicator_input_data_from_roads

This data item contains the actual state of operation of the roadside and grade crossing indicators used to pass instructions to drivers and travelers on roads (surface streets) within the geographic and/or jurisdictional area(s) served by the function. It is used for centralized monitoring the operation of the indicators.

indicator_junction_control_data

This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at junctions on roads served by the function.

indicator_junction_controls

This data item contains the actual control data to be passed to an indicator at a road junction. This will be either the actual indication to be seen by the driver, e.g. red for stop vehicle or green for proceed, or a set of these instructions with duration times put together to form a fixed time signal plan, or an instruction to run using the controller's local intelligence.

indicator_pedestrian_control_data

This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at pedestrian crossings on roads served by the function.

indicator_pedestrian_controls

This data item contains the actual control data to be passed to an indicator at a pedestrian crossing. This will be either the actual indication to be seen by the driver and the traveler, e.g. red for stop vehicle or cross now indication, or a set of these instructions with duration times put together to form a fixed time signal plan, or an instruction to run using the controller's local intelligence.

indicator_ramp_control_data

This data item contains the actual data from which instructions to the driver and traveler can be produced by indicators at entry ramps to highways served by the function.

indicator_response_state

This data item contains the current state of an indicator that is being used to control traffic on the roads (surface streets) and highways. It is used to check that the indicator is performing as requested and may form the basis for a fault report if it is not.

indicator_sign_control_data

This data item contains the actual data for use by indicators that are dynamic message (dms) and other types of signs on roads and freeways served by the function.

indicator_type

This data item contains the type of indicator to which the accompanying output or input data applies. The type may be either intersection signal controller, pedestrian signal controller, dynamic message sign (dms) or multimodal crossing.

information_device_fault_status

This data item is used to show any faults that have been found in roadside information dissemination equipment. This includes highway advisory radio, dynamic message signs, or in-vehicle signs.

lane_dms_controls

This data item contains the actual control data to be passed to an indicator that is a lane control sign. This will be the actual indication that the lane is or is not to be used.

multimodal_crossing_sensor_data

This data item contains the multimodal crossing data obtained from processing the other inputs from sensors around the road network.

node_identity_list

This data item contains a list of nodes for which data is being provided. These nodes will comprise all of those on both the road (surface street) and highway network served by the function.

parking_lot_dms_controls

This data item contains data about the text strings of information about parking lot states that are to be output to drivers using a form of indicators called dynamic message signs (dms). The output data may be a direction indication towards a parking lot where spaces exist, a state indication (open/closed), or a number of spaces currently available depending on the type of indicator and the selected strategy.

pedestrian_demand

This data item contains processed pedestrian surveillance data obtained from sensors within the road (surface street) and highway network served by the TMC. The data is used to determine the traffic control strategy for signalized traffic intersections.

pedestrian_sensor_data
This data item contains the pedestrian data obtained from processing the other inputs from sensors around the road network.

pollution_data_violation
This data item is used within the Manage Traffic and Manage Emergency Services functions to hold data on the actual atmospheric pollutant(s) that are outside the safe standards for air quality and their actual level(s).

pollution_incident
This data item contains details of a current or predicted pollution incident. The incident type will depend on the type of pollutant that is involved.

pollution_output_message
This data item contains the data which the Manage Emissions facility wants output to alert a driver to the fact that the vehicle is generating pollution outside of the standard limits.

pollution_state_area_collection
This data item contains the current states of the various types of pollution within the atmosphere in the geographic area served by the function. It also contains a summary indication of the area air quality.

pollution_state_data
This data item contains data about the current levels of pollution obtained from the store of pollution data.

pollution_state_data_request
This data item contains request for data about current levels of pollution. This data can be requested for a roadside or wide area location.

pollution_state_roadside_collection
This data item contains the digitized values of pollution levels obtained from roadside sensors in the geographic area served by the function.

pollution_state_vehicle_acceptance_criteria
This data item contains data on the pollution levels produced by different types of vehicle under various operating conditions.

pollution_state_vehicle_collection
This data item contains the average levels of the various types of pollution that were being output by a particular type of violating vehicle.

pollution_state_vehicle_log_data
This data item contains a periodic average of the pollution data measured by sensors from actual vehicles.

pollution_vehicle_acceptance_conditions
This data item contains the vehicle operating conditions at which the associated levels of atmospheric pollutants must not be exceeded. If they are then a pollution incident will be generated for the vehicle leading the details being passed to the enforcement agency terminator, which may result in eventual prosecution of the vehicle's owner.

pollution_vehicle_acceptance_data
This data item contains the levels of atmospheric pollutants which are acceptable, i.e. the presence of pollutants from vehicles at or below these levels will not create an out of specification condition that may ultimately lead to a pollution incident being reported. A pollution incident will only be reported if the value for the particular pollutant is exceeded at the vehicle operating condition to which it applies. These operating conditions are specified in an associated data item.

private_vehicle_occupants
This data item contains a count of the number of occupants in a vehicle as measured by a detector located on, or near to the highway, as the vehicles pass by its sensor.

ramp_controls
This data item contains the actual control data to be passed to a ramp meter controller.

reversible_lane_video_images
This data item contains video images of the reversible lanes.

sensor_configuration_data
This data item provides control commands for advanced sensors, including video sensing systems .

sensor_data_for_reversible_lanes
This data item contains data from which a wrong way vehicle is detected in a reversible lane through the use of sensors located.

sensor_fault_data
This data item is used to show that a sensor has developed a fault that means it is not operating correctly. The fault will have been found by a process that is local to the sensor itself.

sensor_identity
This data item contains an identifier of the sensor managed by a sensor station. The identifier would be a code which describes the type of the sensor (e.g. wind, temperature, precipitation, etc.).

station_id
This data item contains the identifier of the sensor station. A sensor station may control a single sensor (environmental or traffic), or may control a number of sensors.

to_media_pollution_data
This data item provides information on current pollution data in a form which will be readily understood by the Media.

traffic_control_device_status
This data item is used within the Manage Traffic function to show any faults that have been found in roadside equipment. This may be in an indicator or in a traffic sensor.

traffic_image_data
This data item contains the data produced by processing image data obtained from visual detection systems. It is analyzed and used to detect traffic conditions such as flow, occupancy, possible incidents, etc.

traffic_sensor_data
This data item contains the data obtained from processing the inputs from sensors around the road network.

traffic_sensor_output
This data item is the output of a single sensor. The output is either raw or aggregated data calculated over a period of time from that sensor.

traffic_sensor_status
This data item is used within the Manage Traffic function to report the status of a sensor. By monitoring this data item, the receiving process can monitor the health and current status of field equipment.

traffic_video_image
This data item contains a video image of sufficient fidelity to support operator monitoring applications. This image can be a by-product of a machine vision application or the end-product of a system dedicated to traffic surveillance.

vehicle_accel_decel_data
This data item contains the acceleration and deceleration characteristics profile for a vehicle over its entire speed range. The data consists of acceleration and deceleration rates for the whole range of vehicle speeds. The values at intermediate speeds must be calculated by interpolation. When this data is provided during the vehicle's manufacture, it will be a guaranteed maximum. When provided by other vehicles, or by the Manage Demand facility within the Manage Traffic function, it will override the maximum values.

vehicle_count

This data item contains a count of the number of vehicles which have been detected at a point location over unit time.

vehicle_detection_data

This data item contains vehicle detection data, i.e. data that provides information about vehicles moving on the road and highway network served by the function.

vehicle_headway_data

This data item contains the headway to be used by a vehicle over its entire speed range. The data item value may be set up during the vehicle's manufacture, or by the Manage Demand facility in the Manage Traffic function. This second set of values will override the first set when received by a vehicle.

vehicle_identity

This data item contains the identity of a vehicle.

vehicle_license

This data item contains the vehicle license number read from a vehicle that is violating the pollution standards.

vehicle_occupancy

This data item contains a count of the time for which a vehicle occupied the point in the surface street or highway at which a detector is located.

vehicle_pollution_alert

This data item is used by the Manage Traffic function as a means of transferring current vehicle pollution data from the Manage Emissions facility to the Manage Emergency Services function to enable enforcement of air quality standards.

vehicle_pollution_message

This data item contains data about the current levels of pollution being output by a vehicle. It is for output to the vehicle driver who is on a freeway or arterial in the geographic and/or jurisdictional area(s) served by the function.

vehicle_sign_data

This data item is used within the Manage Traffic function and contains data for use in producing in-vehicle signage displays. The information sent can fall into two categories - sign data and situation data. Sign data includes permanent fixed signs (e.g.. STOP, YIELD, etc), temporary signs (e.g.. detours), and dynamic message signs. Situation data provides information about traffic conditions, e.g. congestion and speed, on up to eight (8) links. Up to six (6) sets of indicator data may be contained within the data item and they may be for the same or different types of indicator, or for incidents. All data is filtered so that the receiving processes only get that which is relevant to their local geographic area.

vehicle_sign_data_output_fault

This data item contains an indication that a fault has been found with the processing of in-vehicle sign data by the process at the roadside.

vehicle_signage_current_data

This data item contains data that represents the actual roadside traffic indicator outputs, i.e. those from intersection traffic controllers, pedestrian controllers, etc. The indicator outputs will be replicated as in-vehicle signage displays, and will relate to the signs that are covered by each of the roadside broadcast processes.

vehicle_signage_data

This data item contains data for use in producing in-vehicle signage displays. The indicator outputs will be replicated as in-vehicle signage displays, and will relate to the signs that are covered by each of the roadside broadcast processes. The incident details will be for those incidents that are local to the roadside broadcast processes and will be used to provide driver and traveler information

messages in the vehicle.

vehicle_signage_dms_data
This data item contains data that represents the output from actual roadside dynamic message signs (dms). The dms outputs will be replicated as in-vehicle signage displays, and will relate to the signs that are covered by each of the roadside broadcast processes.

vehicle_signage_fixed_data
This data item represents the actual roadside traffic fixed signs, i.e. those for STOP, YIELD and other types of sign. The sign outputs will be replicated as in-vehicle signage displays, and will relate to the signs that are covered by each of the roadside broadcast processes.

vehicle_signage_incident_details
This data item contains data that describes an incident in the area around the location of each of the roadside broadcast processes.

vehicle_signage_output_identity
This data item is used within the Manage Traffic function to identify individual indicators used for t he control of traffic on roads (surface streets) and highways. The indicators can be either intersection signal controllers, pedestrian signal controllers or dynamic message signs (dms).

vehicle_signage_traffic_data
This data item contains vehicle speed and occupancy data for a link that is in the area local to a process that outputs data for use by in-vehicle signage units.

vehicle_smart_probe_data_for_storage
This data item contains the processed vehicle smart probe data collected from a roadside unit, which in turn have received data output by suitably equipped vehicles as they pass by.

vehicle_smart_probe_data_indication
This data item contains the data from a vehicle smart probe, processed to provide an indication of the type of hazard that the vehicle found on the road or freeway.

vehicle_smart_probe_data_output_fault
This data item contains an indication that the output of vehicle smart probe data is faulty. This may be due to data not being received for output, or that the output process itself is at fault.

vehicle_smart_probe_data_source
This data item contains the identity and location of the roadside unit that has collected a particular vehicle smart probe data.

vehicle_smart_probe_data_source_identity
This data item contains the identity of the roadside unit that has collected a particular vehicle smart probe data.

vehicle_smart_probe_data_source_location
This data item contains the location of the roadside unit that has collected a particular vehicle smart probe data.

vehicle_speed
This data item contains the speed of a vehicle which has been detected by a detector located on the highway, as the vehicle flowed over its sensor.

vehicle_tag_data
This data item contains the data from parking lot and toll tags on-board vehicles plus the identity of the unit which received the data.

vehicle_tag_data_source_identity
This data item contains the identity of the roadside unit that has collected a particular vehicle tag data.

vehicle_tag_input_data
This data item contains the data from parking lot and toll tags on-board vehicles which will be used to calculate vehicle journey times for links in the road (surface street) and freeway network served

by the function. The data consists of a uniquely encoded form of the original tag data (using a large integer number) which will identify a particular tag, but not with its actual tag number. This is necessary to protect the identity of the tag while it is being used to calculate vehicle journey times.

vehicle_type

This data item contains an identifier for the type of vehicle for which pollution violations have been detected.

wide_area_pollution_data_list

This data item contains data about the current levels of pollution obtained from the store of pollution data in the area covered by the Traffic Management Center (TMC).