Standards Requirements Package 1: Dedicated Short Range Communications

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1 Introduction to Standards Requirements Documentation

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

1.1 Standards Requirements Document Executive Summary

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

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

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

The next section provides the rationale for several different ratings schemes applied to the architecture interconnects and flows. These include interoperability requirements, technology maturity assessments, and 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 Interfaces

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

1.2 Constructing a Standards Requirements Package

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

This Standards Requirements Package has the following main components:

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

- Leveled Data Item definitions

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

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

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

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

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

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

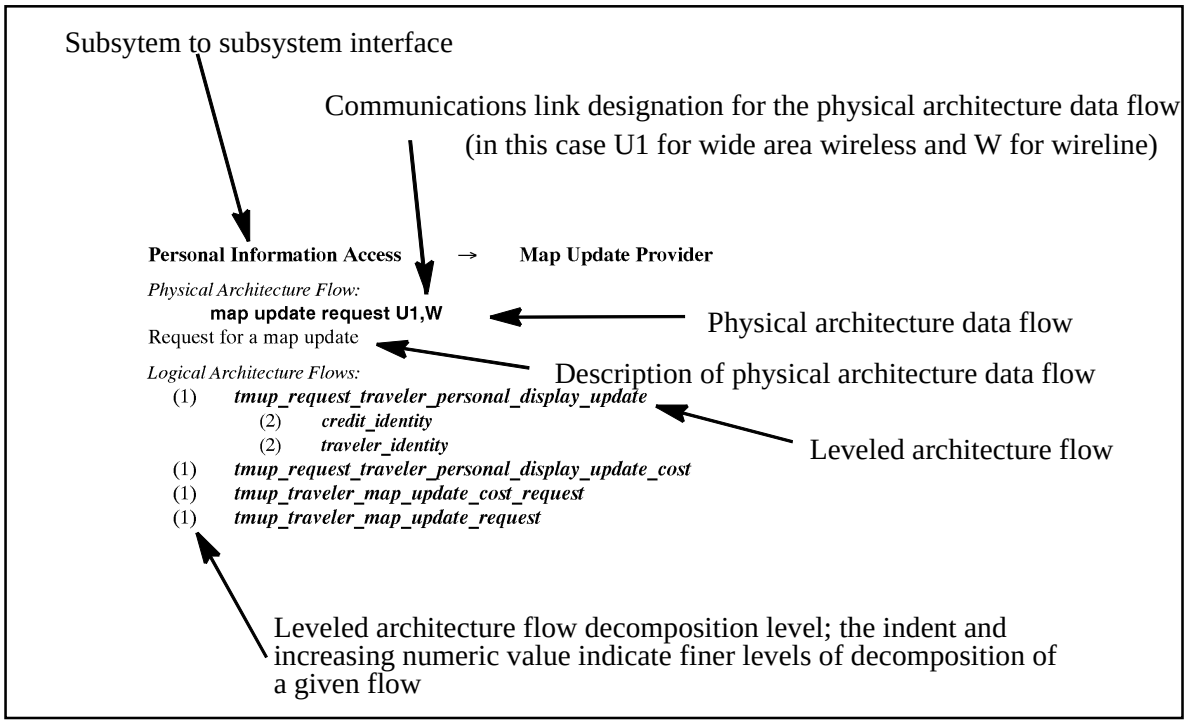

Figure 1 - Example of the parts of an interface decomposition

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

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

2 Introduction: Dedicated Short Range Communications

This is the set of wireless interfaces between roadside devices and the vehicle subsystems. These interfaces are dedicated short range links that most commonly utilize radio frequency or infrared communications technology. The DSRC links support electronic tolling and commercial vehicle electronic clearance in current deployments, and the architecture envisions that parking management, AHS, and in-vehicle signing could also utilize DSRC in the future.

The critical need for standardization for DSRC is to create the possibility of the various applications using the same hardware. This will require the coordination of message set and protocol development. And, of course, common hardware and lower level protocols.

Figure 2 shows the key interfaces described in this standards package.

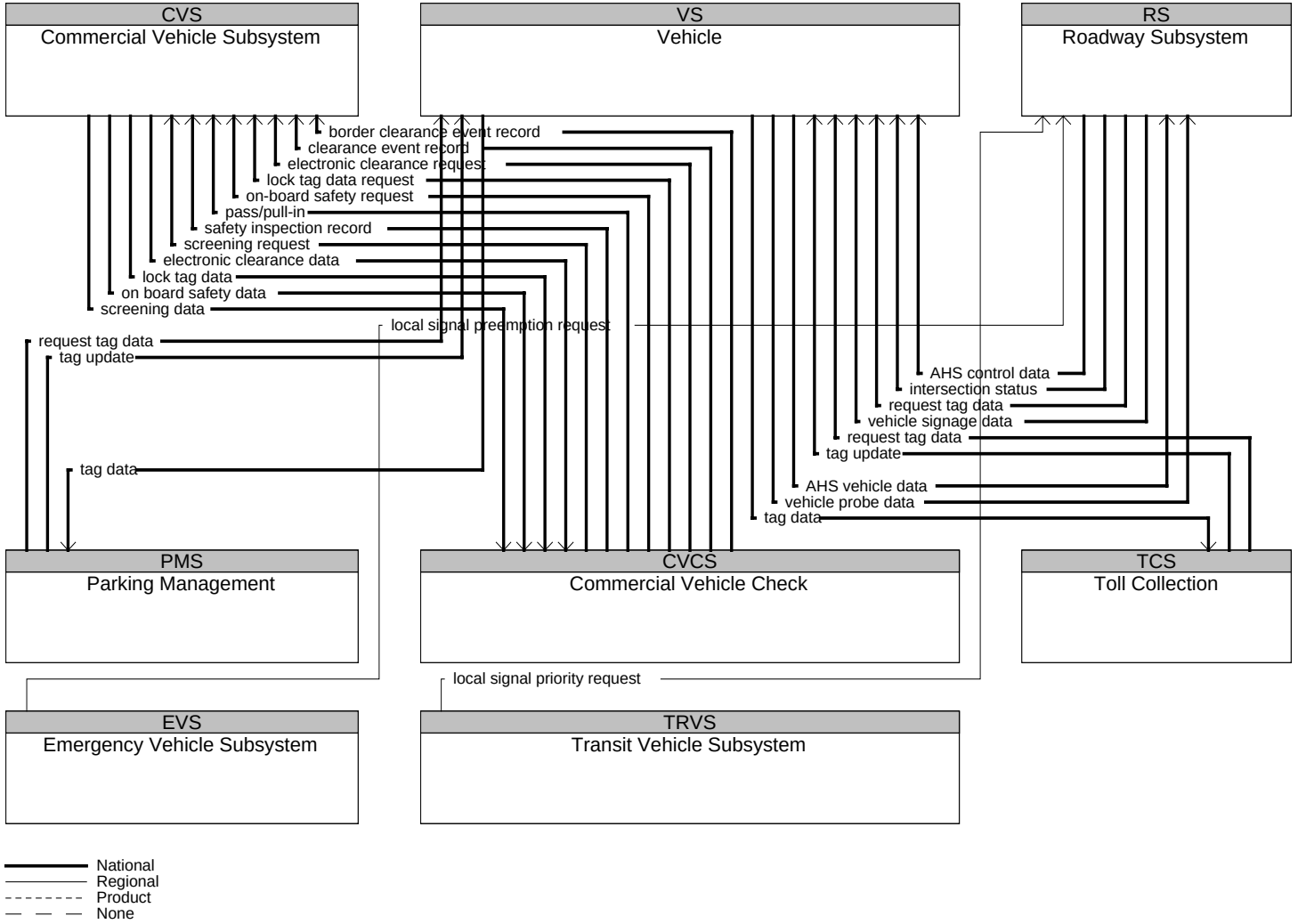

Figure 2 - Dedicated Short Range Communication Interfaces

3 Transaction Sets for Dedicated Short Range Communications (DSRC) Interfaces

In this section we define the transaction sets needed to accomplish different ITS tasks. A message sequence chart format along the lines of those defined under ISO standardization is used for clarity of presentation. The following subsections each discuss the interactions between two subsystem interfaces utilizing DSRC.

The transaction set figures used in this chapter identify the messages that go between vehicles and various roadside subsystems. Where messages follow each other top to bottom, they represent a transaction sequence or protocol. Where messages are separated by a horizontal dotted line, the messages are distinct, and not related in any particular sequence. Notes to the right of the messages, or in some cases groups of messages, amplify on details of the message protocols. Sometimes a number in a circle identifies a following numbered section in the text which also describes the particular message or message sequence function.

3.1 CVO DSRC

Commercial Vehicle Operations in the ITS National Architecture are based on the following key concepts:

1. *Dedicated Short Range Communications via a transponder on the vehicle and a roadside reader which reads from and writes to the vehicle transponder*. At a minimum, the DSRC tag supplies screening data that includes identifiers for carrier, driver and vehicle. The DSRC tag supplies clearance event data (Commercial Vehicle Check station ID, date and time when passed, measurements obtained, bypass status) from the last Commercial Vehicle Check station which wrote to the DSRC tag. The DSRC tag also supports international border crossing and safety inspection.

2. *Commercial Vehicle Drivers and Fleet managers purchase credentials and pay taxes electronically to regional (or state) Commercial Vehicle Administration (CVA) Center subsystems.* Records of these electronic transactions are made available to Commercial Vehicle Check Subsystems (CVCS) (at the roadside) in the region covered by the CVA Subsystem (CVAS). Similarly, results of clearance, safety and border checks made at the CVCS are reported electronically to the CVAS.

3. *The CVA subsystems collectively form a virtual network of a ‘‘national CVA subsystem."* Carrier, vehicle and driver snapshots containing credential and safety identification and status information are assembled and exchanged between CVAS's so that a CVAS can have as little or as much data as is available about carriers, vehicles and drivers at its respective CVCS for screening. Furthermore, on request, it can make detailed carrier, vehicle and driver profiles available to CVCS (or other inquirers) rapidly.

Participation in ITS for CVO will be voluntary. The scenarios in the sections that follow describe how the system will operate for those stakeholders who are fully equipped. Unless mandated by State or Federal Agencies, there will continue to be a mix of the current operations where a vehicle automatically pulls into the roadside station and automated operations as described below.

The DSRC link is used for the following functions:

1. Electronic Clearance

2. International Border Clearance

3. Safety Inspection

Note: the DSRC link can also be used as an interface between the Commercial Vehicle Subsystem (CVS) and the Fleet and Freight Management Subsystem (FMS) for exchange of on-board data, trip data, and cargo data (when the vehicle is at the FMS). Because the CVS to FMS link is usually proprietary to the specific Fleet, this transaction set has not been included in this package.

3.1.1 Electronic Clearance

The following transactions describe the architecture for electronic clearance. The transaction sequence is shown in Figure 3.

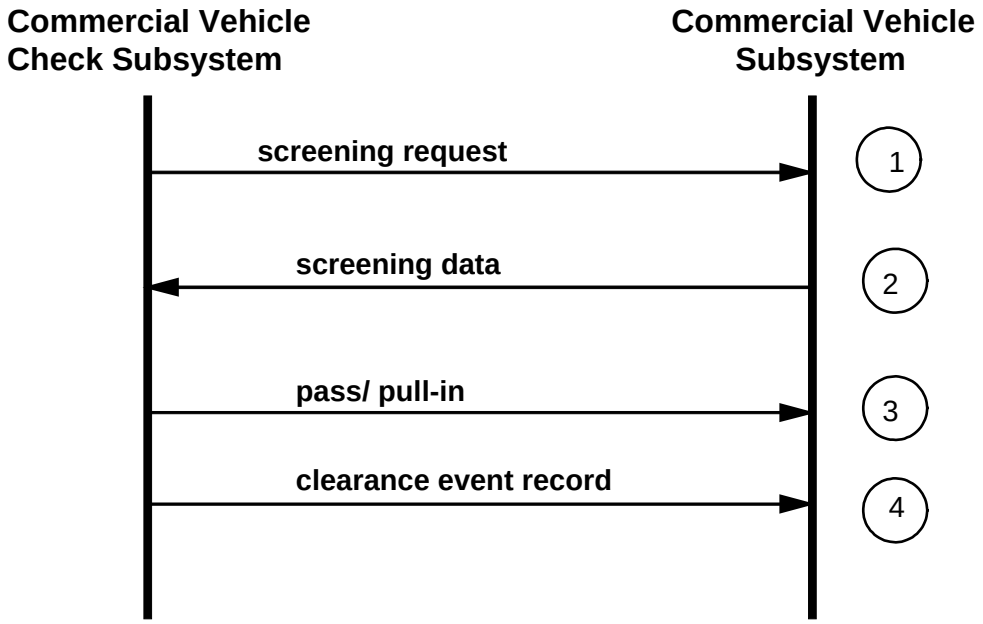

Figure 3 - Electronic Clearance Transaction Set

During operational shifts, the Commercial Vehicle Check Subsystem (CVCS) sends a screening request (flow 1) to the Commercial Vehicle Subsystem (CVS). The DSRC tag in the vehicle sends screening data (flow 2) to the CVCS. This flow contains commercial vehicle tag IDs for vehicle, carrier and driver as well as the Specially Regulated Load Flag and Last Clearance Event info. In addition, the CVCS may use sensors to measure physical characteristics of the commercial vehicle such as presence, weight, weight distribution and number of axles. The CVCS compares the screening data to its database of cleared vehicles, makes a pass or pull in decision and communicates this to the Commercial vehicle (flow 3).

The pass/pull-in message is communicated to the driver one of two ways:

a. If the tag on the vehicle has in-vehicle signage capability, then the driver can be notified via the DSRC beacon. This data flow would be presented to the driver as either an aural or visual message. This method may be preferred by infrastructure designers concerned about accurately communicating the decision to the driver over a range of vehicle speeds, vehicle headways and CVCS processing latencies.

b. Using a simple Dynamic Message Sign: PASS (green) or PULL-IN (red). This method may be preferred by truckers favoring minimum-cost in-vehicle equipment.

The architecture can currently support either of these physical roadside to vehicle communication mechanisms.

Finally, to complete the electronic clearance process, the CVCS writes to the tag the clearance event record (flow 4).

3.1.2 International Border Clearance

Performing electronic clearance at an international border follows a similar transaction sequence as described above. A simplified depiction of the data flows is given in Figure 4. As with the interstate electronic clearance process the use of physical characteristics measured by the CVCS may be used. One additional feature of the international border is the need to verify cargo. This can be performed with an electronic lock. This feature involves a second tag on the vehicle attached to the cargo doors, which is set when the cargo is originally loaded, or when inspected prior to getting to the border. The process is a lock tag data request (flow 1) followed by a lock data response (flow 2). The pass/pull-in could be communicated to the driver in either of the ways mentioned above.

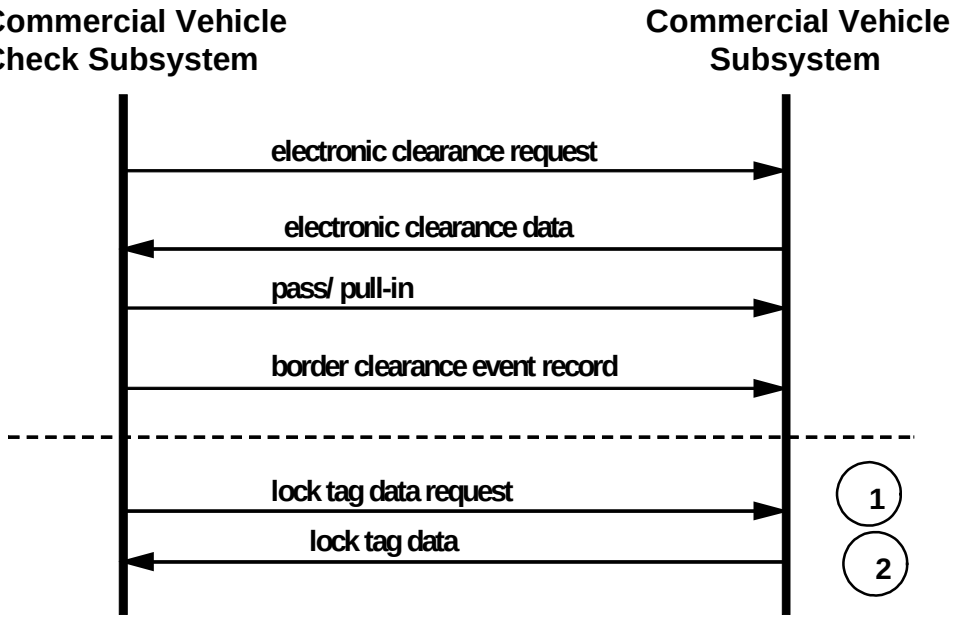

Figure 4 - Electronic International Border Clearance Transaction Set

3.1.3 Safety Inspection

The architecture for automated roadside safety inspection can be configured to support several different evolutionary variations that may arise in meeting this user service requirement. The options are based on assumptions about the amount of on-board equipment and data storage that commercial vehicles will support:

a. In the lowest on-board equipment scenario, the vehicle supports only the capability of Identification Numbers + Flags + Last Clearance Event Info, as described in Section 3.1.1. In this scenario, a Safety Inspector may measure and collect safety data after the vehicle is stopped at the CVCS.

b. In the next scenario, the vehicle contains on-board safety monitoring capability and this information is transferred to a Safety Inspector via a handheld, or fixed beacon after the vehicle has pulled off the highway.

c. In the most advanced scenario, the vehicle supports on-board safety monitoring equipment, and the communications capability to convey this information to the roadside in real-time. In this scenario, some or all of the data that might be collected by a Safety Inspector can be collected and recorded via the tag at mainline speeds mitigating the need to stop some vehicles by applying more sophisticated pass/pull-in processing based on more safety data.

If a roadside CVCS is equipped for both clearance and inspection activities, then clearance and safety inspection screening (making the pass/pull-in decision) should be integrated so that the driver gets one message about whether they must pull over.

The transaction sequence is shown in Figure 5 describe the architecture for automated safety inspection in scenario c above.

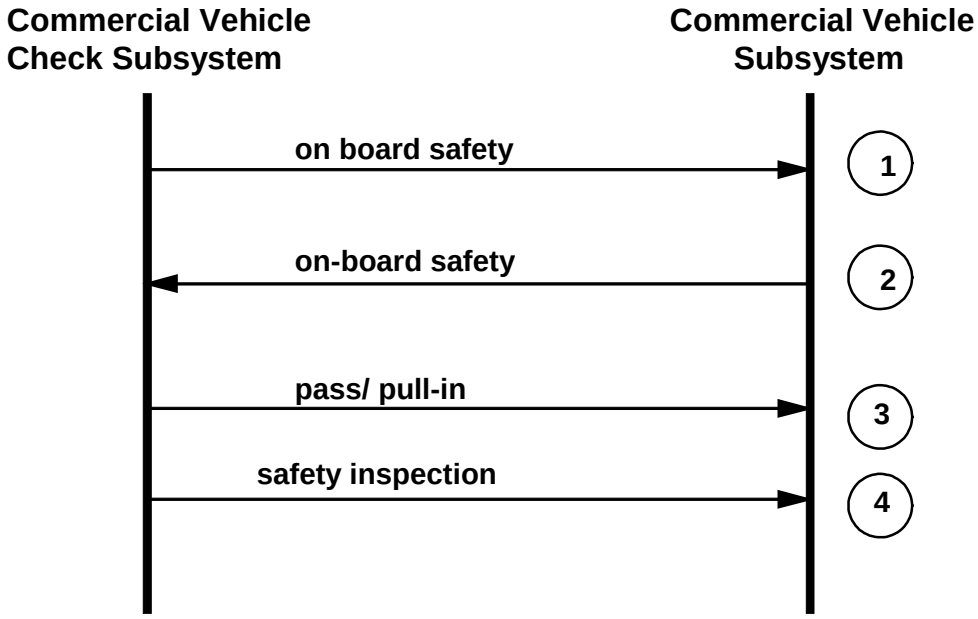

Figure 5 - Automated Roadside Safety Inspection Transaction Set

In the scenario where a real time decision is made to pull-in the vehicle for a safety inspection, the transaction begins with a request for on board data (flow 1). The vehicle responds with the safety data (flow 2). Utilizing physical measurements of the vehicle and allowing for an override function by the CVO Inspector the pull-in decision is made and transmitted to vehicle or driver as discussed in section 3.1.1. (flow 3). Results of the inspection are transmitted to the vehicle tag (for use by future inspection efforts) in the flow inspection record (flow 4).

3.2 Toll Collection

The National ITS Architecture supports several methods of DSRC usage for Toll Collection. These methods fall into two general categories:

1. Financial transactions are handled entirely in the infrastructure. This is the basic credit/ debit tag, with no stored value on the tag.

2. Financial transactions are accomplished on the tag or some other in-vehicle interface. This class of system uses a stored value card, or a smart card technology.

The basic transactions to accomplish both types of system are shown in Figure 6.

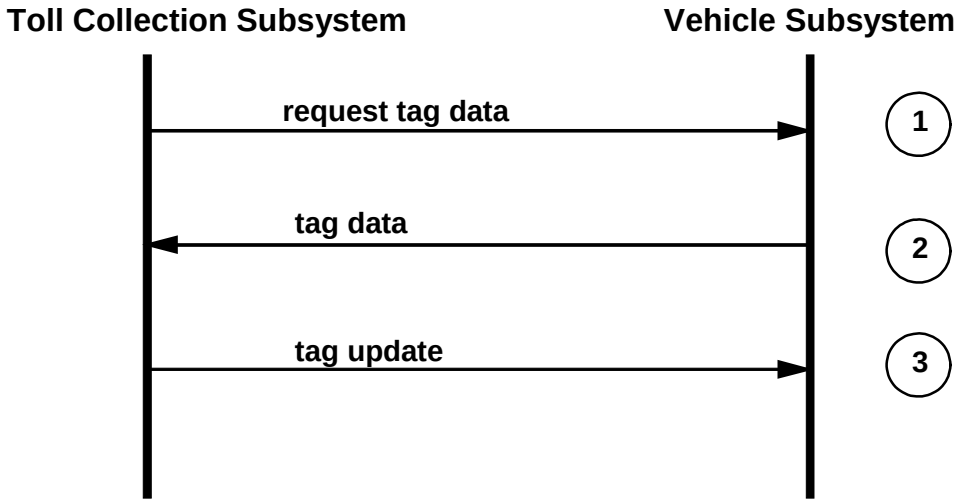

Figure 6 - Electronic Toll Collection Transaction Set

The reader in the Toll Collection Subsystem (TCS) initiates the transaction by sending a request tag data (flow 1). The vehicle tag responds with tag data (flow 2). This will contain a credit identity in systems designated 1 above, and will include in addition the stored value in case 2. For closed toll systems, the tag data will also contain the location and time at which the vehicle entered the system. In these systems this information is used to compute the toll. The reader updates the tag (flow 3). In case 1 this includes only that the transaction has been accomplished. In case 2 the amount to be debited is included. Another instance of the tag update message is for the case where the vehicle is entering a closed toll system. In this case of the tag update message will contain the location and time of entry into the system.

3.3 Parking Management

The interface between the Parking Management System (PMS) and the Vehicle Subsystem (VS) is nearly identical to the Toll Collection / Vehicle interface. The same two types of systems are supported:

1. Infrastructure based financial transactions
2. Tag/ vehicle based financial transactions.

The basic transactions to accomplish both types of system are shown in Figure 6.

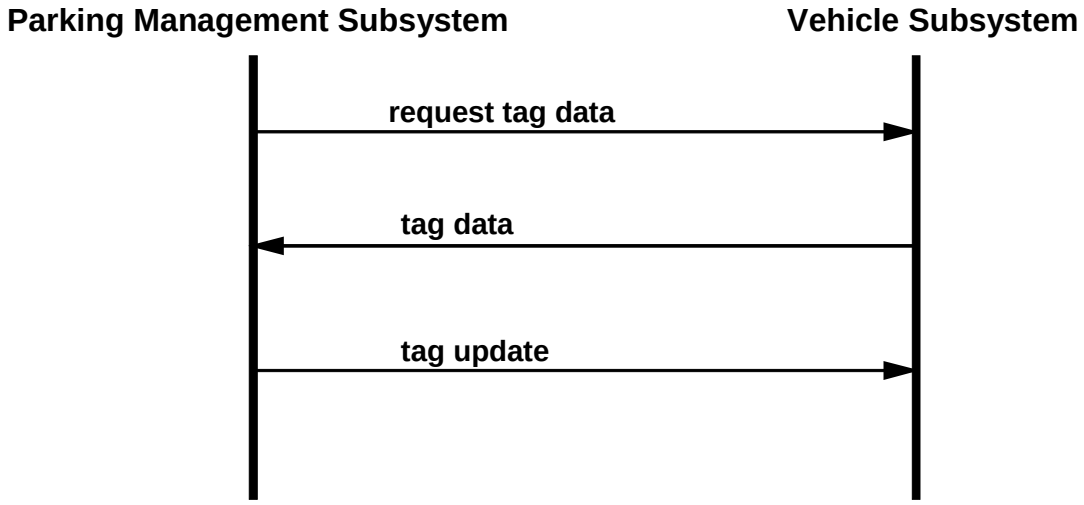

Figure 7 - Electronic Parking Payment Collection Transaction Set

The nature of the transactions is nearly identical to the toll collection case. In the parking case the tag update message includes an entry time/ location which will be read by the PMS reader to determine the amount of parking charge.

3.4 Roadway Interfaces

The interface between the Roadway Subsystem (RS) and the Vehicle Subsystem is utilized to provide the following functionality in the architecture

1. In- Vehicle signing (including travel information which is location specific information provided by beacon to the vehicle)
2. Probe data collection
3. Intersection collision avoidance
4. Automated Highway System (AHS) interface to the infrastructure
5. Emergency vehicle signal preemption
6. Transit vehicle signal priority

3.4.1 In-Vehicle Signing (IVS)

In-vehicle signing involves one way data flows from a roadside beacon to the tag in the vehicle (see Figure 8). The information sent from the roadside to the vehicle for IVS falls 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 includes traffic information (including incident data), dynamic extra- vehicle conditions (e.g. weather), static vehicle conditions (e.g. vehicle weight), and dynamic vehicle conditions (e.g. vehicle speed). This definition of IVS includes the concept of location specific (or location triggered) traveler information. In addition to the above types of signage data, this flow incorporates the concept of transmission of smart probe data from the roadside to the vehicle. See next section for a discussion of smart probes.

Figure 8 - In-Vehicle Signing Transaction

3.4.2 Probe Data Collection

The architecture supports the reading of tag data at the roadside in order to develop traffic flow data at the Traffic Management Subsystem. The roadside requests the tag data and the vehicle probe data is transmitted to the roadside. In addition to the collecting probe data from toll tags, this interface supports the implementation of smart probes. These are instrumented vehicles that can send information from onboard sensors. This information could include weather or road hazard information, as well as measured emissions data from the vehicle. The smart probe information on weather or road hazards can be sent to the TMS for processing, or in a rural environment used by a smart beacon to rebroadcast the information directly to approaching vehicles.

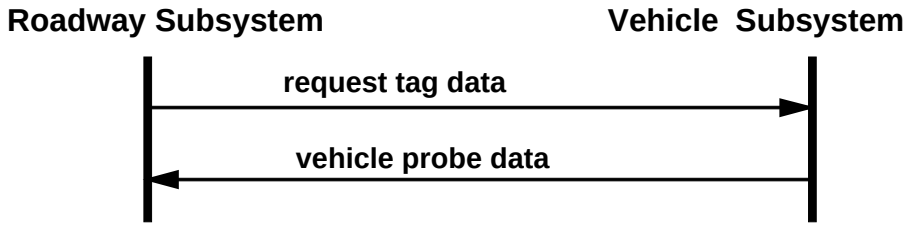

Figure 9 - Probe Data Collection Transaction Set

3.4.3 Intersection Collision Warning/Avoidance

The concept for Intersection collision warning/avoidance is still under investigation and will not be fully developed or implemented for some time. The following requirements are considered by the National Architecture in developing a simple architecture solution.

- There will be an infrastructure component to this function because a vehicle-to-vehicle active or a vehicle based passive only solution will not work in the very case where you most need it- blind intersections.
- The infrastructure must be able to sense non-equipped vehicles and send the information to equipped vehicles. Hence, there will not be a data flow directly from the vehicle to the roadside- there must be some method of sensing vehicles.
- Due to the local nature of the transmission a U2 link from infrastructure to vehicle is expected.

Due to these requirements, the architecture has included a one way flow from roadside to the vehicle as shown in Figure 10.

Figure 10 - Intersection Collision Warning/ Avoidance Transaction

3.4.4 Automated Highway System

The concepts for the infrastructure interface for AHS are under investigation at present and the final solution will not be known for some time. The National AHS Consortium is studying several possible AHS architectures that comprise a range of infrastructure and vehicle functionalities. The National Architecture has created a simple set of flows based on the following requirements:

- There will be some infrastructure interaction with the vehicles (the AHS solution will not be totally contained in the vehicles)
- Some form of control message will go from roadside to vehicle
- Some form of vehicle status message will go from vehicle to roadside.

Figure 11 shows the simple interface currently included in the national architecture. As the National AHS Consortium narrows its design concepts this interface will be extended to match their efforts.

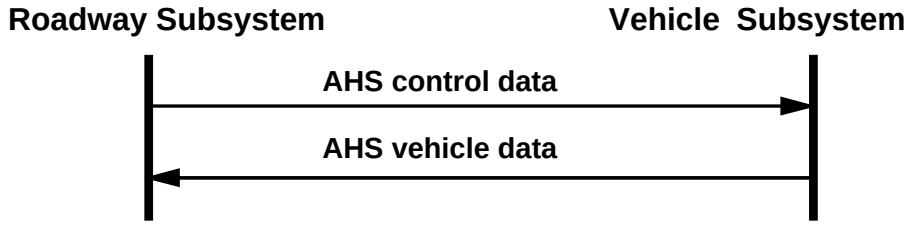

Figure 11 - AHS Transaction Set

3.4.5 Emergency Vehicle Signal Preemption

In the traditional signal preemption scenario the vehicle communicates with a traffic signal controller via a DSRC link as the vehicle approaches the intersection. The data in this case is not subject to any centralized coordination. A status could be sent from the roadside controller to the TMS to indicate that it is processing a preemption request. (Note: the architecture also supports a more complex version of signal preemption where the emergency vehicle is tracked by the Emergency Management Subsystem (EM), which communicates directly with the TMS to request signal preemption. This method of preemption does not make use of a DSRC link.)

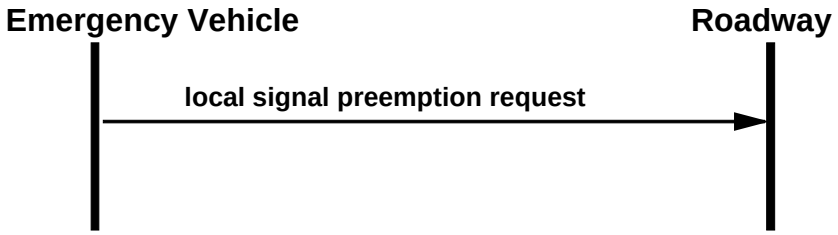

Figure 12 - Emergency Vehicle Signal Preemption Transaction

3.4.6 Transit Vehicle Signal Priority

Where emergency vehicles will typically request signal preemption, transit vehicles typically will request a signal priority (e.g. extending a green phase to allow the transit vehicle to pass through). In the traditional signal priority scenario the transit vehicle will communicate with the intersection controller via a DSRC link to indicate its proximity to the intersection and to request a signal priority. The data in this case is not subject to any centralized coordination. A status can be sent from the roadside controller to the TMC to indicate that it is processing a preemption request. (Note: as in the emergency vehicle case, the architecture also supports a more complex version of signal priority where the transit vehicle is tracked by the Transit Management Subsystem (TRMS), which communicates directly with the TMS to request signal priority. This method does not make use of a DSRC link.)

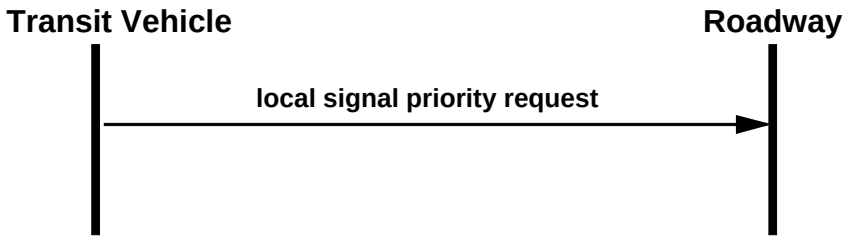

Figure 13 - Transit Vehicle Signal Priority Transaction

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 which must be addressed is does the standard address 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.

4.1 Commercial Vehicle Subsystem -> Commercial Vehicle Check

Physical Architecture Flow: electronic clearance data U2
Information required for electronic clearance (toll, safety, customs, etc.).

Leveled Data Items:

(1) ***commercial_carrier_information***
This data item contains information describing the commercial vehicle carrier.
(1) ***commercial_customs_inspector_identity***
This data item contains the identity of the customs inspector who sealed cargo that is crossing a border. The sealing process will have resulted in this data as well as the time and date being loaded into the lock tag. This data will be checked at each border crossing point to make sure that the cargo has not been touched since in was sealed.
(1) ***commercial_driver_information***
This data item contains information describing the commercial vehicle driver.
(1) ***commercial_on_board_border_data_list***
This data item contains the results of screening of a commercial vehicle's credentials at the commercial vehicle roadside border crossing facilities that it has passed by along its route.
- (2) ***commercial_border_pull_in_output***
  - (3) ***commercial_border_problem***
- (2) ***commercial_roadside_facility_identity***
- (2) ***commercial_vehicle_weight***

(1) ***commercial_on_board_screening_data_list***
This data item contains the results of screening of a commercial vehicle's credentials at the commercial vehicle roadside checkstation facilities that it has passed by along its route.
- (2) ***commercial_cargo_status***
- (2) ***commercial_out_of_service_status***
- (2) ***commercial_roadside_facility_identity***
- (2) ***commercial_screening_override***
  - (3) ***commercial_screening_override_code***
- (2) ***commercial_screening_pull_in_output***

(3) ***commercial_credentials_problem***
(2) ***commercial_vehicle_axle_weight_data***
(2) ***commercial_vehicle_weight***
(1) ***commercial_trip_identity***
This data item contains a trip identity information that is set up by the commercial vehicle manager (or the driver acting in that capacity) for use in checking the commercial vehicle through a border crossing.
(1) ***commercial_vehicle_information***
This data item contains information that will provide the identity of the commercial vehicle.
(1) ***tag_identity***
This data item provides the identity number of a vehicle tag which can be used to various purposes, including preclearance from paying dues, taxes, and other commercial vehicles charges, or by a traveler or driver for payment of current or advanced tolls, fares, or parking lot charges, etc.

Physical Architecture Flow: lock tag data U2
Tag information on cargo lock.

Leveled Data Items:

(1) ***commercial_carrier_information***
This data item contains information describing the commercial vehicle carrier.
(1) ***commercial_customs_inspector_identity***
This data item contains the identity of the customs inspector who sealed cargo that is crossing a border. The sealing process will have resulted in this data as well as the time and date being loaded into the lock tag. This data will be checked at each border crossing point to make sure that the cargo has not been touched since in was sealed.
(1) ***commercial_driver_information***
This data item contains information describing the commercial vehicle driver.
(1) ***commercial_on_board_border_data_list***
This data item contains the results of screening of a commercial vehicle's credentials at the commercial vehicle roadside border crossing facilities that it has passed by along its route.
(2) ***commercial_border_pull_in_output***
(3) ***commercial_border_problem***
(2) ***commercial_roadside_facility_identity***
(2) ***commercial_vehicle_weight***
(1) ***commercial_on_board_screening_data_list***
This data item contains the results of screening of a commercial vehicle's credentials at the commercial vehicle roadside checkstation facilities that it has passed by along its route.
(2) ***commercial_cargo_status***
(2) ***commercial_out_of_service_status***
(2) ***commercial_roadside_facility_identity***
(2) ***commercial_screening_override***
(3) ***commercial_screening_override_code***
(2) ***commercial_screening_pull_in_output***
(3) ***commercial_credentials_problem***
(2) ***commercial_vehicle_axle_weight_data***
(2) ***commercial_vehicle_weight***
(1) ***commercial_trip_identity***
This data item contains a trip identity information that is set up by the commercial vehicle manager (or the driver acting in that capacity) for use in checking the commercial vehicle through a border crossing.
(1) ***commercial_vehicle_information***
This data item contains information that will provide the identity of the commercial vehicle.
(1) ***tag_identity***
This data item provides the identity number of a vehicle tag which can be used to various purposes,

including preclearance from paying dues, taxes, and other commercial vehicles charges, or by a traveler or driver for payment of current or advanced tolls, fares, or parking lot charges, etc.

Physical Architecture Flow: on board safety data U2

Vehicle safety data measured by vehicle sensors and sent to inspection stations

Leveled Data Items:

(1) ***carrier_identity***

This data item contains the identity of the carrier to whom the commercial vehicle belongs. Where the vehicle is operated by the driver, it will be the same as the driver's identity.

(1) ***commercial_credentials***

This data item contains details about a commercial vehicle, e.g. make, model, type, special features, etc.

(1) ***commercial_driver_credentials***

This data item contains details of the commercial vehicle driver's license.

(1) ***commercial_driver_license_citations***

This data item contains details of any citations, etc. recorded against the driver's license.

(1) ***commercial_fuel_purchase_data***

This data item contains details of the quantity and cost of fuel purchased for a commercial vehicle.

(1) ***commercial_inspection_activities_data***

This data item contains a record of the inspection activities that have been carried out on the commercial vehicle.

(2) ***commercial_driver_information***

(2) ***commercial_log_entry_date***

(2) ***commercial_log_entry_location***

(2) ***commercial_log_entry_mileage***

(2) ***commercial_log_entry_time***

(1) ***commercial_inspection_data***

This data item contains the results of a roadside vehicle check which are to be down loaded for storage on-board the vehicle. The data may be eventually retrieved by the driver, the commercial vehicle manager, or at a subsequent roadside inspection.

(1) ***commercial_not_pulled_in***

This data item contains a flag which will indicate if there is a need to pull in a commercial vehicle because of a problem.

(1) ***commercial_repairs_and_service_records***

This data item contains a record of the repair and service work carried out on a commercial vehicle.

(1) ***commercial_safety_systems_diagnostics_results***

This data item contains flags set to show the results of diagnostic checks run by a commercial vehicle's on-board safety system.

(1) ***driver_identity***

This data item contains the identity of the commercial vehicle driver.

(1) ***vehicle_identity***

This data item contains the identity of a vehicle.

Physical Architecture Flow: screening data U2

Data stored in vehicle's tag allowing electronic clearance at border crossings, debits at toll plazas, and clearance at safety inspections.

Leveled Data Items:

(1) ***commercial_carrier_information***

This data item contains information describing the commercial vehicle carrier.

(1) ***commercial_customs_inspector_identity***

This data item contains the identity of the customs inspector who sealed cargo that is crossing a border. The sealing process will have resulted in this data as well as the time and date being loaded into the lock tag. This data will be checked at each border crossing point to make sure that the cargo has not been touched since in was sealed.

(1) ***commercial_driver_information***

This data item contains information describing the commercial vehicle driver.

(1) ***commercial_on_board_border_data_list***

This data item contains the results of screening of a commercial vehicle's credentials at the commercial vehicle roadside border crossing facilities that it has passed by along its route.

(2) ***commercial_border_pull_in_output***

(3) ***commercial_border_problem***

(2) ***commercial_roadside_facility_identity***

(2) ***commercial_vehicle_weight***

(1) ***commercial_on_board_screening_data_list***

This data item contains the results of screening of a commercial vehicle's credentials at the commercial vehicle roadside checkstation facilities that it has passed by along its route.

(2) ***commercial_cargo_status***

(2) ***commercial_out_of_service_status***

(2) ***commercial_roadside_facility_identity***

(2) ***commercial_screening_override***

(3) ***commercial_screening_override_code***

(2) ***commercial_screening_pull_in_output***

(3) ***commercial_credentials_problem***

(2) ***commercial_vehicle_axle_weight_data***

(2) ***commercial_vehicle_weight***

(1) ***commercial_trip_identity***

This data item contains a trip identity information that is set up by the commercial vehicle manager (or the driver acting in that capacity) for use in checking the commercial vehicle through a border crossing.

(1) ***commercial_vehicle_information***

This data item contains information that will provide the identity of the commercial vehicle.

(1) ***tag_identity***

This data item provides the identity number of a vehicle tag which can be used to various purposes, including preclearance from paying dues, taxes, and other commercial vehicles charges, or by a traveler or driver for payment of current or advanced tolls, fares, or parking lot charges, etc.

4.2 Commercial Vehicle Check -> Commercial Vehicle Subsystem

Physical Architecture Flow: border clearance event record U2

Results of border clearance check.

Leveled Data Items:

(1) ***commercial_border_pull_in_output***

This data item contains the output of the result of an analysis of the data from a commercial vehicle that is approaching a roadside checkstation facility, by the process responsible for commercial vehicle border crossing checking. The result is expressed in terms of a pull-in or pass decision for the vehicle.

(2) ***commercial_border_problem***

(1) ***commercial_carrier_information***

This data item contains information describing the commercial vehicle carrier.

(1) ***commercial_driver_information***

This data item contains information describing the commercial vehicle driver.

(1) ***commercial_roadside_facility_identity***

This data item contains the identity of the commercial vehicle roadside checking facility.

(1) ***commercial_vehicle_information***

This data item contains information that will provide the identity of the commercial vehicle.
(1) ***commercial_vehicle_weight***
This data item contains the commercial vehicle weight as measured by roadside sensors, such as weigh-in-motion detectors.

Physical Architecture Flow: clearance event record U2
Results of vehicle clearance activity.

Leveled Data Items:

(1) ***commercial_cargo_status***
This data item contains the status of a commercial vehicle's cargo in terms of its commodity code and its HAZMAT placard.
(1) ***commercial_carrier_information***
This data item contains information describing the commercial vehicle carrier.
(1) ***commercial_driver_information***
This data item contains information describing the commercial vehicle driver.
(1) ***commercial_out_of_service_status***
This data item contains the out of service status of the driver and the vehicle.
(1) ***commercial_roadside_facility_identity***
This data item contains the identity of the commercial vehicle roadside checking facility.
(1) ***commercial_screening_override***
This data item contains the decision made by an inspector at a commercial vehicle roadside checkstation facility to override (or not) the automated pass or pull-in decision made by the process responsible for credentials checking.
(2) ***commercial_screening_override_code***
(1) ***commercial_screening_pull_in_output***
This data item contains the output of the result of an analysis of the data from a commercial vehicle that is approaching a roadside checkstation facility, by the process responsible for commercial vehicle credentials checking. The result is expressed in terms of a pull-in or pass decision for the vehicle.
(2) ***commercial_credentials_problem***
(1) ***commercial_vehicle_axle_weight_data***
This data item contains the details of the number of axles the vehicle has, the weight per axle and the spacing between the axles.
(1) ***commercial_vehicle_information***
This data item contains information that will provide the identity of the commercial vehicle.
(1) ***commercial_vehicle_weight***
This data item contains the commercial vehicle weight as measured by roadside sensors, such as weigh-in-motion detectors.

Physical Architecture Flow: electronic clearance request U2
Request for electronic clearance data (Toll, safety, customs, etc.).

Leveled Data Items:

(1) ***commercial_request_electronic_clearance_data***
This data item contains a request from a commercial vehicle roadside checkstation or border crossing facility for the output of the current contents of a commercial vehicle's tag, plus the electronic lock tag, if one is being carried by the vehicle.

Physical Architecture Flow: lock tag data request U2
Request to supply lock information on cargo lock for retransmission to international border crossing station.

Leveled Data Items:

(1) ***commercial_request_electronic_clearance_data***
This data item contains a request from a commercial vehicle roadside checkstation or border crossing facility for the output of the current contents of a commercial vehicle's tag, plus the electronic lock tag, if one is being carried by the vehicle.

Physical Architecture Flow: on-board safety request U2
Request for onboard vehicle safety data.

Leveled Data Items:

(1) ***commercial_roadside_facility_address***
This data item contains the address at which the roadside facility can be contacted, e.g. wide area network address.
(1) ***commercial_roadside_facility_identity***
This data item contains the identity of the commercial vehicle roadside checking facility.

Physical Architecture Flow: pass/pull-in U2
Command to commercial vehicle to pull into inspection station.

Leveled Data Items:

(1) ***commercial_border_pull_in_output***
This data item contains the output of the result of an analysis of the data from a commercial vehicle that is approaching a roadside checkstation facility, by the process responsible for commercial vehicle border crossing checking. The result is expressed in terms of a pull-in or pass decision for the vehicle.
(2) ***commercial_border_problem***
(1) ***commercial_general_pull_in***
This data item is used to determine if a commercial vehicle is to be pulled in or not.
(1) ***commercial_safety_pull_in_output***
This data item contains the output of the result of an analysis of the data from a commercial vehicle that is approaching a roadside checkstation facility, by the process responsible for commercial vehicle safety checking. The result is expressed in terms of a pull-in or pass decision for the vehicle.
(2) ***commercial_safety_problem***
(1) ***commercial_screening_pull_in_output***
This data item contains the output of the result of an analysis of the data from a commercial vehicle that is approaching a roadside checkstation facility, by the process responsible for commercial vehicle credentials checking. The result is expressed in terms of a pull-in or pass decision for the vehicle.
(2) ***commercial_credentials_problem***

Physical Architecture Flow: safety inspection record U2
Record containing results of commercial vehicle safety inspection.

Leveled Data Items:

(1) ***commercial_inspection_data_output***
This data item contains the results of the commercial vehicle roadside inspection. These are down loaded for storage on-board the vehicle.

Physical Architecture Flow: screening request U2
Request for screening data based on vehicle and possibly cargo's tags.

Leveled Data Items:

(1) ***commercial_request_electronic_clearance_data***
This data item contains a request from a commercial vehicle roadside checkstation or border crossing

facility for the output of the current contents of a commercial vehicle's tag, plus the electronic lock tag, if one is being carried by the vehicle.

4.3 Vehicle -> Parking Management

Physical Architecture Flow: tag data U2
Unique tag ID and related vehicle information for the purposes of payment for services.

Leveled Data Items:

(1) ***credit_identity***
This data item contains the identity number of a credit card which is to be used to secure preclearance from paying dues, taxes, and other commercial vehicles charges, or by a traveler or driver for payment of current or advanced tolls, fares, parking lot charges, or for yellow pages services.
(1) ***date***
This data item specifies a calendar date that is normally used to indicate currency or effectivity of other data.
(1) ***time***
This data item contains the current time of day and will be associated with other data items and (possibly) a date.
(1) ***vehicle_identity***
This data item contains the identity of a vehicle.

4.4 Emergency Vehicle Subsystem -> Roadway Subsystem

Physical Architecture Flow: local signal preemption request U2
Direct control signal or message to a signalized intersection that results in preemption of the current control plan and grants right-of-way to the requesting vehicle.

Leveled Data Items:

(1) ***emergency_vehicle_junction_preemption***
This data item contains data necessary for an emergency services vehicle to be given preemption (priority) at an indicator that is particular set of junction control signals.
(1) ***emergency_vehicle_pedestrian_preemption***
This data item contains data necessary for an emergency services vehicle to be given preemption (priority) at an indicator that is particular set of pedestrian signals.
(1) ***emergency_vehicle_ramp_preemption***
This data item contains the data necessary for an emergency services vehicle to be given preemption (priority) at an indicator that is particular set of highway entry ramp control signals.
(1) ***emergency_vehicle_sign_preemption***
This data item contains data necessary for an emergency services vehicle to have a message output giving it preemption (priority) at an indicator that is a particular dynamic message sign (dms) or fixed message sign that has a transit priority message that can be displayed.

4.5 Transit Vehicle Subsystem -> Roadway Subsystem

Physical Architecture Flow: local signal priority request U2
Request from a vehicle to a signalized intersection for priority at that intersection.

Leveled Data Items:

(1) ***transit_vehicle_junction_preemption***
This data item contains data necessary for a transit vehicle to be given preemption (priority) at an indicator that is a particular set of junction control signals. The data item is sent directly from the transit vehicle to the junction controller, which is assumed to be capable of giving priority to the correct phase(s) for any received preemption request.

(1) ***transit_vehicle_pedestrian_preemption***
This data item contains data necessary for a transit vehicle to be given preemption (priority) at an indicator that is a particular set of pedestrian signals. The data item is sent directly from the transit vehicle to the pedestrian controller, which is assumed to be capable of giving priority to the correct phase.
(1) ***transit_vehicle_ramp_preemption***
This data item contains the data necessary for a transit vehicle to be given preemption (priority) at an indicator that is a particular set of highway entry ramp control signals. The data item is sent directly from the transit vehicle to the ramp controller, which is assumed to be capable of giving priority to the correct ramp or lane if multiple ramps or lanes are involved.
(1) ***transit_vehicle_sign_preemption***
This data item contains data necessary for a transit vehicle to have a message output giving it preemption (priority) at an indicator that is a particular dynamic message sign (dms) or fixed message sign that has a transit priority message that can be displayed. The data item is sent directly from the transit vehicle to the sign controller.

4.6 Vehicle-> Roadway Subsystem

Physical Architecture Flow: AHS vehicle data U2
AHS route and vehicle condition data

Leveled Data Items:

(1) ***ahs_route_data***
This data item contains a list of the route segments that will be used by a vehicle. These route segments will be those that contain automatic highway system (ahs) lanes, and will be used by the vehicle on its ahs controlled route.
(1) ***ahs_vehicle_condition***
This data item is used within the Provide Vehicle Monitoring and Control function. It contains data processed from on-board vehicle sensors that show the vehicle's current operating condition. This data is used to determine its suitability for operating on automatic highway system (ahs) lanes.

Physical Architecture Flow: vehicle probe data U2
Vehicle probe data indicating identity, route segment identity, link time and location.

Leveled Data Items:

(1) ***parking_lot_tag_data***
This data item contains the data that has been provided by the payment instrument being used by the driver at a parking lot. This may be either a credit identity, or the value of the credit currently stored by the payment instrument, to which parking lot charges may be charged.
(1) ***toll_tag_data***
This data item contains the data that has been provided by the payment instrument being used by the driver at a toll plaza. This may be either a credit identity, or the value of the credit currently stored by the payment instrument, to which tolls may be charged.
(2) ***credit_identity***
(2) ***stored_credit***
(2) ***toll_segment_identity***
(1) ***vehicle_smart_probe_data***
This data item contains an indication of a hazard on the road or freeway that has been detected by sensors on-board a passing vehicle. The type of hazard to be encoded will comprise but not be limited to such things as, fog, ice, snow, earth (mud) slides, liquid spill (oil), floods, road subsidence, bridges broken, etc.
(1) ***vehicle_status_details_for_emissions***
This data item contains the operational status of the vehicle which is important because the levels of

pollution vary according to how long the vehicle has been running, i.e. how warm is the engine, and what it is actually doing, e.g. is it stationary, or pulling away from a stop.

4.7 Vehicle -> Toll Collection

Physical Architecture Flow: tag data U2
Unique tag ID and related vehicle information for the purposes of payment for services.

Leveled Data Items:

(1) ***toll_payment_confirmation***
This data item contains confirmation that the previous request for the cost of the current toll to be deducted from the credit currently stored by the driver's payment instrument has been completed successfully.
(1) ***toll_tag_data_collect***
This data item contains the toll tag data that is being collected from on-board the vehicle. This data will be used as the means by which the vehicle will be charged for its use of the toll road.
(2) ***credit_identity***
(2) ***stored_credit***
(2) ***toll_segment_identity***

4.8 Parking Management -> Vehicle

Physical Architecture Flow: request tag data U2
Request for tag information including credit identity, stored value card cash, etc.

Leveled Data Items:

(1) ***parking_lot_cost***
This data item defines the cost of particular vehicle using a space in a parking lot for a particular time period.

Physical Architecture Flow: tag update U2
Update data held in tag which can be read at another screening.

Leveled Data Items:

(1) ***parking_lot_tag_data_update***
This data item contains the parking lot tag data that has been updated. The updated will have loaded the time at which the vehicle entered the parking lot and is for use in charging for the vehicle's use of the lot.
(2) ***credit_identity***
(2) ***date***
(2) ***stored_credit***
(2) ***time***

4.9 Roadway Subsystem -> Vehicle

Physical Architecture Flow: AHS control data U2
Information required for vehicles to operate on AHS lanes.

Leveled Data Items:

(1) ***ahs_check_response***
This data item contains the response to the checking of data from on-board a vehicle to see if it is suitable for operating on automatic highway system (ahs) lanes.
(2) ***ahs_demand_accel_decel_profile***
(3) ***vehicle_accel_decel_data***
(2) ***ahs_demand_headway***

(3) ***vehicle_headway_data***
(2) ***confirmation_flag***

Physical Architecture Flow: intersection status U2
Status of intersection congestion, approaching vehicles, etc.

Leveled Data Items:

(1) ***intersection_collision_avoidance_data***
This data item contains data for a vehicle that shows that it is likely to be involved in a collision at an intersection, unless it takes some avoiding action.

Physical Architecture Flow: request tag data U2
Request for tag information including credit identity, stored value card cash, etc.

Leveled Data Items:

(1) ***parking_lot_tag_data_needed***
This data item request the output of the data from a toll tag that may be on-board a vehicle.
(1) ***toll_tag_data_needed***
This data item requests the output of the data from a parking lot tag that may be on-board a vehicle.

Physical Architecture Flow: vehicle signage data U2
In-vehicle signage data generated by the roadway infrastructure indicating either road conditions, street names, or special information which will be useful for a vehicle passing a specific point on the roadway.

Leveled Data Items:

(1) ***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.
(2) ***vehicle_signage_current_data***
(2) ***vehicle_signage_dms_data***
(2) ***vehicle_signage_fixed_data***
(2) ***vehicle_signage_incident_details***
(2) ***vehicle_signage_traffic_data***
(3) ***vehicle_occupancy***
(3) ***vehicle_speed***
(1) ***vehicle_smart_probe_data_output***
This data item contains the data obtained from vehicle smart probes, processed and formatted for output to vehicles as they pass by.

4.10 Toll Collection -> Vehicle

Physical Architecture Flow: request tag data U2
Request for tag information including credit identity, stored value card cash, etc.

Leveled Data Items:

(1) ***toll_payment_request***
This data item contains the request for the cost of the current toll to be deducted from the credit currently stored by the payment instrument. It is only sent when a value of stored credit has been previously received from the payment instrument.
(1) ***toll_tag_data_request***

This data item contains a request for the toll tag data to be read from the store that is held on-board the vehicle.

Physical Architecture Flow: tag update U2

Update data held in tag which can be read at another screening.

Leveled Data Items:

(1) ***confirmation_flag***

This data item indicates the success or failure of a request or transaction.

(1) ***toll_payment_debited***

This data item contains confirmation that the cost of the current toll will be deducted by the financial institution from the credit identity previously provided by the payment instrument being used by the driver. It is only sent when a credit identity has been previously received from the payment instrument.

(1) ***toll_tag_data_clear***

This data item contains the toll tag data from which any toll segment identity has been cleared. The data will have been used to charge for use of the toll road, and is being cleared to enable its use for future charging.

(2) ***toll_tag_data***

(3) ***credit_identity***

(3) ***stored_credit***

(3) ***toll_segment_identity***

(1) ***toll_tag_data_update***

This data item contains the toll tag data that has been updated. The updated will have loaded the identity of the toll segment at which the vehicle entered the toll road and is for use in charging for the vehicle's use of the toll road.

5 Communications Considerations

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)

There are no wireline interfaces in this standards requirements package

5.3 Wireless Communication Elements (u1 and u2)

All of the communications links in this standards package are short range communications mobile to fixed, defined as u2 in the Communications Architecture. The u2 link is required to provide service between tetherless(or mobile) and close-proximity base stations, as occurs when a tetherless user communicates with a toll station for toll collection, a parking lot booth for fee collection, or the reception of information from roadside transmitters (roadside sign information). The primary use for this link is for rapid query-response interchanges and for local broadcast of information to nearby mobile users. The interchange must take place quickly as the vehicle will need the response for subsequent action. When used for two way communications interference between users is reduced either by physical separation of users or by use of different frequencies within the same band. When the data flow is one directional, it is typically a broadcast function from the fixed station to the mobile user. The u2 link provides wireless communication between the mobile user and the stationary user, or in the reverse direction.

The Communication Layers for Dedicated Short Range Communications are strong candidates for standardization in order to achieve national interoperability. The DSRC links described above have the following requirements:

- High reliability: P(bit error) $<10^{-6}$ when vehicle is moving at speeds up to 200 km/h by a fixed roadside reader and with vehicle transponder separation of a minimum of 0.5 meters.
- High data rates [typically 300 -600 Kbps].
- Two way communication is a general requirement for DSRC, and the DSRC link should be able to support duplex communications. [Although there are some applications, e.g. in-vehicle signing, requiring only one way communications].
- Utilize one frequency band for transmission and receipt of signals. (It is advantageous for national interoperability for all DSRC systems to be using the same basic frequency band, otherwise national interoperability can only be achieved by having readers which work at multiple frequency bands.) [Currently the band being utilized is 902-928 MHz. There is increasing interference from other non-ITS sources in this band, so a move to the 5.8 GHz band is being considered. A band very near this has already been specified in Europe for DSRC applications].
- No network layer requirements- only physical layer and data link layers are required. [There are some implementations of DSRC which utilize a network layer to achieve separation between adjacent beacons. The roadside beacons will be part of a network, but the beacon to vehicle link typically will not be.]
- Utilize an open communications protocol. [At the Data link layer this could be a High Level Data Link Control (HDLC) or a non-proprietary Time Division Multiple Access (TDMA) protocol.]

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 extra attention paid to potential failure modes. For wireline cases, this may indicate alternate phone or other connections are required. For wireless cases (e.g. for AHS applications), special attention will be paid to the transmitters, receivers, and potential interference for these connections.

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

        This timing constraint is related to (but not the same as) another attribute often discussed in specifying systems: latency. Latency is used to quantify end-to-end processing and transmission time (round trip delays). Data with a latency requirement must be handled within a certain time interval. This differs from ”time criticality” in that it is a relative rather than absolute time requirement (e.g. 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.

    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

The following table lists the architecture flows for the DSRC Interfaces that have been assigned special constraints.

Table 1. Architecture Flow Constraints

Source	Destination	Architecture Flow	Communication Service	Special Constraints
Commercial Vehicle Check	Commercial Vehicle Subsystem	border clearance event record	Conversational Data	T
Commercial Vehicle Check	Commercial Vehicle Subsystem	clearance event record	Conversational data	T
Commercial Vehicle Check	Commercial Vehicle Subsystem	electronic clearance request	Conversational data	T
Commercial Vehicle Check	Commercial Vehicle Subsystem	lock tag data request	Conversational Data	T
Commercial Vehicle Check	Commercial Vehicle Subsystem	on-board safety request	Conversational data	T
Commercial Vehicle Check	Commercial Vehicle Subsystem	pass/pull-in	Conversational data	T,R
Commercial Vehicle Check	Commercial Vehicle Subsystem	safety inspection record	Conversational Data	T
Commercial Vehicle Check	Commercial Vehicle Subsystem	screening request	Conversational data	T
Commercial Vehicle Subsystem	Commercial Vehicle Check	electronic clearance data	Conversational data	T
Commercial Vehicle Subsystem	Commercial Vehicle Check	lock tag data	Conversational Data	T
Commercial Vehicle Subsystem	Commercial Vehicle Check	on board safety data	Conversational data	T
Commercial Vehicle Subsystem	Commercial Vehicle Check	screening data	Conversational data	T,R
Emergency Vehicle Subsystem	Roadway Subsystem	local signal preemption request	Conversational data	T,E
Parking Management	Vehicle	request tag data	Conversational data	T,R
Parking Management	Vehicle	tag update	Conversational data	T,R
Roadway Subsystem	Vehicle	AHS control data	messaging data	T,R
Roadway Subsystem	Vehicle	intersection status	messaging data	T,R
Roadway Subsystem	Vehicle	request tag data	Messaging data	T
Roadway Subsystem	Vehicle	vehicle signage data	messaging data	T
Toll Collection	Vehicle	request tag data	Conversational data	T,R
Toll Collection	Vehicle	tag update	Conversational Data	T,R
Transit Vehicle Subsystem	Roadway Subsystem	local signal priority request	Conversational data	T
Vehicle	Parking Management	tag data	Conversational data	T,P
Vehicle	Roadway Subsystem	AHS vehicle data	Conversational data	T,R
Vehicle	Roadway Subsystem	vehicle probe data	Messaging Data	T,P
Vehicle	Toll Collection	tag data	Conversational data	T,P

7 Leveled Data Items

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

The LDI's are given in alphabetical order.

ahs_check_response
This data item contains the response to the checking of data from on-board a vehicle to see if it is suitable for operating on automatic highway system (ahs) lanes.

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_route_data
This data item contains a list of the route segments that will be used by a vehicle. These route segments will be those that contain automatic highway system (ahs) lanes, and will be used by the vehicle on its ahs controlled route.

ahs_vehicle_condition
This data item is used within the Provide Vehicle Monitoring and Control function. It contains data processed from on-board vehicle sensors that show the vehicle's current operating condition. This data is used to determine its suitability for operating on automatic highway system (ahs) lanes.

carrier_identity
This data item contains the identity of the carrier to whom the commercial vehicle belongs. Where the vehicle is operated by the driver, it will be the same as the driver's identity.

commercial_border_problem
This data item is used to identify the nature of a problem with a commercial vehicle's data at a border crossing. It indicates whether the problem was related to data associated with the vehicle, driver, or cargo.

commercial_border_pull_in_output
This data item contains the output of the result of an analysis of the data from a commercial vehicle that is approaching a roadside checkstation facility, by the process responsible for commercial vehicle border crossing checking. The result is expressed in terms of a pull-in or pass decision for the vehicle.

commercial_cargo_status
This data item contains the status of a commercial vehicle's cargo in terms of its commodity code and its HAZMAT placard.

commercial_carrier_information
This data item contains information describing the commercial vehicle carrier.

commercial_credentials
This data item contains details about a commercial vehicle, e.g. make, model, type, special features, etc.

commercial_credentials_problem
This data item contains a character code used to identify the nature of a problem with a commercial vehicle's credentials.

commercial_customs_inspector_identity
This data item contains the identity of the customs inspector who sealed cargo that is crossing a border. The sealing process will have resulted in this data as well as the time and date being loaded

into the lock tag. This data will be checked at each border crossing point to make sure that the cargo has not been touched since in was sealed.

commercial_driver_credentials
This data item contains details of the commercial vehicle driver's license.

commercial_driver_information
This data item contains information describing the commercial vehicle driver.

commercial_driver_license_citations
This data item contains details of any citations, etc. recorded against the driver's license.

commercial_fuel_purchase_data
This data item contains details of the quantity and cost of fuel purchased for a commercial vehicle.

commercial_general_pull_in
This data item is used to determine if a commercial vehicle is to be pulled in or not.

commercial_inspection_activities_data
This data item contains a record of the inspection activities that have been carried out on the commercial vehicle.

commercial_inspection_data
This data item contains the results of a roadside vehicle check which are to be down loaded for storage on-board the vehicle. The data may be eventually retrieved by the driver, the commercial vehicle manager, or at a subsequent roadside inspection.

commercial_inspection_data_output
This data item contains the results of the commercial vehicle roadside inspection. These are down loaded for storage on-board the vehicle.

commercial_log_entry_date
This data item contains the date on which an entry was made into the store of vehicle activity.

commercial_log_entry_location
This data item contains the location where data was loaded into the store of its activities for the commercial vehicle.

commercial_log_entry_mileage
This data item contains the vehicle mileage at which an entry was made into the store of vehicle activity.

commercial_log_entry_time
This data item contains the time at which an entry was made into the store of vehicle activity.

commercial_not_pulled_in
This data item contains a flag which will indicate if there is a need to pull in a commercial vehicle because of a problem.

commercial_on_board_border_data_list
This data item contains the results of screening of a commercial vehicle's credentials at the commercial vehicle roadside border crossing facilities that it has passed by along its route.

commercial_on_board_screening_data_list
This data item contains the results of screening of a commercial vehicle's credentials at the commercial vehicle roadside checkstation facilities that it has passed by along its route.

commercial_out_of_service_status
This data item contains the out of service status of the driver and the vehicle.

commercial_repairs_and_service_records
This data item contains a record of the repair and service work carried out on a commercial vehicle.

commercial_request_electronic_clearance_data
This data item contains a request from a commercial vehicle roadside checkstation or border crossing facility for the output of the current contents of a commercial vehicle's tag, plus the electronic lock tag, if one is being carried by the vehicle.

commercial_roadside_facility_address
This data item contains the address at which the roadside facility can be contacted, e.g. wide area

network address.

commercial_roadside_facility_identity

This data item contains the identity of the commercial vehicle roadside checking facility.

commercial_safety_problem

This data item contains a character code used to identify the nature of a problem with the safety of a commercial vehicle, its driver, or the carrier in general.

commercial_safety_pull_in_output

This data item contains the output of the result of an analysis of the data from a commercial vehicle that is approaching a roadside checkstation facility, by the process responsible for commercial vehicle safety checking. The result is expressed in terms of a pull-in or pass decision for the vehicle.

commercial_safety_systems_diagnostics_results

This data item contains flags set to show the results of diagnostic checks run by a commercial vehicle's on-board safety system.

commercial_screening_override

This data item contains the decision made by an inspector at a commercial vehicle roadside checkstation facility to override (or not) the automated pass or pull-in decision made by the process responsible for credentials checking.

commercial_screening_override_code

This data item contains a code which gives the results of the decision made by an inspector at a commercial vehicle roadside checkstation facility to override (or not) the automated pass or pull-in decision made by the process responsible for credentials checking.

commercial_screening_pull_in_output

This data item contains the output of the result of an analysis of the data from a commercial vehicle that is approaching a roadside checkstation facility, by the process responsible for commercial vehicle credentials checking. The result is expressed in terms of a pull-in or pass decision for the vehicle.

commercial_trip_identity

This data item contains a trip identity information that is set up by the commercial vehicle manager (or the driver acting in that capacity) for use in checking the commercial vehicle through a border crossing.

commercial_vehicle_axle_weight_data

This data item contains the details of the number of axles the vehicle has, the weight per axle and the spacing between the axles.

commercial_vehicle_information

This data item contains information that will provide the identity of the commercial vehicle.

commercial_vehicle_weight

This data item contains the commercial vehicle weight as measured by roadside sensors, such as weigh-in-motion detectors.

confirmation_flag

This data item indicates the success or failure of a request or transaction.

credit_identity

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

date

This data item specifies a calendar date that is normally used to indicate currency or effectivity of other data.

driver_identity

This data item contains the identity of the commercial vehicle driver.

emergency_vehicle_junction_preemption
This data item contains data necessary for an emergency services vehicle to be given preemption (priority) at an indicator that is particular set of junction control signals.

emergency_vehicle_pedestrian_preemption
This data item contains data necessary for an emergency services vehicle to be given preemption (priority) at an indicator that is particular set of pedestrian signals.

emergency_vehicle_ramp_preemption
This data item contains the data necessary for an emergency services vehicle to be given preemption (priority) at an indicator that is particular set of highway entry ramp control signals.

emergency_vehicle_sign_preemption
This data item contains data necessary for an emergency services vehicle to have a message output giving it preemption (priority) at an indicator that is a particular dynamic message sign (dms) or fixed message sign that has a transit priority message that can be displayed.

intersection_collision_avoidance_data
This data item contains data for a vehicle that shows that it is likely to be involved in a collision at an intersection, unless it takes some avoiding action.

parking_lot_cost
This data item defines the cost of particular vehicle using a space in a parking lot for a particular time period.

parking_lot_tag_data
This data item contains the data that has been provided by the payment instrument being used by the driver at a parking lot. This may be either a credit identity, or the value of the credit currently stored by the payment instrument, to which parking lot charges may be charged.

parking_lot_tag_data_needed
This data item request the output of the data from a toll tag that may be on-board a vehicle.

parking_lot_tag_data_update
This data item contains the parking lot tag data that has been updated. The updated will have loaded the time at which the vehicle entered the parking lot and is for use in charging for the vehicle's use of the lot.

stored_credit
This data item contains the value of the credit currently stored by the payment instrument.

tag_identity
This data item provides the identity number of a vehicle tag which can be used to various purposes, including preclearance from paying dues, taxes, and other commercial vehicles charges, or by a traveler or driver for payment of current or advanced tolls, fares, or parking lot charges, etc.

time
This data item contains the current time of day and will be associated with other data items and (possibly) a date.

toll_payment_confirmation
This data item contains confirmation that the previous request for the cost of the current toll to be deducted from the credit currently stored by the driver's payment instrument has been completed successfully.

toll_payment_debited
This data item contains confirmation that the cost of the current toll will be deducted by the financial institution from the credit identity previously provided by the payment instrument being used by the driver. It is only sent when a credit identity has been previously received from the payment instrument.

toll_payment_request
This data item contains the request for the cost of the current toll to be deducted from the credit currently stored by the payment instrument. It is only sent when a value of stored credit has been previously received from the payment instrument.

toll_segment_identity

This data item contains the identity number of a toll segment, which may not be the same physical entity as a route segment or a link as used by traffic management processes.

toll_tag_data

This data item contains the data that has been provided by the payment instrument being used by the driver at a toll plaza. This may be either a credit identity, or the value of the credit currently stored by the payment instrument, to which tolls may be charged.

toll_tag_data_clear

This data item contains the toll tag data from which any toll segment identity has been cleared. The data will have been used to charge for use of the toll road, and is being cleared to enable its use for future charging.

toll_tag_data_collect

This data item contains the toll tag data that is being collected from on-board the vehicle. This data will be used as the means by which the vehicle will be charged for its use of the toll road.

toll_tag_data_needed

This data item requests the output of the data from a parking lot tag that may be on-board a vehicle.

toll_tag_data_request

This data item contains a request for the toll tag data to be read from the store that is held on-board the vehicle.

toll_tag_data_update

This data item contains the toll tag data that has been updated. The updated will have loaded the identity of the toll segment at which the vehicle entered the toll road and is for use in charging for the vehicle's use of the toll road.

transit_vehicle_junction_preemption

This data item contains data necessary for a transit vehicle to be given preemption (priority) at an indicator that is a particular set of junction control signals. The data item is sent directly from the transit vehicle to the junction controller, which is assumed to be capable of giving priority to the correct phase(s) for any received preemption request.

transit_vehicle_pedestrian_preemption

This data item contains data necessary for a transit vehicle to be given preemption (priority) at an indicator that is a particular set of pedestrian signals. The data item is sent directly from the transit vehicle to the pedestrian controller, which is assumed to be capable of giving priority to the correct phase.

transit_vehicle_ramp_preemption

This data item contains the data necessary for a transit vehicle to be given preemption (priority) at an indicator that is a particular set of highway entry ramp control signals. The data item is sent directly from the transit vehicle to the ramp controller, which is assumed to be capable of giving priority to the correct ramp or lane if multiple ramps or lanes are involved.

transit_vehicle_sign_preemption

This data item contains data necessary for a transit vehicle to have a message output giving it preemption (priority) at an indicator that is a particular dynamic message sign (dms) or fixed message sign that has a transit priority message that can be displayed. The data item is sent directly from the transit vehicle to the sign controller.

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_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_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_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_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

This data item contains an indication of a hazard on the road or freeway that has been detected by sensors on-board a passing vehicle. The type of hazard to be encoded will comprise but not be limited to such things as, fog, ice, snow, earth (mud) slides, liquid spill (oil), floods, road subsidence, bridges broken, etc.

vehicle_smart_probe_data_output

This data item contains the data obtained from vehicle smart probes, processed and formatted for output to vehicles as they pass by.

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_status_details_for_emissions

This data item contains the operational status of the vehicle which is important because the levels of pollution vary according to how long the vehicle has been running, i.e. how warm is the engine, and what it is actually doing, e.g. is it stationary, or pulling away from a stop.