

Vehicle Information Exchange Needs for Mobility Applications Version 3.0

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<p>16. Abstract</p> <p>Connected Vehicle to Vehicle (V2V) safety applications heavily rely on the BSM, which is one of the messages defined in the Society of Automotive standard J2735, Dedicated Short Range Communications (DSRC) Message Set Dictionary, November 2009. The BSM is broadcast from vehicles over the 5.9 GHz DSRC band. Transmission range is on the order of 1,000 meters. The BSM consists of two parts:</p> <ul style="list-style-type: none"> • BSM Part 1: core data elements, including vehicle position, heading, speed, acceleration, steering wheel angle, and vehicle size, transmitted at an adjustable rate of about 10 times per second • BSM Part 2: a variable set of data elements drawn from an extensive list of optional elements. Some of these elements are periodically included in a subset of BSM messages at a frequency that is TBD while others are included if certain triggering events occur, e.g., ABS activated. They are added to Part 1 and sent as part of the BSM message, but are transmitted less frequently in order to conserve bandwidth <p>Based on existing documentation of the high priority Dynamic Mobility Applications (DMA), an assessment was made of the information that needs to flow to and from vehicles in order to support these applications, as well as the connected vehicle road weather program. The goals were determine the extent to which the Basic Safety Message (BSM) can support those needs and what additional data elements and messages would be required.</p> <p>The primary findings of the analysis are:</p> <ol style="list-style-type: none"> 1.The Basic Safety Message (BSM), with Part 1 transmitted approximately 10 times per second over Dedicated Short Range Communications (DSRC), is useful for a number of mobility applications, but is not solely sufficient for any of the envisioned mobility applications. 2. The BSM message and DSRC communications are required for some mobility applications, such as the M-ISIG bundle of applications. 3. A subset of the BSM Part 1 and Part 2 data elements provides the majority, but not all, of the data that needs to be sent from vehicles to the infrastructure. This data must either be continually sent to infrastructure systems, at some lower update rate, over an alternative mobile wireless technology, such as cellular data, or be cached on-board the vehicle and then sent in a message containing both current and stored snapshots. 					
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Executive Summary

This white paper presents the results of an assessment of the information that needs to flow to and from vehicles in order to support the high priority Dynamic Mobility Applications (DMA) and related connected vehicle road weather applications listed in Table ES-1. Earlier versions of this document were developed prior to the completion of the system requirements for each bundle of related applications. These have been completed and used as input for this update. As a result, this current version represents a substantial update to the analysis. The findings will undoubtedly continue to change as more information from simulation studies and field tests becomes available.

One of the goals of this analysis was to assess the extent to which the Basic Safety Message (BSM) provides the information needed for the mobility applications. Connected Vehicle to Vehicle (V2V) safety applications heavily rely on the BSM, which is one of the messages defined in the Society of Automotive standard J2735, *Dedicated Short Range Communications (DSRC) Message Set Dictionary*, November 2009. The BSM is broadcast from vehicles over the 5.9 GHz DSRC band. Transmission range is on the order of 1,000 meters. The BSM consists of two parts:

- BSM Part 1:
 - Contains core data elements, including vehicle position, heading, speed, acceleration, steering wheel angle, and vehicle size
 - Is transmitted at an adjustable rate of about 10 times per second, based on radio channel loading
- BSM Part 2:
 - Contains a variable set of data elements drawn from an extensive list of optional elements. Some of these elements are periodically included in a subset of BSM messages at a frequency that is TBD while others are included if certain triggering events occur, e.g., ABS activated.
 - The data elements are added to Part 1 and sent as part of the BSM message, but are transmitted less frequently in order to conserve bandwidth

The BSM message includes only current snapshots (with the exception of path data which is itself limited to a few second's worth of past history data or future path prediction). It is important to note that the fact that a data element is defined as an element of Part 2 of the BSM in the Society of Automotive Engineers (SAE) J2735 standard does not necessarily mean that it will be provided by vehicle manufacturers. Most of the Part 2 elements are defined as optional information in the standard.

Table ES 0-1 High Priority Mobility and Road Weather Applications Sorted by Application Bundle

<p>Enable ATIS: Enable Advanced Traveler Information Systems</p> <ul style="list-style-type: none"> • ATIS: Multi-Modal Real-Time Traveler Information • S-PARK: Smart Park and Ride • T-MAP: Universal Map Application • WX-INFO: Real-Time Route Specific Weather Information for Motorized and Non-Motorized Vehicles 	<p>M-ISIG: Multimodal Intelligent Traffic Signal System</p> <ul style="list-style-type: none"> • FSP: Freight Signal Priority • I-SIG: Intelligent Traffic Signal System • PED-SIG: Mobile Accessible Pedestrian Signal System • PREEMPT: Emergency Vehicle Preemption with Proximity Warning • TSP: Transit Signal Priority
<p>FRATIS: Freight Advanced Traveler Information Systems</p> <ul style="list-style-type: none"> • DR-OPT: Drayage Optimization • F-ATIS: Freight Real-Time Traveler Information with Performance Monitoring • F-DRG: Freight Dynamic Route Guidance 	<p>R.E.S.C.U.M.E.: Response, Emergency Staging and Communications, Uniform Management, and Evacuation</p> <ul style="list-style-type: none"> • EVAC: Emergency Communications and Evacuation • INC-ZONE: Incident Scene Work Zone Alerts for Drivers and Workers • AACN-RELAY: Advanced Automatic Crash Notification System • RESP-STG: Incident Scene Pre-Arrival Staging and Guidance for Emergency Responders
<p>IDTO: Integrated Dynamic Transit Operations</p> <ul style="list-style-type: none"> • D-RIDE: Dynamic Ridesharing • T-CONNECT: Connection Protection • T-DISP: Dynamic Transit Operations 	<p>Road Weather Specific Applications: There is an overlap between the road weather and mobility applications, and much of the road weather requirements are addressed under mobility (e.g., WX-MDSS, Freight Dynamic Route Guidance, and SPD-HARM). Two road weather applications are considered separately:</p> <ul style="list-style-type: none"> • Information for Maintenance and Fleet Management Systems • Variable Speed Limits for Weather-Responsive Traffic Management
<p>INFLO: Integrated Network Flow Optimization</p> <ul style="list-style-type: none"> • CACC: Cooperative Adaptive Cruise Control • Q-WARN: Queue Warning • RAMP: Next Generation Ramp Metering System • SPD-HARM: Dynamic Speed Harmonization 	

The primary findings of the analysis are:

1. **The Basic Safety Message (BSM), with Part 1 transmitted approximately 10 times per second over Dedicated Short Range Communications (DSRC), is useful for a number of mobility applications, but is not solely sufficient for any of the envisioned mobility applications.**
2. **The BSM message and DSRC communications are required for some mobility applications, such as the M-ISIG bundle of applications**

3. A subset of the BSM Part 1 and Part 2 data elements provides the majority, but not all, of the data that needs to be sent from vehicles to the infrastructure. This data must either be continually sent to infrastructure systems, at some lower update rate, over an alternative mobile wireless technology, such as cellular data, or be cached on-board the vehicle and then sent in a message containing both current and stored snapshots.

Many mobility applications require that data be sent to systems such as traffic management systems, for every stretch of covered roadway, but the update rate can be far less than ten times per second. . Since it is infeasible to provide ubiquitous coverage of U.S. roadways using DSRC, the data must be stored for sending when in range of DSRC units spaced along the roadway, as in the original Vehicle Infrastructure Integration (VII) vision, sent via digital cellular, or through a combination of the two. This information exchange must not interfere with DSRC-based V2V safety applications. This might be done using a new Basic Mobility Message (BMM). Candidate data elements for inclusion in a BMM message are listed in Table ES-2. The rationale for selecting the elements for inclusion in Table ES-2 is provided in Chapter 5, along with why some data elements might be included in both the BMM and BSM messages.

Table ES 0-2 Candidate Data elements for Inclusion in a Basic Mobility Message

Data	# Applications ¹	BSM Part 1	BSM Part 2	Exchange Type ²
Airbag deployment	2		✓	Event driven
Ambient air pressure	8		✓	Periodic
Ambient air temperature	9		✓	Periodic
Antilock brake system active over 100 msec	9		✓	Event driven
Brake system status	3	✓		Periodic
Cargo weight	2		✓	Periodic
Compliance with target speed	1			Periodic
Confidence-position	2		✓	Periodic
Confidence-speed/heading/throttle	2		✓	Periodic
Confidence-time	2		✓	Periodic
Current lane	1			Periodic
Descriptive vehicle identifier	1		✓	Periodic
Engine RPM	1			Periodic

¹ Note that the number of applications counts applications that may utilize the BSM or other DSRC messages, so it does not reflect an exact count. In addition, M-ISIG is analyzed as a single application in the analysis. However, any data that ONLY appears in the BSM or other DSRC message is excluded from this chart, so those with a single occurrence do reflect a need to send the information from vehicles to an infrastructure system using other communications.

² Event driven data can be included as optional elements in a Basic Mobility Message, as is done in the Basic Safety Message.

Data	# Applications ¹	BSM Part 1	BSM Part 2	Exchange Type ²
Engine torque	1			Periodic
Exhaust diagnostics	1			Periodic
Exterior lights (status)	8		✓	Periodic
Fleet Owner Code	1		✓	Periodic
Hazard lights active	2		✓	Periodic
HAZMAT status	1		✓	Periodic
Impact sensor status	1			Event driven
Incident report from traveler	1			Event driven
Level of brake application	2		✓	Periodic
Lights changed	8		✓	Event driven
Motion	11	✓		Periodic
Pavement temperature	1			Periodic
Position (local 3D)	14	✓		Periodic
Rain sensor	9		✓	Periodic
Rate of change of steering wheel angle	3		✓	Periodic
Recent or current hard braking	2		✓	Event driven
Relative humidity	1			Periodic
Road coefficient of friction	10		✓	Periodic
Traction control system active over 100 msec	11		✓	Event driven
Trailer weight	3		✓	Periodic
Vehicle data	2		✓	Periodic
Vehicle mass	4		✓	Periodic
Vehicle placarded as HAZMAT carrier	1		✓	Periodic
Vehicle size	6	✓		Periodic
Vehicle type (fleet vehicles)	6		✓	Periodic
Wiper status	9		✓	Periodic
Wipers changed	9		✓	Event driven

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1 Introduction

Purpose

This white paper presents the results of an assessment of the information that needs to flow to and from vehicles in order to support the high priority mobility applications, listed in Table 1-1.³ One of the principal goals of the assessment was to assess the extent to which the information found in Part 1 and Part 2 of the Basic Safety Message (BSM) parts 1 and 2 is sufficient to enable the set of mobility and road weather applications. This paper is intended to provide preliminary answers to four questions:

- To what degree does Part 1 of the BSM, transmitted using Dedicated Short Range Communications (DSRC) meet the needs of the mobility applications?
- Which data elements in parts 1 and 2 of the BSM are needed for mobility applications?
- If BSM data is only sent via DSRC, what extent of DSRC infrastructure is needed to support mobility applications
- What other data, not found in the BSM messages, must be sent to and from vehicles to support mobility applications?

The original study was conducted to address a time-critical need for a qualitative assessment, using the best information available at the time. Since then, both the concepts of operation and the system requirements documents for the high priority applications have been completed. This revised document (Version 3.0) incorporates additional insight from these documents, and as a result, represents a substantial update.

There are many important issues relating to vehicle-based information exchange that are beyond the scope of this paper. These include:

- Which, if any, aspects of BSM part 2 should be internationally harmonized?
- Will the benefits to the vehicle owner provide sufficient value in order for the OEMs to offer optionally equipped vehicles with the needed data elements? Do the benefits justify the additional development time, cost, and complexity?
- The privacy of individuals in the traffic stream must be maintained. Even anonymized data, when shared across multiple jurisdictions, aggregated over time and integrated with disparate data sources may have negative implications for privacy that are not well understood. This issue needs to be carefully studied in advance of deployment.

³ Based on recommendations from stakeholders and USDOT staff, an assessment of deployment readiness, and the prospective federal role, a set of “high priority mobility applications” was developed as part of the connected vehicle mobility program. In addition, these applications were grouped into related sets of applications, called “bundles.” A summary of these applications can be found at http://www.its.dot.gov/dma/dma_development.htm.

Table 1-1 High Priority Mobility and Road Weather Applications Sorted by Application Bundle

<p>Enable ATIS: Enable Advanced Traveler Information Systems</p> <ul style="list-style-type: none"> • ATIS: Multi-Modal Real-Time Traveler Information • S-PARK: Smart Park and Ride • T-MAP: Universal Map Application • WX-INFO: Real-Time Route Specific Weather Information for Motorized and Non-Motorized Vehicles 	<p>M-ISIG: Multimodal Intelligent Traffic Signal System</p> <ul style="list-style-type: none"> • FSP: Freight Signal Priority • I-SIG: Intelligent Traffic Signal System • PED-SIG: Mobile Accessible Pedestrian Signal System • PREEMPT: Emergency Vehicle Preemption with Proximity Warning • TSP: Transit Signal Priority
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<p>IDTO: Integrated Dynamic Transit Operations</p> <ul style="list-style-type: none"> • D-RIDE: Dynamic Ridesharing • T-CONNECT: Connection Protection • T-DISP: Dynamic Transit Operations 	<p>Road Weather Specific Applications: There is an overlap between the road weather and mobility applications, and much of the road weather requirements are addressed under mobility (e.g., WX-MDSS, Freight Dynamic Route Guidance, and SPD-HARM). Two road weather applications are considered separately:</p> <ul style="list-style-type: none"> • Information for Maintenance and Fleet Management Systems • Variable Speed Limits for Weather-Responsive Traffic Management
<p>INFLO: Integrated Network Flow Optimization</p> <ul style="list-style-type: none"> • CACC: Cooperative Adaptive Cruise Control • Q-WARN: Queue Warning • RAMP: Next Generation Ramp Metering System • SPD-HARM: Dynamic Speed Harmonization 	

A note on Road Weather Applications: The Concept of Operations for Road Weather Connected Vehicle Applications identifies six high priority application areas for further development:

1. Enhanced maintenance decision support system
2. Information for maintenance and fleet management systems
3. Variable speed limits for weather-responsive traffic management
4. Motorist advisories and warnings
5. Information for freight shippers

6. Information and routing support for emergency responders.

These application areas, for the most part, do not represent a completely separate set of applications from the mobility applications, but rather highlight the very important role that weather information plays in broader applications (e.g., motorist advisories and warnings that are part of traveler information systems). The weather-specific data for these applications are included within the discussion of those applications. Two of the applications, however, were considered sufficiently distinct from the mobility applications to be considered separately as weather applications: Information for maintenance and fleet management systems and variable speed limits for weather responsive traffic management.

Background

The National Highway Traffic Safety Administration (NHTSA) has announced that they will make a decision in 2013 on whether or not to move forward with rulemaking that would require future vehicles to support Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) data communications for safety applications. The essential information required for V2V safety applications has been standardized in the Basic Safety Message parts 1 and 2. It is envisioned that each equipped vehicle will broadcast Part 1 of the BSM over a DSRC channel, at an adjustable rate of approximately 10 times per second. Part 2 of the BSM contains many optional data elements and is generally included in the BSM broadcast over the same DSRC channel when a triggering event or condition is present.

Because the BSM messages will be broadcast for V2V safety, it is reasonable to examine to what extent those messages alone can support mobility applications, and to what extent the same information, albeit packaged differently and perhaps sent over a different communications medium, could support mobility applications. This study provides an initial answer to these questions.

It is important to note that the fact that a data element is defined as an element of Part 2 of the BSM in the Society of Automotive Engineers (SAE) J2735 standard does not necessarily mean that it will be provided by vehicle manufacturers. Most of the Part 2 elements are defined as optional information in the standard. Moreover, the list of data elements has been accurately described as a “wish list” of desired information. Some of the data elements are currently available on the vehicle’s internal data bus and some are not. Some optional elements defined in the standard are easy to provide, while it may be infeasible to provide others (e.g., the BSM Part 2 element that provides the precipitation rate in tenths of grams per square meter per second).

2 Approach

A very simplified model of Intelligent Transportation Systems was used to examine the information exchange needs. The model included three types of systems: roadside infrastructure, such as traffic signal controllers, “other” infrastructure, such as traffic management centers, and vehicles. Vehicles were further identified by type: light vehicles, transit vehicles, freight vehicles, emergency vehicles, and maintenance vehicles. This model is shown in Figure 2-1. The analysis was focused on information that flowed to, from, or between vehicles (Links 1, 2, 3, 4, or 5, shown in red, in the figure).

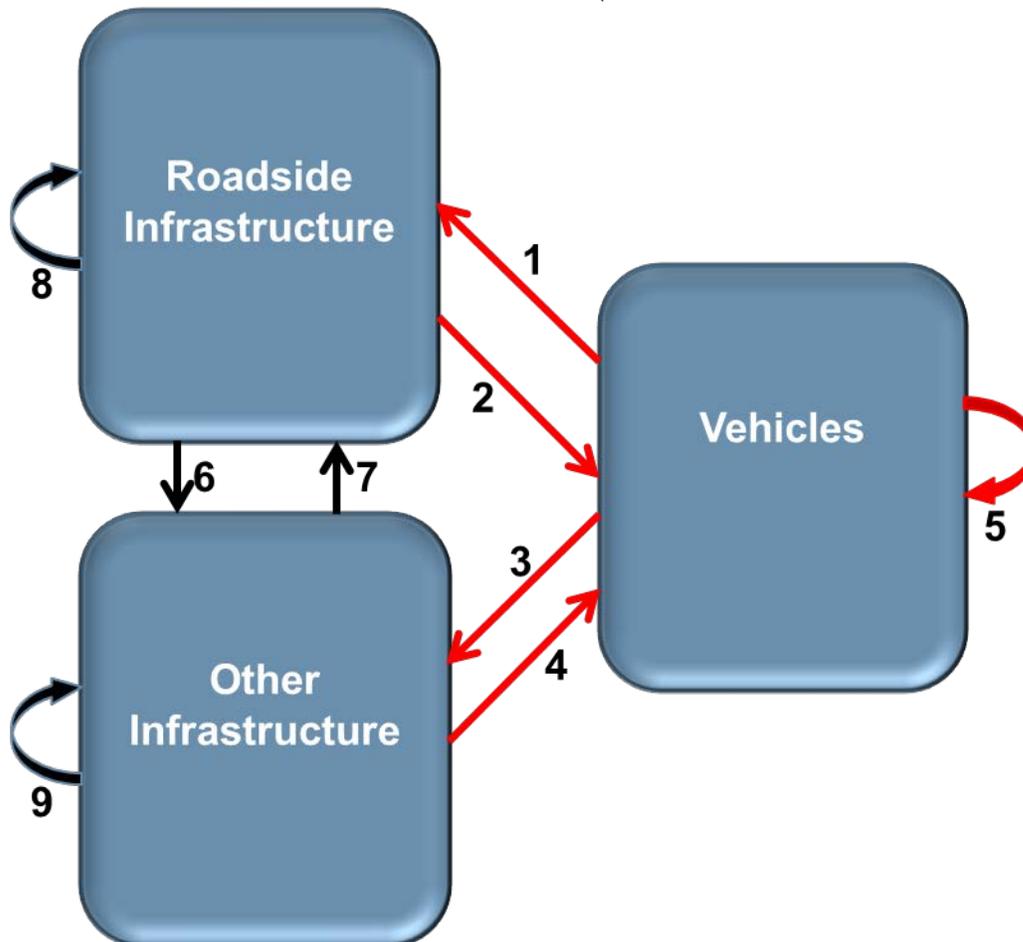


Figure 2-1 Simplified ITS Model Used for Analysis

The information exchange requirements were determined at two levels. The lower level of detail was data elements, which are individual pieces of information, such as vehicle speed or “wipers on”. The higher level was messages, which can be viewed for purposes of this analysis as a logical collection

of data elements that might be bundled into a single message for some purpose (the BSM message, with and without Part 2, are examples of logical groupings used for V2V safety applications).

The analysis was conducted application by application. Twenty-three high priority mobility applications from the six bundles were analyzed, along with two road weather applications. These are listed in Table 1-1. For each application, an assessment was made of what messages and which specific data elements would need to be sent to or from vehicles, to either directly or indirectly support the application. An example of an indirect need would be the Speed Harmonization application indirectly using weather data from vehicles, since weather is one of the factors used to determine the desired speed. A spreadsheet was developed to track which messages and data elements were associated with which applications, with the sources and sinks for each data element or message, the type of exchange (periodic, event driven, or request / reply), and whether or not DSRC communications was required to support the exchange.

The complete list of data elements are listed in Appendices C and D. Appendix C lists the elements sorted by name, while Appendix D sorts the elements by application.

Caveats

This analysis was conducted based on the best data currently available. The findings will undoubtedly change to some extent as the concepts of operation and requirements for the applications are refined through development and testing. In addition, the analysis was focused strictly on the information flows into and out of vehicles. No attempt was made to analyze information exchange requirements between central systems (e.g., a traffic management or transit management center) and roadside devices (e.g., a signal controller) or between central systems.

The analysis looked at messages that might be exchanged to support each application and the data elements that would go into those messages. However, the data elements list is incomplete. Routine data elements that do not relate to the actual application were not included. Examples of elements that were left out include log-in messages, acknowledgements, time stamps, and electronic signatures fields.

This analysis was based on the BSM message as defined in the November 2009 version of SAE J2735 (Version 2). This standard is in the process of being revised and split into multiple standards documents, based on the J2735 Systems Engineering (SE) candidate and input from other domestic and international stakeholders, with the hope that the upcoming version can be substantially harmonized to cover both US and European (EU) needs.

3 The Role of the Basic Safety Message (BSM)

Scenario Development

Five scenarios were defined, built around Parts 1 and 2 of the BSM, in order to determine the extent to which mobility applications could or could not be supported by BSM messages alone, and if the BSM messages are insufficient, what additional information needs to be exchanged. The contents of the Basic Safety Message are listed in Appendix B. The five scenarios were:

1. BSM Part 1 via DSRC (only). This scenario assumes that the only messages flowing into or out of vehicles is the BSM Part 1 message, which is broadcast over DSRC. The infrastructure may receive BSM messages from vehicles, but does not send any messages to vehicles.
2. BSM Part 1 via DSRC plus other incoming messages. This expands scenario 1 to allow infrastructure systems to send other messages to vehicles (I2V messages), using any appropriate communications medium.
3. BSM Parts 1 and 2 via DSRC plus other V2V messages via DSRC and I2V messages. This expands scenario 2 by adding BSM messages containing Part 2 as well as Part 1, broadcast over DSRC, and also allows other V2V information exchange over DSRC.
4. BSM Parts 1 and 2 data elements bundled into one or more new messages and transmitted by other means, plus I2V messages. This is a much broader scenario than the previous three. It assumes that the only data that a vehicle can send out are the data elements found in parts 1 and 2 of the BSM, but that they may be bundled, cached, or aggregated in different ways, sent using different transmission strategies, and/or sent using other mobile wireless communications technologies, such as cellular radio.
5. BSM Parts 1 and 2 data elements bundled into one or more new messages and transmitted by other means plus additional incoming and outgoing messages (I2V, V2I, and V2V). This scenario is totally open, allowing vehicles to send and receive any data over any media.

All five scenarios include a common set of assumptions:

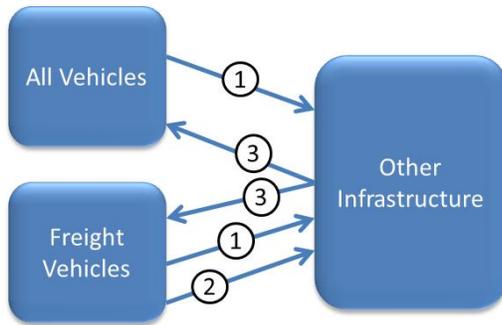
- Roadside DSRC radios are linked to central systems wherever necessary (e.g., DSRC can be used as one hop in a link between a vehicle and a traffic management center or other central system).
- There are large gaps in coverage of roadside DSRC radios. DSRC to the roadside cannot be relied upon by itself to provide frequent updates from all sections of all major roads.
- Roadside data sources that are in use today remain available (e.g., loop detectors, Bluetooth detectors, etc.) Currently implemented communications systems (e.g., cell phones, transit radio systems) remain available, as do privatized probe data sources.

Vehicles have the capability to rebroadcast (relay) certain messages over DSRC. (The R.E.S.C.U.M.E. AACN-RELAY application is built around this capability, and the Q-WARN application also uses it).

Sample Analysis for Dynamic Speed Harmonization

Figure 3-1 shows the information exchange that occurs between vehicles and “other infrastructure” to enable the Dynamic Speed Harmonization (SPD-HARM) application. Other information flows that don’t involve vehicles as the source or sink are outside the scope of this analysis and are not shown. The left hand side shows the information exchange, and the right hand lists the data elements exchanged. Most of the data coming from the vehicles matches data found in parts 1 and 2 of the BSM. The only exceptions are Differential wheel speed, Impact sensor status, Current lane, and Compliance with target speed.⁴ However, unless the entire roadway is equipped with roadside DSRC units, this information would best be sent to the infrastructure using an alternate means of communication, possibly as part of a Basic Mobility Message (BMM). Chapter 4 discusses the data that might be included in a BMM.

⁴ It’s possible that the reference in [7] to “differential wheel speed” is intended as a reference to traction control system activation, which *is* in the BSM. Similarly, while the BSM does not have a field called “impact sensor status” it does have a field to indicate that the vehicle’s airbag has been triggered.



Interface	Data
1	Position (local 3D)
	Motion
	Exterior lights (status)
	Ambient air temperature
	Antilock Brake System active over 100 msec
	Ambient air pressure
	Wiper status
	Lights changed
	Wipers changed
	Rain sensor
	Road coefficient of friction
	Traction Control System active over 100 msec
	Level of brake application
	Differential wheel speed
	Brake System status
	Impact sensor status
	Rate of change of steering wheel angle
Current lane	
Compliance with target speed	
2	Vehicle mass
	Trailer weight
	Cargo weight
3	Target speeds by lane (list)
	Target lane recommendations
	Justification for speed changes

Figure 3-1: Pictorial Depiction of the Data Exchange for Speed Harmonization

Role of the BSM in Mobility Applications

A summary of the types of vehicle-based data needed for each application bundle is provided below, followed by the overall results based on all scenarios and applications.

- **Enable ATIS (Enable Advanced Traveler Information Systems):** With the exception of traveler-provided information, e.g., destination and desired arrival time, the information contained in parts 1 and 2 of the BSM would provide all of the necessary vehicle information for the Enable ATIS applications (e.g., location, speed, traction control events, wiper status).. Although the Enable ATIS applications utilize the information found in the BSM, the information needs to be cached, bundled, and transmitted in one or more new messages, either using DSRC, another medium, or a combination of media.
INFLO (Integrated Network Flow Optimization): The information contained in the two parts of the BSM message would provide most of the necessary vehicle information for the INFLO applications. Ramp Metering could function with just the BSM messages sent over DSRC as planned for safety applications and a “Status of ramp meter” message sent from the roadside infrastructure to vehicles. The other applications in the bundle would require a few additional data elements. In addition, since it is infeasible to provide ubiquitous coverage of U.S. roadways using DSRC, the data must either be continually sent to infrastructure systems, at some lower update rate, over an alternative mobile wireless technology, such as cellular data, or be cached on-board the vehicle and then sent in a message containing both current and stored snapshots.
- **FRATIS (Freight Advanced Traveler Information Systems):** With the exception of request / reply information on desired routes and cargo information, e.g., load drop off time, the information contained in the two parts of the BSM would provide all of the necessary vehicle information for the FRATIS applications. As in the case of INFLO, however, the data must either be continually sent, at some update rate, over an alternative mobile wireless technology, such as cellular data, or be cached on-board the vehicle and then sent in a message containing both current and stored snapshots.
- **M-ISIG (Multimodal Intelligent Traffic Signal System):** With the exception of some transit-specific data, the information contained in the two parts of the BSM would provide all of the necessary vehicle information for the M-ISIG applications. In addition, using the BSM message as currently planned, transmitted over DSRC, is ideal for these applications, since this data is transmitted to local roadside infrastructure systems, which will be sending out Signal Phase and Timing (SPaT) and other intersection-related information to vehicles over the same DSRC communications link.
- **R.E.S.C.U.M.E. (Response, Emergency Staging and Communications, Uniform Management, and Evacuation):** These applications use the data found in parts 1 and 2 of the BSM along with a large number of other vehicle data elements that are not found in the BSM to support the AACN-RELAY and RESP-STG applications (primarily vehicle-based crash data not found in the BSM message, such as occupant safety belt use, vehicle fuel type, vehicle resting position, and crash delta v).
- **IDTO (Integrated Dynamic Transit Operations):** The IDTO applications generally do not make use of the information found in the BSM message. The sole exceptions are

vehicle type used to support the Dynamic Ride-Sharing application and vehicle location. Additional transit-specific information (such as passenger count and schedule adherence) is needed from transit and ride-sharing vehicles to support these applications.

- **Road Weather Applications:** The Information for Maintenance and Fleet Management Systems application does not utilize information found in the BSM message. It requires other, specialized data from maintenance vehicles. The Variable Speed Limits application uses the same weather-related elements of the BSM message used by the SPD-HARM application in the INFLO bundle, but the BSM alone is not sufficient because the recommended speed limits must be sent to vehicles using another message. .

Table 3-1: Summary of the ability of BSM Messages or other messages with BSM content to Support Mobility Applications

Scenario	Scenario Definition	Analysis Results
1	BSM Part 1 V2V via DSRC (only). This scenario assumes that the only message flowing into or out of vehicles is the BSM Part 1 message, which is broadcast over DSRC. The infrastructure may receive BSM messages from vehicles, but does not send any messages to vehicles.	Inadequate to support any mobility application
2	BSM Part 1 via DSRC plus other incoming messages. This expands scenario 1 to allow infrastructure systems to send other messages to vehicles (I2V messages), using any appropriate communications medium.	Sufficient to support Ramp Metering but no other mobility application.
3	BSM Parts 1 and 2 via DSRC plus I2V messages. This expands scenario 2 by adding BSM messages containing Part 2 as well as Part 1, broadcast over DSRC.	Adequate for Ramp Metering and CACC. .
4	BSM Parts 1 and 2 <i>data elements</i> bundled into one or more new messages and transmitted by other means, plus I2V messages. This is a much broader scenario than the previous three. It assumes that the only data that a vehicle can send out are the data elements found in parts 1 and 2 of the BSM, but that they may be bundled, cached, or aggregated in different ways, sent using different transmission strategies, and/or sent using other mobile wireless communications technologies, such as cellular radio.	Adequate to support several additional applications, such as T-MAP, Variable speed limits for weather, and infrastructure-based Q-WARN.
5	BSM Parts 1 and 2 <i>data elements</i> bundled into one or more new messages and transmitted by other means plus additional incoming and outgoing messages (I2V, V2I, and V2V). This scenario is totally open, allowing vehicles to send and receive any data over any media.	By definition, this supports all mobility applications, as whatever data elements and whatever messages are needed are included.

In summary, the Basic Safety Message (BSM), with Part 1 transmitted approximately 10 times per second over Dedicated Short Range Communications (DSRC), is useful for several mobility applications, but is not solely sufficient for most mobility applications.

The same data that is found in the BSM part 1 and 2 messages is also needed for other mobility applications, but it most often needs to either be continually sent to infrastructure systems, at some lower update rate over an alternative mobile wireless technology, such as cellular data, or be cached on-board the vehicle and then sent in a message containing both current and stored snapshots. . The data is often needed for every stretch of roadway, but far less frequently. Since it is infeasible to provide continuous coverage of U.S. roadways using DSRC, the data must be cached on-board the vehicle and then sent as a larger collection of data points. These new messages could be sent to roadside DSRC units spaced along the roadway (as in the original Vehicle Infrastructure Integration vision), sent via digital cellular, or through a combination of the two. If utilizing DSRC, the required level of deployment varies by application. For example, Ramp Metering, Cooperative Adaptive Cruise Control (if vehicle-based), and Queue Warning limited to high priority locations could be supported by selective spot deployment of roadside DSRC equipment. However other applications such as ATIS, Dynamic Speed Harmonization, or infrastructure-based CACC would require a relatively widespread, dense deployment as had originally been envisioned by the VII program. This information exchange, however it is performed, must not interfere with DSRC-based V2V safety applications.

The BSM data elements that are most widely used by mobility applications, albeit not needed in a 10 times per second BSM message, are the vehicle parameters found in Part 1 of the BSM and weather related data found in Part 2 of the BSM. These data elements are shown in Table 3-2.

Table 3-2: BSM Data Elements Used by the Largest Number of Mobility Applications

	BSM Part 1	BSM Part 2
	<p>Motion:</p> <ul style="list-style-type: none"> • Transmission state • Speed • Heading • Steering wheel angle • Acceleration Set (4-way): this includes 3 axes of acceleration plus yaw rate <p>Position (local 3D):</p> <ul style="list-style-type: none"> • Latitude • Longitude • Elevation • Positional accuracy <p>Vehicle size (length and width)</p>	<p>Ambient air pressure</p> <p>Ambient air temperature</p> <p>Antilock Brake System active over 100 msec</p> <p>Exterior lights (status)</p> <p>Lights changed</p> <p>Rain sensor (called a Rain sensor in J2735, but it is a precipitation sensor. J2735 states "The "Rain Sensor" Probe Data Element is intended to inform Probe Data Users as to how hard it was raining/snowing...")</p> <p>Road coefficient of friction</p> <p>Traction Control System active over 100 msec</p> <p>Wipers changed</p> <p>Wiper status</p>

4 Mobility Applications that Require DSRC

Most of the mobility applications rely primarily on communications between vehicles and central infrastructure systems such as traffic management systems, transit management systems, or information service providers. These applications could use cellular data communications, a widely-deployed DSRC network, with the roadside DSRC radios linked back into the infrastructure, or some other means of wide-area mobile communications. However an important subset of mobility applications *requires* DSRC in order to operate. They cannot be supported purely by cellular data. These applications are shown in Table 4-1.

The specific purpose of the AACN-RELAY application is to use DSRC as a supplementary emergency communications system for use when a crashed vehicle is outside of cellular coverage. The AACN messages are sent using DSRC to passing vehicles, who either directly or indirectly relay the messages to emergency responders once they travel to a location with cell coverage.

The CACC application requires rapid, highly reliable, low-latency communications between nearby vehicles to manage the formation of platoons of vehicles and allow safe operation at shorter following distances. It will utilize the BSM message sent over DSRC, supplemented by additional platoon management messages, also sent over DSRC. In addition, some features make use of information exchanged with infrastructure systems, such as infrastructure-provided target speeds and gap recommendations. This V2I communications would not use DSRC. Q-WARN and INC-ZONE operate in a similar manner.

RAMP provides ramp metering operation using connected vehicle technology. The BSM message, already being transmitted over DSRC, is the only information needed by the roadside infrastructure. The roadside infrastructure can communicate ramp metering status back to equipped vehicles using the same DSRC system. This application does not require the use of any additional V2I or I2V communications technology.

The M-ISIG bundle of applications has similar requirements to RAMP. Only DSRC communications is needed for local, highly reliable, low-latency communications between vehicles and the roadside infrastructure.

Table 4-1: Applications Requiring DSRC

Application	Use of BSM and Other DSRC Messaging
AACN-RELAY	Does not use BSM messages, although it uses BSM data. Three messages: AACN message, AACN relay message, and AACN distress message received
CACC	Uses BSM and non-BSM (platoon-related) messages over DSRC. Can operated entirely over DSRC, but complete application also uses non-DSRC to support infrastructure role.
Q-WARN	Uses BSM and non-BSM (queue-related) messages over DSRC. Can operate entirely over DSRC, but complete application also uses non-DSRC to support infrastructure role.
INC-ZONE	Uses BSM and non-BSM messages over DSRC. Also needs non-DSRC communications to send data back to an infrastructure system
RAMP	Uses just DSRC. Uses BSM to provide position and motion, and also a “status of ramp meter” message
M-ISIG bundle of applications	Uses just DSRC. Uses BSM plus non-BSM (signal status, signal priority, and signal preemption related) messages.

5 Candidate Data Elements for a Basic Mobility Message (BMM)

Most of the mobility applications require that data be sent from vehicles to one or more infrastructure systems such as traffic management centers, transit management centers, and information service providers. In the absence of a comprehensive national network of roadside DSRC radio systems, cellular or an alternative wide area mobile wireless data system is needed. Since a large percentage of the required data is needed on a periodic basis (although less frequently than 10 times per second), and multiple applications need the same data, it makes sense to consider use of a common *Basic Mobility Message* (BMM) to transmit this information from vehicles to infrastructure systems.

Based on the material in the various system requirements and other documents, it is possible to assemble a list of candidate data fields for the BMM message. Data elements that are sent periodically are obvious candidates for inclusion. Data elements that are triggered by an event, such as a change in wiper status, are also included in the candidate list. Such data elements are often combined with periodic data in applications and it can be included as optional fields in a message, to be sent only when triggered, as is done with much of the data in Part 2 of the BSM. Data elements that are part of a request / reply dialog, such as a request for a route, are better handled by separate messages.

In developing this list, data elements used only by one transit application, such as passenger count or schedule adherence, and that would be used by an application to relate to a specific individual vehicle, rather than to aggregate information, were excluded from the candidate list.

Based on these criteria, the list of data elements shown in Table 5-1 was developed. The table lists each candidate data element, a rough count of the number of mobility applications that use the data, whether or not the information is also used in the BSM message, and the type of data exchange (periodic or event driven). Some data elements are in both the BSM and BMM because the BSM is sent over DSRC, supporting low latency short range communications requirements between vehicles and between vehicles and the roadside infrastructure, while the BMM is sent over a wider range mobile wireless medium, such as cellular, providing communications between vehicles and central infrastructure systems such as traffic management centers. This is based on the assumption that a dense national network of interconnected roadside DSRC radios is not deployed.

Table 5-1: Candidate Data Elements for a BMM Message

Data	# Applications	BSM Part 1	BSM Part 2	Exchange Type ⁵
Airbag deployment	2		✓	Event driven
Ambient air pressure	8		✓	Periodic
Ambient air temperature	8		✓	Periodic
Antilock brake system active over 100 msec	8		✓	Event driven
Brake system status	3	✓		Periodic
Cargo weight	2		✓	Periodic
Compliance with target speed	1			Periodic
Confidence-position	2		✓	Periodic
Confidence- speed/heading/throttle	2		✓	Periodic
Confidence-time	2		✓	Periodic
Current lane	1			Periodic
Descriptive vehicle identifier	1		✓	Periodic
Engine RPM	1			Periodic
Engine torque	1			Periodic
Exhaust diagnostics	1			Periodic
Exterior lights (status)	7		✓	Periodic
Fleet Owner Code	1		✓	Periodic
Hazard lights active	2		✓	Event driven
HAZMAT status	1		✓	Periodic
Impact sensor status	1			Event driven
Incident report from traveler	1			Event driven
Level of brake application	2		✓	Periodic
Lights changed	7		✓	Event driven
Motion	7	✓		Periodic
Pavement temperature	1			Periodic
Position (local 3D)	10	✓		Periodic
Rain sensor	8		✓	Periodic
Rate of change of steering wheel angle	3		✓	Periodic
Recent or current hard braking	2		✓	Event driven

⁵ Event driven data can be included as optional elements in a Basic Mobility Message, as is done in the Basic Safety Message.

Data	# Applications	BSM Part 1	BSM Part 2	Exchange Type ⁵
Relative humidity	1			Periodic
Road coefficient of friction	9		✓	Periodic
Traction control system active over 100 msec	10		✓	Event driven
Trailer weight	3		✓	Periodic
Vehicle data	2		✓	Periodic
Vehicle mass	3		✓	Periodic
Vehicle placarded as HAZMAT carrier	1		✓	Periodic
Vehicle size	5	✓		Periodic
Vehicle type (fleet vehicles)	3		✓	Periodic
Wiper status	8		✓	Periodic
Wipers changed	8		✓	Event driven

APPENDIX A. Referenced Documents

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5. Mahmassani, Hani, et al. *Concept Development and Needs Identification for Intelligent Network Flow Optimization (INFLO) Concept of Operations*, FHWA-JPO-13-012, RITA ITS JPO, June 14, 2012.
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11. Schweiger, Carol, et. al. *Test Readiness Assessment Summary for Integrated Dynamic Transit Operations*, FHWA-JPO-12-086, ITS Joint Program Office, Research And Innovative Technology Administration (RITA), October 19, 2012.
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13. University of Arizona, et. al. *Multi-Modal Intelligent Traffic Signal System Concept of Operations, Version 2.0 Draft*, September 14, 2012.
14. Battelle, *Response, Emergency Staging, Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.) Concept of Operation (V3.0)*, Federal Highway Administration, November 19, 2012.
15. Battelle, *Response, Emergency Staging, Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.): Report on Functional and Performance Requirements, and High-Level Data and Communication Needs*. Federal Highway Administration Office of Operations, December 9, 2012.
16. University of Arizona, et.al. *Multi-Modal Intelligent Traffic Signal System: Final System Requirements Document*, January 25,, 2013.
17. University of Arizona, et.al. *Multi-Modal Intelligent Traffic Signal System DRAFT Requirements Walkthrough Workbook*, November 19, 2013

APPENDIX B. The Basic Safety Message (Parts 1 and 2)

The Basic Safety Message (BSM) is one of a set of messages defined in the Society of Automotive Engineers (SAE) Standard J2735, *Dedicated Short Range Communications (DSRC) Message Set Dictionary*. Each message in the standard, including the BSM, is made up of a set of *data frames*, which in turn are made up either of other data frames or *data elements*. Data elements are atomic, and are not further subdivided. In a few cases, the text, formal name, and ASN.1 definition found in J2739 provides conflicting information as to whether or not an item is a data frame or data element. For purposes of this analysis, it doesn't really matter.

The BSM consists of two parts. Part 1 is sent in every BSM message. Part 2 consists of a large set of optional elements. Not all elements are available from all vehicles, and which elements are sent, if available, will be based on event criteria that are not specified in J2735.

The table below lists the major data frames and data elements. It is not decomposed completely into data elements, as this would result in a very long list running many pages. Each item in the list is identified as either a data frame (DF) or data element (DE). If the data frame is not decomposed in this appendix, additional information on its content can be found in SAE J2735. "Administrative" components such as message ID number and time stamps are not listed in order to keep the list concise and emphasize the informational content that may be of value to mobility applications.

Part 1 (mandatory)

- Position (local 3D) (DF)
 - Latitude (DE)
 - Longitude (DE)
 - Elevation (DE)
 - Positional accuracy (DE)
- Motion (DF)
 - Transmission and speed (DF)
 - Transmission state (DE)
 - Speed (DE)
 - Heading (DE)
 - Steering wheel angle (DE)
 - Acceleration set (DF)
 - Longitudinal acceleration (DE)
 - Lateral acceleration (DE)
 - Vertical acceleration (DE)
 - Yaw rate (DE)
- Brake system status (DF)
 - Brake applied status (DE)
 - Brake status not available (DE)
 - Traction control state (DE)
 - Antilock brake status (DE)
 - Stability control status (DE)
 - Brake boost applied (DE)
 - Auxiliary brake status (DE)
- Vehicle size (DF)
 - Vehicle width (DE)
 - Vehicle length (DE)

Part 2 (all elements optional, sent according to criteria to be established)

- Vehicle safety extension (DF)
 - Event flags (DE) – A data element consisting of single bit event flags:
 - Hazard lights
 - Intersection stop line violation
 - ABS activated
 - Traction control loss
 - Stability control activated
 - Hazardous materials
 - Emergency response
 - Hard braking
 - Lights changed
 - Wipers changed
 - Flat tire
 - Disabled vehicle
 - Air bag deployment
 - Path history (DF)
 - Full position vector (DF)
 - Date and time stamp (DE)
 - Longitude (DE)
 - Latitude (DE)
 - Elevation (DE)
 - Heading (DE)
 - Transmission and speed (DF) – same as in Part 1
 - Positional accuracy (DE)
 - Time confidence (DE)
 - Position confidence set (DF)
 - Position confidence (DE)
 - Elevation confidence (DE)
 - Speed and heading and throttle confidence (DF)
 - Speed confidence (DE)
 - Heading confidence (DE)
 - Throttle confidence (DE)
 - GPS status (DE)
 - Count (DE) – number of “crumbs” in the history
 - Crumb data – set of one of 10 possible path history point set types, consisting of various combinations of:
 - Latitudinal offset from current position (DE)
 - Longitudinal offset from current position (DE)
 - Elevation offset from current position (DE)
 - Time offset from the current time (DE)
 - Accuracy (DF) – See J2735 standard for more information
 - Heading (DE) – NOT an offset, but absolute heading
 - Transmission and speed (DF) – same as in Part 1, NOT an offset

- Path Prediction (DF)
 - Radius of curve (DE)
 - Confidence (DE)
- RTCM Package (DF) – RTCM (Radio Technical Commission for Maritime Services) is a standardized format for GPS messages, including differential correction messages. J2735 states “The RTCMPackage data frame is used to convey a select sub-set of the RTCM messages (message types 1001 TO 1032) which deal with differential corrections between users. Encapsulates messages are those defined in RTCM Standard 10403.1 for Differential GNSS (Global Navigation Satellite Systems)Services -Version 3 adopted on October 27, 2006 and its successors.
 - Full position vector (DF) – see full contents above under Path history
 - RTCM header (DF)
 - GPS status
 - Antenna offset
 - GPS data – see SAE J2735 and RTCM standards for more information
- Vehicle status (DF)
 - Exterior lights (DE)
 - Light bar in use (DE)
 - Wipers (DF)
 - Wiper status front (DE)
 - Wiper rate (front) (DE)
 - Wiper status rear (DE)
 - Wiper rate (rear) (DE)
 - Brake system status (DF) – same as in Part 1
 - Braking pressure (DE)
 - Roadway friction (DE)
 - Sun sensor (DE)
 - Rain sensor (DE)
 - Ambient air temperature (DE)
 - Ambient pressure (DE)
 - Steering, sequence of:
 - Steering wheel angle (DE)
 - Steering wheel angle confidence (DE)
 - Steering wheel angle rate of change (DE)
 - Driving wheel angle (DE)
 - Acceleration set (DF) – same as in Part 1
 - Vertical acceleration threshold (DE)
 - Yaw rate confidence (DE)
 - Acceleration confidence (DE)
 - Confidence set (DF)
 - Acceleration confidence (DE)
 - Speed confidence (speed, heading, and throttle confidences (DF))
 - Time confidence (DE)
 - Position confidence set (DF)

- Steering wheel angle confidence (DE)
- Throttle confidence (DE)
- Object data, sequence of:
 - Obstacle distance (DE)
 - Obstacle direction (DE)
 - Time obstacle detected (DE)
- Full position vector (DF) – see contents under path history
- Throttle position (DE)
- Speed and heading and throttle confidence (DF) – same as above under “Full position vector”
- Speed confidence (DE) – same as above under “Speed and heading and throttle confidence”
- Vehicle data (referred to as a “complex type” in J2735, rather than an element or frame)
 - Vehicle height (DE)
 - Bumper heights (DF)
 - Bumper height front (DE)
 - Bumper height rear (DE)
 - Vehicle mass (DE)
 - Trailer weight (DE)
 - Vehicle type (DE)
- Vehicle identity (DF)
 - Descriptive name (DE) – typically only used for debugging
 - VIN string (DE)
 - Owner code (DE)
 - Temporary ID (DE)
 - Vehicle type (DE)
 - Vehicle class (drawn from ITIS code standard)
- J1939 data (DF)
 - Tire conditions (DF) – see J2735 standard for list of data elements
 - Vehicle weight by axle (DF) – see J2735 standard for list of data elements
 - Trailer weight (DE)
 - Cargo weight (DE)
 - Steering axle temperature (DE)
 - Drive axle location (DE)
 - Drive axle lift air pressure (DE)
 - Drive axle temperature (DE)
 - Drive axle lube pressure (DE)
 - Steering axle lube pressure (DE)
- Weather report, defined as a sequence of the following:
 - Is raining (DE) – defined in NTCIP standard
 - Rain rate (DE) – defined in NTCIP standard
 - Precipitation situation (DE) – defined in NTCIP standard
 - Solar radiation (DE) – defined in NTCIP standard
 - Mobile friction (DE) – defined in NTCIP standard
- GPS status (DE)

APPENDIX C. Vehicle Data Elements Needed to Support High Priority Mobility Applications

This table lists each data element that originates or terminates in a vehicle and is used by one or more mobility applications. The list is sorted by source of the data and then by data element name. Columns three and four indicate if the element is found in Part 1 or Part 2 of the BSM message, while the fifth column indicates whether or not the element may be useful in determining road weather conditions. This is included to show that most, but not all, desired Part 2 elements are weather-related. The final column shows the sink, or destination, for the data element.

Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
All vehicles	AACN Distress message received				Event driven	All vehicles
All vehicles	Additional crash parameters				Event driven	All vehicles
All vehicles	Airbag deployment		✓		Event driven	All vehicles and Other infrastructure
All vehicles	Ambient air pressure		✓	✓	Periodic	Other infrastructure
All vehicles	Ambient air temperature		✓	✓	Periodic	All vehicles and Other infrastructure
All vehicles	Antilock Brake System active over 100 msec		✓	✓	Event driven	All vehicles and Other infrastructure
All vehicles	Brake system status	✓		✓	Periodic	All vehicles and Infrastructure
All vehicles	Call-back number				Event driven	All vehicles
All vehicles	Compliance with target speed				Periodic	All vehicles
All vehicles	Confidence-position		✓		Periodic	All vehicles and Other infrastructure
All vehicles	Confidence-speed/heading/throttle		✓		Periodic	All vehicles and Other infrastructure
All vehicles	Confidence-time		✓		Periodic	All vehicles and Other infrastructure
All vehicles	Confirm platoon entry request				Request / reply	All vehicles
All vehicles	Crash delta V				Event driven	All vehicles and Other infrastructure
All vehicles	Crash severity prediction				Event driven	All vehicles

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
All vehicles	Credential to access occupants medical records				Event driven	All vehicles and Other infrastructure
All vehicles	Current lane				Periodic	Other infrastructure
All vehicles	Date and time of crash				Event driven	All vehicles and Other infrastructure
All vehicles	Departure location				Event driven and Request / reply	Other infrastructure
All vehicles	Differential wheel speed				TBD	Other infrastructure
All vehicles	Directions and times by mode				Event driven	Other infrastructure
All vehicles	Engine RPM			✓	Periodic	Other infrastructure
All vehicles	Engine torque			✓	Periodic	Other infrastructure
All vehicles	Estimated point of impact				Event driven	All vehicles and Other infrastructure
All vehicles	Exhaust diagnostics			✓	Periodic	Other infrastructure
All vehicles	Exterior lights (status)		✓	✓	Periodic	Other infrastructure
All vehicles	Fuel consumption, range, and range rate				Periodic	All vehicles and Infrastructure
All vehicles	Gap recommendations and target speeds by platoon, location, time				TBD	All vehicles
All vehicles	Hazard lights active		✓		Event driven	All vehicles and Other infrastructure
All vehicles	Impact sensor / Crash delta V		✓		Event driven	All vehicles and Other infrastructure
All vehicles	Impact sensor status				Event driven	Other infrastructure
All vehicles	Incident report from traveler				Event driven	Other infrastructure
All vehicles	Intended platoon position				Request / reply	All vehicles
All vehicles	Intrusion into vehicle occupant compartment				Event driven	All vehicles

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
All vehicles	Level of brake application		✓		Periodic	All vehicles and Infrastructure
All vehicles	Lights changed		✓	✓	Event driven	Other infrastructure
All vehicles	Motion	✓		✓	Periodic	All vehicles and Other infrastructure
All vehicles	Multiple impacts				Event driven	All vehicles
All vehicles	Number of occupants				Event driven	All vehicles
All vehicles	Occupant medical data				Event driven	Other infrastructure
All vehicles	Occupant safety belt use				Event driven	All vehicles
All vehicles	Occupant location				Event driven	All vehicles
All vehicles	Origin and Destination locations and time				Event driven	Other infrastructure
All vehicles	Path history		✓		Periodic	Emergency vehicles
All vehicles	Path prediction		✓		Periodic	Emergency vehicles
All vehicles	Pavement temperature			✓	Periodic	Other infrastructure
All vehicles	Platoon entry request				Request / reply	All vehicles
All vehicles	Platoon exit notification				Event driven	All vehicles
All vehicles	Position (local 3D)	✓		✓	Periodic	All vehicles and Other infrastructure
All vehicles	Pre-event vehicle heading				Event driven	All vehicles
All vehicles	Principal direction of force				Event driven	All vehicles
All vehicles	Propagated Remote vehicle-generated queue detection alert				Event driven	All vehicles
All vehicles	Rain sensor		✓	✓	Periodic	All vehicles and Other infrastructure
All vehicles	Rate of change of steering wheel angle		✓	✓	Periodic	All vehicles and Infrastructure
All vehicles	Recent or current hard braking		✓		Event driven	Other infrastructure
All vehicles	Relative humidity			✓	Periodic	Other infrastructure
All vehicles	Road coefficient of friction		✓	✓	Periodic	All vehicles and Other infrastructure

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
All vehicles	Road coefficient of friction		✓	✓	Periodic	Other infrastructure
All vehicles	Rollover				Event driven	All vehicles
All vehicles	Selected route and mode				Event driven	Other infrastructure
All vehicles	Self-generated queue detection alert				Event driven	All vehicles
All vehicles	Signal Request Message				Event driven	Other infrastructure
All vehicles	Stop line violation		✓		Event driven	Roadside infrastructure
All vehicles	Toll tag data (for travel speed)				Other	Other infrastructure
All vehicles	Traction Control System active over 100 msec		✓	✓	Event driven	All vehicles and Other infrastructure
All vehicles	Vehicle data		✓		Periodic	All vehicles and Other infrastructure
All vehicles	Vehicle fuel type				Event driven	All vehicles and Other infrastructure
All vehicles	Vehicle ID		✓		Periodic	Other infrastructure
All vehicles	Vehicle mass			4	Periodic	All vehicles and Other infrastructure
All vehicles	Vehicle resting position				Event driven	All vehicles and Other infrastructure
All vehicles	Vehicle size	✓			Periodic	All vehicles and Other infrastructure
All vehicles	Vehicle type (fleet vehicles)		✓		Periodic	Emergency vehicles
All vehicles	Vehicle type (fleet)		✓		Event driven, Periodic, and Request / reply	All vehicles and Other infrastructure
All vehicles	Video if available				Event driven	All vehicles
All vehicles	Weather info for freight			✓	Periodic	Other infrastructure
All vehicles	Wiper status		✓	✓	Periodic	All vehicles and Other infrastructure
All vehicles	Wipers changed		✓	✓	Event driven	All vehicles and Other infrastructure

Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
All vehicles and Other infrastructure	Destination				Event driven and Request / reply	Light vehicles
All vehicles and Other infrastructure	Target arrival time				Event driven and Request / reply	All vehicles and Other infrastructure
All vehicles and Other infrastructure	Target departure time				Event driven and Request / reply	All vehicles and Other infrastructure
Emergency vehicles	Emergency responder warning				Event driven	Roadside infrastructure
Emergency vehicles	Incident zones status update				Request / reply	Other infrastructure
Emergency vehicles	Light bar in use		✓		Event driven	Roadside infrastructure
Emergency vehicles	On-coming vehicle alert and warning				Event driven	All vehicles
Emergency vehicles	Public safety vehicle responding to emergency		✓		Event driven	Roadside infrastructure
Emergency vehicles	Siren in use		✓		Event driven	Roadside infrastructure
Emergency vehicles	Still and video images from emergency vehicles				Other	Other infrastructure
Freight vehicles	Cargo weight		✓		Periodic	All vehicles and Infrastructure

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
Freight vehicles	Credentials to access HAZMAT contents				Event driven	All vehicles
Freight vehicles	Descriptive vehicle identifier		✓		Periodic	Other infrastructure
Freight vehicles	Destination and stops				Request / reply	Other infrastructure
Freight vehicles	Electronic manifest				Event driven	All vehicles
Freight vehicles	Fleet Owner Code		✓		Periodic	Other infrastructure
Freight vehicles	Freight terminal queue information request				Request / reply	Other infrastructure
Freight vehicles	Freight weather information request - area				Request / reply	Other infrastructure
Freight vehicles	Freight weather information request - trip path				Request / reply	Other infrastructure
Freight vehicles	HAZMAT status		✓		Periodic	Other infrastructure
Freight vehicles	HAZMAT transportation vehicle identification				Event driven	All vehicles
Freight vehicles	Parking information request				Request / reply	Other infrastructure
Freight vehicles	Parking reservation request				Request / reply	Other infrastructure
Freight vehicles	Real-time information request				Request / reply	Other infrastructure

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
Freight vehicles	Trailer weight		✓		Periodic	All vehicles and Other infrastructure
Freight vehicles	Vehicle height		✓		Periodic	Other infrastructure
Freight vehicles	Vehicle identifying information (make, model, color, year)				Event driven	All vehicles
Freight vehicles	Vehicle license plate number				Event driven	All vehicles
Freight vehicles	Vehicle placarded as HAZMAT carrier		✓		Periodic	Other infrastructure
Freight vehicles	Vehicle shipping company contact phone number				Event driven	All vehicles
Freight vehicles and Other infrastructure	Empty container load matching messages				Request / reply	Freight vehicles and Other infrastructure
Light vehicles	Cost				Request / reply	Other infrastructure
Light vehicles	Driver request for passengers				Request / reply	Other infrastructure
Light vehicles	ETA at destination				Request / reply	Other infrastructure
Light vehicles	ETA for pickup				Request / reply	Other infrastructure
Light vehicles	Number of occupants in vehicle				Request / reply	Other infrastructure
Maintenance vehicles	Current location	✓			Periodic	Other infrastructure
Maintenance vehicles	Powertrain diagnostic information				Periodic	Other infrastructure

Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
Maintenance vehicles	Status of vehicle components (e.g., spreader, plow)				Periodic	Other infrastructure
Maintenance vehicles	Types and amount of materials on-board				Periodic	Other infrastructure
Other infrastructure	Alternate route recommendation				Event driven	Freight vehicles
Other infrastructure	Amount willing to pay				Request / reply	Light vehicles
Other infrastructure	Discovered or predicted congestion alert along current/planned route				Event driven	Freight vehicles
Other infrastructure	Estimated hold time for outgoing vehicles				Event driven	Transit vehicles
Other infrastructure	Evacuation routes information				Request / reply	Transit vehicles
Other infrastructure	Expected arrival time at pickup location				Request / reply	Transit vehicles
Other infrastructure	Freight route guidance response				Request / reply	Freight vehicles
Other infrastructure	Freight route guidance update				Request / reply	Freight vehicles
Other infrastructure	Freight routing restrictions				Request / reply	Freight vehicles
Other infrastructure	Freight routing with travel times				Periodic and Request / reply	Freight vehicles
Other infrastructure	Freight terminal queue information response				Request / reply	Freight vehicles

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
Other infrastructure	Freight weather information response - area				Request / reply	Freight vehicles
Other infrastructure	Freight weather information response - trip path				Request / reply	Freight vehicles
Other infrastructure	Incident alerts				Event driven	Freight vehicles
Other infrastructure	Incoming transfer notification				Event driven	Transit vehicles
Other infrastructure	Info on concierge and maintenance services and locations				Request / reply	Freight vehicles
Other infrastructure	Information from RESP-STG function				Request / reply	Emergency vehicles
Other infrastructure	Justification for speed changes				TBD	All vehicles
Other infrastructure	Manifest information				Event driven	Transit vehicles
Other infrastructure	Map data				Other	All vehicles
Other infrastructure	Number of passengers that requested assistance at pickup location				Request / reply	Transit vehicles
Other infrastructure	Park and ride lot status info				Request / reply	Light vehicles
Other infrastructure	Parking information response				Request / reply	Freight vehicles
Other infrastructure	Parking reservation response				Request / reply	Freight vehicles

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
Other infrastructure	Queue detection alert				Event driven	All vehicles
Other infrastructure	Queue prediction alert				Event driven	All vehicles
Other infrastructure	Real-time information response				Request / reply	Freight vehicles
Other infrastructure	Real-time navigation instructions				Periodic	Emergency vehicles
Other infrastructure	Recommended route				Request / reply	Transit vehicles
Other infrastructure	Regulatory and enforcement info				Request / reply	Freight vehicles
Other infrastructure	Revised routes, including timing				Event driven	Transit vehicles
Other infrastructure	Ride sharing response				Request / reply	Light vehicles
Other infrastructure	Road closure info				Request / reply	Freight vehicles
Other infrastructure	Road conditions				Request / reply	Transit vehicles
Other infrastructure	Schedule				Event driven	Transit vehicles
Other infrastructure	Schedule update				Event driven	Transit vehicles
Other infrastructure	Schedule updates				Event driven	Transit vehicles

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
Other infrastructure	Staging plans				Periodic	Emergency vehicles
Other infrastructure	Still and video images from center				Request / reply	Emergency vehicles
Other infrastructure	Target lane recommendations				TBD	All vehicles
Other infrastructure	Target speeds by lane (list)				TBD	All vehicles
Other infrastructure	T-CONNECT cancellation confirmation				Request / reply	Transit vehicles
Other infrastructure	T-CONNECT transfer modification response				Request / reply	Transit vehicles
Other infrastructure	T-CONNECT transfer response				Request / reply	Transit vehicles
Other infrastructure	T-CONNECT transfer update				Event driven	Transit vehicles
Other infrastructure	Time of dispatch				Request / reply	
Other infrastructure	Time of request				Request / reply	Transit vehicles
Other infrastructure	Traffic reports				Request / reply	Transit vehicles
Other infrastructure	Transfer points / transfer matrix				Event driven	Transit vehicles
Other infrastructure	Updated schedules				Event driven	Transit vehicles

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
Other infrastructure	Voice and data messages to driver				Event driven	Transit vehicles
Other infrastructure	Work zone info				Request / reply	Freight vehicles
Other infrastructure and Roadside infrastructure	Gap recommendations and target speeds by link, and/or platoon by location, time				TBD	All vehicles
Roadside infrastructure	Geographic intersection description				Periodic	All vehicles
Roadside infrastructure	Intersection Status				Periodic	All vehicles
Roadside infrastructure	MMITSS Travel path conflict message				Event driven	All vehicles
Roadside infrastructure	Signal Status Message				Periodic	All vehicles
Roadside infrastructure	Signal, Phase, and Timing data				Periodic	All vehicles
Roadside infrastructure	Status of ramp meter				Periodic	All vehicles
Transit vehicles	Completed transfer				Event driven	Other infrastructure
Transit vehicles	Driver manifest data				Periodic	Other infrastructure
Transit vehicles	Intended travel route through intersection				Event driven	Roadside infrastructure

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
Transit vehicles	Operations data for storage				Periodic	Other infrastructure
Transit vehicles	Passenger count				TBD	Other infrastructure
Transit vehicles	Request being responded to				Event driven	Other infrastructure
Transit vehicles	Schedule Adherence				Periodic	Other infrastructure
Transit vehicles	Status				Periodic	Other infrastructure
Transit vehicles	Status versus schedule				Event driven	Other infrastructure
Transit vehicles	Status versus schedule				Periodic	Other infrastructure
Transit vehicles	T-CONNECT cancellation				Request / reply	Other infrastructure
Transit vehicles	T-CONNECT transfer modification request				Request / reply	Other infrastructure
Transit vehicles	T-CONNECT transfer request				Request / reply	Other infrastructure
Transit vehicles	Transit service type				Event driven	Other infrastructure
Transit vehicles	Vehicle location	✓			Periodic	Other infrastructure
Transit vehicles	Voice and data messages from driver				Event driven	Other infrastructure

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Source	Data Element	BSM Part 1	BSM Part 2	Wx. Related	Exchange Type	Sink
Transit vehicles and Emergency vehicles	Approach road to intersection				Event driven	Roadside infrastructure

APPENDIX D. Data Elements by Application

This table lists each data element that originates or terminates in a vehicle and is used by one or more mobility applications, sorted by DMA bundle and application. The list is sorted by DMA bundle (see Table 1-1) and application. For each element, the fourth and fifth columns indicate if the element is found in Part 1 of the BSM message or Part 2 (or, if neither column is checked, in neither). The last column identifies whether or not the element is a candidate for inclusion in a Basic Mobility Message (BMM) that would be sent from vehicles to infrastructure systems, as described in Chapter 5.

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
Enable ATIS	ATIS	Ambient air pressure	All vehicles	Other infrastructure		✓	✓
Enable ATIS	ATIS	Ambient air temperature	All vehicles	Other infrastructure		✓	✓
Enable ATIS	ATIS	Antilock Brake System active over 100 msec	All vehicles	Other infrastructure		✓	✓
Enable ATIS	ATIS	Departure location	All vehicles	Other infrastructure			
Enable ATIS	ATIS	Destination	All vehicles	Other infrastructure			
Enable ATIS	ATIS	Directions and times by mode	All vehicles	Other infrastructure			
Enable ATIS	ATIS	Exterior lights (status)	All vehicles	Other infrastructure		✓	✓
Enable ATIS	ATIS	Incident report from traveler	All vehicles	Other infrastructure			✓
Enable ATIS	ATIS	Lights changed	All vehicles	Other infrastructure		✓	✓
Enable ATIS	ATIS	Motion	All vehicles	Other infrastructure	✓		✓
Enable ATIS	ATIS	Origin and Destination locations and time	All vehicles	Other infrastructure			
Enable ATIS	ATIS	Position (local 3D)	All vehicles	Other infrastructure	✓		✓
Enable ATIS	ATIS	Rain sensor	All vehicles	Other infrastructure		✓	✓
Enable ATIS	ATIS	Road coefficient of friction	All vehicles	Other infrastructure		✓	✓
Enable ATIS	ATIS	Selected route and mode	All vehicles	Other infrastructure			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
Enable ATIS	ATIS	Target arrival time	All vehicles	Other infrastructure			
Enable ATIS	ATIS	Target departure time	All vehicles	Other infrastructure			
Enable ATIS	ATIS	Toll tag data (for travel speed)	All vehicles	Other infrastructure			
Enable ATIS	ATIS	Traction Control System active over 100 msec	All vehicles	Other infrastructure		✓	✓
Enable ATIS	ATIS	Vehicle size	All vehicles	Other infrastructure	✓		✓
Enable ATIS	ATIS	Wiper status	All vehicles	Other infrastructure		✓	✓
Enable ATIS	ATIS	Wipers changed	All vehicles	Other infrastructure		✓	✓
Enable ATIS	S-PARK	Park and ride lot status info	Other infrastructure	Light vehicles			
Enable ATIS	T-MAP	Map data	Other infrastructure	All vehicles			
Enable ATIS	T-MAP	Motion	All vehicles	Other infrastructure	✓		✓
Enable ATIS	T-MAP	Position (local 3D)	All vehicles	Other infrastructure	✓		✓
Enable ATIS	T-MAP	Vehicle size	All vehicles	Other infrastructure	✓		✓
Enable ATIS	WX-INFO	Ambient air pressure	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Ambient air temperature	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Antilock Brake System active over 100 msec	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Brake system status	All vehicles	Other infrastructure	✓		✓
Enable ATIS	WX-INFO	Engine RPM	All vehicles	Other infrastructure			✓
Enable ATIS	WX-INFO	Engine torque	All vehicles	Other infrastructure			✓
Enable ATIS	WX-INFO	Exhaust diagnostics	All vehicles	Other infrastructure			✓
Enable ATIS	WX-INFO	Exterior lights (status)	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Lights changed	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Motion	All vehicles	Other infrastructure	✓		✓
Enable ATIS	WX-INFO	Pavement temperature	All vehicles	Other infrastructure			✓

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Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
Enable ATIS	WX-INFO	Position (local 3D)	All vehicles	Other infrastructure	✓		✓
Enable ATIS	WX-INFO	Rain sensor	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Rate of change of steering wheel angle	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Relative humidity	All vehicles	Other infrastructure			✓
Enable ATIS	WX-INFO	Road coefficient of friction	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Traction Control System active over 100 msec	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Wiper status	All vehicles	Other infrastructure		✓	✓
Enable ATIS	WX-INFO	Wipers changed	All vehicles	Other infrastructure		✓	✓
FRATIS	DR-OPT	FRATIS does not directly implement drayage operations, but supplies data to private load-matching systems					
FRATIS	F-ATIS	Alternate route recommendation	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Ambient air pressure	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Ambient air temperature	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Antilock Brake System active over 100 msec	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Confidence-position	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Confidence-speed/heading/throttle	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Confidence-time	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Discovered or predicted congestion alert along current/planned route	Other infrastructure	Freight vehicle			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
FRATIS	F-ATIS	Exterior lights (status)	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Freight routing restrictions	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Freight routing with travel times	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Freight weather information request - area	Freight vehicle	Other infrastructure			
FRATIS	F-ATIS	Freight weather information request - trip path	Freight vehicle	Other infrastructure			
FRATIS	F-ATIS	Freight weather information response - area	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Freight weather information response - trip path	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Incident alerts	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Info on concierge and maintenance services and locations	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Lights changed	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Motion	All vehicles	Other infrastructure	✓		✓
FRATIS	F-ATIS	Parking information request	Freight vehicle	Other infrastructure			
FRATIS	F-ATIS	Parking information response	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Parking reservation request	Freight vehicle	Other infrastructure			
FRATIS	F-ATIS	Parking reservation response	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Position (local 3D)	All vehicles	Other infrastructure	✓		✓
FRATIS	F-ATIS	Rain sensor	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Real-time information request	Freight vehicle	Other infrastructure			✓
FRATIS	F-ATIS	Real-time information response	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Recent or current hard braking	All vehicles	Other infrastructure		✓	✓

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
FRATIS	F-ATIS	Regulatory and enforcement info	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Road closure info	Other infrastructure	Freight vehicle			
FRATIS	F-ATIS	Road coefficient of friction	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Traction Control System active over 100 msec	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Vehicle data	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Wiper status	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Wipers changed	All vehicles	Other infrastructure		✓	✓
FRATIS	F-ATIS	Work zone info	Other infrastructure	Freight vehicle			
FRATIS	F-DRG	Ambient air pressure	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Ambient air temperature	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Antilock Brake System active over 100 msec	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Descriptive vehicle identifier	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Destination and stops	Freight vehicles	Other infrastructure			
FRATIS	F-DRG	Empty container load matching messages	Freight vehicle	Other infrastructure			
FRATIS	F-DRG	Empty container load matching messages	Other infrastructure	Freight vehicle			
FRATIS	F-DRG	Exterior lights (status)	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Fleet Owner Code	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Freight route guidance response	Other infrastructure	Freight vehicles			
FRATIS	F-DRG	Freight route guidance update	Other infrastructure	Freight vehicles			
FRATIS	F-DRG	Freight terminal queue information request	Freight vehicle	Other infrastructure			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
FRATIS	F-DRG	Freight terminal queue information response	Other infrastructure	Freight vehicle			
FRATIS	F-DRG	HAZMAT status	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Lights changed	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Rain sensor	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Road coefficient of friction	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Traction Control System active over 100 msec	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Vehicle height	Freight vehicles	Other infrastructure		✓	
FRATIS	F-DRG	Vehicle mass	Freight vehicles	Other infrastructure		✓	
FRATIS	F-DRG	Vehicle placarded as HAZMAT carrier	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Vehicle type (fleet)	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Wiper status	Freight vehicles	Other infrastructure		✓	✓
FRATIS	F-DRG	Wipers changed	Freight vehicles	Other infrastructure		✓	✓
IDTO	D-RIDE	Amount willing to pay	Other infrastructure	Light vehicle			
IDTO	D-RIDE	Cost	Light vehicles	Other infrastructure			
IDTO	D-RIDE	Departure location	Light vehicles	Other infrastructure			
IDTO	D-RIDE	Destination	Other infrastructure	Light vehicle			
IDTO	D-RIDE	Driver request for passengers	Light vehicles	Other infrastructure			
IDTO	D-RIDE	ETA at destination	Light vehicles	Other infrastructure			
IDTO	D-RIDE	ETA for pickup	Light vehicles	Other infrastructure			
IDTO	D-RIDE	Number of occupants in vehicle	Light vehicles	Other infrastructure			
IDTO	D-RIDE	Ride sharing response	Other infrastructure	Light vehicle			
IDTO	D-RIDE	Target arrival time	Other infrastructure	Light vehicle			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
IDTO	D-RIDE	Target departure time	Other infrastructure	Light vehicle			
IDTO	D-RIDE	Vehicle type (fleet)	Light vehicles	Other infrastructure		✓	✓
IDTO	T-CONNECT	Completed transfer	Transit vehicle	Other infrastructure			
IDTO	T-CONNECT	Estimated hold time for outgoing vehicles	Other infrastructure	Transit vehicle			
IDTO	T-CONNECT	Incoming transfer notification	Other infrastructure	Transit vehicle			
IDTO	T-CONNECT	Passenger count	Transit vehicle	Other infrastructure			
IDTO	T-CONNECT	Position (Local 3D)	Transit vehicle	Other infrastructure	✓		✓
IDTO	T-CONNECT	Schedule update	Other infrastructure	Transit vehicle			
IDTO	T-CONNECT	Status versus schedule	Transit vehicle	Other infrastructure			
IDTO	T-CONNECT	T-CONNECT cancellation	Transit vehicle	Other infrastructure			
IDTO	T-CONNECT	T-CONNECT cancellation confirmation	Other infrastructure	Transit vehicle			
IDTO	T-CONNECT	T-CONNECT transfer modification request	Transit vehicle	Other infrastructure			
IDTO	T-CONNECT	T-CONNECT transfer modification response	Other infrastructure	Transit vehicle			
IDTO	T-CONNECT	T-CONNECT transfer request	Transit vehicle	Other infrastructure			
IDTO	T-CONNECT	T-CONNECT transfer response	Other infrastructure	Transit vehicle			
IDTO	T-CONNECT	T-CONNECT transfer update	Other infrastructure	Transit vehicle			
IDTO	T-CONNECT	Transfer points / transfer matrix	Other infrastructure	Transit vehicle			
IDTO	T-CONNECT	Updated schedules	Other infrastructure	Transit vehicle			
IDTO	T-DISP	Driver manifest data	Transit vehicle	Other infrastructure			
IDTO	T-DISP	Manifest information	Other infrastructure	Transit vehicle			
IDTO	T-DISP	Operations data for storage	Transit vehicle	Other infrastructure			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
IDTO	T-DISP	Passenger count	Transit vehicle	Other infrastructure			
IDTO	T-DISP	Request being responded to	Transit vehicle	Other infrastructure			
IDTO	T-DISP	Revised routes, including timing	Other infrastructure	Transit vehicle			
IDTO	T-DISP	Schedule	Other infrastructure	Transit vehicle			
IDTO	T-DISP	Schedule Adherence	Transit vehicle	Other infrastructure			
IDTO	T-DISP	Schedule updates	Other infrastructure	Transit vehicle			
IDTO	T-DISP	Status	Transit vehicle	Other infrastructure			
IDTO	T-DISP	Vehicle location	Transit vehicle	Other infrastructure	✓		
IDTO	T-DISP	Voice and data messages from driver	Transit vehicle	Other infrastructure			
IDTO	T-DISP	Voice and data messages to driver	Other infrastructure	Transit vehicle			
INFLO	CACC	Antilock Brake System active over 100 msec	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Brake system status	All vehicles	All vehicles, Infrastructure	✓		✓
INFLO	CACC	Confidence-position	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Confidence-speed/heading/throttle	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Confidence-time	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Confirm platoon entry request					
INFLO	CACC	Fuel consumption, range, and range rate	All vehicles	All vehicles, Infrastructure			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
INFLO	CACC	Gap recommendations and target speeds by link, and/or platoon by location, time	Other infrastructure, Roadside Infrastructure	All vehicles			
INFLO	CACC	Gap recommendations and target speeds by platoon, location, time	All vehicles	All vehicles			
INFLO	CACC	Hazard lights active	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Impact sensor / Crash delta V	All vehicles	All vehicles, Infrastructure		✓	
INFLO	CACC	Intended platoon position	All vehicles	All vehicles			
INFLO	CACC	Level of brake application	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Motion	All vehicles	All vehicles, Infrastructure	✓		✓
INFLO	CACC	Platoon entry request	All vehicles	All vehicles			
INFLO	CACC	Platoon exit notification	All vehicles	All vehicles			
INFLO	CACC	Position (local 3D)	All vehicles	All vehicles, Infrastructure	✓		✓
INFLO	CACC	Rain sensor	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Rate of change of steering wheel angle	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Road coefficient of friction	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Traction Control System active over 100 msec	All vehicles	All vehicles, Infrastructure		✓	✓

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
INFLO	CACC	Trailer weight	Freight vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Vehicle data	All vehicles	All vehicles, Infrastructure		✓	✓
INFLO	CACC	Vehicle size	All vehicles	All vehicles, Infrastructure	✓		✓
INFLO	Q-WARN	Ambient air temperature	All vehicles	All vehicles, Other infrastructure, Roadside infrastructure		✓	✓
INFLO	Q-WARN	Cargo weight	Freight vehicles	All vehicles, Other infrastructure, Roadside infrastructure		✓	✓
INFLO	Q-WARN	Motion	All vehicles	All vehicles, Other infrastructure, Roadside infrastructure	✓		✓
INFLO	Q-WARN	Position (local 3D)	All vehicles	All vehicles, Other infrastructure, Roadside infrastructure	✓		✓
INFLO	Q-WARN	Propagated Remote vehicle-generated queue detection alert	All vehicles	All vehicles			
INFLO	Q-WARN	Queue detection alert	Other infrastructure	All vehicles			
INFLO	Q-WARN	Queue prediction alert	Other infrastructure	All vehicles			
INFLO	Q-WARN	Self-generated queue detection alert	All vehicles	All vehicles			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
INFLO	Q-WARN	Traction Control System active over 100 msec	All vehicles	All vehicles, Other infrastructure, Roadside infrastructure		✓	✓
INFLO	Q-WARN	Trailer weight	Freight vehicles	All vehicles, Other infrastructure, Roadside infrastructure		✓	✓
INFLO	Q-WARN	Vehicle mass	Freight vehicles	All vehicles, Other infrastructure, Roadside infrastructure		✓	
INFLO	Q-WARN	Wiper status	All vehicles	All vehicles, Other infrastructure, Roadside infrastructure		✓	✓
INFLO	Q-WARN	Wipers changed	All vehicles	All vehicles, Other infrastructure, Roadside infrastructure		✓	✓
INFLO	RAMP	Motion	All vehicles	Roadside infrastructure	✓		
INFLO	RAMP	Position (local 3D)	All vehicles	Roadside infrastructure	✓		
INFLO	RAMP	Status of ramp meter	Roadside infrastructure	All vehicles			
INFLO	SPD-HARM	Ambient air pressure	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Ambient air temperature	All vehicles	Other infrastructure		✓	✓

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
INFLO	SPD-HARM	Antilock Brake System active over 100 msec	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Brake System status	All vehicles	Other infrastructure	✓		✓
INFLO	SPD-HARM	Cargo weight	Freight vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Compliance with target speed	All vehicles	Other infrastructure			✓
INFLO	SPD-HARM	Current lane	All vehicles	Other infrastructure			✓
INFLO	SPD-HARM	Differential wheel speed	All vehicles	Other infrastructure			✓
INFLO	SPD-HARM	Exterior lights (status)	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Impact sensor status	All vehicles	Other infrastructure			✓
INFLO	SPD-HARM	Justification for speed changes	Other infrastructure	All vehicles			
INFLO	SPD-HARM	Level of brake application	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Lights changed	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Motion	All vehicles	Other infrastructure	✓		✓
INFLO	SPD-HARM	Position (local 3D)	All vehicles	Other infrastructure	✓		✓
INFLO	SPD-HARM	Rain sensor	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Rate of change of steering wheel angle	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Road coefficient of friction	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Target lane recommendations	Other infrastructure	All vehicles			
INFLO	SPD-HARM	Target speeds by lane (list)	Other infrastructure	All vehicles			
INFLO	SPD-HARM	Traction Control System active over 100 msec	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Trailer weight	Freight vehicles	Other infrastructure		✓	✓

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
INFLO	SPD-HARM	Vehicle mass	Freight vehicles	Other infrastructure		✓	
INFLO	SPD-HARM	Wiper status	All vehicles	Other infrastructure		✓	✓
INFLO	SPD-HARM	Wipers changed	All vehicles	Other infrastructure		✓	✓
M-ISIG	M-ISIG	Ambient air pressure	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Ambient air temperature	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Antilock Brake System active over 100 msec	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Approach road to intersection	Transit vehicles, emergency vehicles	Roadside infrastructure			
M-ISIG	M-ISIG	Exterior lights (status)	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Geographic intersection description	Roadside infrastructure	All vehicles			
M-ISIG	M-ISIG	Intended travel route through intersection	Transit vehicles	Roadside infrastructure			
M-ISIG	M-ISIG	Intersection Status	Roadside infrastructure	All vehicles			
M-ISIG	M-ISIG	Light bar in use	Emergency vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Lights changed	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	MMITSS Travel path conflict message	Roadside infrastructure	All vehicles			
M-ISIG	M-ISIG	Motion	All vehicles	Roadside infrastructure	✓		

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
M-ISIG	M-ISIG	Passenger count	Transit vehicles	Roadside infrastructure			
M-ISIG	M-ISIG	Position (local 3D)	All vehicles	Roadside infrastructure	✓		
M-ISIG	M-ISIG	Public safety vehicle responding to emergency	Emergency vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Rain sensor	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Road coefficient of friction	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Signal Request Message	All vehicles	Roadside infrastructure			
M-ISIG	M-ISIG	Signal Status Message	Roadside infrastructure	All vehicles			
M-ISIG	M-ISIG	Signal, Phase, and Timing data	Roadside infrastructure	All vehicles			
M-ISIG	M-ISIG	Siren in use	Emergency vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Status versus schedule	Transit vehicles	Roadside infrastructure			
M-ISIG	M-ISIG	Stop line violation	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Traction Control System active over 100 msec	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Transit service type	Transit vehicles	Roadside infrastructure			
M-ISIG	M-ISIG	Vehicle ID	All vehicles	Roadside infrastructure		✓	

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
M-ISIG	M-ISIG	Vehicle mass	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Vehicle size	All vehicles	Roadside infrastructure	✓		
M-ISIG	M-ISIG	Vehicle type (fleet)	Freight vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Wiper status	All vehicles	Roadside infrastructure		✓	
M-ISIG	M-ISIG	Wipers changed	All vehicles	Roadside infrastructure		✓	
R.E.S.C.U.M.E.	AACN-RELAY	AACN Distress message received	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Additional crash parameters	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Airbag deployment	All vehicles	All vehicles		✓	
R.E.S.C.U.M.E.	AACN-RELAY	Call-back number	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Crash delta V	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Crash severity prediction	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Credential to access occupants medical records	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Credentials to access HAZMAT contents	Freight vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Date and time of crash	All vehicles	All vehicles			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
R.E.S.C.U.M.E.	AACN-RELAY	Electronic manifest	Freight vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Estimated point of impact	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	HAZMAT transportation vehicle identification	Freight vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Intrusion into vehicle occupant compartment	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Multiple impacts	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Number of occupants	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Occupant safety belt use	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Occupant location	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Position (local 3D)	All vehicles	All vehicles	✓		
R.E.S.C.U.M.E.	AACN-RELAY	Pre-event vehicle heading	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Principal direction of force	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Rollover	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Vehicle fuel type	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Vehicle identifying information (make, model, color, year)	Freight vehicles	All vehicles			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
R.E.S.C.U.M.E.	AACN-RELAY	Vehicle license plate number	Freight vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Vehicle resting position	All vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Vehicle shipping company contact phone number	Freight vehicles	All vehicles			
R.E.S.C.U.M.E.	AACN-RELAY	Vehicle type (fleet)	All vehicles	All vehicles		✓	
R.E.S.C.U.M.E.	AACN-RELAY	Video if available	All vehicles	All vehicles			
R.E.S.C.U.M.E.	EVAC	Evacuation routes information	Other infrastructure	Transit vehicle			
R.E.S.C.U.M.E.	EVAC	Expected arrival time at pickup location	Other infrastructure	Transit vehicle			
R.E.S.C.U.M.E.	EVAC	Number of passengers that requested assistance at pickup location	Other infrastructure	Transit vehicle			
R.E.S.C.U.M.E.	EVAC	Position (local 3D)	Transit vehicle	Other infrastructure	✓		✓
R.E.S.C.U.M.E.	EVAC	Recommended route	Other infrastructure	Transit vehicle			
R.E.S.C.U.M.E.	EVAC	Road conditions	Other infrastructure	Transit vehicle			
R.E.S.C.U.M.E.	EVAC	Time of dispatch	Other infrastructure	Transit vehicle			
R.E.S.C.U.M.E.	EVAC	Time of request	Other infrastructure	Transit vehicle			
R.E.S.C.U.M.E.	EVAC	Traffic reports	Other infrastructure	Transit vehicle			
R.E.S.C.U.M.E.	INC-ZONE	Emergency responder warning	Emergency vehicles	Roadside infrastructure			
R.E.S.C.U.M.E.	INC-ZONE	Incident zones status update	Emergency vehicles	Other infrastructure			
R.E.S.C.U.M.E.	INC-ZONE	Information from RESP-STG function	Other infrastructure	Emergency vehicles			

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
R.E.S.C.U.M.E.	INC-ZONE	Motion	All vehicles	Emergency vehicles	✓		
R.E.S.C.U.M.E.	INC-ZONE	On-coming vehicle alert and warning	Emergency vehicles	All vehicles			
R.E.S.C.U.M.E.	INC-ZONE	Path history	All vehicles	Emergency vehicles		✓	
R.E.S.C.U.M.E.	INC-ZONE	Path prediction	All vehicles	Emergency vehicles		✓	
R.E.S.C.U.M.E.	INC-ZONE	Position (local 3D)	All vehicles	Emergency vehicles	✓		
R.E.S.C.U.M.E.	INC-ZONE	Road coefficient of friction	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	INC-ZONE	Vehicle size	All vehicles	Other infrastructure	✓		✓
R.E.S.C.U.M.E.	INC-ZONE	Vehicle type (fleet vehicles)	All vehicles	Emergency vehicles		✓	
R.E.S.C.U.M.E.	RESP-STG	Airbag deployment	All vehicles	Other infrastructure		✓	
R.E.S.C.U.M.E.	RESP-STG	Ambient air pressure	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Ambient air temperature	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Antilock Brake System active over 100 msec	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Crash delta V	All vehicles	Other infrastructure			
R.E.S.C.U.M.E.	RESP-STG	Electronic manifest	Freight vehicles	Other infrastructure			
R.E.S.C.U.M.E.	RESP-STG	Estimated point of impact	All vehicles	Other infrastructure			
R.E.S.C.U.M.E.	RESP-STG	Exterior lights (status)	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Hazard lights active	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Lights changed	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Motion	All vehicles	Other infrastructure	✓		✓
R.E.S.C.U.M.E.	RESP-STG	Number of occupants	All vehicles	Other infrastructure			
R.E.S.C.U.M.E.	RESP-STG	Occupant medical data	All vehicles	Other infrastructure			
R.E.S.C.U.M.E.	RESP-STG	Occupant safety belt use	All vehicles	Other infrastructure			
R.E.S.C.U.M.E.	RESP-STG	Position (local 3D)	All vehicles	Other infrastructure	✓		✓

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
R.E.S.C.U.M.E.	RESP-STG	Rain sensor	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Real-time navigation instructions	Other infrastructure	Emergency vehicles			
R.E.S.C.U.M.E.	RESP-STG	Recent or current hard braking	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Road coefficient of friction	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Staging plans	Other infrastructure	Emergency vehicles			
R.E.S.C.U.M.E.	RESP-STG	Still and video images from center	Other infrastructure	Emergency vehicles			
R.E.S.C.U.M.E.	RESP-STG	Still and video images from emergency vehicles	Emergency vehicles	Other infrastructure			
R.E.S.C.U.M.E.	RESP-STG	Traction Control System active over 100 msec	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Vehicle fuel type	All vehicles	Other infrastructure			
R.E.S.C.U.M.E.	RESP-STG	Vehicle resting position	All vehicles	Other infrastructure			
R.E.S.C.U.M.E.	RESP-STG	Vehicle size	All vehicles	Other infrastructure	✓		✓
R.E.S.C.U.M.E.	RESP-STG	Vehicle type (fleet)	Freight vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Wiper status	All vehicles	Other infrastructure		✓	✓
R.E.S.C.U.M.E.	RESP-STG	Wipers changed	All vehicles	Other infrastructure		✓	✓
Weather	Variable Spd Limits for Wx	Ambient air pressure	Maintenance vehicle	Other infrastructure		✓	✓
Weather	Variable Spd Limits for Wx	Ambient air temperature	Maintenance vehicle	Other infrastructure		✓	✓
Weather	Variable Spd Limits for Wx	Antilock Brake System active over 100 msec	Maintenance vehicle	Other infrastructure	✓		✓
Weather	Variable Spd Limits for Wx	Exterior lights (status)	Maintenance vehicle	Other infrastructure		✓	✓

Bundle	Application	Data Element	Source	Sink	In BSM Part 1	In BSM Part 2	Candidate for BMM
Weather	Variable Spd Limits for Wx	Lights changed	Maintenance vehicle	Other infrastructure		✓	✓
Weather	Variable Spd Limits for Wx	Rain sensor	Maintenance vehicle	Other infrastructure		✓	✓
Weather	Variable Spd Limits for Wx	Road coefficient of friction	Maintenance vehicle	Other infrastructure		✓	✓
Weather	Variable Spd Limits for Wx	Traction Control System active over 100 msec	Maintenance vehicle	Other infrastructure	✓		✓
Weather	Variable Spd Limits for Wx	Wiper status	Maintenance vehicle	Other infrastructure		✓	✓
Weather	Variable Spd Limits for Wx	Wipers changed	Maintenance vehicle	Other infrastructure		✓	✓
Weather	Wx Info for Fleet	Current location	Maintenance Vehicle	Other infrastructure	✓		
Weather	Wx Info for Fleet	Powertrain diagnostic information	Maintenance Vehicle	Other infrastructure			
Weather	Wx Info for Fleet	Status of vehicle components (e.g., spreader, plow)	Maintenance Vehicle	Other infrastructure			
Weather	Wx Info for Fleet	Types and amount of materials on-board	Maintenance Vehicle	Other infrastructure			

APPENDIX E. Change from Versions 1 and 2

This update incorporates additional information obtained from the latest available System Requirements documents and updated Concepts of Operation for each of the DMA Bundles. The system requirements documents for the bundles were created after versions 1 and 2 of this report were written. These documents contain a wealth of additional information and were used as key references in this update. However, some details are still to be determined, some information flows will be implementation-dependent, and a small number of internal inconsistencies were found in the requirements documents. As a result, some judgment was still needed in estimating some of the information exchanges.

Overall, there were a substantial number of changes made to the data elements for the applications. In addition, The Integrated Corridor Management bundle and several individual applications (e.g., Electronic Fare Payment) were dropped to reflect the current focus of the DMA program. The M-ISIG applications were merged into one application for purposes of analysis in this paper, as they were analyzed in this manner in the M-ISIG requirements document.

Based on the additional information that is now available, two additional analyses were conducted that were not part of versions 1 or 2 of this report. First, the DMA applications that require DSRC have been identified, as discussed in Chapter 4. Second, the data elements that are candidates for inclusion in a Basic Mobility Message (BMM) this is sent from vehicles to infrastructure systems have been identified. This is discussed in more detail in Chapter 4. Finally, the tables in Appendices C and D now include data flowing both from and to vehicles, whereas the tables in versions 1 and 2 of this report only included data flowing from vehicles

APPENDIX F. List of Acronyms

ABS	Antilock Braking System
AACN	Advanced Automatic Crash Notification
AERIS	Applications for the Environment: Real-Time Information Synthesis
ASN.1	Abstract Syntax Notation One
ATIS	Advanced Traveler Information Systems
BMM	Basic Mobility Message
BSM	Basic Safety Message
CACC	Cooperative Adaptive Cruise Control
DE	Data Element
DF	Data Frame
DMA	Dynamic Mobility Applications
DOT	Department of Transportation
DRG	Dynamic Route Guidance
D-RIDE	Dynamic Ridesharing
DR-OPT	Drayage Optimization
DSRC	Dedicated Short Range Communications
ETA	Estimated Time of Arrival
EU	European Union
[EV] DRG	Dynamic Routing of Emergency Vehicles
EVAC	Emergency Communications and Evacuation
F-ATIS	Freight Real-time Traveler Information with Performance Monitoring
F-DRG	Freight Dynamic Route Guidance
FHWA	Federal Highway Administration
FRATIS	Freight Advanced Traveler Information Systems
FSP	Freight Signal Priority
GIS	Geographic Information System
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HAZMAT	Hazardous material.
I2V	Infrastructure to Vehicle

IDTO	Integrated Dynamic Transit Operations
INC-ZONE	Incident Scene Workzone Alerts for Drivers and Workers
INFLO	Integrated Network Flow Optimization
I-SIG	Intelligent Traffic Signal System
ITIS	International Traveler Information Systems
ITS	Intelligent Transportation Systems
ITS JPO	Intelligent Transportation Systems Joint Program Office
M-ISIG	Multi-Modal Intelligent Traffic Signal System
MDSS	Maintenance Decision Support System
MMITSS	Multi-Modal Intelligent Traffic Signal System
NHTSA	National Highway Traffic Safety Administration
NTCIP	National Transportation Communications for ITS Protocol
PED-SIG	Mobile Accessible Pedestrian Signal System
PREEMPT	Emergency Vehicle Preemption with Proximity Warning
Q-WARN	Queue Warning
RAMP	Next Generation Ramp Metering System
RDE	Research Data Exchange
RESP-STG	Incident Scene Pre-Arrival Staging and Guidance for Emergency Responders
RITA	Research and Innovative Technology Administration
RPM	Revolutions Per Minute
RTCM	Radio Technical Commission for Maritime Services
S-PARK	Smart Park and Ride
SPD-HARM	Dynamic Speed Harmonization
T-CONNECT	Connection Protection
T-DISP	Dynamic Transit Operations
T-MAP	Universal Map Application
TBD	To Be Determined
TSP	Transit Signal Priority
USDOT	United States Department of Transportation
V2I	Vehicle to Infrastructure
VII	Vehicle Infrastructure Integration
VIN	Vehicle Identification Number
VMT	Mileage Based User Fee

WX	Weather
WX-INFO	Real-Time Route Specific Weather Information for Motorized and Non-Motorized Vehicles
WX-MDSS	Enhanced MDSS Communication

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