



SURFACE VEHICLE STANDARD

J2945™/4

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Road Safety Applications

RATIONALE

This SAE Standard defines a new structure called road safety message (RSM) based on the SAE J2735 traveler information message (TIM) to reflect the lessons learned from various deployments. The functionality of the message set is improved for message linking, content segmentation, and message forwarding within a security framework. Five use cases are also considered.

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1. GENERAL [INFORMATIVE]

1.1 Scope

This SAE Standard specifies message set requirements for roadside safety applications, including detailed systems engineering documentation (needs and requirements mapped to appropriate data exchanges). The applications include:

- Curve speed warning (CSW)
- Reduced speed zone warning (RSZW)
- Lane closure warning (LCW)
- Dynamic traveler information (DTI)
- Incident information (INC)

This document defines a new road safety message (RSM) and the use of infrastructure-to-vehicle communications capabilities defined in other standards, including SAE Standards, and the National ITS Architecture. This does not define a single, generic, broadcast application for infrastructure systems, but a message set and structures to support the above listed applications.

The new message and its structure enable additional applications to add new material to the common framework that is defined herein. This allows further development and deployment of new applications with new message content in the future.

The purpose of this document is to enable roadside safety application interoperability using I2V communications, although its use with V2V and V2X is anticipated and not precluded.

1.2 References

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

1.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J2540-2	ITIS Phrase Lists (International Traveler Information Systems)
SAE J2735	V2X Communications Message Set Dictionary
SAE J2945	Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for SAE J2945/x Documents and Common Design Concepts™
SAE J2945/1	On-Board System Requirements for V2V Safety Communications
SAE J2945/3	Requirements for Road Weather Applications
SAE J3067	Candidate Improvements to Dedicated Short Range Communications (DSRC) Message Set Dictionary [SAE J2735] Using Systems Engineering Methods
SAE J3161	LTE Vehicle-to-Everything (LTE-V2X) Deployment Profiles and Radio Parameters for Single Radio Channel Multi-Service Coexistence

1.2.2 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE Std 1609.2 IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Applications and Management Messages

IEEE Std 1609.3 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services

IEEE Registration Authority PSID Public Listing, <https://standards.ieee.org/products-programs/regauth/psid/public>

It should be noted that there are additional standards in the 1609 suite which are not directly referenced here, but which may also be of assistance to implementers.

1.2.3 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO/TS 19091 Intelligent Transport Systems - Cooperative ITS - Using V2I and I2V Communications for Applications Related to Signalized Intersections

1.2.4 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

1.2.4.1 U.S. Department of Transportation (DOT) Publications

Parikh, J., Abubakr, M., Adla, R., Bitar, G., Goudy, R., Kailas, A., Kelkar, A., Meier, J., Sakakida, M., Vijayakumar, V., Yamamoto, M., Deering, R., and Kiger, S. (2017). Vehicle-to-infrastructure program safety applications project: Final report. *U.S. Department of Transportation (DOT)*, report number FHWA-JPO-18-606, <https://rosap.ntl.bts.gov/view/dot/37212>.

U.S. DOT. (2013). Manual on uniform traffic control devices for streets and highways - 2009 edition with 2012 revisions. *U.S. Department of Transportation (DOT) and Federal Highway Administration (FHWA)*.

U.S. DOT. (2016). Privacy impact assessment: National Highway Traffic Safety Administration notice of proposed rulemaking (NPRM) on V2V communications. *U.S. Department of Transportation (DOT) and National Highway Traffic Safety Administration (NHTSA)*, <https://www.transportation.gov/sites/dot.gov/files/docs/Privacy%20-%20NHTSA%20-%20V2V%20NPRM%20-%20PIA%20-%20Approved%20-%20122016.pdf>.

U.S. DOT. (2022). Architecture reference for cooperative and intelligent transportation (ARC-IT). *U.S. Department of Transportation (DOT)*, <https://www.arc-it.net/>.

U.S. DOT. (n.d.). Vehicle-to-vehicle communication technology. *U.S. Department of Transportation (DOT) and National Highway Traffic Safety Administration (NHTSA)*, https://www.nhtsa.gov/sites/nhtsa.gov/files/documents/v2v_fact_sheet_101414_v2a.pdf.

1.2.4.2 NTCIP Publications

AASHTO, ITE, and NEMA. (2009). National transportations communications for ITS protocol: Environmental sensor stration (ESS) interface protocol. *American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), and National Electrical Manufacturers Association (NEMA)*, standard number NTCIP 1204 version v03, <https://www.ntcip.org/file/2018/11/NTCIP1204v0308r3withErrata.pdf>.

AASHTO, ITE, and NEMA. (2016). National transportations communications for ITS protocol: Content outline for NTCIP 1200-series documents (for standards engineering process (SEP) content). *American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), and National Electrical Manufacturers Association (NEMA)*, standard number NTCIP 8002 Annex B1 version v01, https://www.ntcip.org/file/2018/11/NTCIP8002_AnnexB1v0120160919.pdf.

1.2.4.3 NIST Publications

McCallister, E., Grance, T., and Scarfone, K. (2010). Guide to protecting the confidentiality of personally identifiable informatino (PII). *National Institute of Standards and Technology (NIST)*, publication number SP 800-122, <https://csrc.nist.gov/publications/detail/sp/800-122/final>.

1.2.4.4 INCOSE Publications

INCOSE. (2015). Systems engineering handbook: A guide for system life cycle processes and activities, 4th edition. *International Council for Systems Engineering (INCOSE)*.

1.2.4.5 FCC Publications

FCC. (2015). Guidelines for determining the effective radiated power (ERP) and equivalent isotropically radiated power (EIRP) of an RF transmitting system. *Federal Communications Commission (FCC)*, document number 412172 D01, https://apps.fcc.gov/kdb/GetAttachment.html?id=fzIsGm%2Fe68Ymx58IAmzNbw%3D%3D&desc=412172%20D01%20Determining%20ERP%20and%20EIRP%20v01r01&tracking_number=47469.

1.3 General Statements

This outline section is included to comply with NTCIP format.¹ There is no content for this section in this document.

1.4 Terms

For the purposes of this document, the definitions, abbreviations and acronyms found in SAE J2735 shall apply. The following additional definitions, abbreviations and acronyms supersede those found in in SAE J2735 in the case of conflict. The definitions in J2945 are incorporated by reference.

1.4.1 Definitions

For the purposes of this document, the following additional definitions shall apply.

DYNAMIC TRAVELER INFORMATION (DTI): Traditionally, text-based information provided to travelers via variable/dynamic/changeable message signs along or over a roadway. Information may be text-based, graphic/icon based, or audio. The exact method of presentation to a driver is out of scope of this document.

INCIDENT INFORMATION: Information related to (typically) point-based incidents affecting traffic or driving patterns. This may include vehicle collisions, debris on the roadway, or other unstructured events that may or may not have structured map information associated with it.

¹ "NTCIP format" is used throughout this document to refer to the document structure defined in NTCIP 8002 Annex B1 version v01.

ROAD SAFETY MESSAGE (RSM): A message providing timely safety information from an infrastructure entity to a roadway user.

SECURITY CREDENTIAL MANAGEMENT SYSTEM (SCMS): A component that facilitates, issues, distributes, and revokes security credentials for devices operating within the ITS communications system.

1.4.2 Abbreviations

The additional abbreviations and acronyms cited below shall be a part of the terms of this document (and of the other companion volumes and guides) unless specifically cited otherwise.

CSW	Curve Speed Warning
C-V2X	Cellular Vehicle-to-Everything
DSRC	Dedicated Short Range Communication
DTI	Dynamic Traveler Information
EDCA	Enhanced Distributed Channel Access
I2V	Infrastructure-to-Vehicle (also called V2I)
INC	Incident Information
LC	Lane Closure
LTE	Long-Term Evolution
MUTCD	Manual on Uniform Traffic Control Devices
NRTM	Needs to Requirements Traceability Matrix
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
PPPP	ProSe per Packet Priority
RS	Road Safety
RSM	Road Safety Message
RSU	Roadside Unit
RSZW	Reduced Speed Zone Warning
RTM	Requirements Traceability Matrix
SCMS	Security Credential Management System
SSP	Service Specific Permissions
V2V	Vehicle-to-Vehicle
WAVE	Wireless Access in Vehicular Environments
WSMP	WAVE Short Message Protocol

2. CONCEPT OF OPERATIONS [NORMATIVE]

This document provides a set of requirements and a design for the following use cases.

- Reduced speed zone warning (RSZW)
- Curve speed warning (CSW)
- Lane closures (LC)
- Dynamic traveler information (DTI)
- Incident information (INC)

This document includes a Needs to Requirements Traceability Matrix (NRTM) which provides a mapping between the user needs and the functional requirements which have been developed to meet these needs. It also includes a Requirements Traceability Matrix (RTM), which provides a mapping from the functional requirements to the profiled data concept (dialog, message, data frame, or data element) which is required to meet those requirements. The data concepts themselves are taken (by reference) from the SAE J2735 data dictionary, and additional constraints are applied to profile them to meet additional design requirements, when needed. The data concepts used from SAE J2735 are listed in Section 5. Unlike a typical data dictionary entry, these entries simply list the concept (refer to SAE J2735 for details) and then provide any additional profiling constraints needed. Additional content, when needed, is also defined.

This section consists of a concept of operations that identifies user needs related to the applications supported by this document. Developing and explaining these general concepts is the primary content to be found in this section of the document.

2.1 Tutorial [Informative]

This document was developed using an adaptation of the formal systems engineering process defined by INCOSE. The diagram below provides an overview of where system engineering artifacts are located in this document.

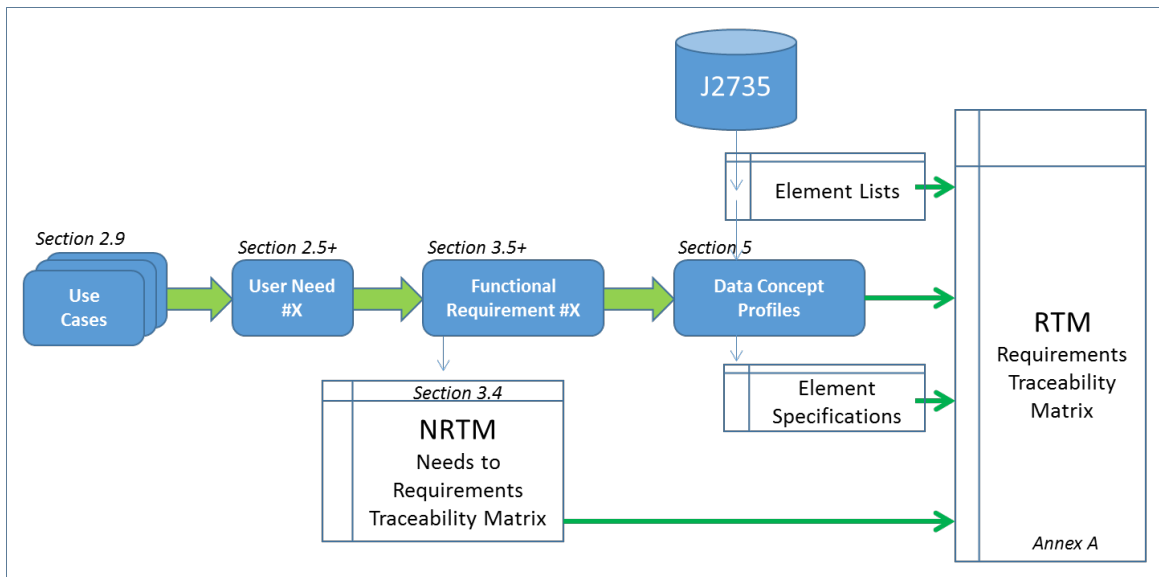


Figure 1 - Location of system engineering artifacts

An overview of how to navigate from user needs to functional requirements in the NRTM to dialogs and data elements in the RTM is shown in [Figure 2](#), which demonstrates how traceability works across the various tables in this document.

User Need

User Need ID	User Need Title	User Need
2.5.2.3.1.3	Transmit Emergency Status	First Responder RVs in active service states need to transmit service state, heading, and location information under both optimal and sub-optimal conditions. This information helps the HV determine the correct response to the presence of the RV.

Requirements

FR ID	Functional Requirement Title	Functional Requirement
3.6.2.1.4	Broadcast Emergency Alert Information	First Responder RV shall broadcast the following information elements: Service State (as specified in Section 2.2.3 Service States), and Event Flags (as specified in J2945/1 Section 6.3.1).

Needs to Requirements Traceability Matrix (NRTM)

User Need ID	User Need Title	FR ID	Functional Requirement Title	Conformance	Support	Additional Specifications
2.5.2.3.1.3	Transmit Emergency Status			M	Yes	
		3.6.2.1.4	Broadcast Emergency Alert Information	M	Yes	

Requirements Traceability Matrix (RTM)

FR ID	Functional Requirement Title	Dialog ID	Data Concept ID	Data Concept Name	Additional Specifications
3.6.2.1.4	Broadcast Emergency Alert Information	4.2.1			
			5.3.2	DF_EVAvehicleExtension	
			5.4.19	DE_ServiceState	
			SAE J2735_201603 6.8	DE_BSMCoreData	Default, Value range restrictions...

J2735

Figure 2 - Needs to requirements traceability**2.2 Current Situation and Problem Statement [Informative]**

This document covers a number of use cases where information is provided from the roadway and/or infrastructure to vehicles and other users (data consumers). Information provided to travelers is intended to help make drivers and other roadway users more aware of their environment and be more prepared for current and upcoming traffic and roadway situations. By being more aware of and prepared for specific driving conditions, users can make more informed decisions regarding travel routes, modes of transportations, departure times, and be more responsive to upcoming situations such as lane closures and construction. By increasing the effectiveness of individual travelers' plans and actions, the transportation system can be more effectively utilized, reducing congestion and increasing opportunities to avoid or minimize collisions and incidents.

2.3 Reference Physical Architecture

The assumptions which developers can reasonably make when developing detailed design descriptions of the road safety system environment are described in the U.S. DOT ARC-IT and incorporated here by reference only. This reference architecture is provided as example only and does not preclude alternate architectures from utilizing the messages and applications described herein.

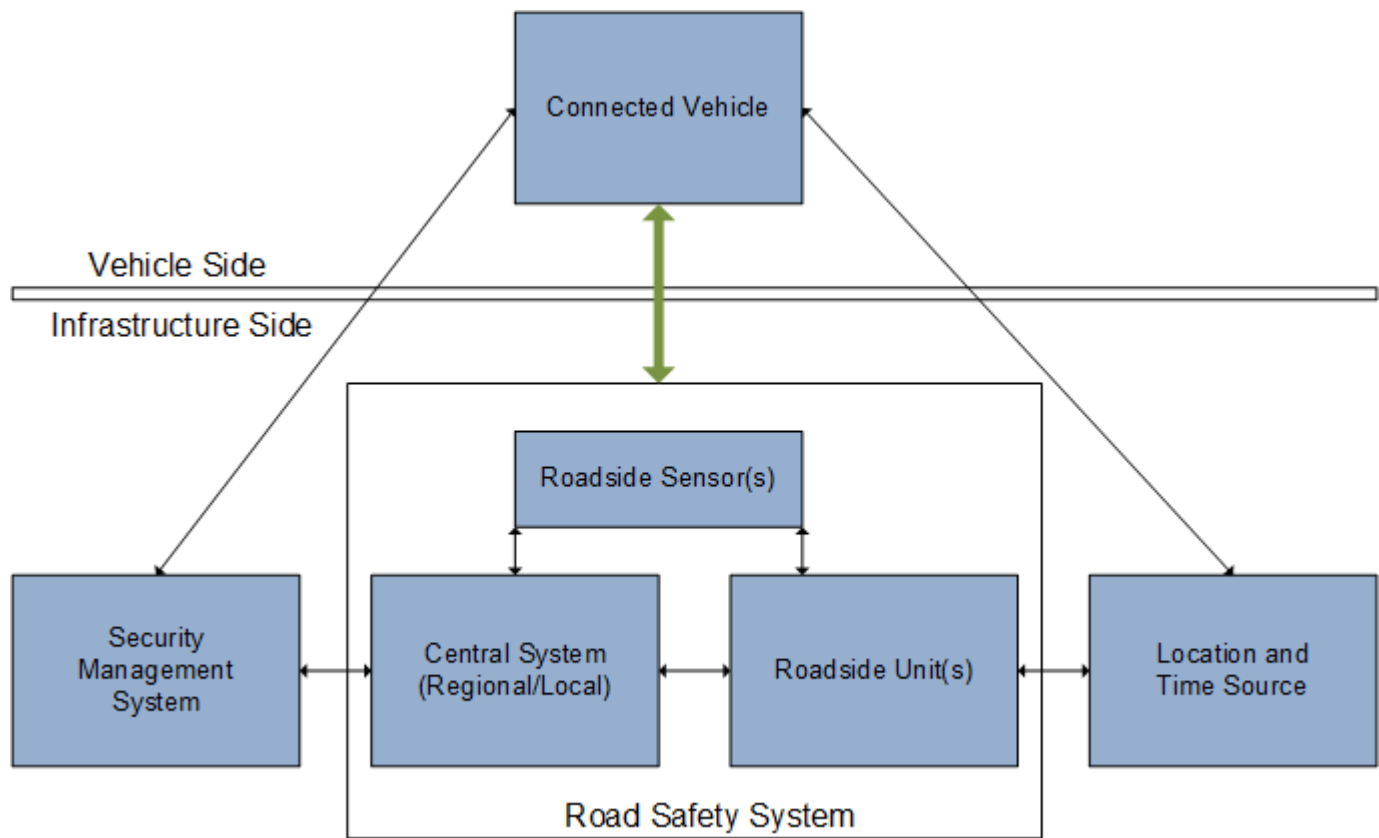


Figure 3 - Reference physical architecture

A note on plural and singular names. It is presumed more than one roadside unit (RSU) and roadside sensor is present in the system. These elements may have direct connections to one another, but this is outside of the scope of this document.

The elements of the system include:

- **Connected vehicle:** A vehicle equipped with devices enabling interoperable network wireless communication with applicable RSUs. Each connected vehicle receives information from the infrastructure (typically via broadcast messages from an RSU; however, information may be received through other channels as well) that relates to a certain I2V safety application use case. The internal functionality of the connected vehicle is outside the scope of the document; only the interface to it is within scope.
- **Roadside unit (RSU):** The RSUs are devices that enable interoperable wireless communication with connected vehicles and personal devices via broadcast messages. Applications or algorithms may run locally on the RSU to process data and generate messages/information to be broadcast to vehicles. Information may be generated on a backhaul system within or external to the central system and may use the RSU as a distribution point. The RSU may also sign locally generated information using credentials provided by the security management system or information may be signed by the central system or other entity from which the information was created.
- **Central system:** Central systems include common infrastructure elements such as a traffic management center (TMC). The central system manages the collection of information and distribution of messages that support the safety applications use cases. The central system may also sign messages using credentials provided by the security management system or otherwise provide or facilitate management of credentials on a RSU.
- **Security management system:** The security management system provides certificates to components of the system to support signing of messages. The security credential management system (SCMS) is outside the scope of this document, but the security profiles used by a central system are within scope.

- Roadside sensor: Roadside sensor(s) are connected to the central system or to an RSU and provide the capability to monitor real-time changes associated with a roadway (e.g., moisture or ice on a curve, wrong way drivers). Roadside sensors may be interconnected through intermediate systems, sometimes referred to as “field masters,” which are assumed part of the central system in this document. The functionality of roadside sensors is outside the scope of this document.
- Location and time source: GPS/GNSS is typically the source for location and time information, but the corresponding functionality is outside the scope of requirements in this document. For messages and content defined herein, locations are assumed to be defined with respect to the most recent WGS84 reference frame.
- Road safety system: The collection of infrastructure components that manage and create the road safety information that is distributed to roadway users. The road safety system may make information available to vehicles and roadway users via alternate means as well (i.e., it is not required that messages be broadcast through physical RSUs).

2.4 Architectural Needs

SAE J2945/4 defines the message and structures used to convey road safety information from infrastructure-based traffic management systems to connected vehicles and other roadway users. Various architectures may be employed to collect roadway data used to generate road safety information. The roadside safety application data may be provided by external systems or derived internally to the central system. The method by which the information is generated is out of scope of this document. Once generated, the road safety system needs to make the information available to roadway users and ensure the integrity of the content can be verified by receivers.

2.4.1 Data Distribution

The road safety system needs to have means for communicating roadside safety application data to vehicles/roadway users. Such means may include wireless communication interfaces in RSUs providing local coverage and/or cellular-like wireless interfaces in base stations that provide wide-area coverage.

2.5 Features

This section includes the user needs associated with roadside safety applications. Many needs are applicable to both the provider of the information (road safety system) and consumer (vehicle or roadway user) but are not duplicated below.

Infrastructure generated safety information is currently communicated to vehicle operators primarily via static or dynamic road signs which limit the granularity and geographic resolution of information. This limitation often means these signs may not inform the vehicle systems of impending hazards at appropriate locations. For the use cases described in this document, dynamic information is provided to connected vehicles so that the vehicles can calculate whether the vehicle operator should be warned or recommended a corrective action. If the information needed to support I2V roadside safety applications is provided to the vehicle via a communications interface from the road infrastructure, vehicles will have the information needed to determine if driver warnings are necessary.

An initial set of applications are described here that leverage traveler information that can be conveyed in the RSM defined by this standard.

The applications use cases within the scope of this document are described in [Table 1](#).

Table 1 - Use case high-level descriptions

Use Case	High-Level Description
Lane closures (LCs)	Lane closures may result from planned construction, debris in the roadway, or incidents. Vehicles provided with advance information regarding lane closures can change their path and/or speed as necessary to accommodate the changes in the roadway topology.
Reduced speed zone warning (RSZW)	Work zones and school zones may have reduced speed limits posted during scheduled times or during periods of activity. Agencies may also implement variable speed limits in areas as a result of traffic congestion (applying speed harmonization to upstream traffic), inclement weather (fog or other causes of reduced visibility), or other factors. These reduced speed limits are generally regulatory in nature, as opposed to advisory, and apply to all vehicles or types/classes of vehicles (i.e., commercial/heavy trucks). Vehicles need to be provided information regarding changes in speed limits in order to appropriately warn drivers of upcoming speed reductions and changes to the standard posted speed limit.
Curve speed warning (CSW)	A curve speed warning is similar to a reduced speed zone warning; however, it provides a recommended or advisory speed as opposed to a regulatory speed limit. There may be additional details provided regarding the roadway including curvature and transient conditions, such as wet or icy roads, that a vehicle can use to determine if it is appropriate to warn a driver of excessive speed based on a computation that considers vehicle dynamics (i.e., vehicles with heavy loads or high center of gravity).
Incidents (INC)	Vehicle collisions, debris in the roadway, and other incidents occur along roadways, often in unplanned locations and at unplanned times. These incidents may result in lane closures or whole road closures and require temporary traffic rerouting. While the physical event itself may be isolated to one direction of traffic, the effects are often seen in traffic travelling in the other direction and on adjacent roads. Broadcasting this information to drivers may allow approaching traffic to be rerouted earlier if necessary or to provide advanced alerting to drivers approaching the incident. This use case communicates information related to specific events along a roadway at specific locations that are generally unplanned and unstructured. These events or disturbances may require one or more authorities to respond. This information generally implies a need for increased awareness by the driver.
Dynamic traveler information (DTI)	Infrastructure operators' primary mechanism for providing information to drivers is through simple text displayed on dynamic message signs (DMS) (also called variable message signs (VMS) or changeable message signs (CMS)). This use case allows infrastructure operators to transition from current traveler information distribution seamlessly, via aforementioned DMS, to more granular and structured information distribution. Information may be presented to drivers based on context, and may or may not include detailed region information. The expectation is that as the number of applications and use case specific structured frames are created and available as payloads in the RSM, the need for and use of this generic information frame will decrease.

2.5.1 Message Structure and Content Needs

In addition to application needs, each of which may have specific needs regarding the RSM content, structure, and organization, there are high-level needs for the message in order to support and promote future extensibility by new applications and use cases and to support generation and consumption by systems with varying capabilities.

2.5.1.1 Common Message Structure

A practical aspect of the message set design goals is the need for a uniform set of structures to be employed across the supported application areas. This provides for the reuse of established methodologies, lowering deployment costs and leveraging prior work. Further, this should provide a well-defined mechanism for the creation of new content as the supported application areas grow with time. The ideal solution would not impact previously defined and deployed application areas.

It is presumed that a common framework can be developed in this first edition of the RSM document that will then be added to in future editions.

2.5.1.2 Common Message Header

A further practical aspect of the message set design goals is the need for a common header element in the message that allows the end user to discern the general contents of the message, the geographical area(s) to which it applies, and other core aspects of the message body content. This provides a common means for the receiver of the message to determine if the message is relevant to their situation without the need to process every informational element present in the message.

2.5.1.3 Cross Message Linking

A further practical aspect of the message set design goals is to be able to reuse and link to supporting information found in other messages of the V2X Communications Message Set (SAE J2735), and potentially other message types developed by others. It is inefficient to repeat such data. When the Wave Short Message Protocol (WSMP) method is used, bandwidth is very limited and large and complex messages are to be discouraged.

Additional information may be available through a range of other media or methods of communication, including streaming audio, images, or video, via AM, FM, satellite, HTTP, TCP/IP, UDP/IP, WSM, or other mechanisms.

Driver distraction is a major cause of accidents. A RSM contains information that may be important for a driver to receive regarding weather conditions, road closures, accidents, and local disasters (explosions, chemical leaks, bomb threats, etc.); however, if the information and actions that must be taken to avoid the threat are too complicated, the steps necessary to read the information may distract the driver and cause an accident or the driver may ignore the critical information while engaged in driving and perhaps listening to audio entertainment. A cross-linking extension for these messages can allow additional information to be conveyed via a channel or channels that may be broadcasting real-time updates to the conditions that prompted the event. Listening to an out-of-band audio clip or a talk channel can provide a more user-friendly and less distracting means of conveying roadside safety information to a driver than a text-based messaging system.

The road safety system needs to indicate individual events that are associated with each other. A single event may be a result of another prior event that is already being managed or a road safety system may manage multiple simultaneous events via a higher level event management process. An example may be a lane closure event and traffic congestion event that are caused by a collision or incident event. Each event may have different times and/or geographic regions applicable to it.

2.5.2 Event Identification

The road safety system needs to uniquely identify each individual event. This will help track events over time and allow vehicles to differentiate between individual events. IDs should be globally unique, potentially constructed from one or more pieces of information including region identification, roadway identification, agency, jurisdiction, time, or other values.

2.5.3 Event Type

The road safety system needs to indicate the type of event that provides a general description of the content that follows. This allows an application to provide some level of information to a user even if the detailed content is not parsed or available. Event types should be high level enough to support future applications and message content without needing to append the supported types here more often than necessary.

2.5.4 Event Location

The road safety system needs to indicate the location of the event. This allows a vehicle to determine geographic applicability of information. Depending on the source of the information used to generate the event and the resolution of available map/geographic data, the type, resolution, and accuracy of the location may vary. Events should have one or more regions of applicability defined and may optionally also have one or more approach regions defined. Individual event content frames may specify if an approach region is necessary.

2.5.4.1 Event Location Definition

The road safety system needs to define locations in terms of WGS-84 latitudes, longitudes, and elevation above the reference ellipsoid. Each type of region that can be utilized may define a specific reference point from which all other points are specified in relative offsets or regions may be defined entirely by explicit latitude and longitude points. For certain region types or sizes (measured by the number of points necessary to define it), it may be more appropriate to leverage relative offsets in order to optimize the encoded message size.

2.5.4.1.1 Event Location Reference Point

Vehicles need to be provided a reference point that can be used to derive the geographic region. The reference point may or may not have contextual significance within the message.

2.5.4.1.2 Event Location Applicable Heading

Vehicles need to be provided the heading or range of headings for which an event is applicable. The applicable heading may be implicitly derived by the region definition itself (for instance, when explicit lanes or roadways are defined by a sequence of consecutive points) or it may be explicitly specified.

2.5.4.1.3 Event Location Uncertainty

Vehicles need to be provided the level of certainty in the accuracy of the region defining the location of the event. Infrastructure systems may use data from a variety of sources, ranging from individual vehicles BSMs or probe data, to reports called in from first responders or other roadway users. Events derived from vehicle BSMs are expected to be accurate to within a few meters or less. Events derived from user reports (i.e., “stalled vehicle about 1/2 mile past Exit 42”) may only be accurate to within hundreds or thousands of meters.

Different types of location definitions may lend themselves to different representations of the location uncertainty. For instance, regions defined as circles or polygons, not along a specific roadway, may have an uncertainty defined in both latitude and longitude for the whole region. For paths or polygons that follow a roadway, the lateral uncertainty (with respect to the direction of travel along the roadway) may be low, while the longitudinal uncertainty (where along the roadway) where the event begins or occurs may be higher. An example of a region with a high longitudinal uncertainty but low lateral uncertainty would be when creating a region that follows a roadway, approaching an incident. An operator knows the incident is on a specific highway (e.g., Northbound Interstate 35), but only knows that it is near a particular mile marker or exit. The region created would follow the path of the road (low lateral uncertainty); however, the exact location along the roadway may only be within 500 m. In this case, an event location uncertainty may be specified indicating a lateral offset/uncertainty of 1 m (or a value appropriate given known accuracy of the road network data), and a longitudinal offset/uncertainty of 500 m (or more or less as appropriate).

2.5.4.2 Event Location Types

The road safety system needs to be able to indicate locations that include single points (location of a single incident or a piece of debris), a broad region such as a circle, polygon, or a path along a roadway.

2.5.4.2.1 Event Location Types - Low Resolution

Vehicles need to be provided with general region definitions such as areas defined by a circle around a point of interest or a large polygon that coarsely defines a region that may or may not follow a specific roadway. Examples of times this region type could be used include large scale evacuation information due to hurricanes or other events, public service announcements such as AMBER alerts, or other times that information may not be constrained to an isolated roadway. There may also be times that more detailed geometry cannot be identified by the source that is generating the information due to limitations of infrastructure map applications but it is still appropriate to generate and send information for an event.

Low resolution regions may cover small or large areas, such as a single intersection, a city block of several intersections, an entire county, or larger areas.

2.5.4.2.1.1 Event Location Types - Circle

The road safety system needs to define a circular region that is defined by a center point and a radius.

2.5.4.2.1.2 Event Location Types - Polygon

The road safety system needs to define a polygonal region that is defined by a sequence of at least three bounding points.

2.5.4.2.2 Event Location Types - Medium Resolution

Vehicles need to be provided with coarse roadway information when an event or information is specific to a known roadway but high-resolution roadway or lane topology may not be available. Examples of times this region type may be used include advanced notification of upcoming incidents, construction, or other events that may affect all lanes of traffic in a general direction of travel, such as notifications of an incident that has one or more lanes blocked on a highway that is accessed by an upcoming ramp or connector from another roadway.

2.5.4.2.2.1 Event Location Types - Broad Region

The road safety system needs to define a broad region that is defined by a consecutive sequence of at least two points with a specified width. The width specified may be the nominal road width or some value that is expected to cover the adjacent roads such as highway service roads or access roads.

Broad paths may cover small or large areas, such as a single approach to an intersection or an entire corridor that is several miles long.

2.5.5 Event Time

The road safety system needs to indicate a start time, end time, and optionally an indication of scheduled recurrences of an event. This information helps vehicles determine when an event is applicable.

2.5.5.1 Event Start Time

The road safety system needs to provide the start time of an event. The start time may be the time at which the event was created in the road safety system for currently active events, or it may be a time in the future for planned events such as lane closures or construction.

2.5.5.2 Event End Time

The road safety system needs to provide the expected end time of an event. There may be events for which the end time is unknown or indefinite.

2.5.5.3 Event Recurrence

The road safety system needs to be able to indicate an event may be a recurring event on a given schedule, such as nightly lane closures or speed changes through school zones. Events may be recurrent throughout a given day, at the same time over multiple days, active during weekdays and/or weekends, and other configurations.

2.5.6 Affected Vehicles

The road safety system needs to indicate classifications of vehicles that are affected by an event. This allows vehicles to determine if a given event applies to them. Information provided from infrastructure operators is at times specific to one or more particular classes of vehicles and/or cargo and may include size or weight restrictions, HAZMAT, or other cargo restrictions, information pertinent to high occupancy vehicles (buses, etc.), or other categories of vehicles. One or more classifications needs to be able to be provided simultaneously. Various well-defined classifications of vehicles exist today and can be employed for this.

2.5.7 Event Updates

The road safety system needs to be able to indicate that information provided for an event has been updated. Updates may be made to the location, time, or event details as a result of more detailed or more accurate information being provided or otherwise made available to the road safety system.

2.5.8 Event Cancellation

The road safety system needs to be able to cancel or end an event prior to a previously provided expiration time.

2.5.9 Application Shared Needs

2.5.9.1 Provide Obstacle Indication

The road safety system needs to provide vehicles with an indication that an obstacle is present on the roadway. This helps the vehicle determine if a warning is necessary.

2.5.9.2 Provide Reduced Visibility Indication

The road safety system needs to provide vehicles with an indication if there is reduced visibility along the roadway. This helps the vehicle determine if a warning is necessary.

2.5.9.3 Provide Indication of People Present

The road safety system needs to provide vehicles with an indication if people are expected to be present in or near the roadway as part of the event. This helps vehicles determine if an advisory is needed for the vehicle operator.

2.5.10 Application Specific Needs

2.5.10.1 Curve Speed Event

The following user needs apply specifically to curve speed warning events.

2.5.10.1.1 Provide Advisory Speed

The road safety system needs to provide vehicles with advised speed for the curve. This helps the vehicle determine safe operating limits for the curve. This is typically the posted recommended speed prior to entering the curve.

2.5.10.1.2 Provide Traction Information

The road safety system needs to provide vehicles with road roughness measurements (depth and width) in microns, and the standard deviation of the measurement. This helps the vehicle determine safe operating limits for the curve.

2.5.10.1.3 Provide Roadway Material

The road safety system needs to provide vehicles with the roadway material of the curve. This helps the vehicle determine the safe operating limits for the curve.

2.5.10.1.4 Provide Minimum Radius

The road safety system needs to provide vehicles with the minimum radius of the curve. This helps the vehicle determine safe operating limits for the curve.

2.5.10.1.5 Provide Bank Angle

The road safety system needs to provide vehicles with the bank angle at the minimum radius of the curve. This helps the vehicle determine safe operating limits for the curve.

2.5.10.1.6 Curve Approach

The road safety system needs to provide vehicles with an approach region to the curve. This helps vehicles determine an appropriate deceleration plan prior to reaching the curve.

2.5.10.1.7 Curve Geometry

The road safety system needs to provide vehicles with the region defining the curve. This helps vehicles determine when they enter and leave the curve.

2.5.10.2 Reduced Speed Zone Event

The following user needs apply specifically to the reduced speed zone warning events. A reduced speed zone may be a work zone, school zone, etc.

2.5.10.2.1 Provide Speed Limit for Reduced Speed Zone

The road safety system needs to provide vehicles with the speed limit within the reduced speed zone. This helps vehicles determine if an advisory is needed for the vehicle operator.

2.5.10.2.2 Reduced Speed Zone Geometry

The road safety system needs to provide vehicles with a region within which the reduced speed applies. This helps vehicles determine where the reduced speed zone is applicable. This should be provided as the applicable region.

2.5.10.2.3 Reduced Speed Zone Approach

The road safety system needs to provide vehicles with an approach region to the reduced speed zone. This helps vehicles determine deceleration plan prior to reaching the reduced speed zone.

2.5.10.3 Lane Closure Warning Needs

The road safety system needs to provide information regarding lane closures.

2.5.10.3.1 Provide Number of Lanes

The road safety system needs to provide vehicles with the number of physical lanes available for vehicles.

2.5.10.3.2 Provide Lane Status

The road safety system needs to provide vehicles with an indication of which lanes are closed.

2.5.10.3.3 Provide Lane Status Consistency

The road safety system needs to provide vehicles with an indication that lane closures may be changing over a given timespan.

2.5.10.3.4 Provide Anomalous Traffic Patterns

The road safety system needs to provide vehicles with an indication that there are or may be anomalous traffic patterns as a result of the lane closure such as construction equipment entering the roadway, slow moving vehicles (including sweepers, plows, and striping) on the roadway, a pilot vehicle leading vehicles on an alternating one-way lane, or others.

2.5.10.3.5 Lane Closure Approach

The road safety system needs to provide vehicles with an approach region to the lane closure. This helps vehicles determine deceleration or lane change plan prior to reaching the closure.

2.5.10.3.6 Lane Closure Geometry

The road safety system needs to provide vehicles with the region defining the lane closure. This helps vehicles determine when they enter and leave the area of the lane closure.

2.5.10.4 Dynamic Traveler Information Needs

The road safety system needs to provide information comparable to what is currently provided via DMS signs.

2.5.10.4.1 Provide Context Information

The road safety system needs to provide vehicles with the type of event for which the information is intended.

2.5.10.4.2 Provide Textual Information

The road safety system needs to provide vehicles with textual information related to an event. It is expected that this information would be comparable to information currently provided on DMS signs over the highway.

2.5.10.4.3 Provide Priority Information

The road safety system needs to provide vehicles with an indication of a priority of the information. The priority may be defined by local agencies or coordinated within a region to prioritize types of information that may be presented to a driver. Examples of the types of content may include public service announcements, AMBER alerts, and alerts of congestion ahead. The priority can be used to determine what is displayed to a driver when multiple pieces of information are applicable over the same area at the same time.

2.5.10.4.4 Provide Content Linking

The road safety system needs to provide vehicles with links to additional content.

2.5.10.4.5 Provide Information Location Applicability

The road safety system needs to provide vehicles with the location where the information applies.

2.5.10.5 Incident Information Needs

The road safety system needs to provide information about the location and timeframe of nearby incidents to help them understand and respond to events along their route, such as unplanned closures or disturbances.

2.5.10.5.1 General Incident Information

The road safety system needs to provide vehicles with a general description of the incident, such as a collision, debris on the road, HAZMAT related, and others.

2.5.10.5.2 Incident Responder Type

The road safety system needs to provide vehicles with the type of responders involved or anticipated, if any.

2.5.10.5.3 Provide Indication of People Present

The road safety system needs to provide vehicles with an indication if people are expected to be present in or near the roadway as part of the event.

2.5.10.5.4 Provide Incident Location

The road safety system needs to provide vehicles with the location of the incident.

2.6 Security

The road safety system requires a data integrity mechanism at a centralized location (i.e., traffic management center) and also in the field for applications/systems that are deployed remotely and may generate information without a central system being directly in the loop. Various information produced by the infrastructure, such as speed limits for instance, may require special approval within the IOO based on infrastructure policies in place and thus may warrant being provided in standalone messages or payloads from other content that does not have the same approval or signing requirements. No privacy needs are identified.

2.6.1 Data Source Authenticity

The system needs to provide a mechanism to authenticate sources of information. This helps vehicles determine that the data is legitimate.

2.6.2 Data Source Authorization

The road safety system needs to be able to attest to the authorization to disseminate certain types of content that may require higher approval levels based on agency or operator policies and authority.

Road safety information can be divided into two main categories: regulatory and informative/advisory.

Regulatory information includes information that conveys traffic laws or regulations and indicates applicability of legal requirements. Examples include information traditionally presented by regulatory signs as defined by the FHWA MUTCD and supplemented by state extensions of the MUTCD, such as speed limits, lane restrictions, and allowed or restricted lane movements. For a complete list of regulatory content, refer to the appropriate MUTCD handbooks. Within the context of the applications and message structures defined in this initial release, inclusion of the RegulatorySpeedLimit frame is the only item that should be considered as regulatory information.

Informative information includes all other non-regulatory information at this time and does not require additional security permissions.

2.6.3 Data Integrity and Availability

The system needs provide a mechanism to verify that data has not been changed or delayed between the road safety system that produced the data and the receivers that consume the data.

2.7 Operational Policies and Constraints

Operational policies for generating and distributing road safety and traveler information may vary from state to state and agency to agency, in particular the level of authority required for generating regulatory information. There is no standardized policy across the United States that defines the policy or process by which local agencies administer regulatory control over roadways within their jurisdiction.

2.8 Relationship to the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) [Informative]

The following are the information flows from the ARC-IT (version 9.1) that are addressed by SAE J2945/4:

- Broadcast traveler information: General traveler information that contains traffic and road conditions, link travel times, incidents, advisories, restrictions, work zones, transit service information, weather information, parking information, and other related traveler information.
- Local traveler information: Traveler information including traffic, road, and weather conditions for a particular locality. This flow includes the location-specific traveler information and time effectivity of the information.
- Reduced speed notification: Reduced speed zone information provided to passing vehicles. This flow provides the reduced speed limit, the location and extent of the reduced speed zone, and associated warning information.
- Lane closure information: Lane closure information provided to passing vehicles. This flow provides information about roadway configuration changes such as lane closures and shifts.

[Table 2](#) shows how these architecture flows are mapped to the service packages providing ITS services that are supported by the user needs in [2.5](#). A service package is the subset of the National ITS Architecture that provides a specific ITS service.

Table 2 - National ITS architecture mapping: traveler information

Service Packages	Information Flow
TI-01 - Broadcast Travel Information	Local traveler information
TI-01 - Broadcast Travel Information	Broadcast traveler information
VS09 - Reduced Speed Zone Warning/Lane Closure	Reduced speed notification
VS09 - Reduced Speed Zone Warning/Lane Closure	Lane closure information
VS05 - Curve Speed Warning	Reduced speed notification

2.9 Operational Scenarios [Informative]

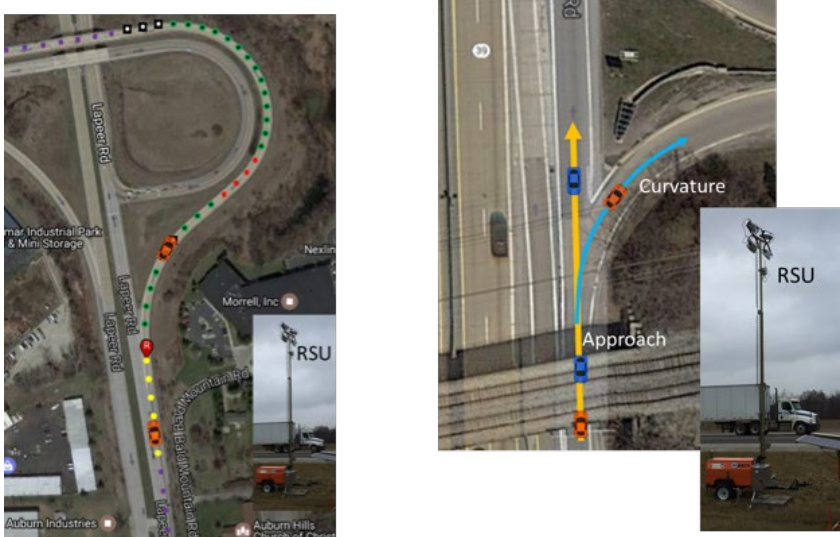
This section describes at a high level how each application works. Each application is described below using an information flow that includes a physical RSU as the means by which vehicles receive the application information from the infrastructure. The use of a physical RSU is for example only. Information may be sent over cellular networks, satellite, or other means.

Each use case should be presented with some or all the following information:

- Use case name.
- Category (typically safety/mobility/environment).
- Short description (summary).
- Actors (participants).
- Goal (desired result).
- Needs (problem to be addressed).
- Constraints/presumptions (limitations or assumptions).
- Geographic scope (range and type).
- Timing scope (current, predictive, recurring, historical).
- Illustration (graphical representation of actors, events, environment).
- Pre-conditions (conditions assumed before start of the use case).
- Main event flow (primary sequence of events and interactions).
- Alternate event flow(s) (alternative sequence given conditions).
- Post-conditions (anticipated conditions after the interactions are complete).
- Information requirements (data elements that are exchanged between actors).
- Issues (concerns related to the use case or implementation).
- Source documents/references (external documents used as reference).

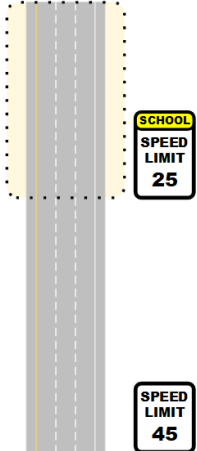
2.9.1 Curve Speed Warning (CSW)

Table 3 - Curve speed warning

Use Case Name	Curve Speed Warning (CSW)
Category	Safety
Short Description	A vehicle approaches a curve and it receives a broadcast message from nearby RSU that includes information used by the vehicle to determine if the driver should be alerted.
Actors	The road safety system and the connected vehicle.
Infrastructure Roles	The system determines the current situation for a specific curve and then provides situation awareness messages to vehicles.
Vehicle Roles	The connected vehicle interprets the situation awareness information and determines the impact on the vehicle and operators.
Goal	Alert driver appropriately (if determined necessary by the vehicle).
Constraints/Presumptions	- The RSU receives the RSM from a central system and stores it for periodic broadcast. - Security functionality in place to enable authentication of data sources and secure data exchange.
Geographic Scope	Localized to a region.
Illustrations	
Pre-Conditions	- The central system has provided the signed message to the RSU. - The connected vehicle can receive information from an RSU and can process the information to provide alerts to the driver.
Main Event Flow	- The RSU is periodically broadcasting information about the curve. - The approaching connected vehicle receives the message from the RSU. - The connected vehicle determines that an alert to the driver is necessary. - The connected vehicle provides the alert to the driver.
Alternative Event Flow	- The RSU is periodically broadcasting information about the curve. - The approaching connected vehicle receives the message from the RSU. - The connected vehicle determines that an alert to the driver is not necessary. - No action is taken.
Post-Conditions	The alert is discarded after the event concludes or the alert is no longer applicable (e.g., driver reduces to proper speed).
Information Requirements	Reference position, roadway traction information, advisory speed, geometry, surface condition, surface material, minimum radius of the curve, bank angle, obstacles, and visibility.

2.9.2 Reduced Speed Zone Warning (RSZW)

Table 4 - Reduced speed zone warning

Use Case Name	Reduced Speed Zone Warning (RSZW)
Category	Safety
Short Description	A connected vehicle approaches a reduced speed zone (e.g., school zone or work zone), and it receives a broadcast message from a nearby RSU that includes information used by the vehicle to determine if the driver should be alerted to reduce vehicle speed.
Actors	The road safety system and the connected vehicle.
Infrastructure Roles	The system determines the current situation for a specific reduced speed zone and then provides situation awareness messages to vehicles.
Vehicle Roles	The connected vehicle interprets the situation awareness information and determines the impact on the vehicle and operators.
Goal	Alert driver appropriately (if determined necessary by the vehicle).
Constraints/Presumptions	▪ The RSU receives the message from a central system and stores it for periodic broadcast. ▪ Security functionality in place to enable authentication of data sources and secure data exchange
Geographic Scope	Localized to a region.
Illustrations	
Pre-Conditions	▪ The central system has provided the signed message to the RSU. ▪ The connected vehicle is capable of receiving information from a RSU and can process the information to provide alerts to the driver.
Main Event Flow	1. The RSU is periodically broadcasting information about the reduced speed zone. 2. The approaching connected vehicle receives the message from the RSU. 3. The connected vehicle determines that an alert to the driver is necessary. 4. The connected vehicle provides the alert to the driver.
Alternative Event Flow	1. The RSU is periodically broadcasting information about the reduced speed zone. 2. The approaching connected vehicle receives the message from the RSU. 3. The connected vehicle determines that an alert to the driver is not necessary. 4. No action is taken.
Post-Conditions	The alert is discarded after the event concludes or the alert is no longer applicable (e.g., driver reduces to proper speed).
Information Requirements	Reference position, speed limit(s), lane information, workers present indication, etc.