



SURFACE VEHICLE STANDARD

J2945™/3

JAN2022

Issued 2020-03
Revised 2022-01

Superseding J2945/3 MAR2020

Requirements for Road Weather Applications

RATIONALE

The Road Weather Applications standard was published in 2020. The purpose of this revision is to update the ASN.1 to support integration with the latest version of SAE J2735.

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Full document details: SAE J2945_3_202201

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1. GENERAL

1.1 Scope

Inclement weather can have a significant impact on surface transportation systems. It can result in hazardous conditions for travelers due to poor visibility, or wet or icy roadways. Weather applications have the potential to provide additional data to surface transportation infrastructure owners and operators, allowing them to better assess the impacts of the weather environment on or around the roadway and to better manage the surface transportation system. Such weather applications can:

- Collect road weather data from connected vehicles and mobile devices, increasing the number of data sources available.
- Provide road weather related traveler information to travelers via connected vehicles and devices, such as when and where a hazardous condition exists.
- Provide the ability to manage road weather response on specific roadways.

This SAE Standard specifies interface requirements between vehicles and infrastructure for weather applications, including detailed systems engineering documentation (needs and requirements mapped to appropriate message exchanges). The purpose of this SAE Standard is to enable interoperability supporting these weather applications over a communications technology agnostic interface.

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 Dedicated Short Range Communications (DSRC) Message Set Dictionary

SAE J2945 Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for SAE J2945/X Documents and Common Design Concepts™

SAE J2945/5 Service Specific Permissions and Security Guidelines for Connected Vehicle Applications

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 1233-1998 (R2002) IEEE Guide for Developing System Requirements Specifications (Replaced by ISO/IEC/IEEE 29148:2011 (<https://www.iso.org/obp/ui/#iso:std:iso-iec-ieee:29148:ed-1:v1:en>))

IEEE Std 1471-2000 IEEE Recommended Practice for Architectural Description for Software-Intensive Systems

IEEE Std 1609.2-2016 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Security Services for Applications and Management Messages (as amended by IEEE Std 1609.2a™-2017 and IEEE Std 1609.2b™-2019)

IEEE Std 1609.3-2020 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services

IEEE Std 1609.4-2016 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Multi-Channel Operation

IEEE Std 1609.12-2019 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Identifiers

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 <http://webstore.ansi.org/>.

ISO/IEC 8824-1:1998 Information Technology - Abstract Syntax Notation One (ASN.1): Specification of Basic Notation

ISO/IEC 8824-2:1998 Information Technology - Abstract Syntax Notation One (ASN.1): Information Object Specification

ISO/IEC 8824-3:1998 Information Technology - Abstract Syntax Notation One (ASN.1): Constraint Specification

ISO/IEC 8824-4:1998 Information Technology - Abstract Syntax Notation One (ASN.1): Parameterization of ASN.1 Specifications

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

ISO/TS 21177 Intelligent Transport Systems - ITS Station Security Services for Secure Session Establishment and Authentication Between Trusted Devices

1.2.4 Other Publications

Noon, R.K, "Engineering Analysis of Vehicular Accidents," February 23, 1994, ISBN: 9780849381041.

NTCIP 1204 v04 National Transportation Communications for ITS Protocol, Environmental Sensor Station (ESS) Interface Protocol, Version 4

1.2.5 Related Publications

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

1.2.5.1 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 J3067 Candidate Improvements to Dedicated Short Range Communications (DSRC) Message Set Dictionary [SAE J2735] Using Systems Engineering Methods

1.2.5.2 NIST Publications

Available from NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

NIST SP800-122 Guide to Protecting the Confidentiality of Personally Identifiable Information (PII)

1.2.5.3 Other Publications

Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT), U.S. DOT ITS JPO, 1200 New Jersey Avenue, SE, Washington, DC 20590, <http://local.iteris.com/arc-it/>.

Specification of the Bluetooth® System (Bluetooth Core Specification), Bluetooth SIG.

INCOSE Systems Engineering Handbook v4, available from INCOSE publications, <http://www.incose.org>.

FCC 412172 D01, "Guidelines for Determining the Effective Radiated Power (ERP) and Equivalent Isotropically Radiated Power (EIRP) of an RF Transmitting System," August 2015.

NTCIP 8002, "National Transportation Communications for ITS Protocol Content Outline for NTCIP 1200-Series Documents (for Standards Engineering Process (SEP) Content)," Annex B1 version v01, American Association of State Highway and Transportation Officials (AASHTO), 444 North Capitol Street, N.W., Suite 249, Washington, D.C. 20001, September 2016.

U.S. DOT, "Concept of Operations for Road Weather Connected Vehicle Applications," May 31, 2013, FHWA-JPO-13-047.

U.S. DOT, "Privacy Impact Assessment," National Highway Traffic Safety Administration Notice of Proposed Rulemaking (NPRM) on V2V Communications, December 2016.

1.3 General Statements

The format of this document differs from the typical SAE document template for technical specifications in order to comply with NTCIP format.¹

1.4 Terms

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

1.4.1 MONITORED PARTICIPATING VEHICLE

A participating vehicle that is being continuously monitored by the weather system. For the purposes of this document, monitored participating vehicles are agency owned or operated fleet vehicles.

1.4.2 NON-PARTICIPATING VEHICLE

A vehicle that is not participating in the uploading of weather data to a weather system (see [1.4.3](#)).

1.4.3 PARTICIPATING VEHICLE

A vehicle that voluntarily provides data to a weather system. Vehicles may be owned or operated by a government agency or an infrastructure owner or operator, or vehicles may be privately owned.

1.4.4 TRANSPORTATION SYSTEM OPERATOR

The person or entity who interfaces with a weather system, typically located at a control center or traffic management center.

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

1.5 Abbreviations

The additional abbreviations and acronyms cited below are terms related to this standard (and of the other companion volumes and guides), unless specifically cited otherwise.

ASN	Abstract Syntax Notation Revision 1; Also: ASN.1
BSM	Basic Safety Message
ConOps	Concept of Operations
CRL	Certificate Revocation List
CV	Connected Vehicle
C-V2X	Cellular Vehicle-to-Everything
DE	Data Element
DF	Data Frame
DMS	Digital Message Sign
DSRC	Dedicated Short Range Communications
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
I2V	Infrastructure-to-Vehicle
ID	Identifier
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
INCOSE	International Council on Systems Engineering
IP	Internet Protocol
IPv6	Internet Protocol Version 6
ITIS	International Traveler Information Systems
ISO	International Organization for Standardization
ITE	Institute of Transportation Engineers
ITIS	International Traveler Information Systems
ITS	Intelligent Transportation System
JER	JSON Encoding Rules
JPO	Joint Program Office
JSON	Javascript Object Notation

LAN	Local Area Network
MAC	Medium Access Control
MIB	Management Information Base
MSG	Message
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute for Standards and Technology
NTCIP	National Transportation Communications for ITS Protocols
NRTM	Needs to Requirements Traceability Matrix
OBE	On-Board Equipment
OBU	On-Board Unit
PDU	Protocol Data Unit
PER	Packed Encoding Rules
PSC	Provider Service Context
PSID	Provider Service Identifier
RSU	Roadside Unit
RTM	Requirements Traceability Matrix
RWIS	Road Weather Information System
SCMS	Security Credential Management System
SP	Special Publication
SSP	Service Specific Permissions
Std	Standard
TCIP	Transit Communications Interface Profiles
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
U.S. DOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything Equipped Object

VRU	Vulnerable Road User
WAVE	Wireless Access in Vehicular Environments
WDMS	Weather Data Management Subsystem
WSM	WAVE Short Message
WSMP	WAVE Short Message Protocol
XER	XML Encoding Rules
XML	eXtensible Markup Language

2. CONCEPT OF OPERATIONS [NORMATIVE]

[Section 2](#) defines the user needs that SAE J2945/3 addresses in subsequent sections. Accepted system engineering processes detail that requirements should only be developed to fulfill well-defined user needs, in terms of the operations and maintenance of the system. The first stage in this process is to identify the ways in which the V2I and I2V weather-related data are likely to be used. For SAE J2945/3, this includes identifying what weather-related data from mobile sources may be used, and how weather applications may use this data, along with data collected from other sources, to improve transportation safety, mobility, and the environment. These weather applications may exist at a traffic management center, on transportation field devices, on vehicles, on mobile devices, or weather data centers.

This concept of operations provides:

- a. A detailed description of the scope of SAE J2945/3.
- b. An explanation of how weather applications fit into the larger context of a connected vehicle environment.
- c. A starting point in developing specifications and the procurement process.
- d. An understanding of the perspective of the designers of SAE J2945/3.

This section is intended for all users, including:

- a. Transportation operations managers.
- b. Transportation operations personnel, including transportation weather specialists.
- c. Transportation engineers.
- d. System integrators.
- e. Application developers.

This section is intended to assist the first three categories of users in understanding how weather-related data from mobile sources, such as equipped vehicles or personal (VRU) devices, can be incorporated into a connected vehicle environment to support weather applications. For this audience, [Section 2](#) serves as the starting point in the agency specification and procurement process. Users can become familiar with each feature addressed in SAE J2945/3 and determine whether or not a feature is appropriate for their agency-specific implementation. If a feature is appropriate, then an agency's procurement specification should be structured to require support for the feature and all of the mandatory requirements related to that feature.

The last two categories of users can gain a more thorough understanding as to why more detailed requirements exist later in SAE J2945/3.

2.1 Tutorial [Informative]

A concept of operations describes a proposed system from the users' perspective. Typically, a concept of operations is used on a project to ensure that the system developers understand the users' needs. Within the application standards, the concept of operations documents the purpose of each feature for which an application standard supports an application. The concept of operations also serves as the starting point for users to select those features that may be appropriate for a specific application.

The concept of operations starts with a discussion of the current situation and issues that have led to the need to deploy systems within the scope of a standard and to the development of the standard itself. This discussion permits both potential users and system developers to understand the situation.

The concept of operations then documents key aspects of the proposed system, including:

- a. Reference physical architecture: The reference physical architecture defines the overall context of the proposed system and defines which specific interfaces are addressed.
- b. Architectural needs: The architectural needs discuss issues and needs relative to the system architecture.
- c. Features: The features identify and describe the various functions that users may want weather applications of a system to perform. These features are derived from the high level user needs identified in the problem statement but are refined and organized into a more manageable structure that forms the basis of the traceability tables contained in [Section 2](#) and [APPENDIX A](#).

Architectural needs and features are collectively called user needs. In [Section 2](#), these user needs lead to the definition of the various functional requirements of a system with weather applications. Basic systems engineering requires that:

- a. Each user need traces to one or more functional requirement(s).
- b. Each functional requirement derives from at least one user need.

This traceability is shown in the NRTM in [3.3.3](#).

SAE J2945/3 is intended for use in a broad range of prospective implementations involving weather applications. Within the NRTM, each user need and requirement is identified as mandatory, optional, or conditional, and users may complete the NRTM to clearly define unique aspects of their implementation. Within SAE J2945/3, items marked mandatory are those that relate to the most basic functionality for a weather application. For specific implementations, the user identifies those optional or conditional needs appropriate for a specific implementation.

Each requirement is presented in the requirements traceability matrix (RTM) in [APPENDIX A](#), which defines how the requirement is fulfilled through the standardized dialogs and data element definitions provided in [Sections 4](#) and [5](#).

A conformant device may support other user needs, as long as they are conformant with the requirements of SAE J2945/3 and the standards it references (e.g., SAE J2735).

2.2 Current Situation and Problem Statement [Informative]

The following is extracted from the Executive Summary of the Concept of Operations for Road Weather Connected Vehicle Applications:

Weather has a significant impact on the operations of the nation's roadway system year-round. Rain reduces traction; winter weather can leave pavements snow-covered or icy. Fog, smoke, blowing dust, heavy precipitation, and vehicle spray can restrict visibility. Flooding, snow accumulation, and wind-blown debris can cause lane obstructions.

Weather events may prompt travelers to change departure times, cancel trips, choose an alternate route, or select a different mode. Slick pavements, low visibility, and lane obstructions lead to driving at lower speeds or with increased following distances. These changes in driver behavior can impact the operation of signalized roadways, where traffic signals are timed for clear, dry conditions, through reduced traffic throughputs, increased delays, and increased travel times. Travel reliability for motorists and commercial vehicle operators is affected by a variety of weather conditions.

Weather also impacts the operational effectiveness and productivity of traffic management agencies and road maintenance agencies through increased costs and lost time.

It is, therefore, an important responsibility of traffic managers and maintenance personnel to implement operational strategies that optimize system performance by mitigating the effects of weather on the roadways. The operational approaches used by these personnel dictate their needs for weather and road condition information. Accurate, timely, route-specific weather information, allows traffic and maintenance managers to better operate and maintain roads under adverse conditions.

Weather applications can assist these managers to better manage and operate their roadways. U.S. DOT has defined three types of road weather management strategies that can be employed in response to adverse weather. These strategies are:

- **Advisory strategies:** These strategies provide information on prevailing and predicted conditions and impacts to motorists.
- **Control strategies:** These strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity.
- **Treatment strategies:** These strategies supply resources to roadways to minimize or eliminate weather impacts.

Advisory strategies are used to advise travelers of road weather conditions and weather-related travel restrictions. Current strategies are focused on the use of dynamic message signs, highway advisory radios, applications on mobile devices and 511 systems. However, these devices can only provide general weather information for all travelers. Connected vehicle weather applications may provide advisories that are geographically localized (e.g., a specific spot on the roadway) or specific to certain types of vehicles (e.g., vehicles that are 15 feet or more in height). These applications can provide the advisories or warnings, if necessary, directly to the traveler.

Control strategies are used to restrict or control traffic flow due to adverse weather conditions. Current strategies include regulating lanes or roadways (e.g., lane reversals, closing roadways, restricting access to specific vehicle types, regulating speed limits). The connected vehicle environment can communicate these road regulations directly to applications on mobile devices and vehicles.

Maintenance managers use road weather information and decision support tools to assess the nature and magnitude of winter storms, determine the level of staffing required during a weather event, plan road treatment strategies (e.g., plowing, sanding, chemical applications), and activate anti-icing/deicing systems. Maintenance managers are also concerned about the impacts of other events such as sand storms and wildfires that may reduce visibility and create hazardous driving conditions. Weather applications can provide this information directly to maintenance vehicles.

Additional information about how this data can be used is provided in Weather-Responsive Traffic Management—Concept of Operations.

2.3 Reference Physical Architecture

[Figure 1](#) represents an overview of what a connected-vehicle road weather system may consist of for a transportation agency, and what information may be applicable for each interface. Within the system, a vehicle/device may correspond to any type of vehicle, including agency-owned fleet, commercial, and personal vehicles or devices.

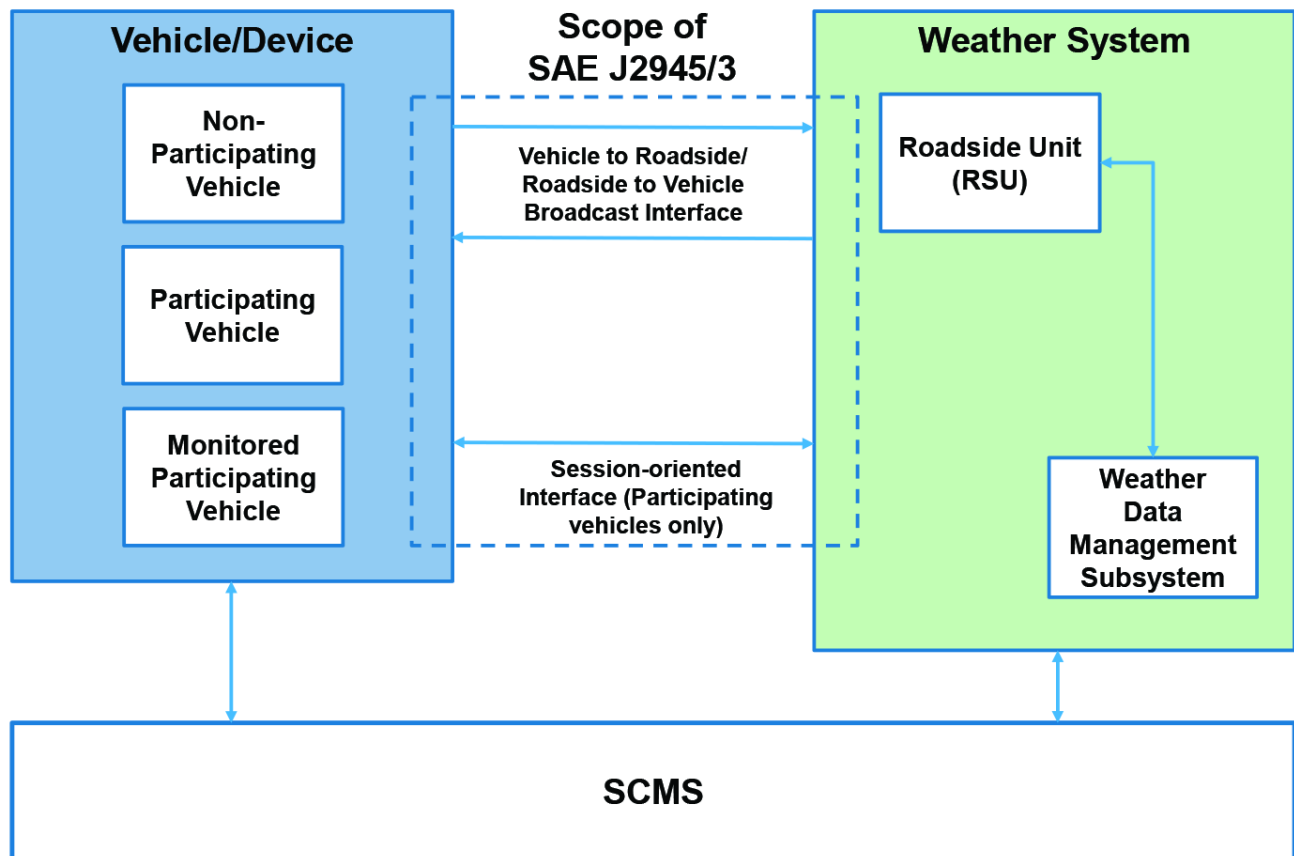


Figure 1 - Reference physical architecture

The major components of the weather architecture include:

- Weather system: For the purpose of this document, the weather system encompasses RSUs and the weather data management subsystem, herein referred to as the system.
- Vehicle/device: A connected vehicle, on-board unit (OBU), or other mobile device that interacts with the system, hereon referred to as vehicle/device.
- Communications interfaces: The interface between the vehicle/device and the system. The interface to the WDMS may be via an RSU or via any alternative interface that supports sessions, such as a cellular network.
- Roadside unit (RSU): A subsystem installed along the roadway used to exchange data with vehicles/devices.
- Weather data management subsystem (WDMS): A subsystem used to process and manage the weather data. The WDMS may be attached to or integrated within a traffic management center (TMC) or other types of central systems used to collect, process, and distribute surface transportation system information.

2.3.1 Vehicles

SAE J2945/3 addresses the interfaces between connected vehicles or mobile devices and transportation management centers. However, some features defined within SAE J2945/3 apply only when the sender of the information is a vehicle, which is reflected in the predicate used in the NRTM ([3.3.1.2](#) and [Table 8](#)).

2.4 Architectural Needs

SAE J2945/3 addresses the interfaces between connected vehicles or mobile devices and transportation management centers. Multiple architectural scenarios may be used to enable communications across the interfaces.

In one operational environment, an RSU may record weather data received via broadcast messages from vehicles/devices, and the RSU forwards the data to a weather data management subsystem, such as a traffic management center. An RSU may also broadcast data it receives from the WDMS to vehicles/devices.

In another operational environment, the communications system enables a direct connection between a vehicle/device and the weather data management subsystem using an IP-based interface.

2.4.1 Receive Weather Information Contained in Broadcast Messages

Roadside units need to be able to receive weather related data from messages broadcast by vehicles/devices, e.g., a BSM.

2.4.2 Broadcast Interface

RSUs and vehicles need to periodically transmit broadcast data.

2.4.3 Interface via Other Standards

The weather data management subsystem and vehicles/devices need to exchange data using internet protocol interfaces.

2.5 Features

This section identifies and describes the various features that may be supported by a weather application. These features are divided as follows:

- a. Receive weather-related data features.
- b. Provide weather-related traveler information features.
- c. Weather-related traffic management features.
- d. Manage roadway treatment features.

2.5.1 Receive Weather-Related Data Features

Receive weather-related data collection features describe user needs related to the aggregation of weather data for roadway segments. Data is collected from personal or fleet vehicles; weather spotters and citizen observers may also provide weather data. This data is used by transportation system operators as inputs for weather forecast models, traveler information dissemination systems, and maintenance decision support systems.

2.5.1.1 Receive Basic Weather Related Data

This section identifies and describes the various features that a transportation system operator needs from a typical connected vehicle to describe the current weather situation at a point location.

2.5.1.1.1 Determine Time of a Vehicle Providing Weather Situation Data

A transportation system operator needs to receive the date and time when a vehicle/device recorded the environmental data readings describing the weather situation.

2.5.1.1.2 Determine Location of a Vehicle Providing Weather Situation Data

A transportation system operator needs to receive the location where a vehicle/device recorded the environmental data readings describing the weather situation. The location of the environmental data readings is described by its geographic location and the direction of travel (heading) of the vehicle.

2.5.1.1.3 Receive External Air Temperature Data

A transportation system operator needs to receive the external air temperature from a vehicle/device. The external air temperature is a factor that may be used to predict the pavement temperature, which may indicate the likelihood of icing on the roadway pavement, or the likelihood of the roadway pavement buckling because of high temperatures. Note that this user need is included in this section instead of [2.5.1.2](#) because the types of environmental sensors associated with [2.5.1.2](#) are not available on most vehicles, but air temperature sensors are common on many types of vehicles.

2.5.1.1.4 Receive Wiper Data of a Vehicle

A transportation system operator needs to receive the wiper data of a vehicle. The wiper data, which is described by the sweep rate for the front and back windshields, may be used to estimate the likelihood and intensity of precipitation occurring over a road segment.

2.5.1.1.5 Receive the Status of a Vehicle's Exterior Lights

A transportation system operator needs to receive the status of the exterior (external) lights on a vehicle. Vehicles may be equipped with different types of external lights and with different capabilities. External lights may include headlights, fog lights, and parking lights. Capabilities may include daytime running lights or automatic light controls. The status of the external lights may be used to determine the presence of fog, dust, or current levels of ambient lighting affecting visibility for motorists.

2.5.1.1.6 Receive Accelerometer Data of a Vehicle

A transportation system operator needs to receive the forces measured by accelerometers on a vehicle. The rate of acceleration obtained from the accelerometer may be used to infer the potential presence of road weather hazards requiring motorist response, such as sudden deceleration at a weather boundary.

2.5.1.1.7 Receive Anti-Lock Braking System Status of a Vehicle

A transportation system operator needs to receive the status of the anti-lock braking system of a vehicle. The state of the anti-lock braking system may be used to infer the presence of adverse road conditions, such as ice.

2.5.1.1.8 Receive Traction Control System Status of a Vehicle

A transportation system operator needs to receive the status of the traction control system of a vehicle. The state of the traction control system may be used to infer the presence of adverse road conditions, such as ice.

2.5.1.1.9 Receive Stability Control System Status of a Vehicle

A transportation system operator needs to receive the status of the stability control system of a vehicle. The state of the stability control system may be used to infer the presence of adverse road conditions, such as ice.

2.5.1.1.10 Receive Speed of a Vehicle

A transportation system operator needs to receive the speed of a vehicle. The speed of a vehicle may be used to infer the potential presence of roadway hazards or weather incidents requiring motorist response.

2.5.1.2 Receive Environmental Sensor Data from Participating Vehicles

This section identifies and describes additional features to [2.5.1.1](#) that a transportation system operator needs from a vehicle equipped with special sensors not found commonly found on most vehicles. These sensors enable additional ambient environmental data surrounding a vehicle to describe the current weather situation at the time and location described in [2.5.1.1.1](#) and [2.5.1.1.2](#).

2.5.1.2.1 Receive Atmospheric Pressure Data

A transportation system operator needs to receive the external atmospheric pressure at a point location from a vehicle/device. Atmospheric pressure as a function of time and place may be used to estimate changing weather conditions.

2.5.1.2.2 Receive Wind Data

A transportation system operator needs to receive the wind conditions at a point location from a vehicle/device. Wind conditions may be used to determine if vehicle restrictions should be issued for a roadway segment, such as lower travel speed advisories or restricting high profile vehicles from a bridge or other affected roadway segment.

2.5.1.2.3 Receive Relative Humidity Data

A transportation system operator needs to receive the relative humidity at a point location from a vehicle/device. Relative humidity may be used to plan moisture sensitive maintenance activities, such as painting, to predict ice buildup on the roadway, and to infer the presence of precipitation.

2.5.1.2.4 Receive Dew Point Temperature

A transportation system operator needs to receive the dew point temperature at a point location from a vehicle/device. The dew point temperature may be directly measured or determined mathematically. The dew point temperature allows a transportation system operator to determine the maximum temperature when condensation will form on a roadway or the likelihood of fog.

2.5.1.2.5 Receive Pavement Conditions about a Roadway Segment

A transportation system operator needs to receive pavement conditions at a point location from a vehicle/device. Pavement conditions include pavement surface temperature, presence of moisture on the pavement, the type of moisture, roadway friction information, and depth of moisture accumulation. Pavement conditions may be used to determine the presence of dangerous conditions where roadway safety may be affected. Pavement conditions may also be used to prioritize the roadway for treatment.

2.5.1.2.6 Receive Visibility

A transportation system operator needs to receive the visibility at a point location from a vehicle/device. Inadequate visibility is a hazard for motorists traveling on a road segment and may be used to determine if a roadway restriction or speed limit reduction is necessary.

2.5.1.2.7 Receive Precipitation

A transportation system operator needs to receive precipitation information for a roadway segment from a vehicle/device. This includes measurement of the type (e.g., rain, snow, sleet, etc.) and intensity of precipitation. This may be used to determine if a roadway restriction or speed limit reduction is necessary.

2.5.1.2.8 Receive Total Solar Radiation

A transportation system operator needs to receive solar radiation data at a point location from a vehicle/device. This may be used to determine rate of ice or snow melt, or to indicate how quickly pavement surface conditions may change with temperature.

2.5.1.3 Citizen Reported Environmental Conditions

This section identifies and describes the features a transportation system operator needs to collect human-observed weather conditions. Observed data may be input into a vehicle/device from observers, such as maintenance vehicle drivers or private citizens on the roadway. Data reported by an observer is subjective in nature as opposed to data measured by a sensor.

2.5.1.3.1 Determine Time of an Observer Providing Weather Situation Data

A transportation system operator needs to determine the date and time when an observer makes his observation of the environmental conditions describing the weather situation.

2.5.1.3.2 Determine Location of an Observer Providing Weather Situation Data

A transportation system operator needs to determine the applicable road segments corresponding to an observer's reported environmental conditions describing the weather situation. This is determined by the location and the direction of travel (heading), if available, of the observer when the environmental conditions are observed.

2.5.1.3.3 Receive Road Situation Data from an Observer Providing Weather Situation Data

A transportation system operator needs to receive the road condition observed by an observer. The road conditions indicate the state of the roadway (e.g., dry, wet, icy, snow accumulation) and may be used to determine the presence of dangerous driving conditions or to aid in maintenance/construction scheduling.

2.5.1.3.4 Receive Weather Conditions from an Observer Providing Weather Situation Data

A transportation system operator needs to receive the reported weather conditions by an observer. The current atmospheric weather conditions, including sky condition, visibility situation (e.g., clear, cloudy, overcast), or the presence of precipitation (e.g., rain, snow). This may be used to determine the presence of dangerous driving conditions or to aid in maintenance/construction scheduling.

2.5.2 Provide Weather-Related Traveler Information Features

Traveler information features describe user needs for providing weather related information to travelers. Information may be sent to any class of vehicle operating on a roadway, including private vehicles, commercial vehicles, emergency vehicles, maintenance vehicles, etc.

2.5.2.1 Provide Weather-Related Traveler Information

A transportation system operator needs to provide alert and advisory messages to vehicles/devices. Alert messages containing weather related travel information should be provided to travelers quickly enough so that the traveler can appropriately respond to the alert. For example, an alert may be about pavement conditions such as an ice patch in the current path of a moving vehicle. Other examples include "chains required" or "no oversize loads." Alerts typically indicate restrictions due to weather conditions and require immediate action.

Advisory messages inform motorists of weather-related travel information that may affect a traveler's travel habits or path. This may include weather forecast information, adverse road conditions, weather-related lane or roadway closures, advisory speed, wind information, visibility, etc. Advisories are typically not as time-sensitive as alerts.

2.5.2.2 Provide Routing Advice for Specific Vehicles

A transportation system operator needs to provide weather related routing advice to individual specific vehicles, such as emergency vehicles and maintenance vehicles. The routing is not intended to be turn-by-turn guidance, but higher-level guidance, such as use a specific roadway (e.g., use I-35).

2.5.3 Weather-Related Traffic Management

These features describe user needs related to managing or controlling traffic flow on the surface transportation network.

2.5.3.1 Provide Regulatory Speed Limit

A transportation system operator needs to provide current speed restrictions for road segments. Regulatory speed limits may change as a result of adverse weather conditions.

2.5.3.2 Provide Advisory (Recommended) Speed

A transportation system operator needs to provide current speed recommendations for road segments. Maximum recommended travel speed may change as a result of adverse weather conditions.

2.5.4 Manage Roadway Treatment Features

These features describe user needs for optimal roadway treatment in response to a current or forecasted weather event. This is particularly applicable to winter roadway maintenance.

2.5.4.1 Monitor Effectiveness of the Roadway Treatment Plan on the Surface Pavement Conditions

A transportation system operator needs to retrieve the roadway treatment configuration applied by a maintenance vehicle. For example, based on observed conditions, a maintenance vehicle operator may use a configuration different than the current treatment plan.

2.5.4.2 Send Roadway Treatment Plan

A transportation system operator needs to send a new or updated roadway treatment plan to a maintenance vehicle. This plan may be for treatment of a roadway before or after a weather event. For example, this plan may be used to provide an anti-icing/de-icing strategy to a maintenance vehicle which may include type or quantity of anti-icing/de-icing agent applied for a specific location or segment of roadway.

2.5.4.3 Send Roadway Treatment Routing/Directions

A transportation system operator needs to send roadway treatment routing and directions to a maintenance vehicle. The transportation system operator issues these instructions to optimally account for priority and efficiency when managing roadway treatments.

2.6 Security

The general security needs for these use cases are described in this section.

These security constraints reflect the sensitive nature of certain data, which is necessary to protect (e.g., roadway treatment plans and routing instructions, or personally identifiable information).

2.6.1 Data Source Authenticity

The system needs to provide a mechanism to authenticate sources of weather data.

2.6.2 User Privacy

Participation in the system needs to be optional, with personally identifiable information not being stored.

2.7 Operational Policies and Constraints

Operational policies for road weather management activities vary from state to state, both in terms of their detail and their formality. All vary significantly in terms of scope and level of detail; many state transportation agencies have documented policies and procedures that describe strategies for conducting winter and non-winter maintenance activities under various adverse weather conditions. Overall, there are no standardized operational policies or processes related to road weather management across the United States. However, there are guidance documents available for road weather management strategies, but it is the discretion of the state agencies whether to use those recommended practices. As of publication of SAE J2945/3, the documents are available at:

FHWA Road Weather Management Program Publications: <https://ops.fhwa.dot.gov/weather/resources/publications.htm>.

Road Weather Management Exchange: <https://collaboration.fhwa.dot.gov/dot/fhwa/RWMX/default.aspx>.

National Transportation Library: <https://rosap.ntl.bts.gov/>.

There may be external constraints on the development of road weather applications. These constraints should reflect national policy decisions set by NHTSA.² At the time of the publication of this standard, there are no national policies set by NHTSA related to road weather applications.

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

The following are architecture flows from ARC-IT (version 8.3) that are addressed by SAE J2945/3. Flows covered are between vehicle on-board equipment (OBE) and roadside units (RSU)/centers. Vehicles are represented by either vehicle on-board Equipment (VOBE), emergency vehicle on-board equipment (EOBE), or maintenance and construction vehicle on-board equipment (MCOBE). Roadside units are represented by connected vehicle roadside equipment (CVRE). Centers are represented by either maintenance and construction management centers (MCMC) or emergency management centers (EMC).

- Vehicle environmental data: Data from vehicle safety and convenience systems that can be used to estimate environmental and infrastructure conditions, including measured air temperature, exterior light status, wiper status, sun sensor status, rain sensor status, traction control status, anti-lock brake status, vertical acceleration, and other collected vehicle system status and sensor information. The collected data is reported along with the location, heading, and time that the data was collected. Both current data and snapshots of recent events (e.g., traction control or anti-lock brake system activations) may be reported.
- Road weather advisories: Segment-specific weather and road conditions including real-time advisories of deteriorating road and weather conditions, medium-term advisories for the next 2 to 12 hours, and long-term advisories more than 12 hours into the future. The advisories may include advisories that are issued by the RSE based on locally collected environmental data (e.g., an ice on bridge advisory).
- 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.
- Road closure information: Road closure information provided to passing vehicles. This flow provides information about the road closure with diversion information.
- Road weather advisories for emergency response: Segment-specific weather and road conditions including real-time advisories of deteriorating road and weather conditions, medium-term advisories for the next 2 to 12 hours, and long-term advisories more than 12 hours into the future. This flow is filtered, tailored, and augmented to support emergency responders.
- Environmental sensor data: Current road conditions (e.g., surface temperature, subsurface temperature, moisture, icing, treatment status) and surface weather conditions (e.g., air temperature, wind speed, precipitation, visibility) as measured and reported by fixed and/or mobile environmental sensors. Operational status of the sensors is also included.

[Table 1](#) 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.

² The most current policy guidance available at time of publication is contained in U.S. Department of Transportation's Privacy Impact Assessment, National Highway Traffic Safety Administration Notice of Proposed Rulemaking (NPRM) on V2V Communications, December 2016.

Table 1 - National architecture mapping (V2I)

User Need Group	Source	Architecture Flow	Destination	Service Packages
Data Collection	VOBE	Vehicle Environmental Data	CVRE	WX01: Weather Data Collection WX03: Spot Weather Impact and Warning
Data Collection	MCOBE	Environmental Sensor Data	MCMC	WX01: Weather Data Collection MC04: Winter Maintenance
Traveler Information	CVRE	Road Weather Advisories	VOBE	WX03: Spot Weather Impact and Warning
Traveler Information	CVRE	Reduced Speed Notification	VOBE	WX03: Spot Weather Impact and Warning
Traveler Information	CVRE	Lane Closure Information	VOBE	WX03: Spot Weather Impact and Warning
Traveler Information	CVRE	Road Closure Information	VOBE	WX03: Spot Weather Impact and Warning
Traveler Information	EMC	Road Weather Advisories for Emergency Response	EOBE	PS02: Routing Support for Emergency Responders

2.9 Operational Scenarios [Informative]

The operational scenarios in this standard consist of example use cases associated with weather data. The operational scenarios do not imply any specific requirements or design. The illustrations represent use cases where the practical implementation involves instances of the architectural components in [Figure 1](#). Alternatives to communicating via RSUs are permitted by this document. In addition, the WDMS may interface to third party sensors or data servers. These interfaces are outside the scope of this document.

2.9.1 Weather Data Collection

Table 2 - Weather data collection use case

Use Case Name	Weather Data Collection
Category	Safety, Mobility, and Environment
Infrastructure Role	Collection of road weather information from vehicles/devices.
Short Description	Weather information is collected from participating vehicles and processed by the WDMS to support other use cases, such as weather-related traveler information, traffic management, and roadway treatments.
Goal	Improved quality of weather knowledge for management of road infrastructure.
Constraints	1. Number of vehicles/devices collecting and providing weather data along or near a roadway segment. 2. Accuracy of the weather data being reported (e.g., in the case of a citizen report). 3. Security solution in place to enable authentication of data sources and secure data exchange
Geographic Scope	Localized to roadways where sufficient vehicles/devices are equipped to report weather.
Actors	1. Vehicles/devices. 2. Roadside units (RSU) or other communications systems (e.g., cellular). 3. WDMS.
Illustration	<pre> graph LR subgraph Vehicles NPV[Non-Participating Vehicle] PV[Participating Vehicle] MPV[Monitored Participating Vehicle] end subgraph Weather_System [Weather System] RSU[Roadside Unit RSU] WDMS[Weather Data Management Subsystem] end NPV -- "BSM broadcasts" --> RSU PV -- "Session-oriented interfaces (participating vehicles only)" --> RSU MPV -- "Session-oriented interfaces (participating vehicles only)" --> RSU RSU --> WDMS </pre>
Preconditions	Vehicle/devices equipped with the necessary sensors or applications to collect the weather data, and the interface to report it.
Main Flow	1. The vehicle/device collects weather-related data. 2. The vehicle/device transmits the environmental data to the WDMS through the RSU. 3. The WDMS receives weather data from the vehicle/device equipped with weather data sensors. The WDMS may also collect information from environmental sensor stations, and other third party weather information providers. 4. The WDMS processes the environmental data received from all sources for quality control and aggregates the data by road segment. 5. Aggregated road weather data is stored by the WDMS for future use in weather-related traveler information, traffic management, and treatment plans.
Alternate Flow(s)	1. The weather data may also be collected from participating vehicles via alternative communications interfaces such as a cellular system.
Post-Conditions	Improved accuracy and performance of several road weather applications for roadway operations.

Information Requirements	SAE J2945/3 interfaces only (see illustration) Vehicle/device → WDMS • Time, location, and direction • External air temperature • Wipers • Exterior lights • Accelerometer data • Anti-lock braking system status • Traction control system status • Stability control system status • Speed • Atmospheric pressure • Wind • Humidity and/or dewpoint temperature • Visibility • Precipitation information • Solar radiation
Issues	Need sufficient number of vehicles to collect data to achieve high quality.
Source Documents/References	ARC-IT, Service Area 12, https://local.iteris.com/arc-it/html/servicepackages/sa12.html

2.9.2 Provide Weather-Related Traveler Information

Table 3 - Weather-related traveler information use case

Use Case Name	Provide Weather-Related Traveler Information
Category	Safety, Mobility, and Environment
Infrastructure Role	Send weather-related traveler information to vehicles/devices.
Short Description	Weather information that was previously collected from vehicles and other sources is processed by the WDMS and used to send weather-related advisories to vehicles on a corresponding roadway segment. This use case can readily be extended to also support weather-related traffic management (e.g., roadway restrictions) and motorist advisories and warnings (MAW); e.g., speed advisories.
Goal	Provide weather-related traveler information for the purpose of decision making by individual road users.
Constraints	1. Number of vehicles/devices collecting and providing weather data along or near a roadway segment. 2. Accuracy of the weather data being reported (e.g., in the case of a citizen report). 3. Security solution in place to enable authentication of data sources and secure data exchange.
Geographic Scope	The roadway segment to which the weather-related traveler information applies.
Actors	1. Vehicles/devices. 2. Roadside units (RSU) or other communications systems (e.g., cellular). 3. WDMS. 4. Other data sources that may interface to the WDMS, e.g., environmental sensor stations described in NTCIP 1204 or traffic information providers (outside the scope of this document).
Illustration	<pre> graph LR subgraph Weather_System [Weather System] RSU[Roadside Unit RSU] WDMS[Weather Data Management Subsystem] RSU --> WDMS end NPV[Non-Participating Vehicle] -- "Road Weather Message Broadcasts" --> RSU PV[Participating Vehicle] -- "Session-oriented interfaces (participating vehicles only)" --> RSU MPV[Monitored Participating Vehicle] -- "Session-oriented interfaces (participating vehicles only)" --> RSU RSU --> WDMS WDMS --> ESS[Environmental Sensor Station] </pre>

Preconditions	Vehicle/devices equipped with the necessary interface and applications to receive the weather data.
Main Flow	1. The WDMS processes and aggregates weather-related data. 2. The WDMS transmits the weather-related traveler information to the vehicle/device via the RSU. 3. Vehicle/device receives the weather-related traveler information. 4. The vehicle/device issues a corresponding advisory to the driver/user.
Alternate Flow(s)	The weather-related traveler information may also be distributed via alternative communications interfaces such as a cellular system.
Post-Conditions	Road users consume the information to improve safety and mobility, and make travel-related decisions.
Information Requirements	SAE J2945/3 interfaces only (see illustration) WDMS → vehicle/device • ITIS codes related to weather • ITIS text (e.g., for routing advice) • Advisory speed
Issues	Vehicles/devices need to be capable of processing received weather information .
Source Documents/References	ARC-IT, Service Area 12, https://local.iteris.com/arc-it/html/servicepackages/sa12.html .

2.9.3 Manage Roadway Treatment Plans

Table 4 - Roadway treatment plans use case

Use Case Name	Manage Roadway Treatment Plans
Category	Safety, Mobility, and Environment
Infrastructure Role	Send roadway treatment instructions to maintenance vehicles (e.g., snow plows).
Short Description	A maintenance decision support system (MDSS) is typically used to support managing roadway treatment plans and dispatching vehicles capable of carrying out a treatment plans for a corresponding roadway segment. The WDMS provides a means of communicating the treatment plan to a corresponding vehicle.
Goal	Timely treatment of a road to improve safety and mobility; e.g., in the case of an icy bridge or snow-covered road.
Constraints	1. Accurate data from the MDSS to support dispatching of vehicles effectively. 2. Security solution in place to enable authentication of data sources and secure data exchange.
Geographic Scope	The roadway segment to which the treatment plan applies.
Actors	1. Vehicles/devices. 2. Roadside units (RSU) or other communications systems (e.g., cellular). 3. WDMS. 4. MDSS.
Illustration	<pre> graph LR MPV[Monitored Participating Vehicle] <--> Session-oriented Interface RSU[Roadside Unit RSU] subgraph Weather_System [Weather System] RSU WDM[Weather Data Management Subsystem] end RSU --> WDM WDM <--> MDSS[MDSS] </pre>
Preconditions	Vehicle/devices equipped with the necessary interface and capabilities to receive and execute the treatment plan.

Main Flow	1. The MDSS processes and aggregates weather-related data. 2. The MDSS transmits the weather-related information to the vehicle/device via the WDMS and RSU. 3. The vehicle/device receives the treatment plan. 4. Driver/user of the vehicle/device issues executes the treatment plan.
Alternate Flow(s)	The treatment plan may also be distributed via alternative communications interfaces such as a cellular system.
Post-Conditions	Improved efficiency and timely execution of treatment plans.
Information Requirements	SAE J2945/3 interfaces only (see illustration) MDSS → WDMS → vehicle/device • ITIS codes related to weather • ITIS text (e.g., for routing advice) • Treatment plan
Issues	Vehicles/devices need to be capable of processing received information.
Source Documents/References	ARC-IT, Service Area 12, https://local.iteris.com/arc-it/html/servicepackages/sa12.html .

3. FUNCTIONAL REQUIREMENTS [NORMATIVE]

3.1 Tutorial [Informative]

Detailed information about requirements may be found in NTCIP 8002 Annex B1 Section 3. Refer also to 3.1.4 of SAE J2945.

Information about NRTM notation may be found in NTCIP 8002 Annex B1 section 3.3. Text appearing in [3.3.1](#) through [3.3.3](#) implements NTCIP 8002 Annex B1 section 3.3, and is reprinted with permission © 2016 AASHTO/ITE/NEMA from NTCIP 8002 Annex B1.

The NRTM can be used by:

- a. A user or specification writer to indicate which requirements are to be implemented in a project-specific implementation.
- b. The protocol implementer, as a checklist to reduce the risk of failure to conform to the standard through oversight.
- c. The supplier and user, as a detailed indication of the capabilities of the implementation.
- d. The user, as a basis for initially checking the potential interoperability with another implementation.

3.2 Scope of the Interface [Informative]

The scope of the broadcast interface is limited to the broadcast of application-specific messages between RSUs and vehicles/devices. The session-oriented interface enables exchange of data between vehicle/device and the WDMS via any communications system that supports the session protocols as specified in this document.

3.3 Needs to Requirements Traceability Matrix (NRTM)

As noted above, the NRTM provides a mapping between the user needs and the functional requirements which have been developed to meet those needs.

3.3.1 Notation [Informative]

Information about NRTM notation may be found in NTCIP 8002 Annex B1 section 3.3.

3.3.1.1 Conformance Symbols

The following symbols are used to indicate status in the conformance column of the NRTM table:

Table 5 - Conformance symbols

Symbol	Value
M	Mandatory: The weather system is required to implement this functionality.
M.#	Every item of the group labeled by the same numeral # is mandatory, but only one is active at a time.
O	Optional: The weather system does not need to implement the feature to be standards compliant.
O.# (range)	Part of an option group: At least the number of options indicated by the “(range)” is required from the options labeled with the same numeral #. ⁽¹⁾
C	Conditional: The weather system must implement functionality corresponding to this requirement if another requirement is implemented.
N/A	Not-applicable (i.e., logically impossible in the scope of the standard).
X	Excluded or prohibited.

⁽¹⁾ The O.# (range) notation is used to show a set of selectable options (e.g., O.2 (1..*)) would indicate that one or more of the option group two options must be implemented. Two character combinations are used for dynamic requirements. In this case, the first character refers to the static (implementation) status, and the second refers to the dynamic (use); thus, .MO. means mandatory to be implemented, optional to be used.

3.3.1.2 Conditional Status Notation

The following predicate notation may be used:

Table 6 - Predicate notations

<predicate>:	This notation introduces a single item that is conditional on the <predicate>.
<predicate>::	This notation introduces a table or a group of tables, all of which are conditional on the <predicate>.
(predicate)	This notation introduces the first occurrence of the predicate either in the NRTM table or that specific user need. The feature associated with this notation is the base feature for all options that have this predicate in their conformance column.

The <predicate>: notation means that the status following it applies only when the NRTM states that the feature or features identified by the predicate are supported. In the simplest case, <predicate> is the identifying tag of a single NRTM item. When the group predicate is true then the associated section shall be completed. The symbol <predicate> also may be a Boolean expression composed of several indices. .AND., .OR., and .NOT. shall be used to indicate the Boolean logical operations.

The predicates used in this document map to sections as follows:

- IP interface: Indicates the mandatory or optional nature of a feature when the interface described in [3.4.3](#) is available.
- Vehicle: Indicates the mandatory or optional nature of a feature when the sender of the corresponding information is a vehicle

3.3.1.3 Support Column Symbols

The support column can be used by a procurement specification to identify the required features for the given procurement or by an implementer to identify which features have been implemented. In either case, the user circles the appropriate answer (yes, no, or N/A) in the support column:

Table 7 - Support column symbols

Yes	To be supported (or supported) by the implementation.
No	Does not have to be supported (or not supported) by the implementation.
N/A	Not applicable.

3.3.2 Instructions for Completing the NRTM [Informative]

To claim conformance with this standard, an implementation must satisfy the mandatory and selected optional requirements as identified in the NRTM.

The columns in the NRTM table are the user need ID and user need title columns, FR ID (functional requirement ID) and FR title (functional requirement title) columns, the conformance column, the support column, and the additional specifications column.

3.3.2.1 User Need ID and User Need Title Columns

The NRTM is based upon the user needs defined in each section. The section number and user need name are indicated within these columns.

3.3.2.2 FR ID and FR Title Columns

The requirements are defined within [3.5](#) to [3.6](#). The NRTM references the traces from user needs to these requirements. The section number and requirements name are indicated within these columns.

3.3.2.3 Conformance Column

The notations and symbols used to indicate status and conditional status in the NRTM, for this column are defined in [3.3.1.1](#) and [3.3.1.2](#). Not all of these notations and symbols may be used in SAE J2945/3.

3.3.2.4 Support Column

In the “support” column, each response shall be selected either from the indicated set of responses (for example: yes, no, N/A), or it shall reference additional items that are to be attached.

If a conditional requirement is inapplicable, use the not applicable (N/A) choice.

3.3.2.5 Additional Specifications Column

The additional specifications column may (and should) be used by a procurement specification to provide additional notes and requirements for the product to be procured or may be used by an implementer to provide any additional details about the implementation. In some cases, default text already exists in this field, which the user should complete in order to fully specify the implementation. However, additional text can be added to this field as needed to fully specify a feature. Performance requirements should also be specified in this column.

3.3.3 Needs to Requirements Traceability Matrix (NRTM) Table

To claim conformance with this standard, an implementation shall satisfy the mandatory and selected optional requirements as identified in the NRTM.

Table 8 - NRTM table

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
2.3	Reference Physical Architecture					
2.3.1 (Vehicle)	Vehicles			O	Yes/No	
2.4	Architectural Needs					
2.4.1	Receive Weather Information Contained in Broadcast Messages			M	Yes	
		3.4.1	Receive Weather Information Contained in Broadcast Messages	M	Yes	
2.4.2	Broadcast Interface			M	Yes	
		3.4.2	Broadcast Interface	M	Yes	
2.4.3 (IP Interface)	Interface via Other Standards			O	Yes/No	
		3.4.3	Interface via Other Standards	M	Yes	
2.5	Features					
2.5.1	Receive Weather-Related Data Features					
2.5.1.1	Receive Basic Weather Related Data					
2.5.1.1.1	Determine Time of a Vehicle Providing Weather Situation Data			M	Yes	
		3.5.1.1.1	Determine Time of a Vehicle/Device Providing Weather Situation Data	M	Yes	
2.5.1.1.2	Determine Location of a Vehicle Providing Weather Situation Data			M	Yes	
		3.5.1.1.2	Determine Location of a Vehicle/Device Providing Weather Situation Data	M	Yes	
2.5.1.1.3	Receive External Air Temperature Data			IP Interface:O	Yes, no, N/A	
		3.5.1.1.3	Receive External Air Temperature Data	M	Yes	
2.5.1.1.4	Receive Wiper Data of a Vehicle			Vehicle, IP Interface:O	Yes, no, N/A	
		3.5.1.1.4	Receive Wiper Status of a Vehicle	M	Yes	
2.5.1.1.5	Receive the Status of a Vehicle's Exterior Lights			Vehicle:M	Yes, N/A	
		3.5.1.1.5	Receive the Status of a Vehicle's Exterior Lights	M	Yes	
2.5.1.1.6	Receive Accelerometer Data of a Vehicle			Vehicle:M	Yes, N/A	
		3.5.1.1.6	Receive Accelerometer Data of a Vehicle	M	Yes	

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
2.5.1.1.7	Receive Anti-Lock Braking System Status of a Vehicle			Vehicle:M	Yes, N/A	
		3.5.1.1.7	Receive Anti-Lock Braking System Status of a Vehicle	M	Yes	
2.5.1.1.8	Receive Traction Control System Status of a Vehicle			Vehicle:M	Yes, N/A	
		3.5.1.1.8	Receive Traction Control System Status of a Vehicle	M	Yes	
2.5.1.1.9	Receive Stability Control System Status of a Vehicle			Vehicle:M	Yes, N/A	
		3.5.1.1.9	Receive Stability Control System Status of a Vehicle	M	Yes	
2.5.1.1.10	Receive Speed of a Vehicle			Vehicle:M	Yes, N/A	
		3.5.1.1.10	Receive Speed of a Vehicle	M	Yes	
2.5.1.2	Receive Environmental Sensor Data from Participating Vehicles					
2.5.1.2.1	Receive Atmospheric Pressure Data			IP Interface:O	Yes, no, N/A	
		3.5.1.2.1	Receive Atmospheric Pressure Data	M	Yes	
2.5.1.2.2	Receive Wind Data			IP Interface:O	Yes, no, N/A	
		3.5.1.2.2	Receive Wind Data	M	Yes	
2.5.1.2.3	Receive Relative Humidity Data			IP Interface:O	Yes, no, N/A	
		3.5.1.2.3	Receive Relative Humidity Data	M	Yes	
		3.5.1.2.3.1	Receive Relative Humidity Data Source Information	M	Yes	
2.5.1.2.4	Receive Dew Point Temperature			IP Interface:O	Yes, no, N/A	
		3.5.1.2.4	Receive Dew Point Temperature	M	Yes	
		3.5.1.2.4.1	Receive Dew Point Temperature Data Source Information	M	Yes	
2.5.1.2.5	Receive Pavement Conditions about a Roadway Segment			IP Interface:O	Yes, no, N/A	
		3.5.1.2.5	Receive Pavement Conditions about a Roadway Segment	M	Yes	
		3.5.1.2.5.1	Pavement Surface Temperature	M	Yes	
		3.5.1.2.5.2	Presence of Moisture	M	Yes	
		3.5.1.2.5.3	Type of Moisture	M	Yes	
		3.5.1.2.5.4	Depth of Moisture	M	Yes	
		3.5.1.2.5.5	Roadway Friction Information	M	Yes	
2.5.1.2.6	Receive Visibility			IP Interface:O	Yes, no, N/A	
		3.5.1.2.6	Receive Visibility Situation	M	Yes	
2.5.1.2.7	Receive Precipitation			IP Interface:O	Yes, no, N/A	
		3.5.1.2.7	Receive Precipitation Data	M	Yes	

