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Intelligent transport systems — Event-based probe vehicle data

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National foreword

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Foreword

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ISO/TS 29284 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Introduction

Probe vehicle systems are being investigated and deployed throughout the world. It is expected that the number of practical systems will grow steadily over the next few years. In TC 204/SWG 16.3, probe vehicle systems and probe data have been examined, and it is concluded that in many cases communications airtime will be a scarce and expensive commodity, and therefore efficient probe data reporting systems which rely on techniques to use airtime efficiently and economically are essential. One way to accomplish this is to shift data aggregation tasks in to the probe vehicle itself. Vehicles that feature this advanced form of on board probe data processing will report information based on the occurrence of actual events as opposed to delivering a constant stream of raw vehicle probe data. Event-based probe data reporting will allow economic use of communication capacity.

As probe vehicle systems have to collect and manage probe data from a variety of vehicles from different vehicle manufacturers, the standardization of these event-based messages is essential. To do this, a common framework for event-based probe vehicle message reporting is also required.

The purpose of this project is to develop (1) a reference architecture for event-based probe data reporting within an architecture which encompasses both this function and standard probe data reporting defined in ISO 22837; (2) the basic data framework for defining event-based probe data messages; and (3) the concrete definition of these messages.

The benefits of this standardization include:

— It helps system developers and operators to specify efficient probe data collection and processing systems. It also promotes communication and mutual understanding among the developers and the operators of probe systems.

— It helps system developers who are developing probe vehicle systems to define a key tool for communications-efficient probe data systems, i.e. event-based probe data reporting.

— Probe data may be collected from various vehicles of different vehicle manufacturers. It provides a common framework for handling event-based probe data.

Intelligent transport systems — Event-based probe vehicle data

1 Scope

This Technical Specification specifies:

— reference architecture for event-based probe vehicles which encompasses event-based probe data and standard probe data elements (ISO 22837:2009);

— basic data framework of event-based probe data reporting, based on ISO 22837:2009;

— the definition of an initial set of event-based probe data elements. These elements will be commonly used in typical event-based probe data enabled application domains, such as traffic, weather, and safety. Standardizing these event-based probe data elements facilitates the development of probe vehicle systems and the distribution of probe data. This is not intended to be an exhaustive listing of event-based probe data probe data elements.

This Technical Report provides a common framework for defining event-based probe data messages to facilitate the specification and design of probe vehicle systems.

It provides concrete definitions of event-based probe data elements.

It serves as a supplement to ISO 22837:2009, and specifies additional normative data (probe data elements) that are delivered by an event-based probe data system.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 22837:2009, *Vehicle probe data for wide area communications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
probe vehicle system
system consisting of vehicles which collect and transmit probe data and land-based centres which collate and process data from many vehicles to build an accurate understanding of the overall roadway and driving environment

[ISO 22837:2009, 4.1]

3.2
vehicle sensor
device within a vehicle that senses conditions inside and/or outside the vehicle or that detects actions that the driver takes

[ISO 22837:2009, 4.2]

3.3
probe data
vehicle sensor information formatted as probe data elements and/or probe messages that is processed, formatted, and transmitted to a land-based centre for processing to create a good understanding of the driving environment

[ISO 22837:2009, 4.3]

3.4
event-based probe message
stuctured collation of probe data elements that represents occurrence of a defined event for transmission to a land-based centre

Note 1 to entry: An event-based probe data message is sent only when a specific incident or event occurs. It is not transmitted in a periodic manner. The transmission of an event-based probe message itself indicates that an event has occurred. An event-based probe message is defined as a probe message that is not triggered by a periodically occurring condition (i.e. time or distance). A typical trigger is the detection of a different situation by the vehicle on board system (i.e. low visibility or traffic jam entry). An event may be defined as a simple incident, such as a change in status of a standard probe data element (i.e. fog light switching state), or can refer to a complex incident detected by a detection algorithm (i.e. traffic jam entry).

3.5
probe data element
data item included in a probe message

[ISO 22837:2009, 4.4]

3.6
event-based probe data element
item of data included in an event-based probe message, typically describing the event that has triggered the transmission of the message

3.7
core data element
probe data element which appears in all probe messages

[ISO 22837:2009, 4.5]

3.8
probe message
structured collation of data elements suitable to be delivered to the onboard communication device for transmission to a land-based centre

Note 1 to entry: It is emphasized that a probe message should not contain any information that identifies the particular vehicle from which it originated or any of the vehicle's occupants, directly or indirectly. In delivering a probe message to be transmitted by the onboard communication device, the onboard data collection system will request that the message be packaged and transmitted without any vehicle or occupant identifying information. [ISO 22837:2009, 4.6]

3.9
processed probe data
data from probe data messages which has been collated and analysed in combination with other data

[ISO 22837:2009, 4.7]

4 Reference architecture

4.1 Reference architecture for probe vehicle systems

The reference architecture for probe vehicle systems presents the initial categorization of system components and their relationships from a conceptual point of view. A component is depicted as a

UML class and represents an encapsulation of functions and data that is conceptually considered as an individual entity in the probe vehicle system. A relationship is depicted as a UML association and represents potential control and/or data flow among components.

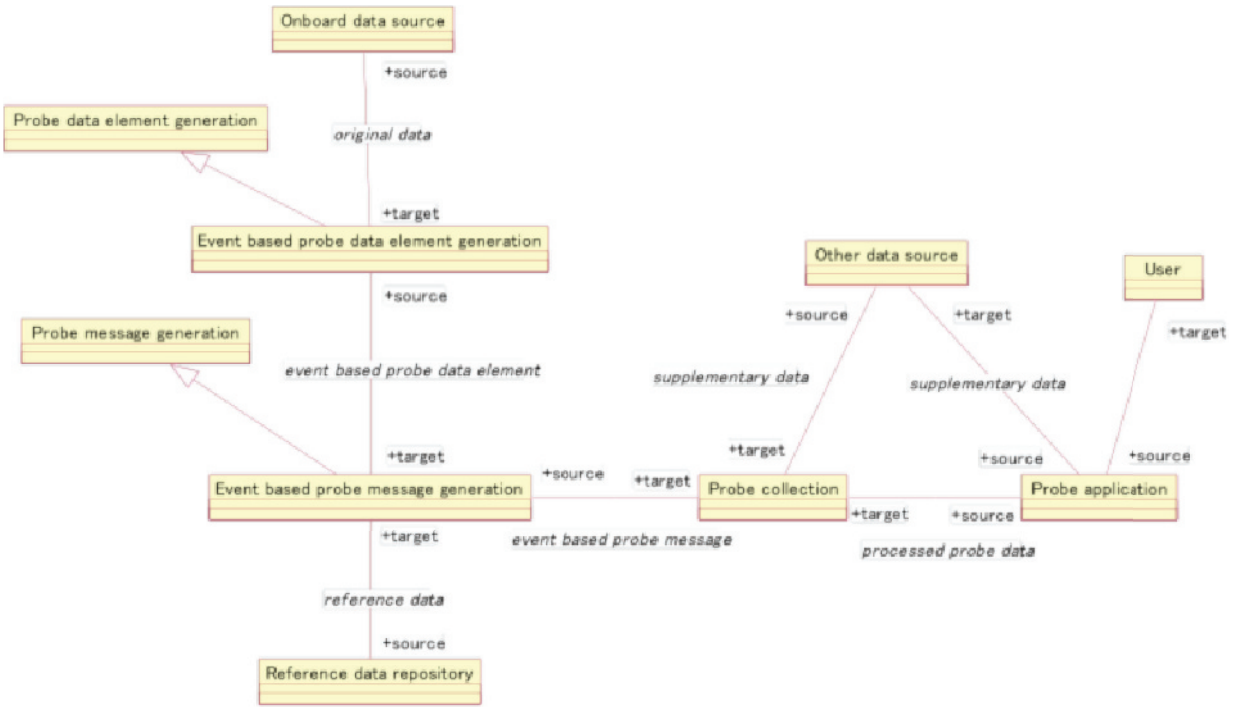

Figure 1 — Overall structure of the reference architecture for probe vehicle systems

The followings are the components of this reference architecture.

• **Onboard data source** (from ISO 22837:2009). The onboard data source provides original data that will become a probe data element. Original data may be raw sensor data or data from other onboard applications. Onboard data sources may be (various types of) sensors, onboard systems, etc.

• **Probe data element generation** (from ISO 22837:2009). Probe data element generation creates probe data elements from original data. All of the following cases are included: 1) no processing (probe data element is identical to original data), 2) normalize original data (probe data element is the result of performing a calculation or transformation on original data), and 3) process original data to generate new type of data (multiple items of original data are processed, possibly over a time period, to produce the probe data element, e.g.“traffic jam detected”).

• **Event-based probe data element generation.** Event-based probe data element generation creates from probe data elements that represents occurrence of a defined event.

• **Probe message generation** (from ISO 22837:2009). Probe message generation creates and formats probe messages from probe data elements and sends them to probe collection. Here, “send” is at the application layer, not the communication layer. Probe message generation manages the timing of sending messages as an application issue. Actual message transmission out the vehicle is left to the communication layer. Probe message generation may refer to stored reference data, to assist with data transformation or to help determine whether a probe message should be sent.

• **Event-based probe message generation.** Event-based probe message generation is a special type of probe message generation that creates and formats event-based probe messages from event-based probe data elements and sends them to probe collection when the event is detected.

• **Referenced data repository** (from ISO 22837:2009). Referenced data repository holds data for reference by the probe message generator.

• **Probe collection** (from ISO 22837:2009). Probe collection is a land-side activity that receives probe messages sent by vehicles and extracts probe data from these messages.

• **Probe processing** (from ISO 22837:2009). Probe processing receives collected probe data from probe collection and processes it (for example, using analysis and fusion). Probe processing does not receive any information from probe collection that identifies the vehicle or driver.

• **Probe application** (from ISO 22837:2009). Application which uses information produced by probe processing.

• **Other data source** (from ISO 22837:2009). Other data source provides additional data that is used for probe processing and/or by probe applications. Other data sources may be road authorities, police, weather information providers, etc.

• **User** (from ISO 22837:2009). Entity that receives services and/or information produced from probe data. Users may be drivers, road authorities, police, weather services, public agencies, individual users (of cell phones, PDAs), etc. Each relationship in this reference architecture is represented as a data and/or control flow. The followings are those data and flow in this reference architecture.

• **Original data** (from ISO 22837:2009). Data used for probe data generation. Original data may be raw sensor data or data from other onboard applications.

• **Reference data** (from ISO 22837:2009). Data stored in a repository and referred to for probe data generation. Reference data may be (among other things) historical data and/or statistical data.

• **Event-based probe data element.** Event-based probe data element is an item of data included in a event-based probe message, that represents an occurrence of a defined event.

• **Event-based probe message.** A message in the application layer. An event-based probe message consists of several event-based probe data elements (always including core data elements) that convey meaningful information to centre-side probe collection components.

• **Collected probe data** (from ISO 22837:2009). Probe data collected by the probe collection component, to be sent to probe processing components.

• **Supplementary data** (from ISO 22837:2009). Data from other data sources (non-vehicle) that is also used in probe processing and/or by probe applications.

• **Processed probe data** (from ISO 22837:2009). Data from probe data messages which has been collated and analysed in combination with other data (For the general definition of processed probe data, see 3.9.)

• **Service, information** (from ISO 22837:2009). The value-added result of combining processed probe data with supplementary data for delivery to users.

4.2 Extended information package for event-based probe data

The reference architecture for probe data represents the initial categorization of probe data from a conceptual point of view. This is defined by ISO 22837:2009. The reference architecture for probe data consists of multiple packages in UML notation. Each package includes conceptual entities that are identified from a specific point of view. Each conceptual entity is depicted as a UML class.

Figure 2 is the overall package structure of the reference architecture for probe data(from ISO 22837:2009).

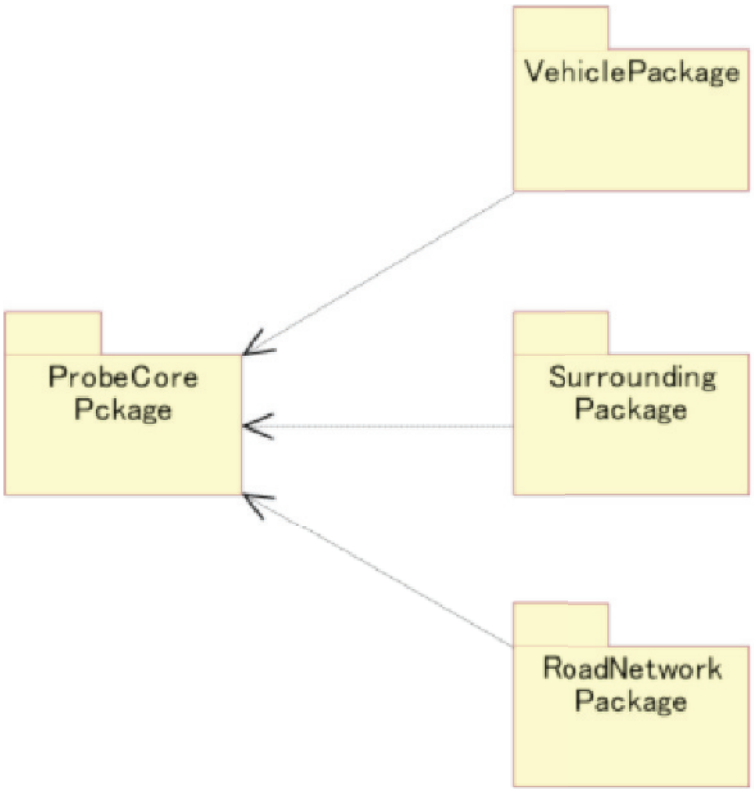

Figure 2 — Package structure of reference architecture for probe data

Each package includes the conceptual entities from a different specific viewpoint. Each conceptual entity is an object class. Each class has properties. Figure 3 shows the conceptual entities for the ProbeCorePackage.

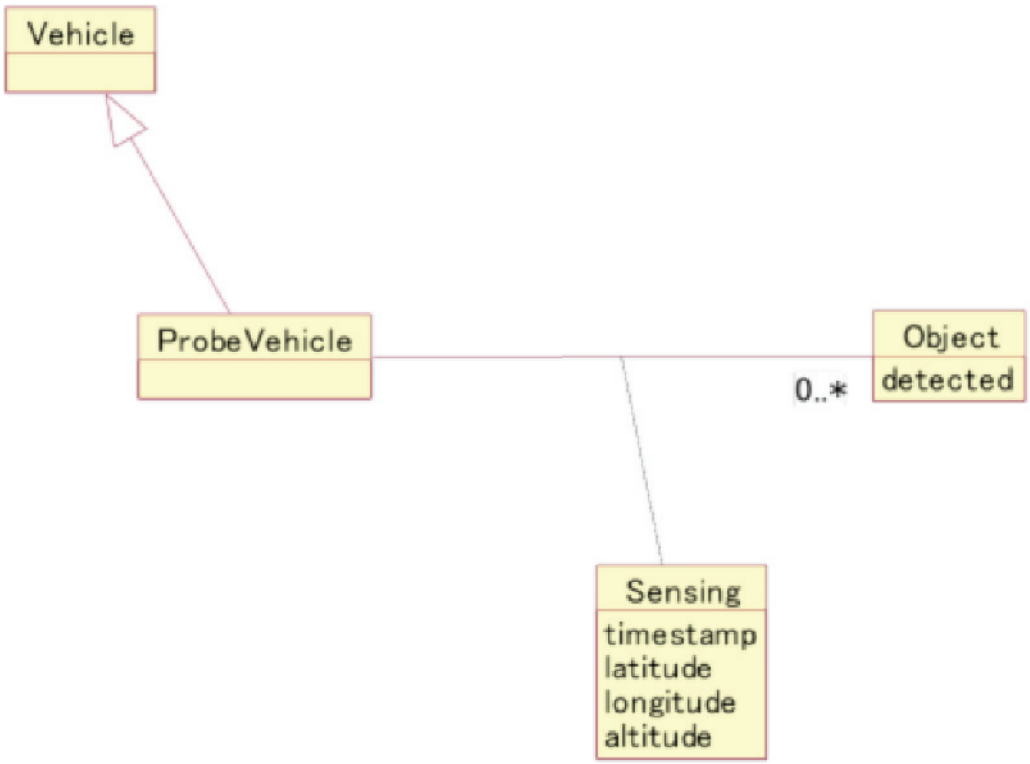

Figure 3 — Entities of ProbeCorePackage

Event-based probe data is a system which detects some change of a situation within vehicles. The vehicles need to grasp where this change of a situation (event) happened, when transmitting probe data messages. Then, the concept of an “area” package is introduced into the vehicle package defined by ISO 22837:2009.

This concept package enables transmission of the probe message which showed the generating place and influence range of an event. Figure 4 shows the conceptual entities for the area package

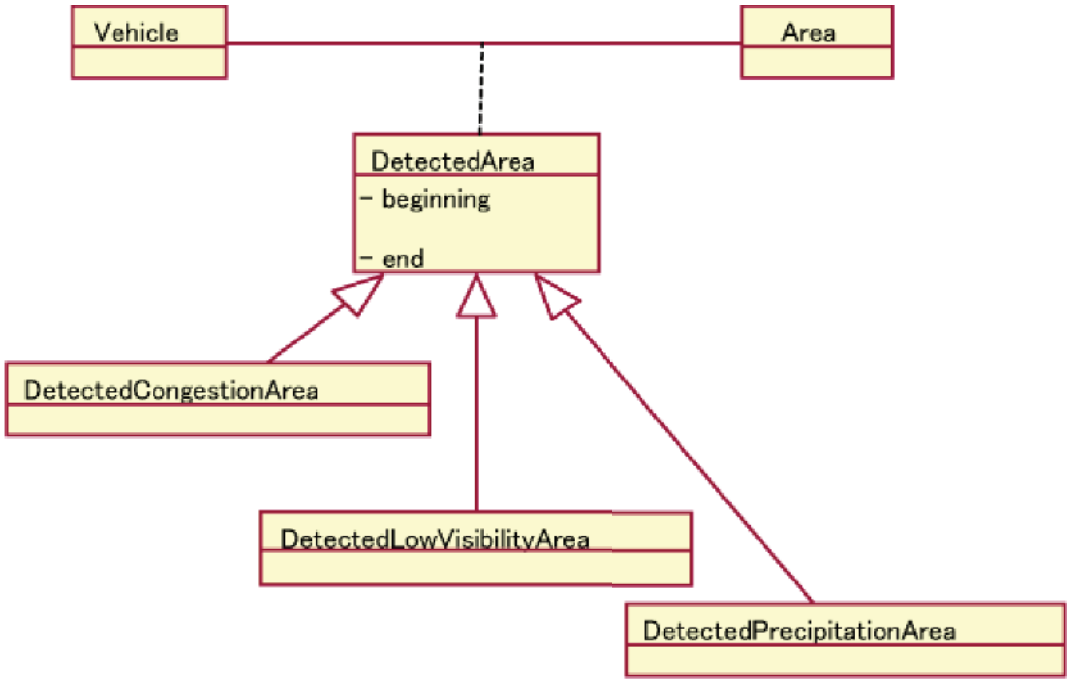

Figure 4 — Concept of area package

5 Event-based probe data message

5.1 Concept of core data elements (from ISO 22837:2009)

"Core data elements" are information added to all event-based probe data elements and probe messages. Core data elements consist of a timestamp which shows the time when the event was sensed and a location stamp which specifies the vehicle's location at the time the event was sensed.

Core data elements are specified in ISO 22837:2009. Figure 5 shows a concept of core data elements from ISO 22837:2009.

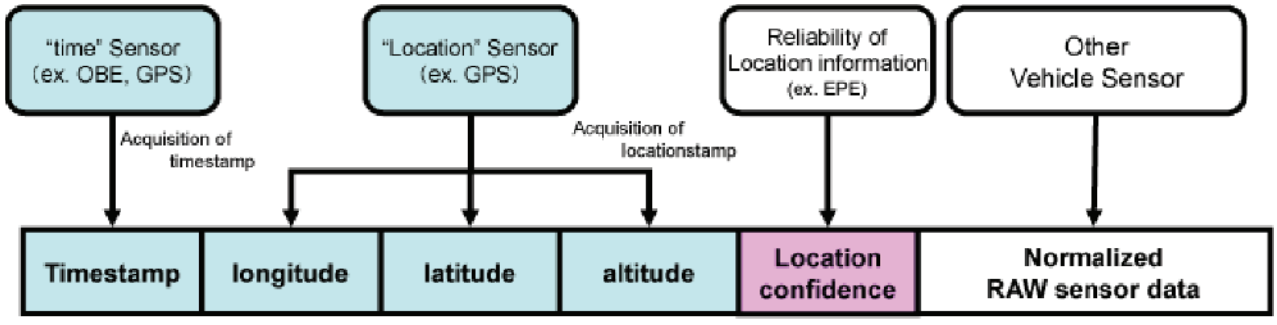

Figure 5 — Concept of core data elements

5.2 Structure of event-based probe data message

An event-based probe data message is a special type of probe message. It must include event-based probe data elements that represent occurrences of defined events. Event-based probe data messages consist

of a timestamp that shows the time when the event was sensed and a location stamp that specifies the vehicle's location at the time the event was sensed, similar to core data elements.

Figure 6 shows a structure of an event-based probe data message.

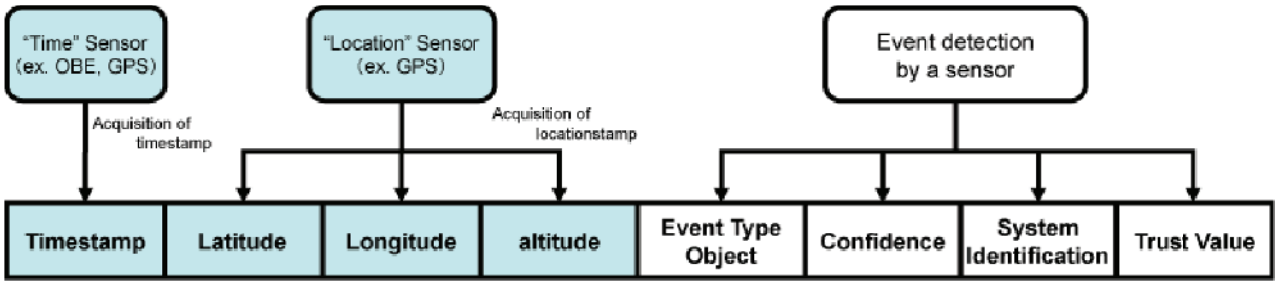

Figure 6 — Structure of an event-based probe data message

5.3 Timestamp

Specified within ISO 22837:2009.

5.4 Latitude

Specified within ISO 22837:2009.

5.5 Longitude

Specified within ISO 22837:2009.

5.6 Altitude

Specified within ISO 22837:2009.

5.7 Event type object

The event type object defines the event that triggered the event-based probe message. Event types are defined in Clause 6.

5.8 Confidence

Confidence provides the receiver of event-based probe data with information about how likely it is that the detected event has actually occurred. Confidence is expressed as a percentage value from 1 to 100 and is typically derived from the on board sensor's false alarm rate. Where percentage is the number of occurrences, a correct value would be derived from a statistically significant sample size. A value of "0" indicates that confidence is unknown or indeterminate due to system implementation.

5.9 System identification (optional)

This value is a unique identifier assigned to a specific vehicle side implementation.

5.10 Trust value (optional)

The trust value represents the number of occurrences of the same event in the same location at the same time as observed by multiple vehicles. The value is incremented by each vehicle (or device) that observes the event.

NOTE This value is dedicated to vehicle-to-vehicle communication. Number of vehicles that detected the same event, in the same location, at the same time. For example, if a vehicle knows that three vehicles detected the same event (traffic jam), in the same location, vehicle sets trust value to "3".

6 Event type object

Table 1 lists the events which can be detected:

Table 1 — Event type object

Event type	Event ID	Event value	Description
DetectedAreaCongestion	1	1	This event is continuously (depending on configuration) generated while the vehicle is experiencing congestion.
DetectedArea.Beginningof.Congestion	1	2	This event is generated when the vehicle is entering congestion.
DetectedArea.Endof.Congestion	1	3	This event is generated when the vehicle has exited congestion.
DetectedArea.FreeFlowingTraffic	2	1	This event is continuously (depending on configuration) generated while the vehicle is experiencing free flowing traffic.
DetectedArea.Beginningof.FreeFlowing-Traffic	2	2	This event is the same as End of Congestion (1.3)
DetectedArea.Endof.FreeFlowingTraffic	2	3	This event is the same as Beginning of Congestion (1.1)
DetectedArea.SlipperyRoad	3	1	This event is continuously (depending on situation) generated while the vehicle is experiencing slippery road.
DetectedArea.Beginningof.SlipperyRoad	3	2	This event is generated when the vehicle detects it is entering a slippery road.
DetectedArea.Endof.SlipperyRoad	3	3	This event is generated when the vehicle has exited a slippery road.
DetectedArea.Precipitation	4	1	This event is continuously (depending on configuration) generated while the vehicle is experiencing precipitation.
DetectedArea.Beginningof.Precipitation	4	2	This event is generated when the vehicle is entering an area in which it is experiencing precipitation.
DetectedArea.Endof.Precipitation	4	3	This event is generated when the vehicle has detected the end of precipitation.
DetectedArea.LowVisibility	5	1	This event is continuously (depending on configuration) generated while the vehicle is experiencing low visibility.
DetectedArea.Beginningof.LowVisibility	5	2	This event is generated when the vehicle first detects low visibility.

Table 1 *(continued)*

DetectedArea.Endof.LowVisibility	5	3	This event is generated when the vehicle has detected the end of low visibility.
DetectedArea.Crash	6	1	This event is generated when the vehicle has crashed.
DetectedArea.Breakdown	7	1	This event is generated when the vehicle is experiencing a breakdown.
DetectedArea.EmergencyBrake	8	1	This event is generated when the vehicle has performed an emergency brake.
DetectedArea.DirtRoad	9	1	This event is generated when the vehicle is transiting from a smooth paved road to an unpaved road.

7 Reference event-based probe data message

Table 2 — Reference event-based probe data message

Name	Description	Data source	Data type	Format	Unit of measure	Valid value rule	Data quality

DetectedArea.Congestion	This event is continuously (depending on configuration) generated while the vehicle is experiencing congestion.	Depends on implementation	DetectedArea.Congestion:: = SEQUENCE {
			Event ID 1
			EventValue 1
			}
				SEQUENCE	CODE	INTEGER	n.a.

DetectedArea.Beginningof.Congestion	This event is generated when the vehicle is entering congestion.	Depends on implementation	DetectedArea.BeginningCongestion:: = SEQUENCE {
			Event ID 1
			EventValue 2
			}
				SEQUENCE	CODE	INTEGER	n.a.

DetectedArea.Endof.Congestion	This event is generated when the vehicle has exited congestion.	Depends on implementation	DetectedArea.End.Congestion:: = SEQUENCE {
			Event ID 1
			EventValue 3
			}
				SEQUENCE	CODE	INTEGER	n.a.

DetectedArea.FreeFlowingTraffic	This event is continuously (depending on configuration) generated while the vehicle is experiencing free flowing traffic.	Depends on implementation	DetectedArea.FreeFlowingTraffic:: = SEQUENCE {
			Event ID 2
			EventValue 1
			}
				SEQUENCE	CODE	INTEGER	n.a.

DetectedArea.Beginningof.FreeFlowingTraffic	This event is the same as End of Congestion(1.3)	Depends on implementation	DetectedArea.Beginning.FreeFlowingTraffic:: = SEQUENCE {
			Event ID 2
			EventValue 2
			}
				SEQUENCE	CODE	INTEGER	n.a.

DetectedArea.Endof.FreeFlowingTraffic	This event is the same as Beginning of Congestion(1.1)	Depends on implementation	DetectedArea.End. FreeFlowingTraffic:: = SEQUENCE {
			Event ID 2
			EventValue 3
			}
				SEQUENCE	CODE	INTEGER	n.a.

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