
**Intelligent transport systems —
Definition of data elements and data
frames between roadside modules
and signal controllers for cooperative
signal control**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Signal controllers and traffic control centres optimize signal timings based on real-time traffic information for each approach. For example, signal controllers may extend the green time for an approach with a long queue.

The aim of this document is to define data elements and data frames that are useful for optimising local and coordinated signal operations.

ISO 22951 (PRESTO) specifies the message sets for signal system pre-emption and priority for transit vehicles including communications between roadside modules and signal controllers. This document complements PRESTO by defining message sets for traffic information that is useful for optimizing normal signal operations. Thus, signal controllers and traffic management centres can generate signal timings referring to the messages of PRESTO and this document.

The red arrows in [Figure 1](#) illustrate message flows that are within scope of this document.

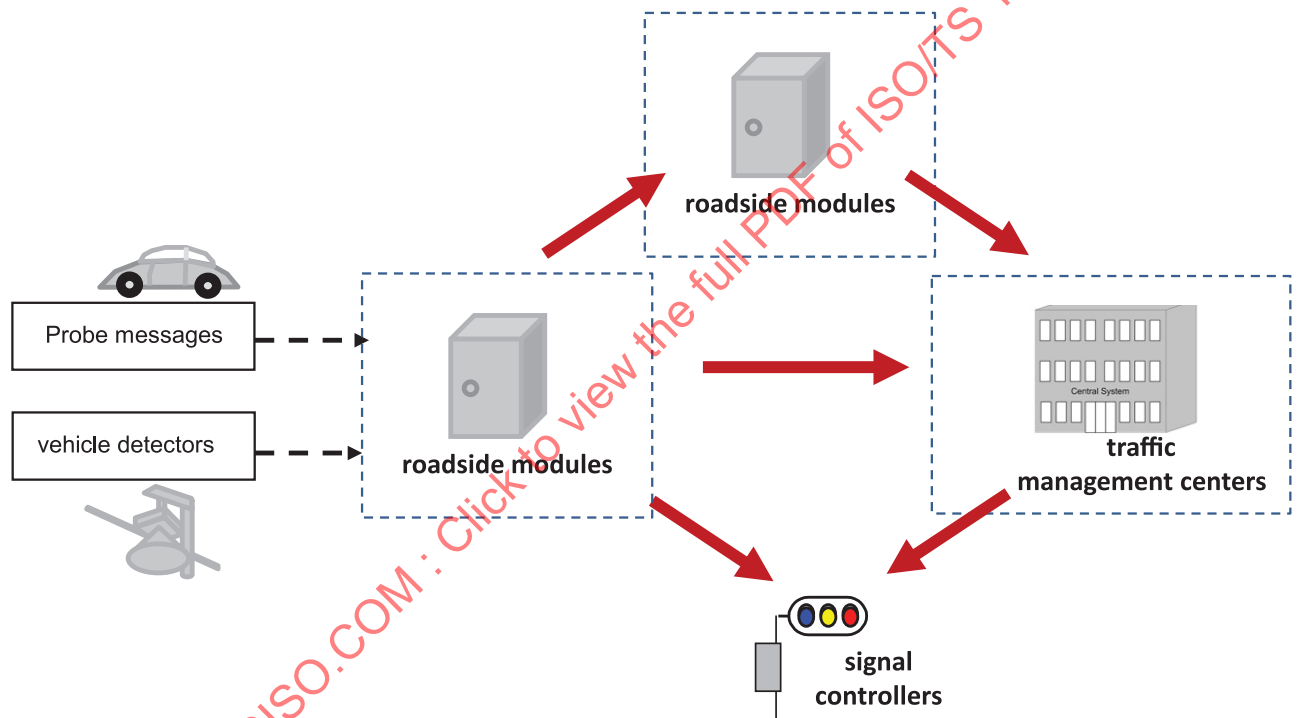


Figure 1 — Physical scope of this document

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Intelligent transport systems — Definition of data elements and data frames between roadside modules and signal controllers for cooperative signal control

1 Scope

This document specifies data elements and data frames for messages

- a) exchanged between roadside modules and:
 - 1) signal controllers,
 - 2) traffic management centres, and/or
 - 3) other roadside modules.
- b) exchanged between traffic management centres and signal controllers.

NOTE Roadside modules can generate data based on inputs from vehicle detectors and/or probe data transmitted by vehicles. This document does not address how the roadside module generates the data; it only addresses communication after receiving and processing raw data from one or more sources.

EXAMPLE A roadside module can calculate vehicle volume, average speed, and queue length by utilizing data from vehicle detectors and probe information.

The data structure follows the framework specified in ISO 14817-1, and the data elements and data frames are described by description name, object identifier, definition, and data type following ISO 14817-1. The specifications of this document complement those from ISO/TS 19091 and other standards.

The roadside modules can be constructed in any manner using any architecture including the ITS station as described in ISO 21217, or other hardware and software constructs.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 14817-1, *Intelligent transport systems — ITS central data dictionaries — Part 1: Requirements for ITS data definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14817-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

adaptive signal control

signal control concept where vehicular traffic in a network is detected at one or more points upstream and/or downstream and algorithmically combined with other information to predictively optimize traffic signal operations

3.2

conflicting turn

turn manoeuvre that conflicts with another manoeuvre at an intersection

3.3

cooperative signal control

signal control utilizing not only vehicle detector data but also V2I communication data

3.4

dilemma zone

area upstream of a traffic signal in which different drivers are likely to make different decisions on whether they should continue through or stop at the signal as they see the signal indication change from green to yellow

Note 1 to entry: There are two types of dilemma zones. Type I occurs when yellow and red clearance times are too short for a driver to either stop or clear the intersection before the beginning of a conflicting phase. Type II, also known as an "Option Zone", or "Indecision Zone". This occurs as the result of different drivers making different decision on whether to go or stop, upon the change from a green to yellow indication.

3.5

flow rate

equivalent hourly rate at which vehicles, bicycles, or persons pass a point on a lane, roadway, or other trafficway, computed as the number of vehicles, bicycles, or persons passing the point, divided by the time interval (usually less than 1 h) in which they pass

Note 1 to entry: It is expressed as vehicles, bicycles, or persons per hour.

3.6

phase

signal controller timing unit associated with the control of one or more movements

3.7

probe data

vehicle sensor information, formatted as probe data elements and/or probe messages, that is processed, formatted, and transmitted to a roadside module to create a good understanding of the driving environment

3.8

queue

line of vehicles, bicycles, or persons waiting to be served by the system in which the flow rate from the front of the queue determines the average speed within the queue

Note 1 to entry: Slowly moving vehicles or people joining the rear of the queue are usually considered part of the queue. The internal queue dynamics can involve starts and stops. A faster-moving line of vehicles is often referred to as a moving queue or a platoon.

3.9

roadside module

group of components, or applications, installed at the roadside that can be controlled and/or monitored by a remote entity

3.10

signal controller

roadside module that manages the right-of-way at an intersection, typically by displaying green, yellow, and red indications to the intersection's various approach lanes

4 Symbols and abbreviated terms

PRESTO Data Dictionary and Message Sets for Pre-emption and Prioritization Signal System for Emergency and Public Transport Vehicles

5 Conformance

In order to claim conformance with this document, the structure of data elements and the data frames between roadside modules and signal controllers shall follow the data types described in [Clause 7](#).

6 Use cases

6.1 General

This Clause describes several usage examples where data defined within this document can be used.

6.2 Macroscopic signal control systems

Many adaptive signal control systems perform macroscopic control functions on a central computer, which determines the signal parameters such as cycle length, split and offset based on congestion information. These systems aim to reduce delays and stops by improving the timing efficiency of green indications at critical intersections and maximizing traffic capacity.

Conventionally, volumes and occupancy from vehicle detectors have been used for the input of these systems; the introduction of connected vehicles now allow probe data to be used for this purpose ([Figure 2](#)). Probe data can be received over short range communication technologies and processed by roadside modules; the processed data can then be transferred to traffic control centres. Probe data can also be collected via wide area communication. In this case, the central computers process the collected raw probe data and calculate signal parameters by combining processed probe data transferred from roadside modules (but care must be taken not to duplicate data in this process).

The central computer calculates optimal signal parameters and transmits them to signal controllers every a few minutes. Sometimes micro control functions described in [6.2](#) is combined with macro control functions by signal controllers.

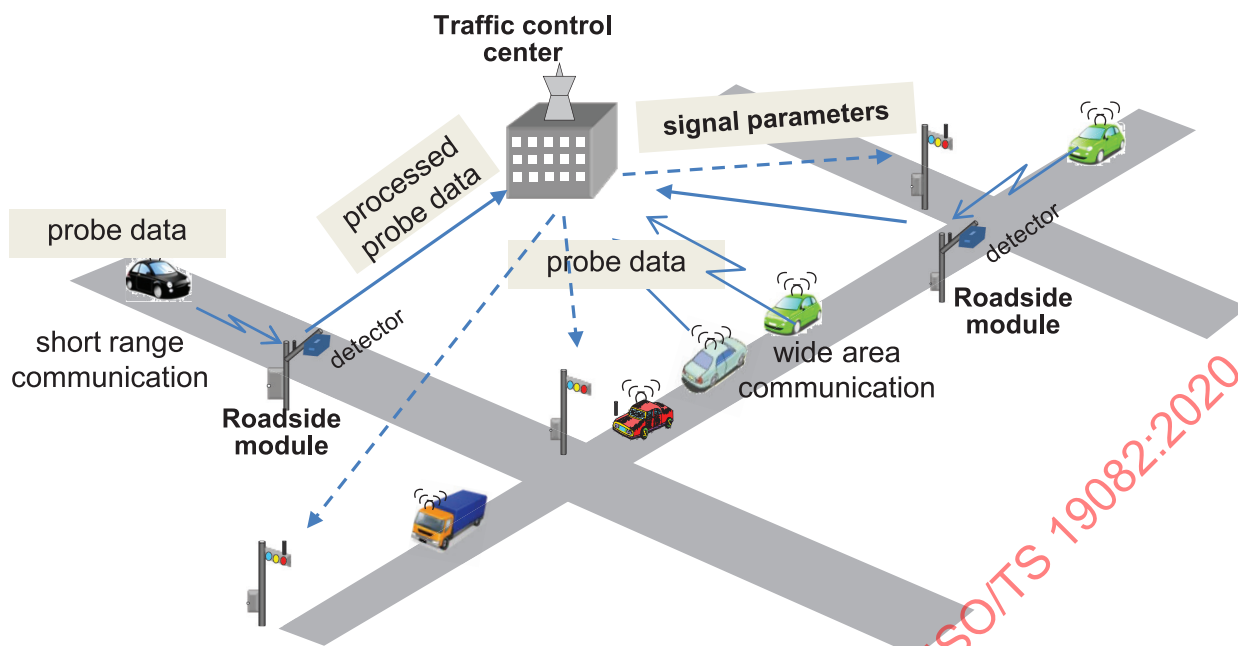


Figure 2 — Macroscopic signal control system

An example flow of macroscopic signal control systems is shown below:

- Roadside modules with detectors gather raw data of the presence and position of vehicles.
- Vehicles equipped with in-vehicle units transfer probe data to roadside modules.
- The roadside modules calculate some characteristic data of intersections, e.g. flow rate, average speed, divergence rate, and vehicle type ratio by utilizing data from vehicle detectors and probe data.
- The roadside modules transfer the calculated data to the traffic management centre.
- The traffic management centre calculates the optimum parameters for intersections, e.g. splits, cycles, and offsets and transfers them to the signal controllers.

Another example of macroscopic signal control systems is shown below:

- The vehicle detectors gather raw data of the presence of vehicles and the positions of vehicles.
- Vehicles which equip in-vehicle units transfer probe data to roadside modules.
- The roadside modules assemble data of each vehicle, e.g. position, speed, stop position. The roadside modules can generate snapshots of vehicle positions.
- The roadside modules transfer the assembled data to the traffic management centre.
- The traffic management centre calculates some characteristic data of each intersection, e.g. flow rate, average speed, divergence rate and vehicle type ratio, utilizing data from roadside modules, then calculates the optimum parameters for intersections, e.g. splits, cycles, and offsets and transfers them to the signal controllers.

6.3 Micro signal control systems

Roadside modules are usually installed near an intersection in local control systems. Probe data is collected via short range wireless communication (referred to as "localized communications" in ITS, see e.g. ISO 21215, ISO 29281-1). Traffic signals with actuated conflicting turns are an example of this kind of system. This system optimizes the left-turn phase time according to the presence and numbers of queued vehicles. [Figure 3](#) shows one of the examples (a left hand turn for roads that drive on the right).

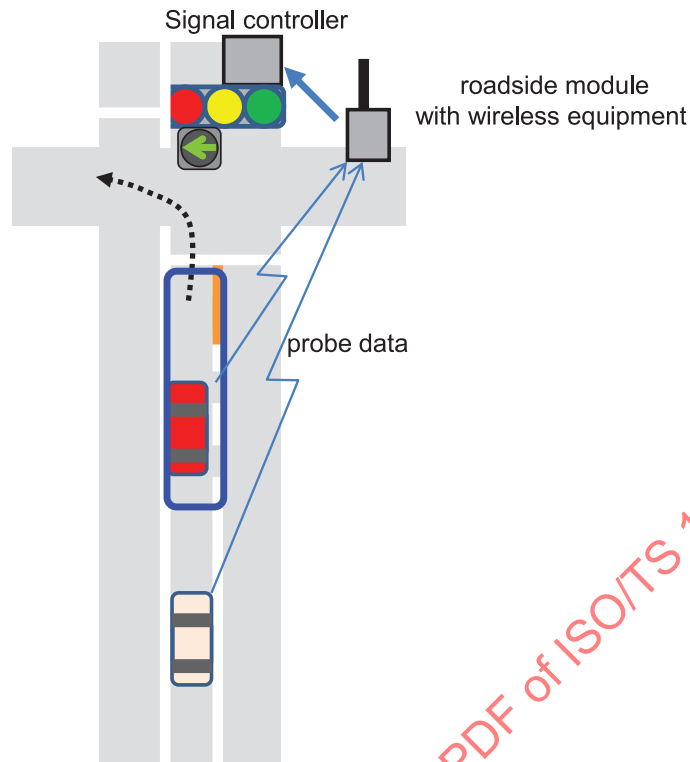


Figure 3 — Actuated conflicting turns

An example flow of left-turn control systems is shown below:

- The vehicle detectors gather raw data of the presence of vehicles and the position of vehicles.
- Vehicles which equip in-vehicle units transfer probe data to roadside modules.
- The roadside modules assemble data of vehicle presence and each vehicle's position and speed.
- The roadside modules calculate the queue length of vehicles, and the time gap between vehicles.
- The roadside modules transfer the processed data to the signal controller.
- The signal controller decides the phase timing with the processed data. For example, the signal controller extends the green phase if vehicles are present in a specified area.

Another example of micro signal control systems is the dilemma zone control system. The dilemma zone control system minimizes the number of vehicles in the dilemma zone by adjusting the start time of the yellow and red signal phase either earlier or later, based on observed vehicle locations and speeds. [Figure 4](#) shows the examples.

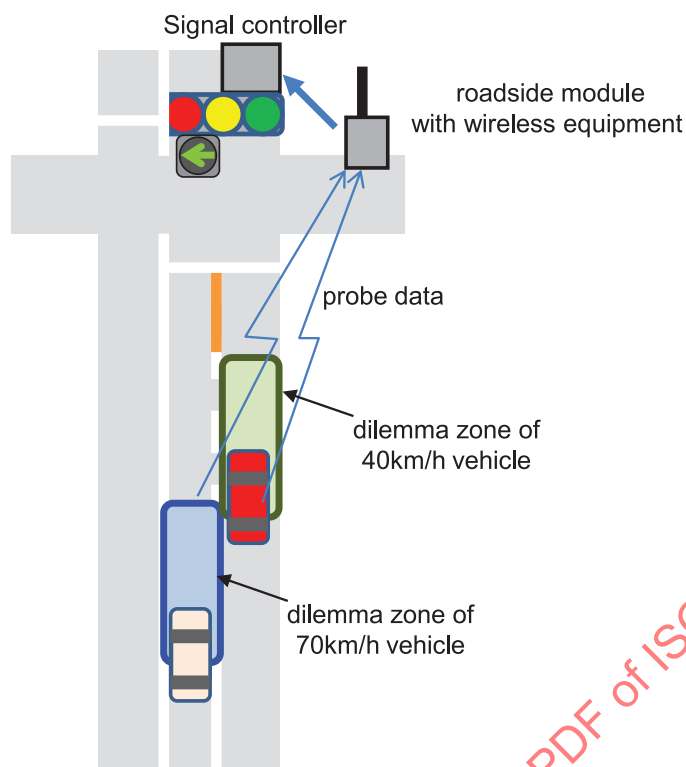


Figure 4 — Dilemma zone control systems

An example flow of dilemma zone control systems is shown below:

- The vehicle detectors gather raw data of the presence of vehicles and the position of vehicles.
- Vehicles which equip in-vehicle units transfer probe data to roadside modules.
- The roadside modules pick up the data of important vehicles for the dilemma zone control system.
- The roadside modules transfer the processed data to the signal controller.
- The signal controller decides the phase timing with the processed data. For example, the signal controller finishes the green phase if a vehicle enters the dilemma zone.

6.4 Data frames for the use cases

In these use cases, the data frames in [Table 1](#) shall be used.

Table 1 — Data frames for use cases

Data frames	Macroscopic signal control	Micro signal control
Snapshot.vehiclePositions:VehiclePositionSnapshot	✓	✓
Intersection.snapshot:Measure	✓	✓
vehicle.LocalPosition:Measure		✓
Intersection.latestStartupLostTimes:measure	✓	
IntersectionLane.FlowRatePerLane:measure	✓	
IntersectionApproach.DivergenceRate:percent	✓	
Intersection.VehiclePresent:boolean		✓
Geolocation.VehiclePresent:boolean		✓
Intersection.VehicleAmount:quantity	✓	

Table 1 (continued)

Data frames	Macroscopic signal control	Micro signal control
Geolocation.VehicleAmount:quantity	✓	
Intersection.averageHeadway:duration	✓	
Intersection.queueLength:measure	✓	✓
Intersection.stopPositions:measure	✓	
Link.travelTime:duration	✓	
Intersection.meanVehicleSpeed:measure	✓	
Intersection.VehicleSpeed:measure		✓
Intersection.largeVehiclePercentage:percent	✓	
Intersection.VehicleGapSize:measure	✓	✓
Intersection.CycleLength:duration	✓	
Intersection.Split:percent	✓	
Intersection.relativeOffset:duration	✓	
Intersection.absoluteOffset:duration	✓	

7 Data elements and frames

7.1 General

In this clause the data elements and frames for communications between roadside modules and signal controllers, traffic management centres, and/or other roadside modules are defined. These data elements and frames are used for realizing signal controls in [Clause 6](#).

7.2 Data elements

Data elements are the components of data frames specified in [7.3](#). [Table 2](#) shows the data elements for expressing each data.

Table 2 — Data elements

Descriptive name	OID	Definition	Multiplicity	Data type	Unit of measure	Valid value rule
IntersectionLane. meanVehicleSpeed:measure		The arithmetic mean speed of the vehicles travelling in the intersection lane.	1	Type-measure-kmh-u8	1 kilometre per hour	
IntersectionLane. approachingFrom:code		The compass direction from which vehicles enter the intersection.	1	Type-code-compass16 (North, North-northeast, Northeast, East-northeast, East, East-southeast, Southeast, South-southeast, South, South-southwest, Southwest, West-southwest, West, West-northwest, North-west, North-northwest)	code	
IntersectionLane. approachingVehicleDistance:measure		The distance from the leading edge of an approaching vehicle and the stop line associated with the vehicle's lane.	1	Type-measure-metre-s16 (-32768..32767)	metre	
IntersectionLane. freeFlowRate:measure		The number of queued authorized entities that flow across the stop bar for the intersection lane per unit time after the startup time has expired and before the signal terminates its green time. It is expressed in the equivalent entities per hourly rate. The type of authorized entity is defined by the definition of the intersection lane in the intersection map (i.e., a vehicle would be the authorized entity in a lane designated for vehicles).	1	Type-measure-pcph-u16	car units per one hour	
Snapshot.dailyTimestamp:datetime		The time of day at which the snapshot was taken. It is represented as nominal milliseconds from midnight, in the local time zone unless otherwise specified.	1	Type-time	millisecond	
Vehicle.travelTime:duration		The average time required for vehicles to traverse the link.	1	Type-duration-sec-u16	second	
Vehicle.Speed:measure		The instantaneous speed of the vehicle.	1	Type-measure-kmh-u16	1 kilometre per hour	
Vehicle.Type:code		The type of vehicle described in ISO 3833.	1	Type-code-vehicle-type-iso3833	code	

Table 2 (continued)

Descriptive name	OID	Definition	Multiplicity	Data type	Unit of measure	Valid value rule
IntersectionLane.largeVehiclePercentage :percent		The percentage of large motor vehicles within the stream of entities crossing the stop bar.	1	Type-percent	percent	
Vehicle downstreamSpacing:measure		The distance between the leading edge of the vehicle to the trailing edge of the next vehicle in front of it in the same lane.	1	Type-measure-metre-u8	metre	the value 255 indicates that no vehicle is detected within 254 metres in front of it within the same lane
IntersectionApproach.straightPercent :percent		The percentage of vehicles on the intersection approach that have gone straight	1	Type-percent	percent	
IntersectionApproach.rightPercent :percent		The percentage of vehicles on the intersection approach that have gone right	1	Type-percent	percent	
IntersectionApproach.leftPercent :percent		The percentage of vehicles on the intersection approach that have gone left	1	Type-percent	percent	
IntersectionLane.vehiclePresent :boolean		An indication of whether there are any vehicles present in a specified area of the approach lane.	1	Type-boolean	boolean	
IntersectionLane.vehicleAmount :quantity		A count of how many vehicles are present in a specified area of the approach lane.	1	Type-quantity-u16	number	
IntersectionLane.averageHeadway :duration		The average time between the leading edge of two subsequent vehicles at an intersection as they cross the stop line once the signal has been green for 6 seconds and as averaged over a predetermined time.	1	Type-duration-sec-u16	second	
IntersectionLane.queueLength:measure		The length of a series of vehicles whose flow is controlled by the lead vehicle. Remarks: A queue boundary is typically determined by a distance gap for stopped vehicles, a time gap for high speed vehicles, or a combination of the two for slow moving vehicles.	1	Type-measure-metre-u12	metre	The value 4 095 shall mean a length in excess of 4 094 metres

Table 2 (continued)

Descriptive name	OID	Definition	Multiplicity	Data type	Unit of measure	Valid value rule
SignalPhase.currentindication:code		The indication currently being output for the signal phase.	1	Type-code-signalphase-indication	code	The defined domain is ENUMERATED { Unavailable (0), Dark (1), Stop-then-proceed (2), Stop-and-remain (3), Pre-movement (4), Permissive-movement-allowed (5), Protected-movement-allowed (6), Permissive-clearance (7), Protected-clearance (8), Caution-conflicting-traffic (9) }
IntersectionLane.latestLostTime		The time required for the second queued vehicle to cross the stop line after the associated phase changed. If fewer than two cars were queued at the start of green, the value shall be 0.	1	Type-duration-sec-u16	second	
Signal.CycleLength:duration		The time required for a complete sequence of signal indications. Expressed in seconds.		Type-duration-sec-u16	second	
SignalPhase.Split:percent		The time allotted for the phase during coordinated operations. Expressed in percent.		Type-percent	percent	
Signal.Offset:duration		The time relationship between coordinated phases defined reference point and a master reference. Expressed in seconds.		Type-duration-sec-u16	second	

Table 3 — Data elements in referred standards

Descriptive name	Definition	Referred standard
GeoLocation.latitude:measure	The latitude of the location using the WGS-84 realization that is in effect at the time the data is recorded.	ISO 14817-1
GeoLocation.longitude:measure	The longitude of the location using the WGS-84 realization that is in effect at the time the data is recorded.	ISO 14817-1
GeoLocation.altitude:measure	The altitude of the location using the WGS-84 realization that is in effect at the time the data is recorded.	ISO 14817-1
Lane.id:number	The number that uniquely identifies the lane within the intersection	ISO 14296
Intersection.id:number	The number that uniquely identifies the intersection among all of those managed by the operating agency.	ISO 14296

7.3 Data frames for processed and statistical data

Data frames consist of the data elements specified in [6.1](#) or other data frames. [Table 4](#) shows the data frames for expressing processed and statistical data.

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Table 4 — Data frames

Descriptive name	OID	Definition	Multiplicity	Data type
Snapshot.vehiclePositions:VehiclePositionSnapshot		A summary of the location of vehicles at an instant in time.		SEQUENCE { time Snapshot.timestamp, vehPositions (SIZE(0..65535)) OF vehicle.Position3D }
Intersection.snapshot:Measure		A summary of the location of vehicles at an intersection at an instant in time.		SEQUENCE { time Snapshot.timestamp, vehPositions (SIZE(0..65535)) OF vehicle.LocalPosition }
vehicle.LocalPosition:Measure		The position of vehicles expressed with the distance and direction from intersections.		SEQUENCE { identifier Intersection.number, approach IntersectionLane.approachingFrom, distance IntersectionLane.approachingVehicleDistance, identifier IntersectionLane.number }
Snapshot.dateStamp:datetime		A Gregorian calendar date expressed		SEQUENCE { year integer 16, month month date day of month }
Intersection.latestStartupLostTimes :measure		The time required for the second queued vehicle to cross the stop line after the associated phase changed at an intersection. If fewer than two cars were queued at the start of green, the value shall be 0.		SEQUENCE { phase SignalPhase.currentindication, approach IntersectionLane.approachingFrom, lostTimes (SIZE(0..255)) OF Intersection.latestLostTime }

Table 4 (continued)

Descriptive name	OID	Definition	Multiplicity	Data type
IntersectionLane.FlowRatePerLane :measure		The number of queued authorized entities that flow across the stop bar for the intersection lane per unit time after the startup time has expired and before the signal terminates its green time. It is expressed in the equivalent entities per hourly rate. The type of authorized entity is defined by the definition of the intersection lane in the intersection map (i.e. a vehicle would be the authorized entity in a lane designated for vehicles).		SEQUENCE { flowRate IntersectionLane.freeFlowRate, identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number }
IntersectionApproach.DivergenceRate :percent		The percentage of vehicles on the intersection approach that have gone straight, right, and left.	1	SEQUENCE { straight IntersectionApproach.straightPercent, right IntersectionApproach.rightPercent, left IntersectionApproach.leftPercent, identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number }
Intersection.VehiclePresent:boolean		Information whether one or plural vehicles exist in specified areas. The area can be written with start location and end location. This frame can be used for micro signal control systems.	1	SEQUENCE { present IntersectionLane.vehiclePresent, identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number, start vehicle.LocalPosition, end vehicle.LocalPosition }

Table 4 (continued)

Descriptive name	OID	Definition	Multiplicity	Data type
Geolocation.VehiclePresent:boolean		Information whether one or plural vehicles exist in specified areas. The area can be written with start location and end location. This frame can be used for micro signal control systems.		SEQUENCE { present IntersectionLane.vehiclePresent, identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number, start Vehicle.position3D, end Vehicle.position3D }
Intersection.VehicleAmount:quantity		A count of how many vehicles are present in a specified area of the approach lane.		SEQUENCE { amount IntersectionLane.vehicleAmount, identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number, start vehicle.LocalPosition, end vehicle.LocalPosition }
Geolocation.VehicleAmount:quantity		A count of how many vehicles are present in a specified area of the approach lane.		SEQUENCE { amount IntersectionLane.vehicleAmount, identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number, start Vehicle.position3D, end Vehicle.position3D }
IntersectionLane.averageHeadway:duration		The average time between the leading edge of two subsequent queued vehicles at an intersection as they cross the stop line once the signal has been green for 6 seconds and as averaged over a predetermined time (to the end of green).		SEQUENCE { gap IntersectionLane.averageHeadway, identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number }

Table 4 (continued)

Descriptive name	OID	Definition	Multiplicity	Data type
Intersection.stopPositions:measure		The position where vehicles stop at the latest red phase.		SEQUENCE { vehPositions (SIZE(0..65536)) OF vehicle.LocalPosition identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number }
Intersection.queueLength:measure		The length of a series of vehicles whose flow is controlled by the lead vehicle. Remarks: A queue boundary is typically determined by a distance gap for stopped vehicles, a time gap for high speed vehicles, or a combination of the two for slow moving vehicles.		SEQUENCE { queue IntersectionLane.queueLength, identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number }
Link.travelTime:duration		The average time required for vehicles to traverse the link.		SEQUENCE { travel Vehicle.travelTime, identifier Intersection.number, start Vehicle.position3D, end Vehicle.position3D }
Intersection. meanVehicleSpeed:measure		The arithmetic mean speed of the vehicles travelling in the intersection lane.		SEQUENCE { vehSpeed IntersectionLane.meanVehicleSpeed identifier Intersection.number, approach IntersectionLane.approachingFrom, identifier IntersectionLane.number:number, amount IntersectionLane.vehicleAmount OPTIONAL, start vehicle.LocalPosition OPTIONAL, end vehicle.LocalPosition OPTIONAL }