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Second edition
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Electronic fee collection — Support for traffic management

Perception de télépéage — Aide pour la gestion du trafic

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Contents

Page

Foreword

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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 document 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*.

This second edition cancels and replaces the first edition of ISO/TS 21192:2019, which has been technically revised.

The main changes are as follows:

— Clause 3 has been updated and ISO/TS 17573-2 has been made the primary source for terms and definitions;

— data definitions have been updated, including making reference to ISO 17573-3 as the primary source.

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

Electronic fee collection (EFC) systems have been introduced in many countries where collected revenue is mostly used for funding the construction or maintenance of roads. EFC is also used for traffic management to reduce congestion in urban areas, such as London and Stockholm, since tolling is closely related to travel demand elasticity.

Traffic management is becoming more important as a tool used for reduction of congestion and emissions control in urban areas. EFC schemes such as the smart route selection and managed lanes are some of the key EFC applications used to support traffic management.

This document contains the following annexes:

— Data type specifications are given in Annex A;

— The implementation conformance statement proforma, to be completed by suppliers that claim their implementations are in conformity with this document, is provided in Annex B;

— Annex C specifies the procedures for data exchange, in accordance with the referenced standards;

— Examples of EFC used for traffic management in other countries:

  — Annex D presents a new method for traffic management, called smart route selection, in which EFC will be used for selecting a route in the Tokyo metropolitan area to divert traffic out of central parts of the metropolitan area;

  — Annex E presents the Electronic Road Pricing scheme in Singapore;

  — Annex F presents managed lanes including services known as high occupancy vehicle (HOV) lanes and high occupancy tolls (HOT) on interstate freeways in the USA;

  — Annex G presents the dynamic pricing scheme to improve the environment in Japan;

— Annex H shows the data flow model of EFC support for traffic management;

— Annex I provides examples of data flows between components of EFC and road traffic management systems;

— Annex J explains principles and considerations of privacy and quality of data.

Electronic fee collection — Support for traffic management

1 Scope

This document identifies the architecture of a toll system environment in which a toll charger (TC) can act to support traffic management with the use of a tariff scheme.

This document defines:

— the architecture relevant to the scope of this document;

— a standard framework and data flow model;

— an exchange of information between a TC and a road and traffic manager (RTM), e.g.:

  — level of service (LOS);

  — tariff scheme;

  — data which is needed to support traffic management (vehicle probe and traffic flow data).

The detailed definitions of mandatory and optional elements in real implementation are outside the scope of this document. This document does not define communication stacks or timings.

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/FDIS 12855[1)], *Electronic fee collection — Information exchange between service provision and toll charging*

ISO 14827-2, *Intelligent transport systems — Data interfaces between centres for transport information and control systems — Part 2: AP-DATEX*

ISO 14827-3, *Transport information and control systems — Data interfaces between centres for transport information and control systems — Part 3: Data interfaces between centres for intelligent transport sytems (ITS) using XML (Profile A)*

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

ISO/TS 17573-2 *Electronic fee collection — System architecture for vehicle related tolling — Part 2: Vocabulary*

ISO 17573-3 *Electronic fee collection — System architecture for vehicle-related tolling — Part 3: Data dictionary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TS 17573-2 and the following term and definition 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

1) Under revision. Stage at the date of publication: ISO/FDIS 12855:2024.

— IEC Electropedia: available at https://www.electropedia.org/

3.1
level of service
LOS
rating of the quality of transportation facilities and services from the user perspective, with reference to speed, convenience and comfort, to evaluate problems and potential solutions

4 Abbreviated terms

EFC	Electronic Fee Collection
OBE	On-Board Equipment
LOS	Level of Service
RSE	Roadside Equipment
RTM	Road and Traffic Manager
TC	Toll Charger

5 Architectural concepts and information exchanges

5.1 General

This clause specifies the role model of EFC support for traffic management in terms of its roles and relationship with EFC and traffic management related roles. The information exchanges needed by a toll charger (TC) and an RTM to perform their roles are described in this clause.

5.2 Role model

ISO 17573-1 defines four main roles in the electronic fee collection domain. Figure 1 shows the role model expanded with one role with support for traffic management. Interactions between the management role of road and traffic operation environment and the charging role of the tolling environment are both management and operational information flows, e.g. information flows regarding setting a tariff scheme, or daily operation of the tolling.

The main purpose of the role Management of road and traffic operation environment is to manage road and traffic operation environment, by defining and maintaining the set of rules. that define the policy of traffic management. It should be noted that the role for traffic management is part of the traffic management domain. Hence, this document describes the interface between the two domains, see Figure 1.

The responsibilities of the role allocated to the traffic management domain include:

— definition of the level of service (LOS), including required transport performance which is appropriate for a regional transportation network;

— provision of road usage data, including transit data to identify vehicle movements and usage of the road infrastructure and to calculate the relevant tolls;

— operation of travel demand model, including definition of a new tariff scheme to improve traffic management.

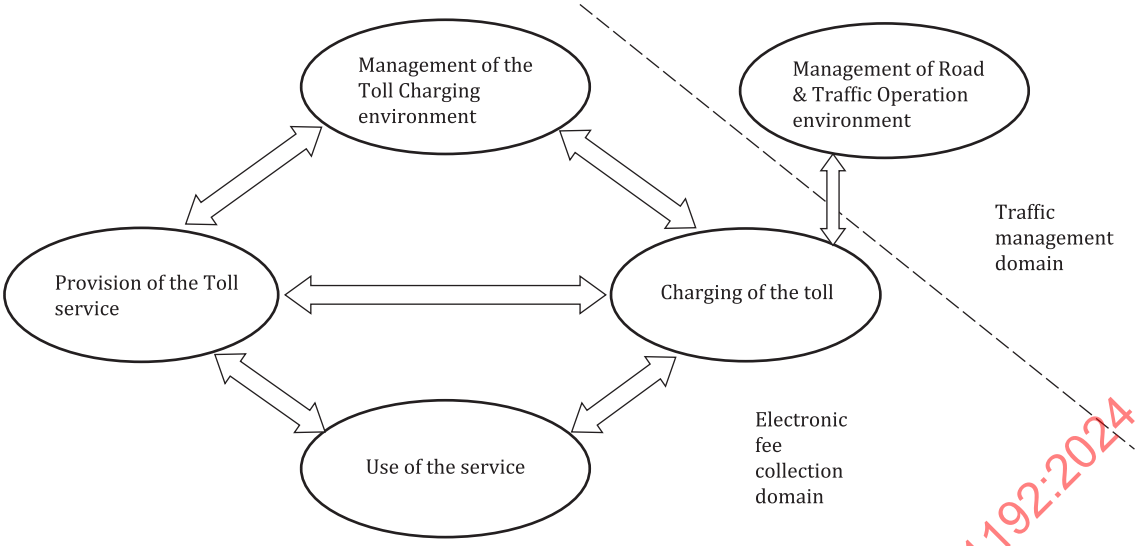


Figure 1 — Role model in EFC domain to support traffic management domain

5.3 Data flow model

The TC needs to establish and maintain close contact with the relevant RTM to use a tariff scheme for traffic management. In Figure 2, the data flow model for EFC support for traffic management is shown with RTM, which plays an important role for traffic management in a region. The corresponding data flow of this document is shown in the double line arrows between TC and RTM.

The tasks and responsibilities of TC and RTM to support traffic management are as follows.

— RTM is responsible for road transport network operation, including monitoring of the level of transport service. RTM defines the LOS and sets transport performance requirements, based on the regional transport policy and traffic status, and sends them to TC.

— TC operates a tariff scheme, based on the transport performance requirements to optimize the toll revenue and the LOS, and provides it to RTM. TC calculates and charges the toll and provides real time toll-relevant information to RTM.

— RTM monitors the LOS by using vehicle probe and traffic flow data. RTM provides real time toll-relevant information to the users through the roadside information equipment, on-board equipment (OBE), in-car navigation devices, or web pages. RTM provides the road usage data required for tolling upon request from TC.

— RTM runs the travel demand model, to pursue better traffic management, and requests a new tariff scheme with the current data from the TC.

— TC evaluates and sets a new tariff scheme and sends it back to RTM.

— RTM activates the new tariff scheme, runs the travel demand model, and requests a new tariff scheme if necessary.

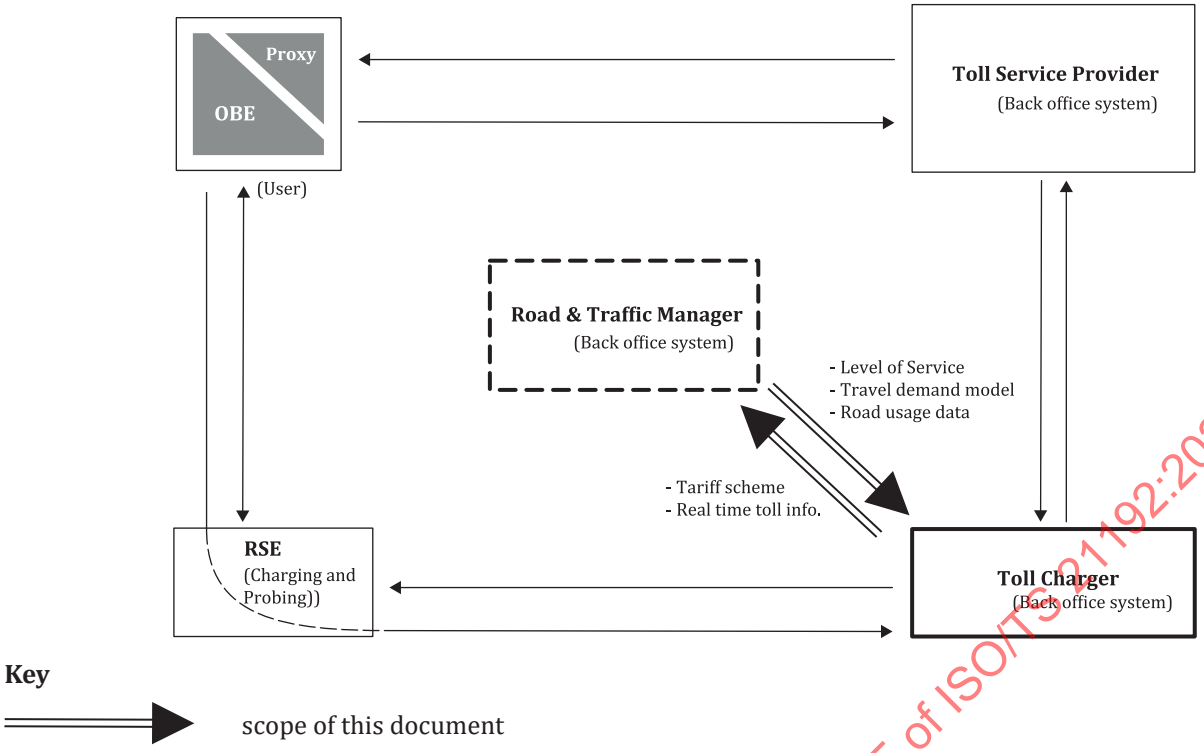


Figure 2 — Data flow model

A detailed presentation of the data flow model for EFC support to traffic management is provided in Annex H.

5.4 Information exchanges between TC and RTM

The information exchanges between TC and RTM, to support the traffic management with the use of EFC scheme, shall follow the order of the exchanges described in Figure 3.

The first step is to define the LOS by RTM. RTM shall send a performance request based on definition of the LOS to TC. TC shall incorporate the LOS requirements in tariff scheme and provide it to RTM.

The second step is to levy the toll. The real time toll information shall be provided to RTM upon levying the toll to disseminate necessary tolling information to the road users. RTM shall provide road usage data collected from OBE as vehicle probe data to TC. The probe data is the vehicle data (with time-stamped in the scheme unique identifiers) that is used to determine traffic conditions, and to measure the vehicle's progress through the network. This includes route information, starts and stops, current position and speed and other information (e.g. heading, speed changes and snapshots of recent events) that can be used to estimate traffic conditions. TC calculates the tolls of individual vehicles. The vehicle probe data can also be transmitted to TC, where TC may calculate the tolls even when the road usage data cannot be collected.

The third step is to run the travel demand model and evaluate the tariff scheme. When the tariff scheme is found to be unsatisfactory for the LOS, new tariff scheme is defined to meet LOS requirements by running the demand model. RTM shall request TC to evaluate and set a new tariff scheme. (See informative Annex I for more detailed information on data flows between RSE and OBE).

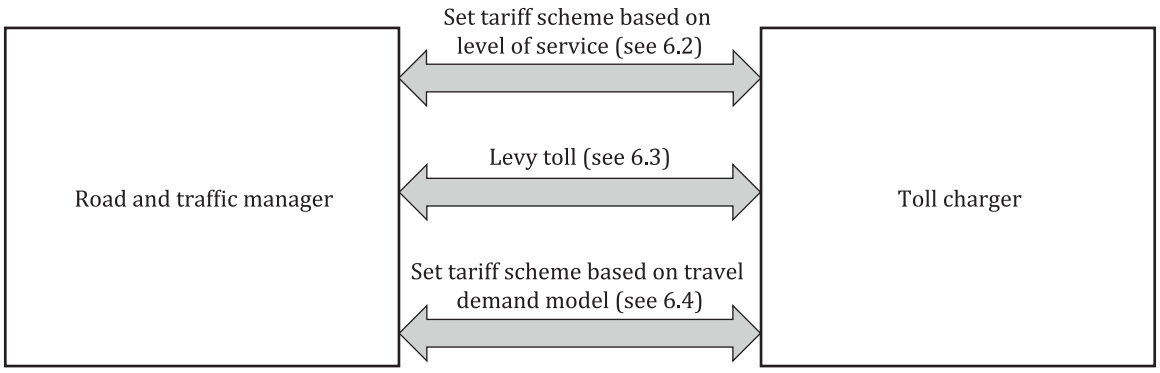


Figure 3 — Information exchanges between TC and RTM

6 General requirements for data exchange

6.1 General

Data to be exchanged for traffic management is categorized as traffic flow related, traffic incident-related and tolling-related data. The purposes of the data are shown in Table 1, together with the terms which are required to evaluate the performance of traffic management. The performance measures, which are required to set and evaluate the tariff scheme for supporting traffic management, should be categorized into congestion management, tolling, safety, monitoring environmental impact, monitoring goods movement, and total management.

Table 1 — Exchanging data for traffic management purposes

Exchanging data	Traffic management purpose					
	Congestion management	Tolling	Safety	Monitoring environmental impact	Monitoring goods movement	Total management
Traffic speed	✓	✓	✓	✓	✓	✓
Traffic volume	✓			✓		✓
Traffic density	✓					✓
Vehicle type/ fleet composition	✓	✓		✓	✓	✓
Traffic incident data			✓			✓
Toll data (revenues and transactions)		✓				✓

The interface specifications of traffic management domain and EFC domain shall refer to ISO 14827-2 and ISO 14827-3 for traffic management and ISO 12855 for EFC, respectively. The interface between RTM and TC is specified by referring to data exchange procedure in ISO 12855, ISO 14827-2 and ISO 14827-3.

The specifications of the ASN.1 data types, relating to the data elements described in Clause 6, shall be in accordance with Annex A.

To facilitate reading, the following conventions are adopted in this document:

a) the ASN.1 data elements are written with a lower case first letter using `Courier New` font;

b) the corresponding ASN.1 data types are written with an upper case first letter using `Courier New` font.

This document allows the implementer to define suitable protocol procedures such as basic interaction, protocol mechanism, and choice of transfer protocol. The implementation conformance statement proforma

provided in Annex B shall be used by a supplier claiming that its implementation is in conformity with this document.

The reference interface specification based on these standards is shown in Annex C. This document defines the data attributes as application data units (ADUs) for EFC supporting traffic management. The data exchanges shall be in accordance with Annex C.

The description of data message in Clause 6 is ADU based on ISO 12855. Basic transaction flow including `AckADU` is described in ISO 12855:—, Clause 6.

The following basic data attributes are described in 6.2 to 6.4:

— LOS;

— tariff scheme;

— real time toll information;

— road usage data;

— new tariff scheme request.

The following annexes provide examples of EFC supported traffic management.

— Annex D presents an example of a smart route selection scheme;

— Annex E presents an example of an electronic road pricing scheme;

— Annex F presents managed lanes in the USA;

— Annex G presents an example of an emission control scheme, based on the usage of transit data;

— Annex I provides examples of data flows between components of EFC and road traffic management systems.

Typical data flows using messages described in 6.2 to 6.4 between RTM, RSE, OBE and TC are shown in Annex H.

6.2 Transaction: Set tariff scheme based on LOS

6.2.1 Overview

`LevelOfService` and `TariffScheme` are exchanged between the RTM and TC for setting and revising tariff scheme based on LOS as shown in Figure 4.

For each correct `LevelOfServiceAdu` the RTM sends, the TC shall respond with one corresponding `TariffSchemeAdu`. For each correct `TariffSchemeAdu` the TC sends, the RTM shall respond with one corresponding and positive `AckAdu`. Any incorrect ADU shall respond with a negative `AckAdu`.

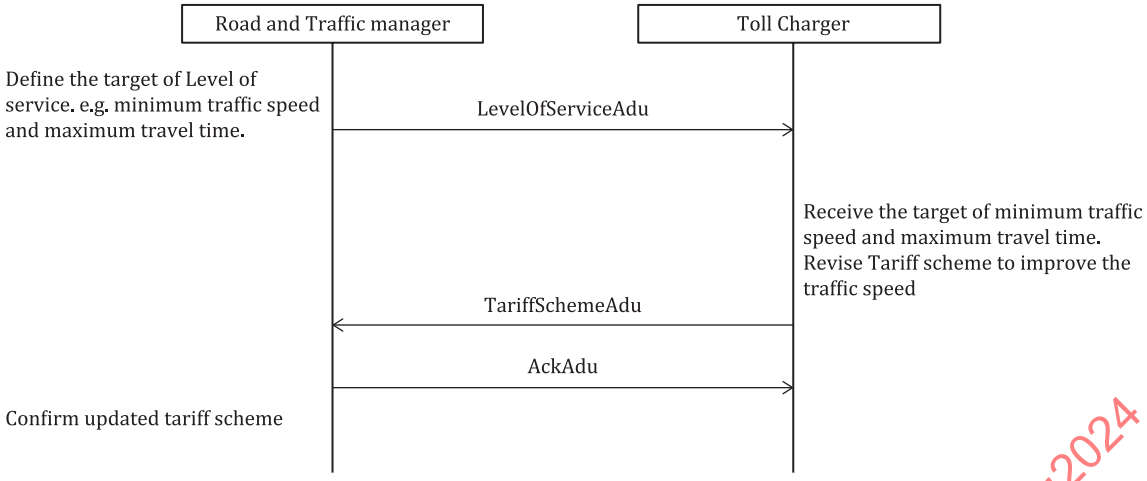


Figure 4 — Sequence diagram of `LevelOfService` and `TariffScheme`

6.2.2 Message: `LevelOfServiceAdu`

LOS, the rating of the quality of transportation facilities and services from the user perspective, plays a major role in evaluation of the transportation system (see Annex A, `LevelOfService` for syntax definition). In case of basic motorway sections, the LOS should be based on traffic density. Speed and flow are also related to traffic densities and the LOS.

The semantics are defined in Table 2.

Table 2 — Semantic definitions for data type `LevelOfServiceAdu`

Data element	Type	Semantic definition	Informative remarks
`userInformation`	`UTF8String(SIZE(1..255))`	A human readable message from RTM about target trafficStatus, TravelSpeed and TravelTime.	
`trafficStatus`	`TrafficStatus ::= UTF8String(SIZE(1))`	A classification agreed bilaterally between implementors.	Data source is roadside vehicle detector, closed-circuit television. EXAMPLE Highway Capacity Manual [13] defines six levels of service, designated by the letters A through F, with A being the highest LOS and F the lowest.
`minimumTrafficSpeed`	`MinimumTrafficSpeed ::= VehicleSpeed VehicleSpeed ::= REAL`	Minimum target vehicle speed on average on a certain road measured in km/h.	Data source is roadside vehicle detector. velocity(m/s) is used in ISO 22837.
`maximumTravelTime`	`MaximumTravelTime::=REAL`	A time interval in seconds. Maximum travel time on average on a certain route	Data source is probe data, Automatic licence Plate Recognition.

6.2.3 Message: `TariffSchemeAdu`

A tariff scheme, i.e. the set of rules to determine the toll, shall be determined to optimize the toll revenue and the LOS for suitable traffic management (in accordance with Annex A, `TariffScheme` for syntax definition). The tariff scheme shall be classified into three schemes:

— fixed toll;

— dynamic toll;

— combination type of both fixed toll and dynamic toll;

The fixed toll scheme, applied according to a predefined tariff scheme, is usually expressed as the form of the tables with the data of the toll based on the route, time of day, day of week, vehicle class, and user class. The dynamic toll scheme is expressed as the toll adjusted in real time in response to the actual traffic situation or other external actual conditions. The dynamic toll is determined by considering both the basic toll and the traffic management. In case of the combination type of both fixed and dynamic tolls, the toll is determined with the statistics of the traffic flow of the week or seasonal changes.

The semantics are defined in Tables 3 to 7.

Table 3 — Semantic definitions for data type `TariffSchemeAdu`

Data element	Data type	Semantic Definition	Informative remarks
`userInformation`	`UTF8String(SIZE(0..255))`	A human readable message from RTM about tariff scheme.	
`fixedToll`	`FixedToll`	See Table 4	Fixed toll is a toll based on route, time of day, day of week, vehicle class, user class (e.g. number of passengers) Data source is TC (Travel demand model), traffic statistics.
`dynamicToll`	`DynamicToll`	See Table 6	Dynamic toll is a toll based on status of traffic flow. Data source is TC (Travel demand model, toll computation model), traffic statistics.
`combinationOfToll`	`CombinationOfToll`	See Table 7	Combination of tolls is a toll combined by both fixed and dynamic. Data source is TC (Travel demand model, toll computation model), traffic statistics.

Table 4 — Semantic definitions for data type `FixedToll`

Data element	Data type	Semantic definition
`tollBasedOnRoute`	`TollBasedOnRoute`	Indicator of tariff table with trip route of the vehicle. See Table 5.
`timeOfDay`	`TimeCompact`	Imported from ISO 17573-3
`dayOfWeek`	`Weekday`	Imported from ISO 17573-3
`vehicleClass`	`VehicleClass`	Imported from ISO 17573-3
`userClass`	`DriverCharacteristics`	Imported from ISO 17573-3

Table 5 — Values and semantics for data type `TollBasedOnRoute`

Name	Semantics	Value
`Disabled`	The route-based tariff table is disabled.	0
`Active`	The route-based tariff table is active.	1
	Values reserved for future CEN and ISO use	2..127
	Values reserved for private use	128..255

Table 6 — Semantic definitions for data type `DynamicToll`

Data element	Data type	Semantic definition
`statusOfTrafficFlow`	`StatusOfTrafficFlow ::= INTEGER (0..511)`	Average vehicle speed [km/h] on certain roads

Table 7 — Semantic definitions for data type `CombinationOfToll`

Data element	Data type	Semantic definition
`tollBasedOnRoute`	`TollBasedOnRoute`	Indicator of tariff table with trip route of the vehicle. 1 is active, 0 is disable.
`timeOfDay`	`TimeCompact`	Imported from ISO 17573-3
`dayOfWeek`	`Weekday`	Imported from ISO 17573-3
`vehicleClass`	`VehicleClass`	
`userClass`	`Int1Unsigned`	Imported from ISO 17573-3
`statusOfTrafficFlow`	`StatusOfTrafficFlow ::= INTEGER (0..511)`	Average vehicle speed [km/h] on certain roads

6.3 Transaction: Levy toll

6.3.1 Overview

`RealTimeTollInformation` is provided by TC to RTM for displaying real-time toll information text on VMS, in-vehicle device, or OBE. `RoadUsageData` is provided by RTM to TC for analysing traffic conditions and updating tariff schemes. These data exchanges are shown in Figure 5 and performed in parallel.

For each correct `RealTimeTollInformationAdu` the TC sends, the RTM shall respond with one corresponding `AckAdu`. For each correct `RoadUsageDataAdu` the RTM sends, the TC shall respond with one corresponding and positive `AckAdu`. Any incorrect ADU shall be replied to with a negative `AckAdu`.

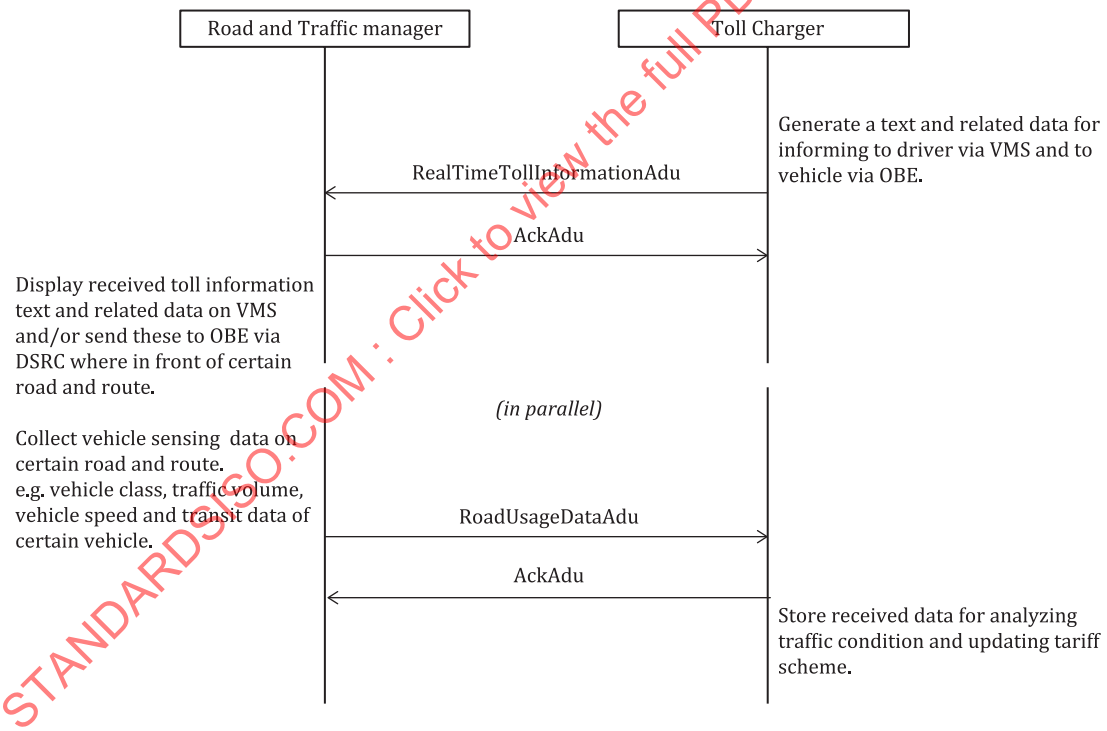


Figure 5 — Sequence diagram of `RealTimeTollImformation` and `RoadUsageData`

6.3.2 Message: `RealTimeTollInformationAdu`

In case of the fixed toll scheme, RTM and the users only need the toll table to find the toll at the present time. However, in the case of the dynamic toll and the combination toll types, real time toll information, which is displayed on variable message signs, in-car navigation devices, or web pages for the users, shall be sent to RTM (see Annex A, `RealTimeTollInformation` for syntax definition).

The semantics is defined in Tables 8 to 10.

Table 8 — Semantic definitions for data type `RealTimeTollInformationAdu`

Data element	Data type	Semantic definition	Informative remarks
`userInformation`	`UTF8String(SIZE(0..255))`	A human readable message from RTM about Real-time Toll Information.	
`tollTable`	`TollTable`	See Table 9	Data source is TC.
`realTimeToll`	`RealTimeToll`	See Table 10	Data source is RTM (status of traffic flow), TC (toll by vehicle class).

Table 9 — Semantic definitions for data type `TollTable`

Data element	Data type	Semantic Definition
`tollByVehicleClass`	`VehicleClass`	Vehicle class information
`Route`	`Layout`	Road route information Imported from ISO 12855
`timeOfDay`	`Time`	Time information of the day to identify the time-zone (`startTime` and `endTime`).
`startTimeOfDay`	`GeneralizedTime (OPTIONAL)`	Start time of time-zone information of the day.
`endTimeOfDay`	`GeneralizedTime (OPTIONAL)`	End time of time-zone information of the day.
`dayOfWeek`	`Weekday`	Day information of week to identify the day of calendar. Imported from ISO 17573-3
`startDayOfWeek`	`GeneralizedTime (OPTIONAL)`	Start day of period in the week.
`endDayOfWeek`	`GeneralizedTime (OPTIONAL)`	End day of period in the week.

Table 10 — Semantic definitions for data type `RealTimeToll`

Data element	Data type	Semantic definition
`statusOfTrafficFlow`	`StatusOfTrafficFlow ::= INTEGER (0..511)`	Average vehicle speed [km/h] on certain roads
`CertainRoutesOfRoadnetwork`	`Layout`	Road link ID as route spot to distinguish certain vehicle trip routes
`tollByVehicleClass`	`VehicleClass`	Vehicle class information

6.3.3 Message: RoadUsageDataAdu

Road usage data, necessary to calculate the toll, is required for TC with two different types of data. One shall be traffic flow data which is used for accumulating a toll amount by hour, day, week, and year, and the other one shall be transit data which is used to determine the toll of individual vehicles where the toll scheme is based on the vehicle's driven routes, sections, or areas (see Annex A, `RoadUsageData` for syntax definition). The `VehicleSpeed` shall be in accordance with ISO 22837.

The semantics is defined in Tables 11 to 13.

Table 11 — Semantic definitions for data type `RoadUsageDataAdu`

Data element	Data type	Semantic definition	Informative remarks
`userInformation`	`UTF8String(SIZE(0..255))`	A human readable message from RTM about road usage data.	
`trafficFlowData`	`TrafficFlowData`	See Table 12	Data source is roadside vehicle detector, closed-circuit television, probe data.
`transitDataOfVehicles`	`TransitDataOfVehicles`	See Table 13	Data source is probe data.

Table 12 — Semantic definitions for data type `TrafficFlowData`

Data element	Data type	Semantic definition
`vehicleClass`	`VehicleClass`	Vehicle class of certain vehicle
`trafficVolume`	`INTEGER`	Average traffic volume [vehicle/h] on certain roads
`averageSpeed`	`VehicleSpeed`	Average vehicle speed [km/h] on certain roads
`trafficDensity`	`INTEGER`	Traffic density [vehicle/km] on certain roads

Table 13 — Semantic definitions for data type `TransitDataOfVehicles`

Data element	Data type	Semantic definition
`TransitDataOfVehicles`	`tripRoute ::= Layout`	Road link ID as route spot to distinguish certain vehicle trip routes

6.4 Transaction: Set tariff scheme based on travel demand model

6.4.1 Overview

`TariffSchemeRequest` and `TariffScheme` are exchanged between the RTM and TC for revising tariff scheme based on recent traffic conditions as shown in Figure 6.

For each correct `TariffSchemeRequestADU` the RTM sends, the TC shall respond with one corresponding `TariffSchemeAdu`. For each correct `TariffSchemeAdu` the TC sends, the RTM shall respond with one corresponding and positive `AckADU`. Any incorrect ADU shall respond with a negative `AckAdu`.

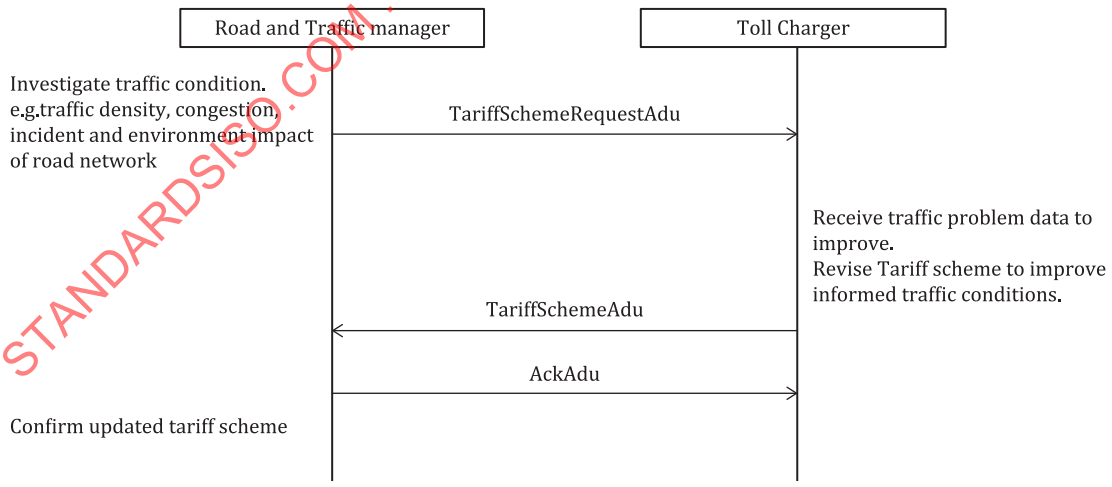


Figure 6 — Sequence diagram of `TariffSchemeRequest` and `TariffScheme`

6.4.2 Message: `TariffSchemeRequestAdu`

It is important for RTMs to pursue optimal traffic management based on various factors since it often occurs that the traffic patterns and the types and environmental performances of vehicles change as

economic and social conditions vary (such as the ratio of the electric vehicles). RTM should use factors of unbalanced density of transportation network, unfavourable congestion, unexpected increase of incidents, and unfavourable environmental impact upon requesting a new tariff scheme (see Annex A, `TariffScheme` for syntax definition).

The semantics is defined in Tables 14 to 18.

Table 14 — Semantic definitions for data type `TariffSchemeRequestAdu`

Data element	Data type	Semantic definition	Informative remarks
`userInformation`	`UTF8String(SIZE(0..255))`	A human readable message from RTM about Traffic Scheme Request	
`unbalancedDensityOfTransportationNetwork`	`UnbalancedDensityOfTransportationNetwork`	See Table 15	Data source is roadside vehicle detector, probe data.
`unfavourableCongestion`	`UnfavourableCongestion`	See Table 16	Data source is roadside vehicle detector, probe data.
`unexpectedIncreaseOfIncidents`	`UnexpectedIncreaseOfIncidents`	See Table 17	Data source is TC, RTM, Police agency.
`unfavourableEnvironmentalImpact`	`UnfavourableEnvironmentalImpact`	See Table 18	Data source is roadside vehicle detector, probe data, Pollution level sensor.

Table 15 — Semantic definitions for data type `UnbalanceddensityOfTransportationNetwork`

Data element	Data type	Semantic definition
`trafficVolumes`	`INTEGER`	Average traffic volume [vehicle/h] on certain roads
`averageSpeed`	`VehicleSpeed`	Average vehicle speed [km/h] on certain roads
`trafficDensity`	`INTEGER`	Traffic density [vehicle/km] on certain roads

Table 16 — Semantic definitions for data type `UnfavourableCongestion`

Data element	Data type	Semantic definition
`trafficVolumes`	`INTEGER`	Average traffic volume [vehicle/h] on certain roads
`averageSpeed`	`VehicleSpeed`	Average vehicle speed [km/h] on certain roads
`trafficDensity`	`INTEGER`	Traffic density [vehicle/km] on certain roads
`speedChangeBetweenCertainSection`	`VehicleSpeed`	Vehicle speed difference between start point and end point of certain road sections

Table 17 — Semantic definitions for data type `UnexpectedIncreaseOfIncidents`

Data element	Data type	Semantic definition
`numberOfIncidents`	`INTEGER`	Number of incidents on certain roads per year

Table 18 — Semantic definitions for data type `UnfavourableEnvironmentalImpact`

Data element	Data type	Semantic definition
`trafficVolumes`	`INTEGER`	Average traffic volume [vehicle/h] on certain roads
`averageSpeed`	`VehicleSpeed`	Average vehicle speed [km/h] on certain roads
`Noise`	`INTEGER`	Average dB on certain roads Indicator of noise level
`atmosphericEnvironment`	`INTEGER`	ppm (parts per million)/day on certain roads Indicator of PM, nOx, sOx in air
`airPolluters`	`UTF8String(SIZE(0..255))`	A human readable message from RTM about measured air pollutants such as particulate matter (PM), ozone (O_3), nitrogen dioxide (nOx) and sulphur dioxide (sOx).

6.4.3 Message: `TariffSchemeAdu`

The response to the request of new tariff scheme is replacement information for current tariff scheme. Therefore, message of `TariffSchemeAdu` as new tariff scheme shall be the same message and semantic definitions with `TariffSchemeAdu`, defined in 6.2.3, response to the request of `LevelOfServiceAdu`.

6.5 Privacy and quality of data

The information flow of vehicle probe data is a crucial flow of information in traffic management. The collected data is used to measure vehicle's progress through the network, e.g. current position, speed, heading and snapshots of recent events, that can be used to estimate traffic conditions. This data can be used to identify an individual and is then by definition personal information (PI) that has to be managed in a way that protects the privacy of the individual that can be identified.

Another crucial flow of information is the traffic flow data collected and handled by the roadside ITS sub-system. Data that is unique for each vehicle, e.g. OBE and vehicle licence plate number, may be used for identifying an individual. Privacy should be considered in the design and operation of Traffic Management supported by EFC.

The ITS service, Traffic Management supported by EFC, is based on information on traffic flow conditions. The information is used for optimising the use of the road network. This implies monitoring the traffic flow conditions and controlling the traffic flows by means of pricing the road use. The user acceptance of the service is closely related to the quality and efficiency of the ITS service, and quality and efficiency is related to the quality of the traffic flow information that is collected. This implies that the complete value chain of information flow should ensure the data quality parameters availability, integrity, authenticity, confidentiality and accountability.

The details of privacy and quality of data are discussed in Annex J.

Annex A
(normative)

Data type specification

The EFC data types and associated coding related to the EFC data elements, described in Clause 6, are defined using the Abstract Syntax Notation One (ASN.1) technique according to ISO/IEC 8824-1. The unaligned packed encoding rules according to ISO/IEC 8825-2 are applied.

The ASN.1 module is identified by the object identifier {iso(1) standard(0) 21192 version2(2) minorVersion1(1)}.

The actual ASN.1 module is contained in the attached file "ISO21192 EfcSupportTrafficManagement V2.1" which can be directly imported in an ASN.1 compiler. This file is available for download via https://standards.iso.org/iso/ts/21192.

The syntax and semantics of the data types in the ASN.1 types in the above-mentioned file that is imported shall comply with ISO 17573-3, respectively.

Table A.1 provides the SHA-256 cryptographic hash digests for the referenced files, offering a means to verify the integrity of the referenced files. The SHA-256 algorithm is specified in NIST 180-4.[7]

Table A.1 — SHA-256 cryptographic hash digests

File Name	SHA-256 cryptographic hash digest
ISO21192 EfcSupportTrafficManagement V2.1	d18071c1b700ef29988d7090d2b50d64d2b8ac-4412413f0857ab7f27178b40fc

It is important to be aware that pasting the text of the file into one of the hash digest computation pages available on the web can result in a non-matching hash digest due to changes in the underlying coding.

Annex B
(normative)

Implementation conformance statement proforma

B.1 General

To evaluate the conformance of a particular implementation, it is necessary to have a statement of those capabilities and options that have been implemented. This is called an implementation conformance statement (ICS).

This annex presents the pro forma to be used for the attributes defined in Annex A, with ICS templates that are to be filled in by equipment suppliers.

B.2 Purpose and structure

The purpose of this ICS is to provide a mechanism whereby a supplier of an implementation of the attribute in media defined in this document can provide information about the implementation in a standardised manner.

The ICS is subdivided as follows:

— identification of the implementation;

— identification of the protocol;

— global statement of conformance;

— ICS tables.

B.3 Instruction for completing ICS

B.3.1 Definition of support

A capability is said to be supported if the implementation under test (IUT) can:

— generate the corresponding operation parameters (either automatically or because the end user requires that capability explicitly),

— interpret, handle and, when required, make available to the end user the corresponding error or result.

A protocol element is said to be supported for a sending implementation if it is able to generate it under certain circumstances (either automatically or because the end user requires relevant services explicitly).

A protocol element is said to be supported for a receiving implementation if it is correctly interpreted and handled and, when appropriate, made available to the end user.

B.3.2 Status column

This column indicates the level of support required for conformance. Values in this column are:

m mandatory support is required;

o optional support is permitted for conformance to this document. If implemented, it shall conform to the specifications and restrictions contained in the standard. These restrictions may affect the optionality of other items;

c the item is conditional (support of the capability is subject to a predicate);

- the item is not applicable;

i the item is outside the scope of this ICS.

In the ICS tables, every leading item marked “m” shall be supported by the IUT. Sub-items marked “m” shall be supported if the corresponding leading item is supported by the IUT.

B.3.3 Support column

This column shall be completed by the supplier or implementer to indicate the level of implementation of each item. The proforma has been designed such that values required are the following:

Y Yes, the item has been implemented;

N No, the item has not been implemented;

- the item is not applicable.

All entries within the ICS pro forma shall be made in ink. Alterations to such entries shall be made by crossing out, not by erasing or making the original entry illegible, and by writing the new entry alongside. All such alterations to records shall be initialled by the person who made them.

B.3.4 Item reference numbers

Each line within the ICS which requires that implementation details be entered is numbered at the left- hand edge of the line. This numbering is included as a mean of uniquely identifying all possible implementation details within the ICS. This referencing is used both inside the ICS, and for references from other test specification documents.

The means of referencing individual responses is done in the following sequence:

a) a reference to the smallest individual response enclosing the relevant item;

b) a solidus character (“/”);

c) the reference number of the row in which the response appears;

d) if, and only if, more than one response occurs in the row identified by the reference number, implicit labelling of each possible entry as “a”, “b”, “c”, etc., from left to right, with this letter appended to the sequence.

B.4 ICS proforma tables

B.4.1 Identification of the implementation

The following proforma (Table B.1 to Table B.11) shall be used to identify the implementation on TC side.

Table B.1 — Identification of ICS

Item no.	Question	Response
1	Date of statement (YYYY/MM/DD)	
2	ICS serial number	
3	System conformance statement cross-reference	

Table B.2 — Identification of the implementation or system or both

Item no.	Question	Response
1	Common service right provider name	
2	Version number	
3	Other information	

Table B.3 — Identification of the media supplier

Item no.	Question	Response
1	Organization name	
2	Contact name(s)	
3	Address	
4	Telephone number	
5	E-mail address	
6	Other information	

Table B.4 — Identification of the media

Item no.	Question	Response
1	Brand name	
2	Type, version	
3	Manufacturer ID	
4	Serial numbers of supplied units	
5	Other information	

Table B.5 — Identification of the document

Item no.	Question	Response
1	Title, reference no., publication date of the document	
2	Document edition number	
3	Other information	

B.4.2 ICS proforma tables

This part of the ICS identifies the supported application context, communication services and attributes in data exchange between RTM and TC.

Table B.6 — Application Data Units (ADUs)

Item no.	Element	Reference	Status	Support
1	`LevelOfServiceAdu`	6.2.2	o	
2	`TariffSchemeAdu`	6.2.3	o	
3	`RealTimeTollInformationAdu`	6.3.2	o	
4	`RoadUsageDataAdu`	6.3.3	o	
5	`TariffSchemeRequestAdu`	6.4.2	o	

Table B.7 — Data requirements regarding LOS

Item no.	Element	Reference	Status	Support
1	`userInformation`	6.2.2	o	
2	`trafficStatus`	6.2.2	o	
3	`minimumTrafficSpeed`	6.2.2	o	
4	`maximumTravelTime`	6.2.2	o	

Table B.8 — Data requirements regarding Tariff scheme

Item no.	Element	Reference	Status	Support
1	`userInformation`	6.2.3	o	
2	`fixedToll`	6.2.3	o	
3	`dynamicToll`	6.2.3	o	
4	`combinationOfToll`	6.2.3	o	

Table B.9 — Data requirements regarding Real time toll information

Item no.	Element	Reference	Status	Support
1	`userInformation`	6.3.2	o	
2	`tollTable` (In case of fixed toll)	6.3.2	o	
3	`realTimeToll` (In case of dynamic toll, or combination of fixed and dynamic toll)	6.3.2	o	

Table B.10 — Data requirements regarding Road usage data

Item no.	Element	Reference	Status	Support
1	`userInformation`	6.3.3	o	
2	`trafficFlowData`	6.3.3	o	
3	`transitDataOfVehicle`	6.3.3	o	

Table B.11 — Data requirements regarding Tariff scheme request

Item no.	Element	Reference	Status	Support
1	`userInformation`	6.4.2	o	
2	`unbalancedDensityOfTransportationNetwork`	6.4.2		
3	`unfavourableCongestion`	6.4.2	o	
4	`unexpectedIncreaseOfIncidents`	6.4.2	o	
5	`unfavourableEnvironmentalImpact`	6.4.2	o	

Annex C
(normative)

Reference standards for data exchange

C.1 General

The data exchange procedures of data attribute defined in Clause 6 are explained in this annex. Data exchange is performed between RTM and TC in reference to the relating standard ISO 12855 for EFC and the ISO 14827 series for traffic management. The data attributes that are exchanged as application interface are defined in Clause 6.

The relations between attribute data and data unit in application interface in the case of ISO 12855 and the ISO 14827 series are explained in the following subclause.

C.2 Data exchange procedure based on ISO 12855

The interface definition of data exchange between TC and toll service provider with ASN.1 format is explained in ISO 12855.

The basic interface procedure for Information exchange is described as follows in ISO 12855.

— Basic interaction protocol;

— Basic protocol mechanisms.

Data attributes described in Clause 6 are transferred by `Iso21192Adus`.

```
Iso21192InfoExchange ::=                SEQUENCE {
     infoExchangeContent                Iso21192InfoExchangeContent,
     infoExchangeAuthenticator          ApduAuthenticator OPTIONAL
     }

Iso21192InfoExchangeContent ::=         SEQUENCE {
     Apci                               ApciFields, -- Header
     Adus                               Iso21192Adus
     }
Iso21192Adus ::= CHOICE {
     requestAdus                        [1]    SEQUENCE OF RequestADU,
     ackAdus                            [2]    SEQUENCE OF AckADU,
     levelOfService                     [3]    SEQUENCE OF LevelOfService,
     tariffScheme                       [4]    SEQUENCE OF TariffScheme
     realTimeTollInformation            [5]    SEQUENCE OF RealTimeTollInformation
     roadUsageData                      [6]    SEQUENCE OF RoadUsageData
```

```
      tariffSchemeRequest                [7]    SEQUENCE OF TariffSchemeRequest
      }
```

C.3 Data exchange procedure based on the ISO 14827 series

The interface definition of end-application messages within centres in transport information and control system (TICS) is explained in the ISO 14827 series. This interface is defined using ASN.1 in ISO 14827-2 and is specified using ''XML message as a basic requirement'' in ISO 14827-3.

The interface procedure for Information exchange is as per ISO 14827-2. Data structures are specified in ASN.1 by ISO 14827-2.

Data attributes described in Clause 6 are transferred by `ISO21192PDUs`.

```
Iso21192DataPacket ::= SEQUENCE {
      version-cd ENUMERATED {
                Experimental,
                Version-1,
                …},
      data-txt          OCTET STRING,
      crc-rd            OCTET STRING( SIZE(2) )
      }
Iso21192C2cAuthenticatedMessage ::= SEQUENCE {
      authenticationInfo-txt          OCTET STRING SIZE(0..255)),
      dataPacket-nbr                  INTEGER (0..4294967295),
      dataPacketPriority-cd           INTEGER(0..10),
      options                         HeaderOptions,
      pdu                             Iso21192PDUs
      }
Iso21192PDUs ::= CHOICE {
      --[1][2] is N.A for consistency with number of Iso21192Adus in C.2.
      levelOfService                  [3]    SEQUENCE OF LevelOfService,
      tariffScheme                    [4]    SEQUENCE OF TariffScheme
      realTimeTollInformation         [5]    SEQUENCE OF RealTimeTollInformation
      roadUsageData                   [6]    SEQUENCE OF RoadUsageData
      tariff scheme request           [7]    SEQUENCE OF RoadUsageData
      }
```

The message rules and procedures for communication as profile A, Simple Object Access Protocol (SOAP), are described in ISO 14827-3 as follows. Tag scripts for composing XML messages are defined in ISO 14827-3.

Data attributes described in Clause 6 are stored as payload with XML tag.

Annex D
(informative)

Smart route selection in Japan

D.1 General

In the Tokyo metropolitan area, where the construction of outer ring expressways has been completed, a user can choose a suitable route considering travel time and toll amount in the complex network consisting of three ring motorways and nine radial expressways. Road operator will provide optimized tariff table for balancing the traffic among selectable roads aiming mitigation of congestion with monitoring real traffic. Figure D.1 shows an image of a smart route selection using probe data.

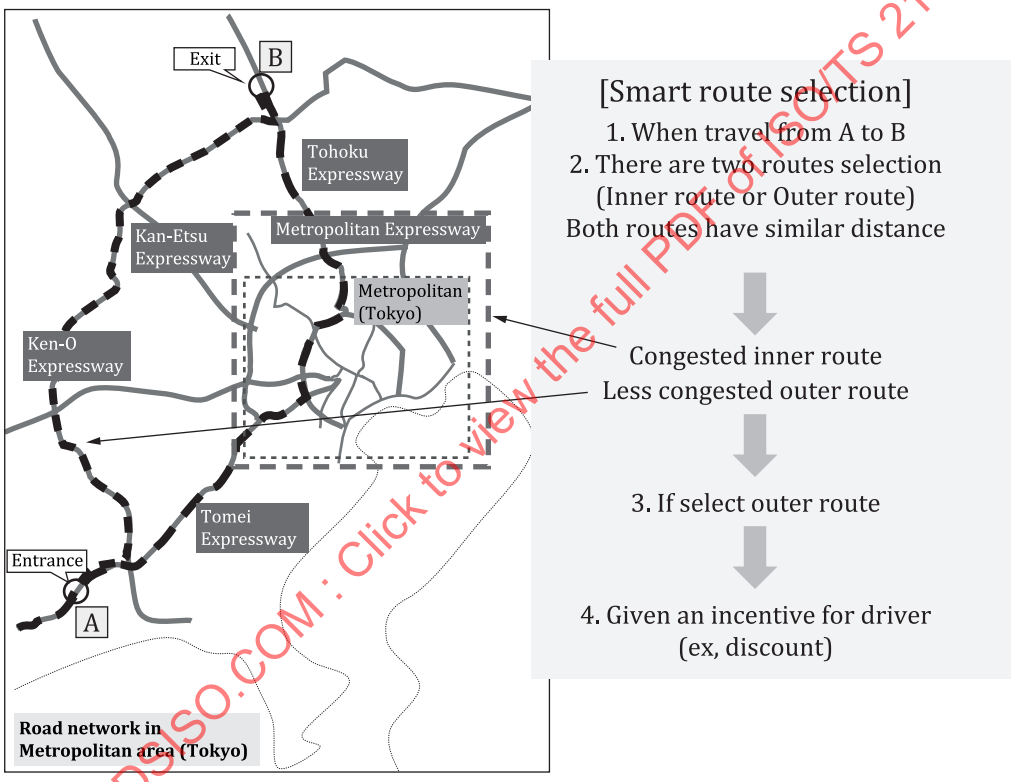


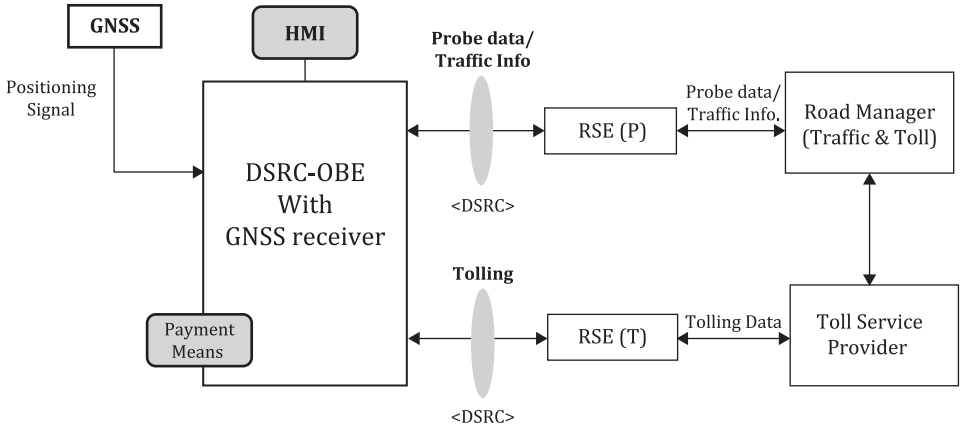
Figure D.1 — Image of smart route selection using probe data in Tokyo metropolitan area

D.2 System configuration and functions

A tolling system consists of DSRC-OBE with a GNSS receiver, RSE for tolling, RSE for probe data/traffic information, and each Central Equipment for Toll Service Provider and Road Manager as shown in Figure D.2.

RSE for tolling is installed at each Entry lane and Exit lane, covered by a tolling system. RSE for probe data/traffic information, installed on expressways, provides route information and uploads GNSS based probe data from OBE.

A toll amount determined by the combination of Entry, selected Route and Exit is settled to advise a vehicle to avoid congestion in the central Tokyo region.



Key

RSE(P) RSE for Probe data/Traffic Info, along Highway

RSE(T) RSE for Tolling at entry and exit lanes

Figure D.2 — System configuration of EFC system for smart route selection

Annex E
(informative)

Electronic Road Pricing (ERP) in Singapore

E.1 General

In Singapore, Electronic Road Pricing (ERP) has been operated since 1998 to reduce congestion in the Central Business District (CBD) and expressways. The technology of ERP is based on DSRC where both the bank related prepaid card (NETS card) and the common transportation prepaid card (EZ-Link card) are available for payment.

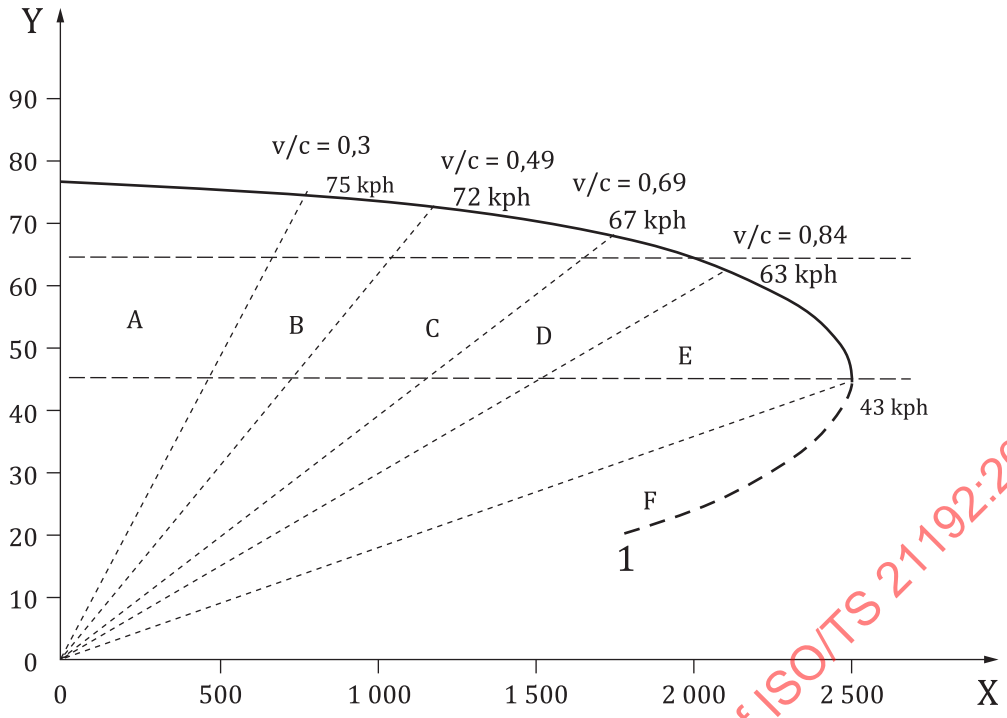
The charging rate is defined to keep LOS where minimum speed is maintained, e.g. 20 km/h in CBD and 45 km/h on expressways.

E.2 Traffic control by charge rate

Setting of LOS in traffic requires measurable data for traffic analysis. The traffic volume-to-velocity, the also known as Q-V curve, is generally used for traffic analysis and used for setting of LOS in traffic. This LOS is also used for the purpose of traffic control by tolling.

Figures E.1[14] and E.2[14] show LOS from A to F on the traffic volume-to-capacity curve for expressways and arterial roads respectively. LOS is defined to maintain maximum road capacity with stable operation as indicated as the area E in these figures.

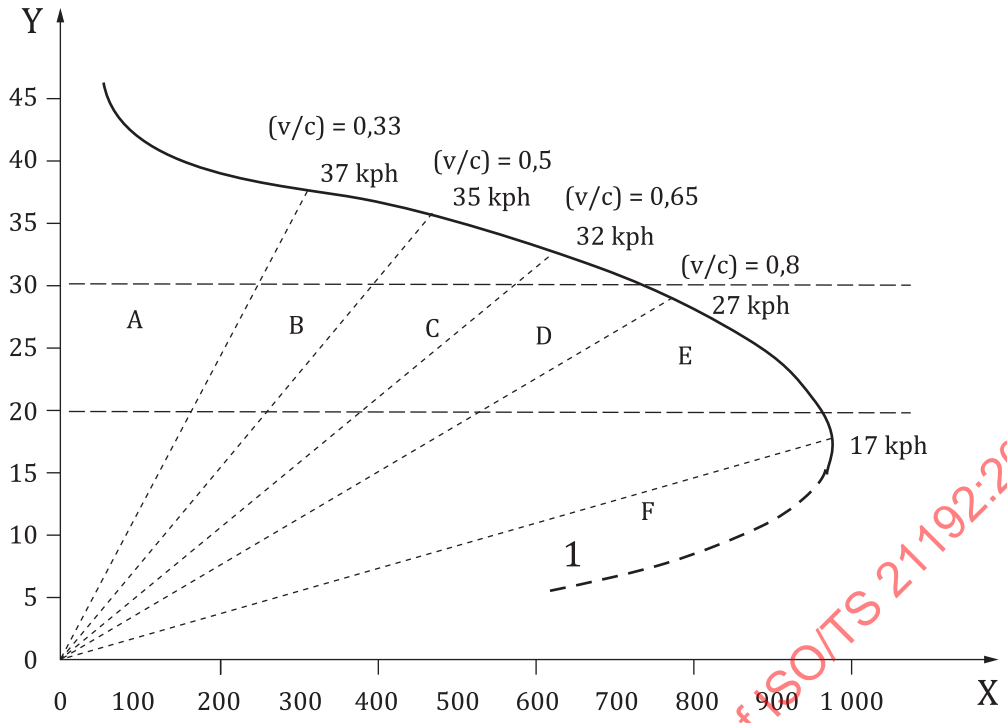
Figure E.3[14] shows the managing concept of traffic flow, which aims to increase the rate when traffic speed goes down to 45 km/h on expressways and to increase the rate when traffic speed goes down to 20 km/h on arterial roads to maintain LOS of E.



Key

X traffic flow (vehicle/hour/lane)
Y speed (km/hour)
1 (unstable region)
v/c volume-to-capacity

Figure E.1 — Traffic volume-to-velocity curve on expressways



Key

X traffic flow (vehicle/hour/lane)
Y speed (km/hour)
1 (unstable region)
v/c volume-to-capacity

Figure E.2 — Traffic volume-to-velocity curve on arterial roads

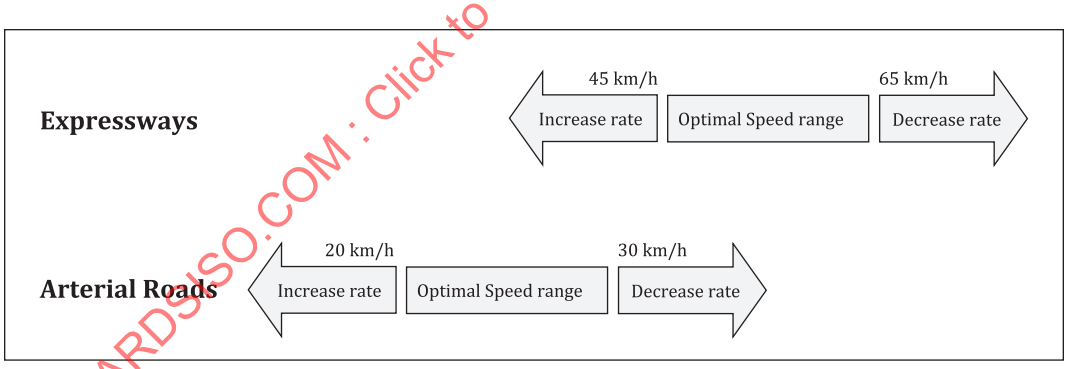


Figure E.3 — Managing concept of traffic flow

Annex F
(informative)

Managed lanes in the USA

While interstate freeways in the USA are free of charge, special managed lanes have been introduced and operated known as HOV lanes and HOT lanes. In the managed lanes, a vehicle with a defined number or more persons can pass by free of charge, or a vehicle can pass by paying the toll even if with less persons. The minimum driving speed or time to destination can be maintained by varying toll rates in accordance with traffic conditions.

In I-405 in Washington state, the toll rate is updated every five minutes based on traffic flow data where the toll rate is displayed on the VMS at the roadside. The toll is changed dynamically from 75 cents to $ 10. Figure F.1[15] shows flows of information exchange between TC and the traffic management centre.

In the managed lanes, traffic data measured by loop coil detectors in five minutes is sent to the traffic management centre where the toll rates are determined based on traffic volume, speed, and occupancy. Though the detailed algorithm to calculate the toll rates is not disclosed, a general method is to raise the toll rate when average vehicle speed goes down or to lower the toll rate when it goes up. The concept of dynamic toll rate is shown in Figure F.2,[15] and an example of average speed versus toll rate is shown in Figure F.3[15].

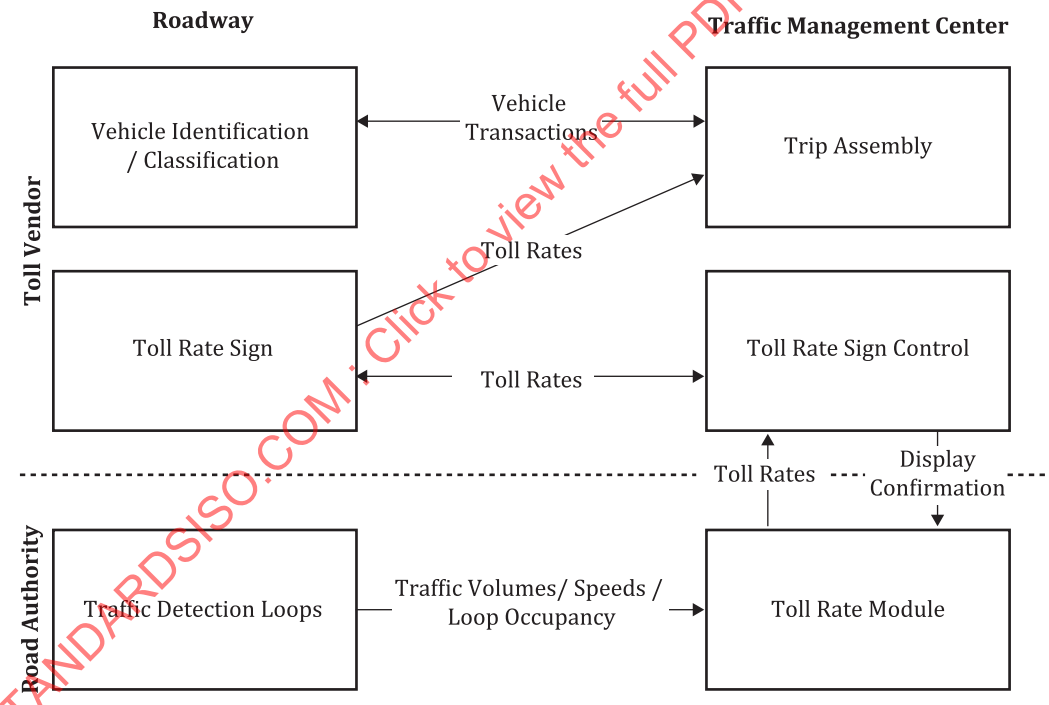
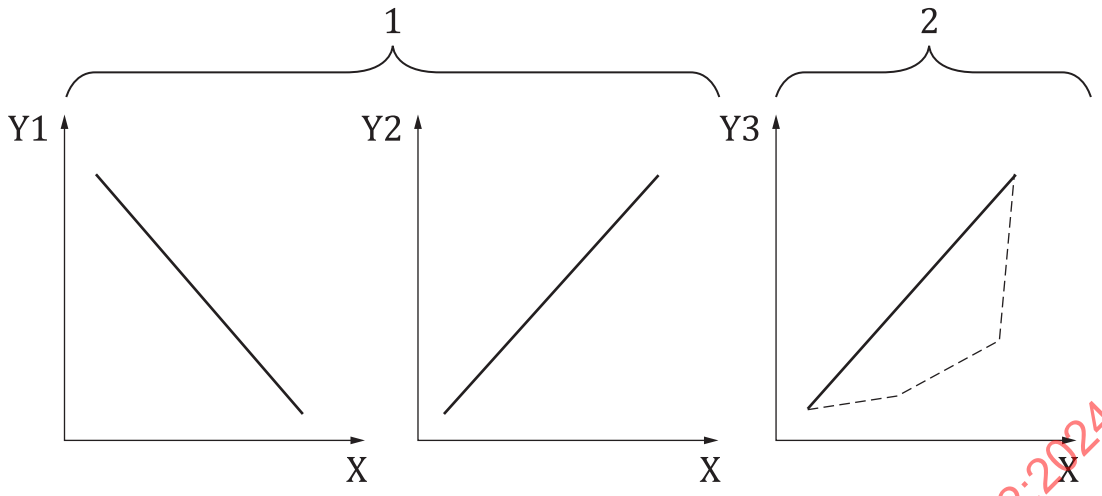


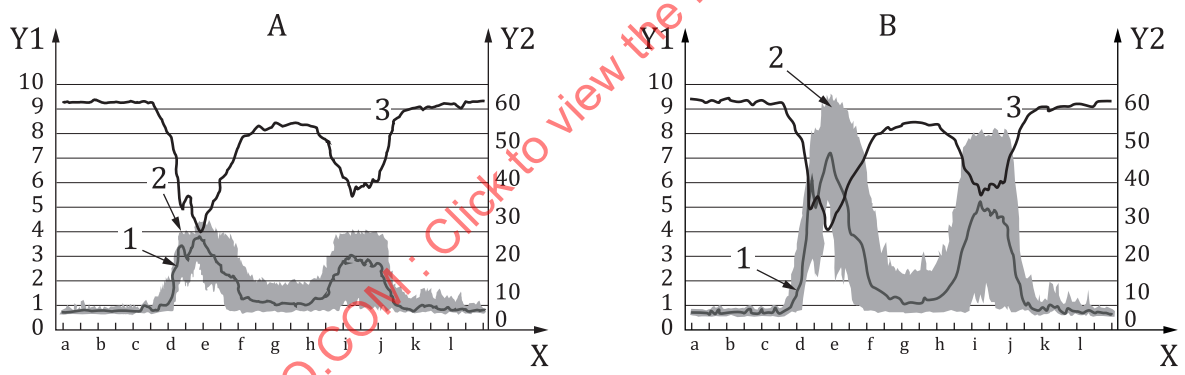
Figure F.1 — Information exchange between toll charger and traffic management centre



Key

X time
Y1 speed
Y2 occupancy
Y3 toll rates
1 primary inputs
2 output

Figure F.2 — Concept of dynamic toll rate



Key

X time
Y1 toll rates
Y2 speed
A,B weekday average speed vs. toll rate
1 5 % dispersion toll rates
2 95 % dispersion toll rates
3 speed

a 0:00:00 AM
b 2:00:00 AM
c 4:00:00 AM
d 6:00:00 AM
e 8:00:00 AM
f 10:00:00 AM
g 0:00:00 PM
h 2:00:00 PM
i 4:00:00 PM
j 6:00:00 PM
k 8:00:00 PM
l 10:00:00 PM

Figure F.3 — Example of average speed vs. toll rate