TECHNICAL SPECIFICATION

ISO/TS 21192

First edition
2019-10

Electronic fee collection — Support for traffic management

Perception du télépéage — Aide pour la gestion du trafic

Reference number
ISO/TS 21192:2019(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

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.

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

— a new movement 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 Tokyo (see Annex D);

— Electronic Road Pricing in Singapore (see Annex E);

— Managed lanes [including services known as high occupancy vehicle (HOV) lanes and high occupancy tolls (HOT)] on interstate freeways in the USA (see Annex F).

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

Figure 1 shows the scope of this document in the data flow model.

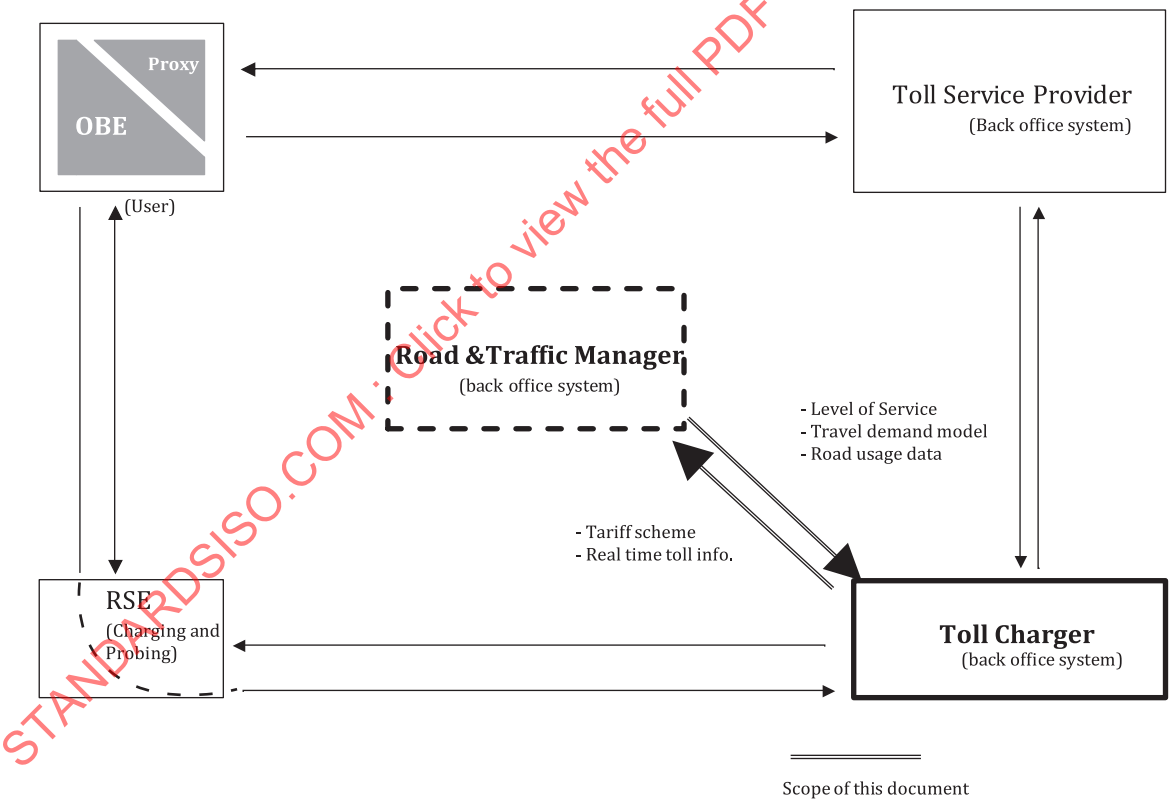

Figure 1 — Scope of this document in data flow model

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.

The scope of this document defines:

— the architecture related to the scope;

— 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).

This document is a toolbox standard of application protocol data units (APDUs), which can be used for the assigned purpose. 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.

Data types and associated coding related to the data elements described in Clause 6 are defined in Annex A, using the abstract syntax notation one (ASN.1) according to ISO/IEC 8824-1. This document allows the implementer to define suitable protocol procedures such as basic interaction, protocol mechanism, and choice of transfer protocol.

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 12855:2015, *Electronic fee collection — Information exchange between service provision and toll charging*

ISO 14827-1, *Transport information and control systems — Data interfaces between centres for transport information and control systems — Part 1: Message definition requirements*

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

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 14906, *Electronic fee collection — Application interface definition for dedicated short-range communication*

ISO 17575-3, *Electronic fee collection — Application interface definition for autonomous systems — Part 3: Context data*

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.

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
electronic fee collection
EFC
fee collection by electronic means

[SOURCE: ISO 17573-1:2019, 3.5, modified — Note 1 to entry has been deleted.]

3.2
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

3.3
transport performance requirement
needed *level of service* (3.2) related to a set of operational goals and performance measures, e.g. speed, travel time, freedom to manoeuvre, traffic interruptions, comfort or convenience

3.4
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

[SOURCE: ISO 22837:2009, 4.3]

3.5
road and traffic manager
RTM
manager responsible for a road transport network operation including monitoring of the level of transport service

3.6
road usage data
travel data accumulated per road user, which is used to calculate the toll due

3.7
tariff scheme
set of rules to determine the fee due for a vehicle within a toll domain

[SOURCE: ISO 12855:2015, 3.12]

3.8
traffic flow information
traffic related data

EXAMPLE Average speed, traffic volume, level of congestion.

3.9
transit data
road usage data (3.6) necessary to calculate fees based on used road sections or passage of certain points

3.10
travel demand model
model for estimating travel demand and behaviour

3.11
dynamic toll
toll adjusted in real time in response to the actual traffic situation or other actual external conditions

3.12
fixed toll
toll applied according to a predefined tariff scheme

4 Abbreviated terms

EFC	Electronic Fee Collection (ISO 17573-1)
OBE	On-Board Equipment (ISO 14906)
LOS	Level of Service
RSE	Roadside Equipment (ISO 14906)
RTM	Road and Traffic Manager
TC	Toll Charger (ISO 17573-1)

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 the four main roles in the toll charging environment. Figure 2 shows the role model expanded with one role to support for traffic management. Interactions between the management role of road and traffic operation environment and the charging role of the toll are both management and operational information flows, e.g. information flows regarding setting a tariff scheme, or daily operation of the tolling.

The role related to the management of road and traffic operation environment is identified to manage a road and traffic operation environment, i.e. defining and maintaining a set of rules that, taken together, defines the policy of traffic management. It should be noted that the role related to traffic management is not part of the EFC domain, but it belongs to the traffic management domain. Hence, this document describes the interface between the two domains, see Figure 2.

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

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

— provision of road usage data, including transit data to find the individual vehicle trace of the routes and to calculate the tolls;

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

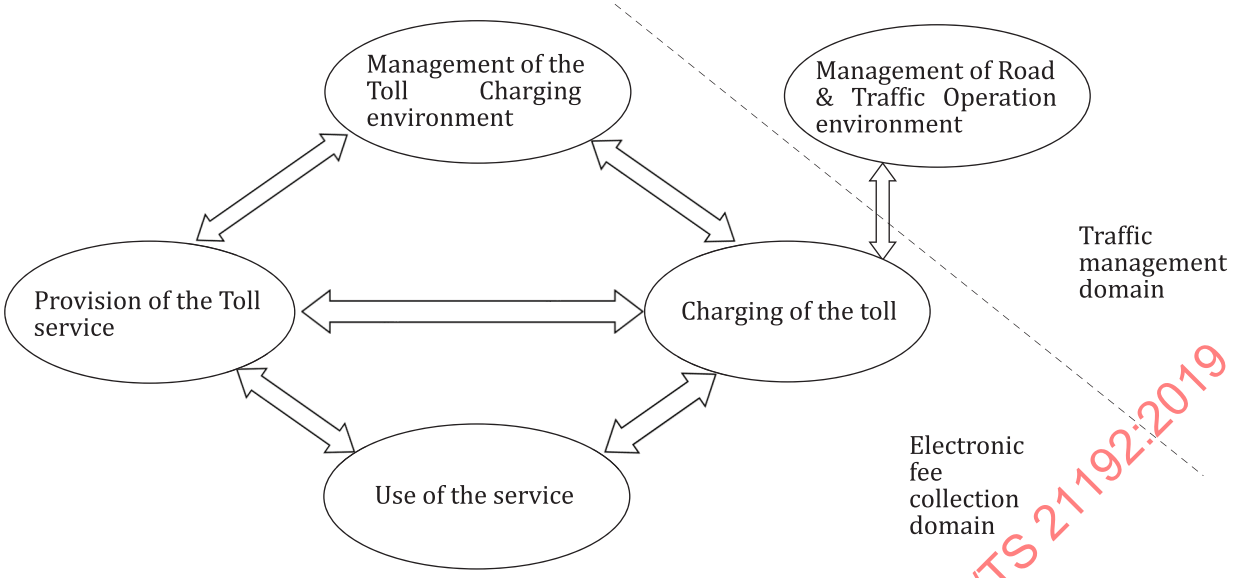

Figure 2 — Role model in the toll charging environment to support traffic management

5.3 Data flow model

The TC needs to establish and maintain close contact with the relevant RTM in order to use a tariff scheme for traffic management. In Figure 3, 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, in the centre of the EFC architecture standard. The corresponding data flow of this document is shown in the double line arrows between TC and RTM.

The roles and tasks of TC and RTM to support traffic management are as follows:

— RTM is a manager responsible for a 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 sets a tariff scheme, based on the transport performance requirements to optimize the toll revenue and the LOS, and sends it to RTM. TC levies tolls and sends real time toll information to RTM.

— RTM monitors the LOS by taking vehicle probe data and traffic flow data. RTM provides real time toll information for the users through the roadside information equipment, on-board equipment (OBE), in-car navigation devices, or web pages. RTM sends 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 running 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.

Upon considering the roles, the data flow model is depicted as Figure 3 with RTM in the centre of the basic EFC system architecture.

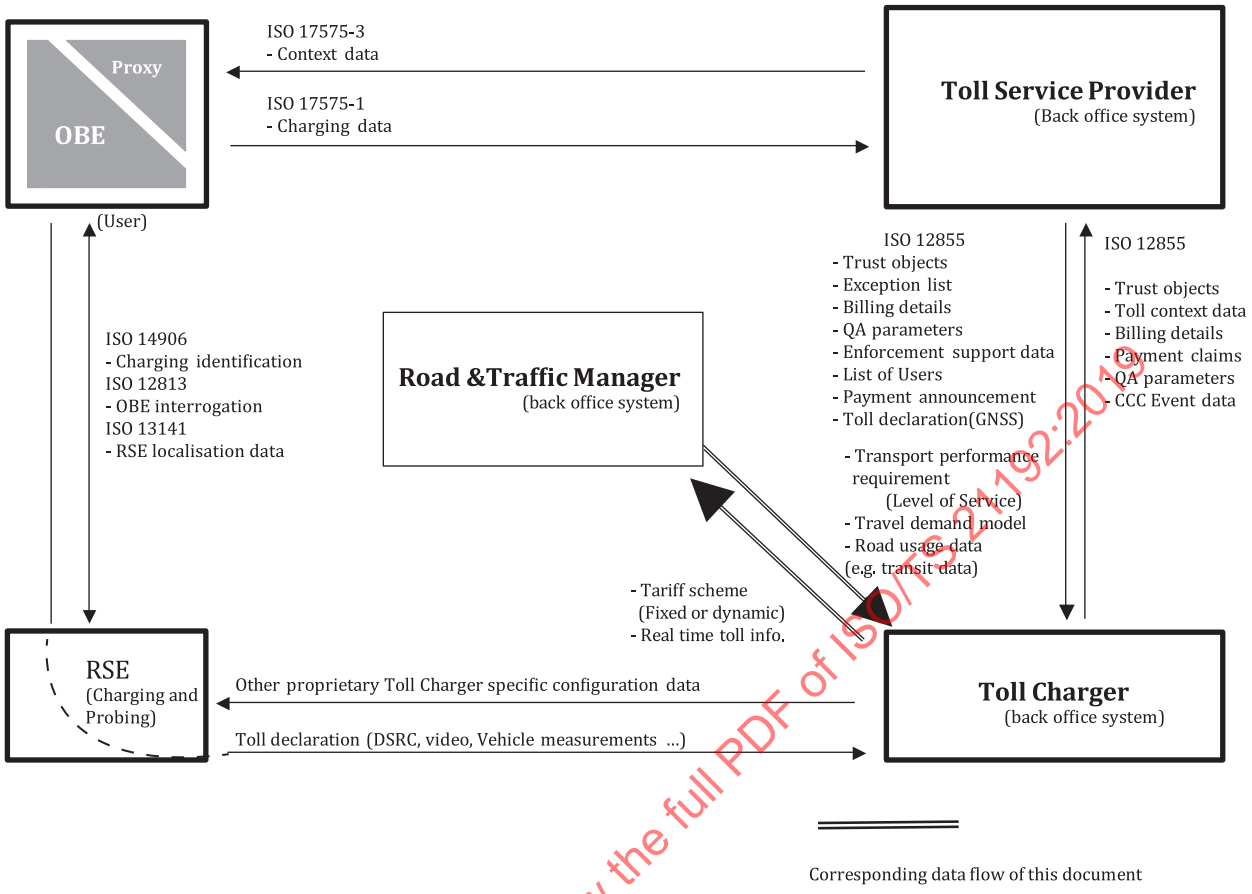

Figure 3 — Data flow model

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 be the flows with the time order of the exchanges, which are described as in Figure 4.

The first step is to define the LOS by RTM, then RTM shall send a performance request in terms of definition of LOS to TC. TC shall set a tariff scheme to satisfy the LOS and send it to RTM.

The second step is to levy the toll. The real time toll information shall be sent to RTM upon levying the toll to disseminate necessary tolling information to the road users, and RTM shall provide road usage data which are collected from OBE as vehicle probe data. The probe data is the vehicle data that is used to determine traffic conditions, time stamped unique identifiers, and to measure a vehicle's progress through the network, e.g. current position, speed, and heading and snapshots of recent events. This includes route information, starts and stops, speed changes, and other information that can be used to estimate traffic conditions. TC then calculates the tolls of individual vehicles. The vehicle probe data can also be transmitted to TC, where TC may calculate the tolls without the road usage data sent from RTM.

The third step is to run the travel demand model and evaluate the tariff scheme. When the tariff scheme is found to be not satisfactory with the LOS and a new tariff scheme is expected to meet LOS better by running the model, RTM shall request TC to evaluate and set a new tariff scheme. (See Annex I in detail including RSE and OBE.)

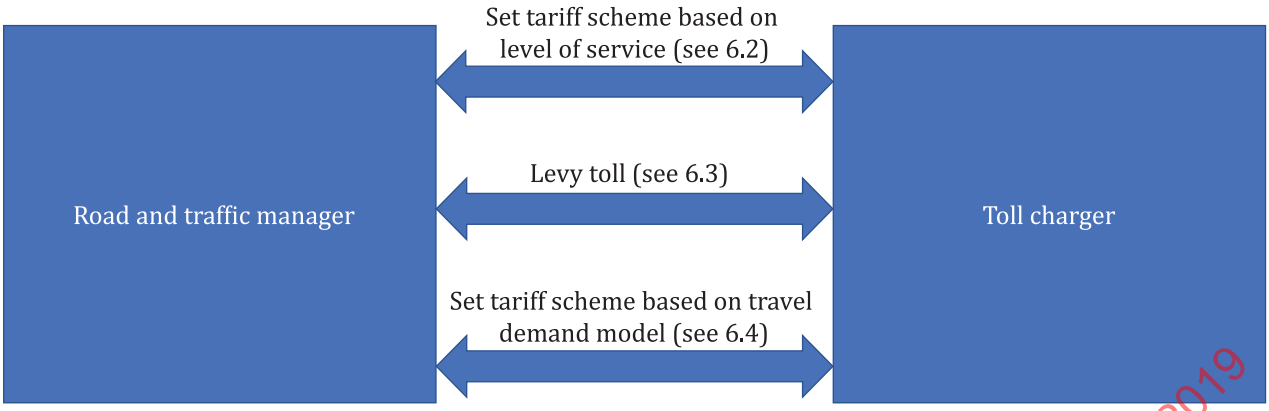

Figure 4 — Information exchanges between TC and RTM

6 General requirements for data exchange

6.1 General

Data to be exchanged for traffic management are 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 classified as the categories of congestion management, tolling, safety, monitoring environmental impact, monitoring goods movement, and total management.

Table 1 — Exchanging data and purposes for evaluating the performance of traffic management

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 centres and EFC centres are defined in ISO 14827 for traffic management and ISO 12855 for EFC, respectively. The interface between RTM and TC shall be defined in reference to the data exchange procedure in ISO 12855 and/or message exchange procedure in ISO 14827. 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 description of data message in Clause 6 is ADU based on ISO 12855. Basic transaction flow including AckADU is described in ISO 12855:2015, Clause 6 also.

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.

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 5.

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

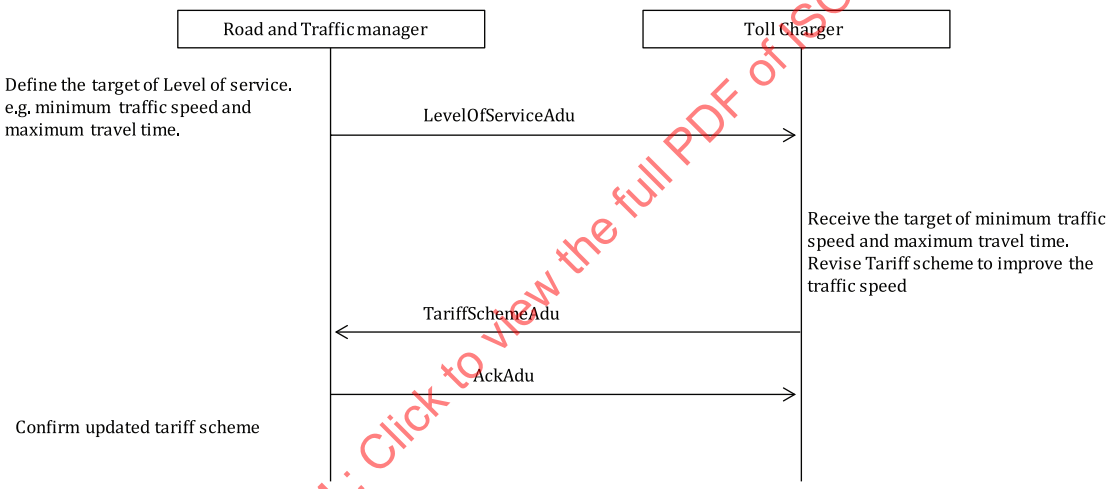

Figure 5 — Sequence diagram of LevelOfService and TariffScheme

6.2.2 Message: LevelOfServiceAdu

LOS, the rating of the quality of transportation facilities and services from the user perspective, shall be a factor to evaluate the transportation system (see Annex A, LevelOfService for syntax definition). In the case of basic motorway sections, the LOSs should be based on density. Speed and flow are also related to densities and the LOS.

The semantic definitions are in Table 2:

Table 2 — Semantic definitions for data type LevelOfServiceAdu

Data element	Semantic definition	Type	Informative remarks
userInformation	A human readable message from RTM about target trafficStatus, TravelSpeed and TravelTime.	UTF8String(SIZE(0..255))	
trafficStatus	A classification agreed bilaterally between implementors.	TrafficStatus ::= UTF8String(SIZE(1))	NOTE 1 Data source is roadside vehicle detector, closed-circuit television EXAMPLE Highway Capacity Manual by TRB. TRB defines six levels of service, designated by the letters A through F, with A being the highest LOS and F the lowest.
minimumTrafficSpeed	Minimum target vehicle speed on average on a certain road measured in km/h.	MinimumTrafficSpeed ::= VehicleSpeed VehicleSpeed ::= REAL	NOTE 2 Data source is roadside vehicle detector NOTE 3 velocity(m/sec.) is used in ISO 22837
maximumTravelTime	a time interval in seconds. Maximum travel time on average on a certain route	MaximumTravelTime::=REAL	NOTE 4 Data source is probe data, Automatic license 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 (see Annex A, TariffScheme for syntax definition). The tariff scheme shall be classified into three schemes: fixed toll, dynamic toll, and combination of both fixed and dynamic. 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 semantic definitions are in Tables 3 to 6.

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	NOTE 1 Fixed toll is a toll based on route, time of day, day of week, vehicle class, user class (e.g. number of passengers) NOTE 2 Data source is TC (Travel demand model), traffic statistics
dynamicToll	DynamicToll	See Table 5	NOTE 3 Dynamic toll is a toll based on status of traffic flow NOTE 4 Data source is TC (Travel demand model, toll computation model), traffic statistics

Table 3 *(continued)*

Data element	Data type	Semantic Definition	Informative remarks
combinationOfToll	CombinationOfToll	See Table 6	NOTE 5 Combination of tolls is a toll combined by both fixed and dynamic NOTE 6 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	INTEGER	Indicator of tariff table with trip route of the vehicle. 1 is active, 0 is disable.
timeOfDay	Time	See ISO 17575-3
dayOfWeek	INTEGER	See Table 6
vehicleClass	VehicleClass	See Table 6
userClass	DriverCharacteristics	See ISO 14906

Table 5 — Semantic definitions for data type DynamicToll

Data element	Data type	Semantic definition
statusOfTrafficFlow	INTEGER	Average vehicle speed [km/h] on certain roads

Table 6 — Semantic definitions for data type CombinationOfToll

Data element	Data type	Semantic definition
tollBasedOnRoute	INTEGER	Indicator of tariff table with trip route of the vehicle. 1 is active, 0 is disable.
timeOfDay	Time	See ISO 17575-3
dayOfWeek	INTEGER	Day of the week 0=Sunday, 1=Monday, 2=Tuesday, 3=Wednesday, 4=Thursday, 5=Friday, 6=Saturday
vehicleClass	VehicleClass	See ISO 14906
userClass	Int1	See ISO 14906
statusOfTrafficFlow	INTEGER	Average vehicle speed [km/h] on certain roads

6.3 Transaction: Levy toll

6.3.1 Overview

RealTimeTollInformation is informed from TC to RTM for displaying real-time toll information text on VMS, in-vehicle device, or OBE. RoadUsageData is informed from RTM to TC for analysing traffic conditions and updating tariff schemes. The data exchanges are shown in Figure 6 and performed in parallel.

For each correct RealTimeTollInformationAdu the TollCharger 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.

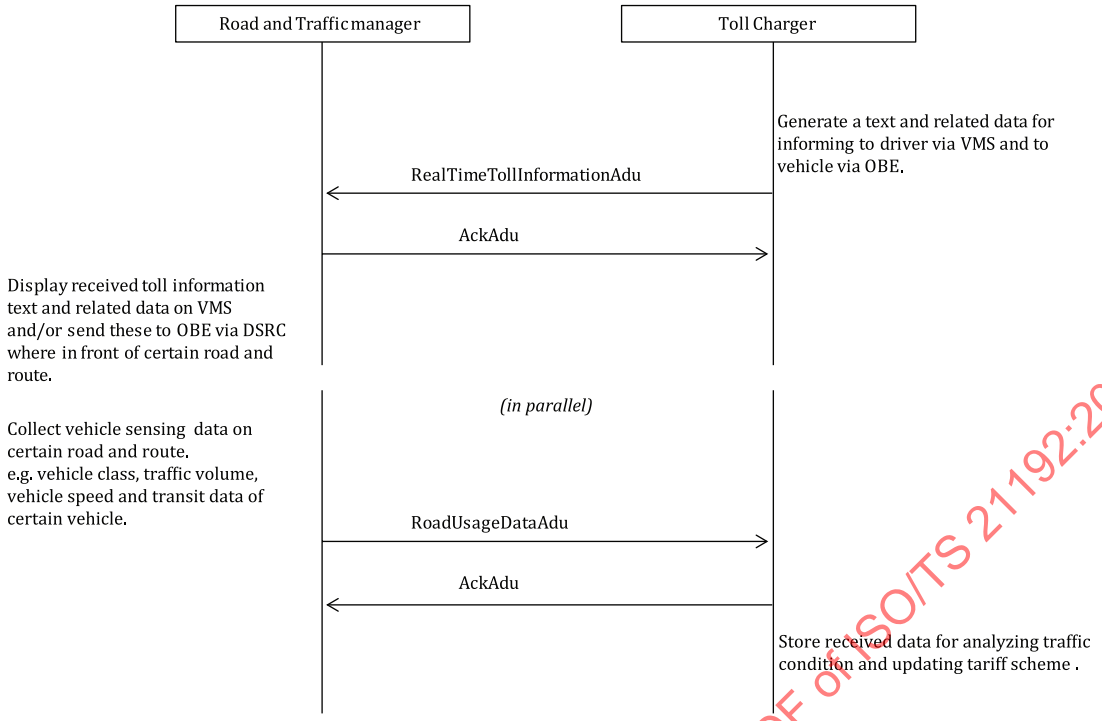

Figure 6 — Sequence diagram of RealTimeTollImformation and RoadUsageData

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. But in 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 semantic definitions are in Tables 7 to 9.

Table 7 — 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 8	NOTE 1 Data source is TC
realTimeToll	RealTimeToll	See Table 9	NOTE 2 Data source is RTM (status of traffic flow), TC (toll by vehicle class)

Table 8 — Semantic definitions for data type TollTable

Data element	Data type	Semantic Definition
tollByVehicleClass	VehicleClass	Vehicle class information in tariff See ISO 14906
Route	RoadNetwork	Road route information in tariff See ISO 17575-3
timeOfDay	Time	Time information of the day in tariff to identify the time-zone (startTime and endTime) in tariff scheme.
startTimeOfDay	GeneralizedTime (OPTIONAL)	Start time of time-zone information of the day.

Table 8 *(continued)*

Data element	Data type	Semantic Definition
endTimeOfDay	GeneralizedTime (OPTIONAL)	End time of time-zone information of the day.
dayOfWeek	INTEGER	Day information of week in tariff to identify the day of calendar in tariff scheme. See Table 6.
startDayOfWeek	GeneralizedTime (OPTIONAL)	Start day of period in the week.
endDayOfWeek	GeneralizedTime (OPTIONAL)	End day of period in the week.

Table 9 — Semantic definitions for data type RealTimeToll

Data element	Data type	Semantic definition
statusOfTrafficFlow	INTEGER	Average vehicle speed [km/h] on certain roads
CertainRoutesOfRoadnetwork	Roadnetwork	Road link ID as route spot to distinguish certain vehicle trip routes
tollByVehicleClass	VehicleClass	Vehicle class information in tariff See ISO 14906

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 semantic definitions are in Tables 10 to 12.

Table 10 — 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 11	NOTE 1 Data source is roadside vehicle detector, closed-circuit television, probe data
transitDataOfVehicles	TransitDataOfVehicles	See Table 12	NOTE 2 Data source is probe data

Table 11 — Semantic definitions for data type TrafficFlowData

Data element	Data type	Semantic definition
vehicleClass	VehicleClass	See ISO 14906 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 12 — Semantic definitions for data type TransitDataOfVehicles

Data element	Data type	Semantic definition
TransitDataOfVehicles	roadNetwork ::= RoadNetwork	See ISO 17575-3 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 7.

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

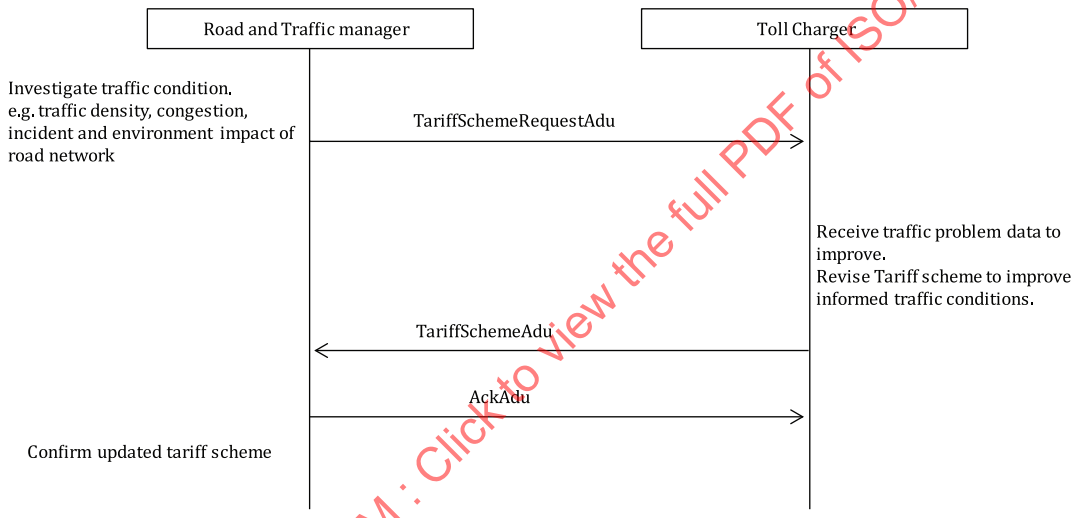

Figure 7 — Sequence diagram of TariffSchemeRequest and TariffScheme

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 semantic definitions are in Tables 13 to 17.

Table 13 — 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 14	NOTE 1 Data source is roadside vehicle detector, probe data
unfavourableCongestion	UnfavourableCongestion	See Table 15	NOTE 2 Data source is roadside vehicle detector, probe data
unexpectedIncreaseOfIncidents	UnexpectedIncreaseOfIncidents	See Table 16	NOTE 3 Data source is TC, RTM, Police agency,
unfavourableEnvironmentalImpact	UnfavourableEnvironmentalImpact	See Table 17	NOTE 4 Data source is roadside vehicle detector, probe data, Pollution level sensor

Table 14 — 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 15 — 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 16 — Semantic definitions for data type UnexpectedIncreaseOfIncidents

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

Table 17 — 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

Table 17 *(continued)*

Data element	Data type	Semantic definition
noise	INTEGER	Average dB on certain roads Indicator of noise level
atmosphericEnvironment	INTEGER	ppm/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 (O3), nitrogen dioxide (NOx) and sulphur dioxide (SOx).

6.4.3 Message: TariffSchemeAdu

This message shall have the same requirements and definitions as the one defined in 6.2.3.

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 a vehicle's progress through the network, e.g. current position, speed, heading and snapshots of recent events, including route information, starts, and stops, speed changes, and other information that can be used to estimate traffic conditions. The data could 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 could 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 license plate number, may be used for identifying an individual. Privacy shall be taken into account 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 described 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.

Some data elements in this document are imported as ASN.1 format from ISO 22837 although they are defined in ISO 22837 using the XML format. The semantics of these data elements shall comply with ISO 22837.

The actual ASN.1 module is contained in the attached files "ISO21192(2019) EfcSupportTrafficManagementV1.asn", which can be directly imported in a compiler.

The syntax and semantics of the ASN.1 types in the attached file "ISO21192(2019) EfcSupportTrafficManagementV2.asn" that are imported shall comply with ISO 14906 and ISO 17575-3.

NOTE 1 The above referenced files files (i.e. "ISO21192(2019)EfcSupportTrafficManagementv2.asn") are available for download via a hyperlink at www.itsstandards.eu/index.php/efc#EFCstandards and at http://standards.iso.org/iso/ts/21192/ed-1/en.

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.

Table A.1 — SHA-256 cryptographic hash digests

File Name	SHA-256 cryptographic hash digest
ISO21192 EfcSupportTrafficManagementV1.asn	d8807e714420b40fd788bdec8d345446f38b7acdb48 5745df1f843b7e7d92e56

NOTE 2 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

In order 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 also, 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 may be:

m mandatory support is required;

o optional support is permitted for conformance to the standard. 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 are used to identify the implementation on TC side.

Table B.1 — Identification of ICS

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

Table B.2 — Identification of the implementation and/or system

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	

Table B.6 *(continued)*

Item no.	Element	Reference	Status	Support
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	Traffic status	6.2.2	o	
3	Minimum traffic speed	6.2.2	o	
4	Maximum travel time	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	Fixed toll	6.2.3	o	
3	Dynamic toll	6.2.3	o	
4	Combination of above	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	Toll table (In case of fixed toll)	6.3.2	o	
3	Real-time toll (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	Unbalanced density of transportation network	6.4.2		
3	Unfavourable congestion	6.4.2	o	
4	Unexpected increase of incidents	6.4.2	o	
5	Unfavourable environmental impact	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 sub-clause.

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
        tariff scheme request       [7]     SEQUENCE OF RoadUsageData
        }
```

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 defined using 'XML message as fundamental requirements' in ISO 14827-3.

The 'message definition requirements' are described in ISO 14827-1.

The interface procedure for Information exchange is as per ISO 14827-2. Data structures are defined 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 greater Tokyo metropolitan area, the construction of outer ring expressways will be almost finished in a few years for aiming at reducing traffic congestion in the central Tokyo area.

In the complex network consisting of three ring expressways and nine radial expressways, a user can select a suitable route with consideration of traveling time and toll amount. Figure D.1 shows an image of a smart route selection using probe data.

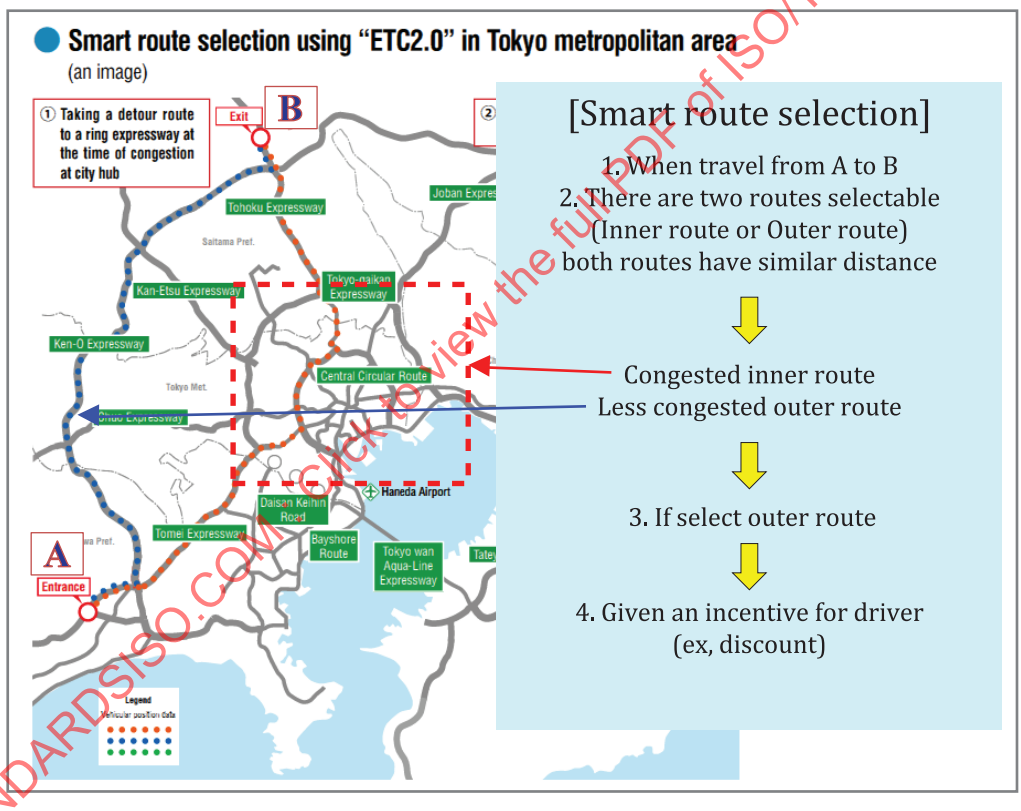

Figure D.1 — Image of smart route selection using probe data in Tokyo metropolitan area

Source: Ministry of Land Infrastructure and Transport of Japan.

D.2 System configuration and functions

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 as the same as present tolling system. The other type of RSE, 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.

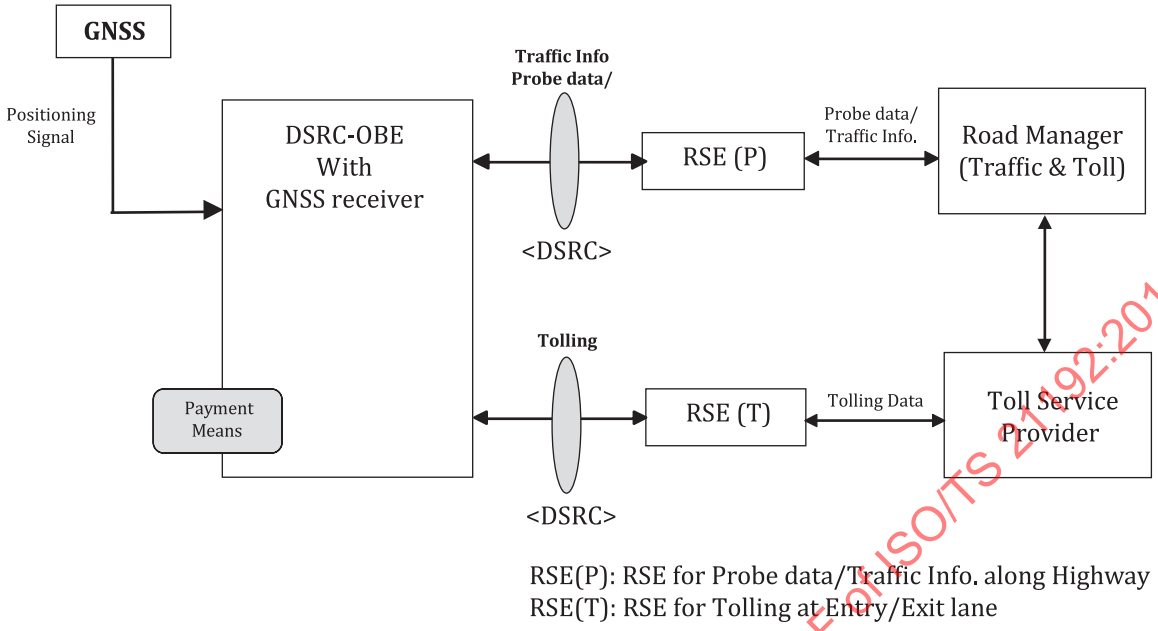

Figure D.2 — System configuration of EFC system for smart route selection

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

Figures E.1 and E.2 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.

Figure E.3 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 in order to maintain LOS of E.

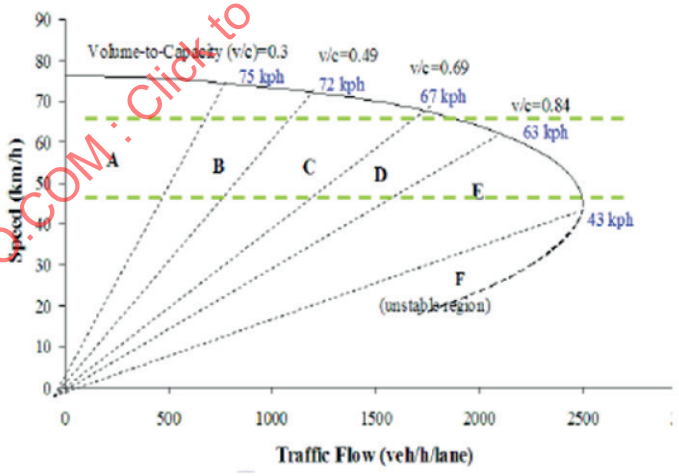

Figure E.1 — Q-V curve on expressways

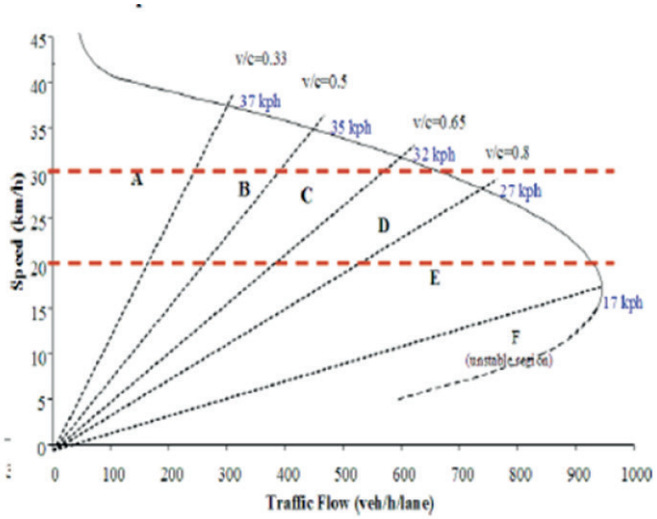

Figure E.2 — Q-V curve on arterial roads

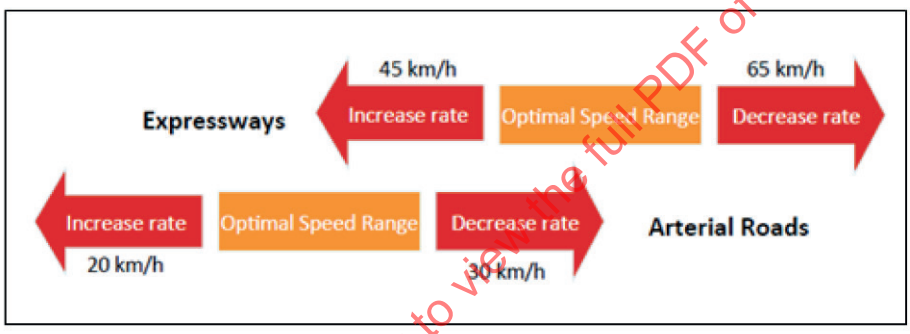

Figure E.3 — Managing concept of traffic flow

Source: Land Transport Authority of Singapore (LTA).

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 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, and an example of average speed versus toll rate is shown in Figure F.3.

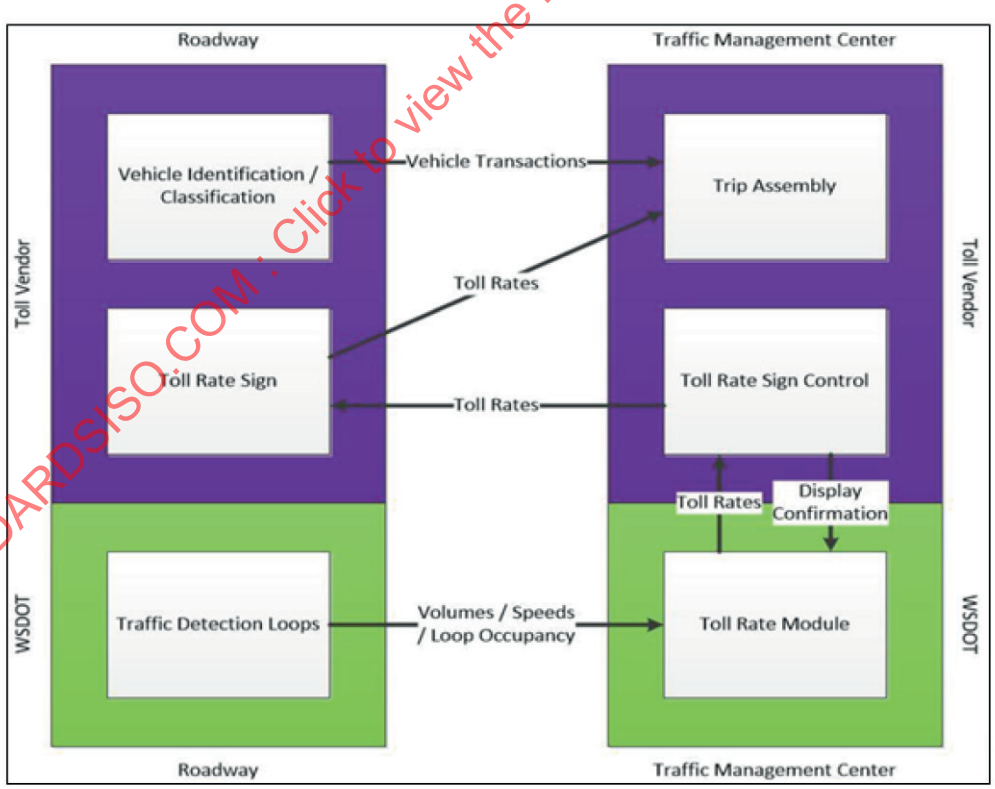

Figure F.1 — Information exchange between toll charger and traffic management centre