



SURFACE VEHICLE STANDARD	J3217/R™	JAN2024
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Road User Charging		

RATIONALE

This document defines electronic fee collection for road user charging, including the concept of operations, reference system architecture, user needs, system functional and performance requirements, and ASN.1 entities such as messages and related data frames and elements, to enable road user charging.

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1. SCOPE

The scope of this document is the concept of operations including reference system architecture, the user needs, the system functional and performance requirements, the messages, the corresponding data frames and elements, and other related functionality to enable road user charging.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J2735 V2X Communications Message Set Dictionary

SAE J2945/1 On-Board System Requirements for V2V Safety Communications

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

SAE J3217 V2X-Based Fee Collection

SAE J3268 Listing of Provider Service Identifiers and Associated Application Technical Reports

2.1.2 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE Std 1609.2-2022™ IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Applications and Management Messages

2.1.3 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO 17575-1 Electronic fee collection - Application interface definition for autonomous systems - Part 1: Charging

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

ISO 12855 Electronic fee collection - Information Exchange Between Service Provision and RUC Charging (Second Edition 2015-12-15)

ISO/TS 21177 Intelligent transportation systems - ITS station security services for secure session establishment and authentication between trusted devices

3. DEFINITIONS

3.1 ONBOARD EQUIPMENT

All required equipment on-board a vehicle for performing required EFC functions and communication services.

3.2 ROAD USAGE CHARGING APPLICATION (RUC APPLICATION/RUC APP)

The entity that receives the RUC charging configuration, computes the corresponding RUC usage data and fees, and sends them to the corresponding RUC Service Provider. This application may reside exclusively on the OBE or may partially or fully reside in the cloud.

3.3 RUC CHARGER

The entity that levies the fee and provides the fee schedules to the service provider.

3.4 RUC SERVICE PROVIDER

The entity providing RUC services to the OBE/RUC Application. This entity provides funds on behalf users to different RUC Chargers.

4. ABBREVIATIONS

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

3GPP	Third Generation Partnership Project
CRL	Certificate Revocation List
EFC	Electronic Fee Collection
GNSS	Global Navigation Satellite System
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
kph	Kilometers per hour
LTE	Long Term Evolution
NTCIP	National Transportation Communications for ITS Protocols
OBE	Onboard Equipment
ODP	Open Distributed Processing
OEM	Original Equipment Manufacturer
PC5	ProSe Communications 5
PSID	Provider Service Identifier
RUC	Road User Charging

SCMS	Security Credential Management System
TAM	Toll Advertisement Message
TCP	Transmission Control Protocol
TLS	Transport Layer Security
UTC	Universal Coordinated Time
V2X	Vehicle to Everything
WAVE	Wireless Access in Vehicular Environments
WSM	WAVE Short Message
WSA	WAVE Service Advertisement
WSMP	WAVE Short Message Protocol

5. CONCEPT OF OPERATIONS

Road user charging (RUC) is a per-distance or per-time based fee levied on road users. The fee is charged for road use where revenue is collected based on distance or time traveled. RUC is sometimes referred to as vehicle miles traveled (VMT) fees. Depending on how RUC is structured, it may also be used as a tool to manage mobility, demand and congestion, encourage fuel or vehicle efficiency, and provide a more equitable fee structure for transportation funding.

The following sections describe the RUC concept of operations and features necessary to implement the system. This document assumes the user has already chosen to participate in the RUC system. As such, this document does not address opt-in or opt-out features.

5.1 Current Situation and Problem Statement [Informative]

5.1.1 System Overview

In RUC systems the vehicle's onboard equipment contains a map database with all the roads in the applicable jurisdictions and information on fees associated with road usage in certain geographic areas. When jurisdictions change road prices, regular downloads by the OBEs enable new fee structures to be deployed and updated. The OBE calculates payments to all the jurisdictions based on the road segments or areas the vehicle uses, and the corresponding fees. At the end of a charging period, the vehicle/OBE aggregates the various fees and computes the fees due to the appropriate agency or a private-road owner. This enables subsequent charging of the vehicle owner's account.

For a RUC system to support correct computation of fees, positioning and timing capabilities are needed, as well as defined maps. In this document, the jurisdictions collecting RUC fees are assumed responsible for ensuring use of suitable maps. Toward that end, certification of RUC Service Providers for both map validity and establishing trust is necessary for implementation. The SCMS providers responsible for issuing certificates are typically involved in the chain of certification, so that only certified entities can obtain valid certificates.

On the vehicle side of the system, this document requires conformance with SAE J2945/1 regarding positioning and timing accuracy. SAE J2945/1 conformance combined with suitable maps is expected to provide adequate performance for the purpose of RUC. Both the vehicle/application side and infrastructure side require valid certificates to establish communication, and both RUC Application/OBE and RUC Service Provider side are expected to undergo some level of certification before commercial operation. Certification is outside the scope of this document and is expected to be based on the policies of the agencies ultimately collecting the fees.

5.1.2 RUC Guiding Concepts and Principles

The following list provides the basis for the technical solution specified in this document:

- Road User Charging is generally a pay-per-distance and/or pay-per-time charge instead of a tax paid per gallon on fuel. This is similar to utilities (e.g., gas and electric); customers pay for what they use. RUC can be time or distance based or defined by any combination of rules concerning when the roadway is used and by what type of user/vehicle.
- A per-distance or per-time charge would be measured using the instruments available to the OBE, e.g., GNSS, odometer, etc.¹ This method uses location-based data to calculate total distance driven with differentiation between in and out-of-jurisdiction roads with periodic billing as a built-in function of the OBE. The ability to charge out-of-jurisdiction residents needs to be supported.
- The OBE is expected to use the positioning system to record when and where the car is traveling. At the end of the pay period (e.g., monthly), distance or time driven totals are organized according to jurisdiction owed, and the OBE accesses the driver's RUC account to dispense payment to a RUC Service Provider, which is responsible for distribution of the fees to the relevant entities. Typically, the period between report and purge will not exceed 30 days, but that policy is outside the scope of this document. For auditing and revenue distribution purposes, this document provides the capability to submit itemized reports.
- Trip history data (origin, destination, path history) will not be required to be shared with RUC Service Providers or government agencies. An individual's privacy needs to be protected, and this document defines a solution that provides protection of user data from being used by third parties without consent.

NOTE 1: The interface defined in this document is designed to protect privacy. Alternative architectures like the distributed RUC App architecture described in Section A.6 can also be used with the standardized interface specified herein.

NOTE 2: RUC Applications may provide users the ability to view and share their travel histories. Such a feature is outside the scope of this document.

- Data is stored in secure environments, including on-board equipment, RUC Service Provider centers and other end entities, and their interfaces are secured using cybersecurity techniques. The system needs to be secure from potential cyber-attacks. Access to data shall be restricted to authorized entities only.
- Interoperability with systems across jurisdictions nationally is necessary.
- Ability to certify the distance/time reporting at the vehicle/make/model level by an independent third party is needed.
- The system needs to account for vehicle types and exemptions (e.g., disadvantaged categories).
- Every jurisdiction needs to be responsible for establishing the usage fee structures associated with its roadways.
- The system needs to adhere to open standards and architecture (e.g., support for third-party devices).²
- Online and in-vehicle calculators for consumers to estimate RUC fees for a trip should be provided, but the means for doing so and the privacy enforcement mechanisms thereof are outside the scope of this document.

¹ Note that additional capabilities (e.g., odometer readings, map databases) likely need to be combined with GNSS to account for environments with poor GNSS signal, e.g., tunnels.

² While this standard defines a privacy protecting interface between a Provider and OBE, RUC Applications may include support for credit card transactions in vehicles, for example to support rental cars. While this standard does not address a user interface in the vehicle, such implementations are possible while conforming to SAE J3217/R.

- The following items are out of scope:
 - The interface between RUC Service Provider and RUC Charger
 - Minimum performance and certification methodology

RUC systems operate without relying on dedicated road-side infrastructure. RUC systems use satellite positioning, often combined with additional sensor technologies such as gyroscopes, odometers, and accelerometers, to localize the vehicle and to find its position on a map containing the charged geographic objects, such as charged roads or charged areas. From the charged geographic objects, the vehicle characteristics, the time of day and other data that are relevant for describing road use, the tariff and ultimately the road usage fees are determined. RUC systems are best suited to implement area charging regimes, and in some cases road segment-based RUC regimes.

This document includes security, interface, and message specifications for RUC Applications.

5.2 Reference Architecture

5.2.1 Business Architecture

ISO 17573 uses the enterprise viewpoint concepts of the ODP Reference Model to define an EFC architecture in terms of actors, roles and policies. The well-established role model defined in ISO 17573 is summarized in Figure 1. Note that these are the business interactions, not data exchange interfaces.

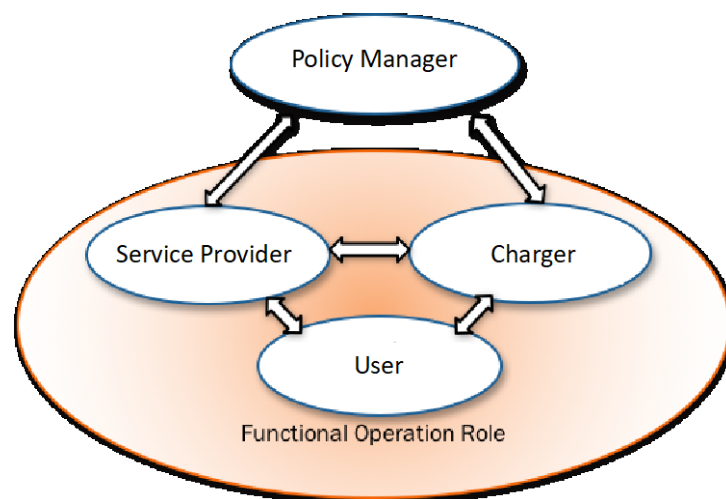


Figure 1 - Illustration of roles in EFC

The Charger levies RUC for the use of vehicles in a RUC domain. It defines the RUC regime and interfaces with the RUC User and RUC Service Provider system.

The Service Provider provides RUC services to Users across one or more RUC Chargers. It is responsible for providing the basic mechanisms, organizational structures, and information transfer tools needed to run an EFC system.

The User of the service is a customer of a RUC Service Provider, i.e., one liable for payment of RUC, owner of the vehicle, fleet operator or driver depending on the context. It covers all aspects of using the RUC system and, if applicable, of the transport service. Implementations of RUC systems in various domains commonly refer to this role as, e.g., driver, user, or customer.

Policy Manager is a specific role that is identified to manage a RUC charging environment, i.e., defining and maintaining a set of rules that, taken together, define the policy of a given regime or of the overall RUC charging environment. In the ISO 17573 business architecture this is referred to as Interoperability Manager.

A detailed description of the roles and their responsibilities can be found in ISO 17573-1 clause 6.

5.2.2 Reference Architecture

The complete technical architecture for RUC systems is defined in ISO 12855. Figure 2 provides an overview of the architectural elements and identifies a relevant subset of the interfaces and data flows between them. While the Charger and RUC Service Provider are included in the architecture for context, the scope of requirements in this document is the interface between RUC Service Provider and OBE. Systems in which the RUC Application is implemented in a distributed architecture that spans cloud-based services as well as vehicle-based software are allowed by this standard. The scope of this standard is limited to the interface between the RUC Service Provider and that RUC Application, and regardless of whether the application is implemented wholly on an OBE or via some form of distributed processing, the interface specified in this document is unaffected and applicable to both architectures.

For a further description of this reference architecture, refer to ISO 12855.

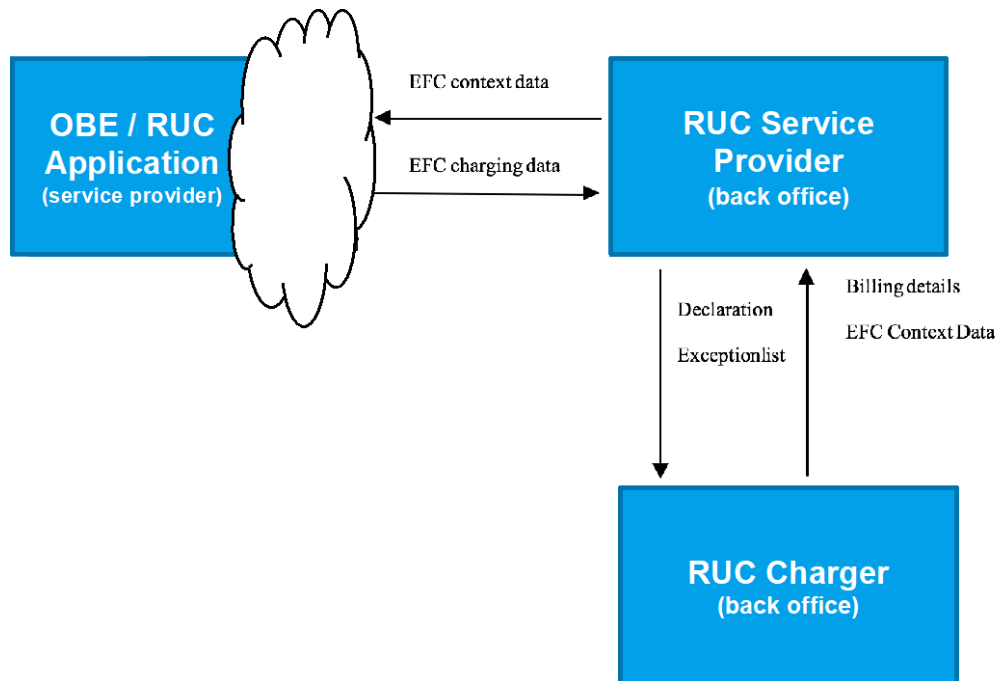


Figure 2 - Reference architecture

The main architectural elements are:

- The (RUC Service Provider's) front end (top left box in Figure 2) equipment where RUC information and usage data are stored, collected, and processed composed of:
 - OBE/RUC Application associated with a vehicle and used for computing RUC fees and communicating with the RUC Service Provider.
- The RUC Service Provider back-office, central equipment which processes data for/from the RUC Charger and which manages the front ends.
- The RUC Charger back-office, central equipment which processes data for/from the RUC Charger.

The interface between the RUC Service Provider's front end and the back office is regarded as system internal and not relevant for data exchange between a RUC Charger and various RUC Service Providers.

Figure 3 provides an overview of the reference interface architecture used to implement a RUC system. A RUC configuration is sent to the OBE/RUC Application from a provider, which contains the information necessary for the OBE/RUC Application to compute fees.

RUC Report messages are sent to the RUC Service Provider by the OBE/RUC Application to report usage and corresponding fees.

The SCMS issues certificates to both RUC Service Provider and OBE/RUC Application, but the communications interface to an SCMS is outside the scope of this document. The architecture includes the SCMS because being equipped with certificates is a prerequisite to data exchange between OBE and RUC Service Provider.

In RUC systems there is no communications interface between OBE and RUC Charger; the data necessary to determine payment is not exposed to the RUC Charger. This is consistent with the privacy principles discussed earlier in this section.

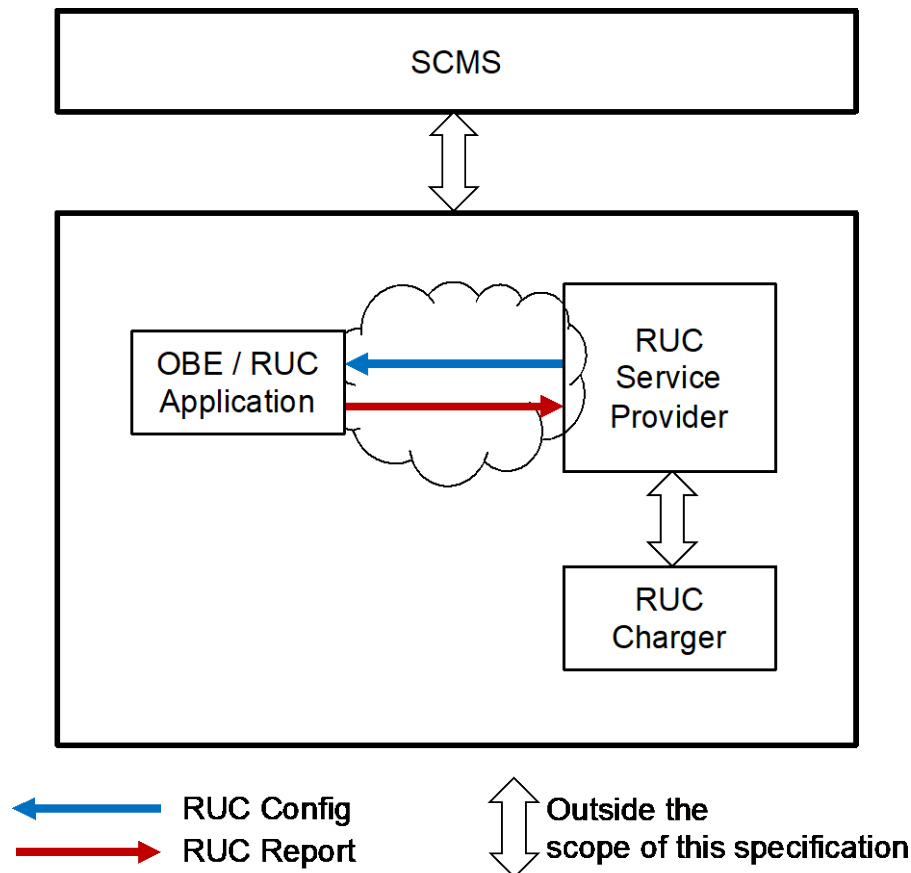


Figure 3 - RUC system interface reference architecture

For convenience, from here on the OBE/RUC Application is referred to as OBE.

5.3 Features

5.3.1 Common Features

Refer to SAE J3217, 5.3.1.

5.3.2 Features in RUC Systems

This clause collects features that are specific to RUC Systems.

5.3.2.1 RUC Service Provider features

5.3.2.1.1 Provide RUC Context Data

The RUC Service Provider needs to provide RUC Charger fees to the OBE. This information is used to generate RUC usage declarations ultimately provided to the RUC Charger and to provide RUC payment status and user-specific RUC payment information to the user.

5.3.2.1.2 Provide RUC Declaration

The RUC Service Provider needs to generate RUC declarations related to use of the RUC road by its customers. These are declaration of payments owed by the RUC Service Provider to the RUC Charger based on usage reported by OBE.

5.4 Security

The interface between the OBE and RUC Service Provider uses transport layer security (TLS) with IEEE 1609.2 certificates. In order to receive certificates, the OBE needs to have access to a Security Credential Management System (SCMS).

5.4.1 Data Integrity

The system needs to ensure that messages transmitted by the OBE are not modified in transit. Note that payment auditing is outside the scope of this document, but RUC system users are expected to have the ability to reproduce their data from their OBE if desired according to whatever policies are set by the jurisdiction corresponding to the RUC Charger.

5.4.2 Authentication

The OBE and RUC Service Provider need to verify that the other is a trusted entity prior to data exchange on their interface. Refer to the Annex for more information on the topic of trust.

5.4.3 Authorization

The system needs to ensure that the OBE (vehicle) is authorized to act in the role it claims (e.g., police or non-agency vehicle). Some vehicles may be exempt from RUCs. This is enabled by the SSP design.

5.4.4 Non-Repudiation

The system needs to ensure that the sender/OBE cannot deny that it sent the information.

5.4.5 Data Confidentiality

The system needs to ensure the protection of personally identifiable information that can be used to uniquely identify an individual, vehicle or vehicle owner.

5.4.6 Physical Security

The OBE hardware or equivalent environment used to host the RUC Application needs to provide tamper proof or tamper evident levels of physical protection.

5.5 Operational Scenarios

Area-based charging using jurisdictional boundaries or RUC Charger-defined zones:

- Time in area
- Distance in area

Road-segment based charging:

- Road segments based on time driven
- Road segments based on distance driven

6. REQUIREMENTS

6.1 Architectural Requirements

6.1.1 Mapping and Positioning

The system shall be capable of identifying vehicle location within a primary jurisdiction (in North America this is a State within the U.S., Canada, or Mexico), within the second level jurisdiction below state (e.g., county, parish, etc.) and the current roadway it is on. This generally is supported by pre-loading maps into the OBE. Knowing state and county is required to implement the charging scheme, and if segments are also defined, the current roadway is needed to apply the rules associated with virtual toll advertisements using a SAE J3217 Toll Advertisement Message (TAM) (see Table 2).

NOTE: The accuracy of map databases may affect fee amounts reported by RUC Reports. RUC Applications are expected to use approved map databases and be certified for performance before receiving 1609.2 certificates.

6.1.1.1 Map and Charging Configuration Freshness

OBE shall query the RUC Service Provider for configuration updates at least once per week or upon vehicle/OBE startup. If newer maps and configurations for the current and surrounding areas are available, the new configuration is applied according to the start date of the configuration.

NOTE: This entails querying a back-end system for map and charging configuration updates, and for the purpose of receiving RUC Configurations and corresponding charging configurations, this document supports a query of the RUC Service Provider by the OBE. The suitability and freshness of maps is out of scope of this document but is recommended to be agreed on between SCMS providers, RUC Service Providers and the jurisdictions collecting RUC fees. There are already many commercially available, actively maintained map databases that are suitable for applications such as RUC, and jurisdictions simply need to approve of use of specific existing databases.

When one or more toll advertisement messages are included in a configuration, the toll approach and toll zone maps are used according to SAE J3217, and the corresponding fees are reported according to the RUC configuration's payment schedule as opposed to upon exiting the toll road, for example.

6.1.1.2 Positioning and Timing Performance Requirements

The positioning and timing performance of the system used to compute RUC fees (based on distance and/or time) shall conform to SAE J2945/1, 6.2.4, 6.3.6.5, and 6.3.6.6.

NOTE: This requirement can be verified by inspection if the same equipment is being used to generate BSMs, and it has already been certified to be conformant with SAE J2945/1.

6.1.2 Communications Interfaces

The communication interface between OBE and RUC Service Provider shall be over secure HTTP (HTTPS). This requires periodically establishing an internet connection between the OBE and RUC Service Provider via a cellular network or other IP-based network connection.

6.2 RUC Data Exchange Requirements

6.2.1 RUC Config

The RUC Configuration message shall be used to provide the vehicle with the necessary information to compute its owed charges for each RUC Charger.

6.2.1.1 RUC Config Message Contents

The RUC Configuration message contents are defined in Table 1.

Table 1 - RUC config contents

Data Object (ASN.1 Entity)	Description	Type	Source
RoadUserChargingConfigMessage	Top level message.	Sequence	This document
chargerInfoTable	Data used to identify the RUC Charger and compute fees owed.	Sequence (999...)	This document
ChargerInfo	A single instance or entry in the chargerInfoTable.	Sequence	This document
chargerID	ID of the RUC Charger.	Object identifier	This document
descriptiveName	Text string (optional).	IA5String (1-63)	SAE J2735
timeStamp	DDateTime: the time the configuration was created (UTC).	Sequence	SAE J2735
chargingConfig	Contains the geographic areas and road segments subject to the RUC Charger's charging scheme.	See Table 2	This document

Table 2 shows the contents of chargingConfig, which is how the fee schedule is communicated to the OBE. This fee schedule allows charging by jurisdiction and in geometrically defined regions. The fee schedule also allows for the virtualization of SAE J3217 toll gantries, using Toll Advertisement Messages (TAMs) with the added capability of being able to charge both traditional tolling schemes as well as distance or time-based schemes that use virtual gantries.

Note also that the charging structure (fee schedule) supports RUC Charger-defined categories as specified in SAE J3217. This allows RUC Chargers to offer, for example, low-income and law enforcement exemptions. Multiple RUC Charger-defined categories are supported. This document uses the SAE J3217 ChargesTable entity to enable charging based on characteristics indicated by the RUC Service Provider, e.g., vehicle classes, weight.

Table 2 - Charging configuration contents

ChargingConfig	Contains information necessary for the OBE to compute charges owed for the subject RUC Charger.	Sequence	This document
ConfigInfo	Information.		
configID	Identifies the RUC Charger configuration.	Integer (0..64)	This document
configVersion	Version number.	Integer (0..64)	This document
startDate	Date and time after which the configuration is applied. Older configurations with the same ID are replaced upon startDate.	DDateTime	This document and SAE J2735
expirationDate	Date the configuration expires. An updated or new configuration must be made available at least one week prior to the expiration date of an existing configuration.	DdateTime	This document and SAE J2735

configurationFeeType	Fee type: 1. Excluded from RUC in the corresponding area/roadway. 2. Replaces other charges for the same area. 3. Added to other charges for the same area. NOTE: A replacement fee can be set to zero to exclude specific areas and road segments. Also note that one ChargingConfig does contain multiple fee types. A configuration that replaces or excludes the fees associated with another configuration are sent to OBE separately and with a unique ConfigID.	Enumeration	This document
reportSched	How frequent to send the RUC Report (e.g., hourly, weekly, monthly, etc.), includes. RUC Reports are typically assumed due within 30 days after the first instance of configuration being used and the first payment schedule period has expired, e.g., if the report is due weekly, after the first week of driving in that area, the payment for that week of use is due within 30 days. Payment due dates are outside the scope of this specification and subject to the policies of the jurisdictions.	Enumerated	This document
PrimaryRegionChargingInfo	Mandatory to be included, but ChargingFees is optional and may be omitted if subregions, areas, or segments are included, e.g., there is not state-wide fee, but the primary region is still identified).	Sequence	This document
primaryRegionCountry	ISO CountryCode.	BIT STRING	ISO 17573-3
chargingPrimaryRegion	Initially this is a choice between a state in the U.S., Canada, and Mexico and an extensibility marker to support future jurisdictions outside North America.	Choice	
usCanMexState	Used if ISO country code indicates U.S., Canada, or Mexico.	IA5String	This document
ChargingFees	Optional. The base level set of charges by time of day and type of vehicle. Note that if only one class of vehicle is included in the ChargesTable, the fee applies to that class and all classes below it, e.g., if only FHWA class 13 is included, the fee applies to classes 1 through 13.	See Table 3	This document
SubRegionChargingInfo	Optional.	Sequence (1..999) of subregions and corresponding fees	This document
SubRegion	County or jurisdictional subregion next level down from PrimaryRegion. A RUC Charger must publish the OIDs associated with its counties or equivalent subregions for the RUC Service Provider to equip vehicles with that information.	Relative OID (relative to the charger OID in Table 1)	This document
ChargingFees	The additional or replacement set of charges by time of day and type of vehicle at the county (or equivalent) level.	See Table 3	This document



AreaOrSegmentChargingInfo	Optional. ChargingConfig includes a sequence of chargingAreaOrSegment entities.	Sequence	This document
ChargingAreaOrSegment	Choice between Area or Segment.	Choice	This document
Area	Elements of Area-based charging.	Sequence	
areaID	Identifier for the charging area.	Relative OID (relative to the charger OID in Table 1)	
chargingArea	Uses ValidRegion. Allows use of shapes (circles and polygons) to define charging areas. Excludes options other than circles and polygons. Heading slice may also be used to indicate the valid range of headings over which the region is used. If all headings are applicable, heading slice is set to all 1s.	Sequence	This document and SAE J2735
chargingFees	Uses the ChargingFees ASN.1 entity: The additional or replacement set of charges by time of day and type of vehicle for a shape-defined region.	Sequence	This document
Segment			
segmentID	Identifier for the segment.	Sequence	This document
chargingSegment	Sequence of Toll Advertisement Message (TAM) - multiple toll points can be represented by including multiple TAMs. Used to virtualize traditional tolling or charge per distance/per time on the segment defined by the TAMs. Virtualization of TAM enables more granular approaches, including lane-based fees.	Sequence (1..999)	This document, SAE J3217
chargingUnits	Optional. If present, the charge indicated in the TAM is on a per distance or time basis according to the units setting of this entity (per mile, per km, per minute, per hour...). Note that use of TAM also allows time or distance-based charging on a lane-level basis (charges are computed based on the charging rules for each lane and the corresponding distance/time spent therein). If chargingUnits is excluded from the configuration when a TAM is used, the traditional tolling charges as defined in SAE J3217 are applied, and the charges are reported according to the payment schedule.	Enumeration	

Multiple overlapping areas and road segments are supported by this document. Figure 4 illustrates how multiple charging areas and segments can overlap. In the case of overlapping areas and segments, the fees are added, unless the fee is indicated as a replacement charge for the geographic level above it, in which case the applicable subregion or road segment fee is used instead of the fee indicated by the next-level up region/jurisdiction.