SAE INTERNATIONAL

SURFACE VEHICLE STANDARD

J3217™ JUN2022

Issued 2022-06

V2X-Based Fee Collection

RATIONALE

This document defines profiles for V2X electronic fee collection—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 V2X-based tolling and other financial transactions.

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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 V2X-based fee collection and other financial transactions.

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 J2945 Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for SAE J2945/X Documents and Common Design Concepts

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 J3161 LTE Vehicle-to-Everything (LTE-V2X) Deployment Profiles and Radio Parameters for Single Radio Channel Multi-Service Coexistence

SAE J3161/1 On-Board System Requirements for LTE-V2X V2V Safety Communications

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 IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Applications and Management Messages (as amended by IEEE Std 1609.2aTM-2017 and IEEE Std 1609.2bTM-2019)

IEEE Std 1609.3 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services

2.1.3 ISO Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ISO 17573-1 Electronic Fee Collection - System Architecture for Vehicle-Related Tolling - Part 1: Reference Model

ISO 17573-3 Electronic Fee Collection - System Architecture for Vehicle-Related Tolling - Part 3: Data Dictionary ASN.1 file: https://standards.iso.org/iso/ts/17573/-3/ed-1/en/ISO17573-3(2021)EfcDataDictionary.asn

ISO 12855 Electronic Fee Collection - Information Exchange Between Service Provision and Toll Charging (Second Edition 2015-12-15)

2.1.4 Other Publications

RTCM 10403.3 Differential GNSS (Global Navigation Satellite Systems) Services - Version 3 + Amendment 1 (April 28, 2020) - A more efficient alternative to RTCM 10402.3

3. DEFINITIONS

3.1 ROADSIDE EQUIPMENT

Equipment located along the road, ether fixed or mobile.

3.2 ON-BOARD EQUIPMENT

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

3.3 CHARGER

The entity that levies the fee.

3.4 SERVICE PROVIDER

The entity providing EFC services and the on board equipment.

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
DSRC	Dedicated Short Range Communications
EFC	Electronic Fee Collection
ETC	Electronic Toll Collection
E-UTRA	Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HARQ	Hybrid Automatic Repeat Request
HOT	High-Occupancy Toll (Lane)
HOV	High-Occupancy Vehicle (Lane)
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transportation Systems
LOS	Line of Sight
LPN	License Plate Number
LPR	License Plate Recognition

LTE	Long Term Evolution
MAC	Medium Access Control
MAP	SAE J2735 Map Data Message
MCS	Modulation and Coding Scheme
MHz	Megahertz
MSM4	Multiple Signal Message (Type 4)
NTCIP	National Transportation Communications for ITS Protocols
OBE	On-Board Unit
OBE	On-Board Equipment
OEM	Original Equipment Manufacturer
OTA	Over the Air
PC5	ProSe Communications 5
PDU	Protocol Data Unit
PER	Packet Error Ratio
PHY	Physical Layer
PICS	Protocol Implementation Conformance Statement
PII	Personal Identifiable Information
PPPP	ProSe per Packet Priority
PSID	Provider Service ID
RAN	Radio Access Network
RSE	Roadside Unit
RSE	Roadside Equipment
RTCM	Radio Technical Commission for Maritime Services
SCMS	Security Credential Management System
SDO	Standards Developing Organizations or Standards Development Organization
SPDU	Session Protocol Data Unit
SSP	Service-Specific Permissions
TAM	Toll Advertisement Message
TUM	Toll Usage Message
TUMack	Toll Usage Message Acknowledgement

Tx	Transmit
UTC	Universal Coordinated Time
Uu	UMTS Air Interface
V2X	Vehicle-to-Everything Equipped Object
WAVE	Wireless Access in Vehicular Environments
WSA	WAVE Service Advertisement
WSM	WAVE Short Message
WSMP	WAVE Short Message Protocol

5. CONCEPT OF OPERATIONS

The following sections describe the V2X fee collection concept of operations and features necessary to implement the system. Note that participation in a V2X fee collection system is optional, and this document assumes the user has already chosen to participate in the system. As such, this document does not address opt in or opt out features.

5.1 Current Situation and Problem Statement (Informative)

V2X-based fee collection is widely applied for purposes such as:

- Construction, operation, and maintenance of road transport infrastructure such as pavement, bridges, etc.
- Influencing and managing the traffic flow (e.g., congestion charging).

Charging for the use of roadways can be performed effectively using electronic fee collection (EFC). EFC is an intelligent transportation system (ITS) service that allows users to pay fees electronically, with the aim to limit delays, congestion, and environmental impact.

The geographic area where road tolls are applied is called the toll domain. The toll domain may encompass a road network, a specific section of road (e.g., a bridge, a tunnel or a ferry connection), or a specific area offering a service (e.g., a parking lot).

The set of rules governing the collection of toll in a toll domain is called a toll regime. A toll regime can be of the following types/subtypes:

- Road segment pricing: A fee is charged for driving on specific segments of roads. This includes casts where payment is required at each toll point.
- Closed network pricing: A fee is charged for driving on a road network and depends only on the points where the vehicle enters and leaves the network.
- Object pricing: A fee is charged for the use of road transportation objects (e.g., tunnel, ferries, passes, parking).

The focus of this document is on infrastructure-based tolling using V2X communications. Infrastructure-based EFC systems use an access technology that enables localized communications between the OBE and the RSE to collect charging data “on the spot.” A suitable access technology is required to support the exchange of data between OBE and RSE, and the localization of the OBE. Infrastructure-based EFC systems are one solution suited to implement road segment-based tolling and pricing.

The interoperability of EFC systems is an important aspect to enable drivers to make use of the EFC service using a single contract and OBE across multiple toll domains.

The recent development of standards for V2X (notably V2I) communication has brought new technologies into play that could be very well used for a new generation of electronic fee collection systems. This could bring benefits in terms of re-use of ITS equipment being deployed in vehicles in future, while keeping the solid foundation of the existing EFC standards and best practices.

5.1.1 Relationship to ARC-IT

The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) classifies electronic toll collection as traffic management, and electronic toll collection is described in service package TM10. This document is consistent with the architecture described therein (refer to https://www.arc-it.net/html/servicepackages/sp109.html#tab-3).

5.2 Reference Architecture

5.2.1 Business Architecture

ISO 17573 uses the enterprise viewpoint concepts 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 interractions, not data excchange interfaces.

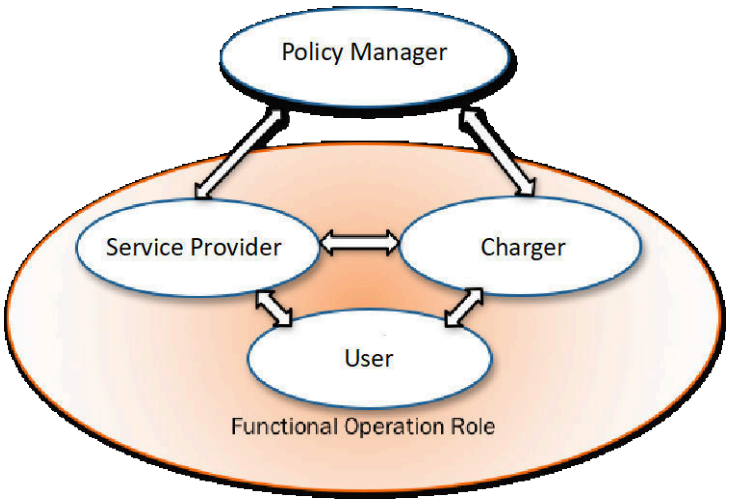

Figure 1 - Illustration of roles in EFC

The charger levies toll for the use of vehicles in a toll domain. It defines the toll regime and operates the toll system, including the interface between OBE and RSE.

The service provider provides toll services to users across one or more chargers. It is responsible for providing the basic artifacts, mechanisms, organization structures, and information transfer tools needed to run an EFC system.

The user of the service is a customer of a service provider, i.e., one liable for toll, owner of the vehicle, fleet operator, or driver, depending on the context. Implementations of toll systems in various domains commonly refer to this role as driver, user, or customer.

Policy manager: A specific role is identified to manage a toll charging environment, i.e., defining and maintaining a set of rules that, taken together, defines the policy of a given regime or of the overall toll 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 infrastructure-based system 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 service provider are included in the architecture for context, the scope of requirements in this document is the interface between RSE and OBE. The features described in the EFC system are also related to the service provider and charger, and those features are satisfied with the data exchanged between RSE and OBE.

For a further description, refer to ISO 12855.

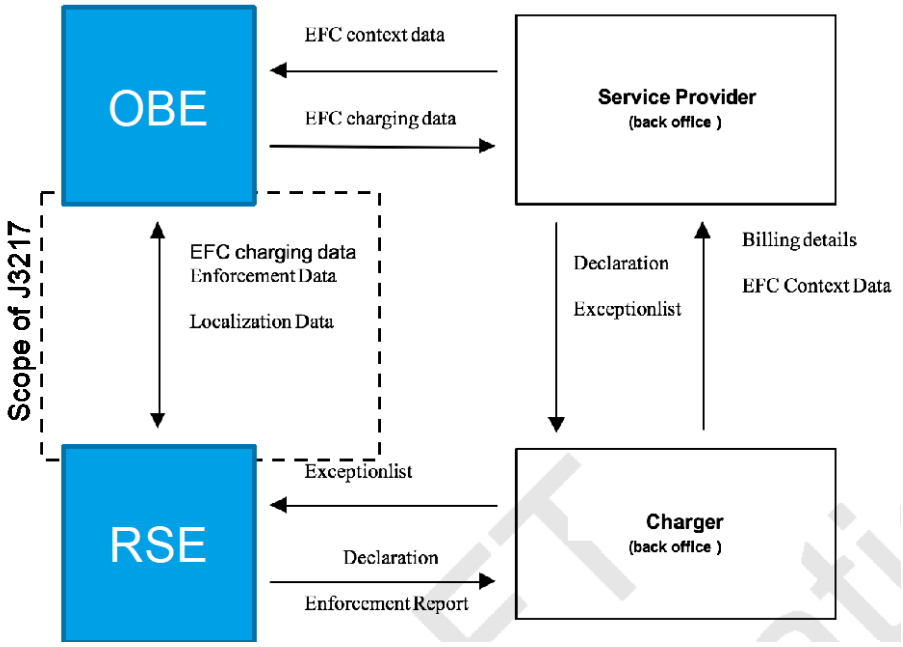

Figure 2 - Reference technical architecture

The main architectural elements are:

- The (service provider's) front end (top left box in Figure 2), equipment where road tolling information and usage data are stored, collected and processed.
- OBE, equipment on-board a vehicle for performing electronic fee collection (EFC) functions and communication services. The OBE is issued by and part of the toll service provider.
- The (charger's) RSE, equipment located along the road to enable localized communication with OBEs.
- The service provider back-office, central equipment which processes data for/from the charger and which manages the front ends.
- The charger back-office, central equipment which processes data for/from the service provider and which manages the RSEs.

The main interfaces in the architecture are those that "open up" the system and make it interoperable:

- The back office interface between service provider and charger for the exchange of all necessary data. This interface is outside the scope of this document.
- The OBE to RSE interface for the exchange of data for local charging, enforcement data (e.g., license plate number), and localization purposes (see 7.1.1).