An introduction to standardization of electronic fee collection (EFC)

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Outline

1. Introduction to standards
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   2. System architecture
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   5. Info exchanges between Toll Charger and Service Provider
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3. The European electronic toll service and CEN EFC standards
   Annex – Published EFC CEN/ISO standard deliverables
1) Introduction to standards

What is a standard?
• A document approved by recognized standardization body (CEN, ISO,..)
• Voluntary in application
• Intended to be used repeatedly in products and systems, creating synergies and reducing costs

Benefits – support for agreements
• Interoperability of products and services
• Open and competitive market development
• Standards are more stable and enjoy broader market acceptance than project / industry specifications
1) Standards, laws and specifications

Standards are not laws
- Facilitate agreements
- Sometimes referred to as part of legislation, e.g. the [European electronic toll service (EETS)](http://example.com)

Standards are more stable than (project) specifications
- Structured decision-making and voting procedures
- Clear ownership of documents
- Handling of comments, revision and corrections
- Often referred to in public procurements
- Test standards often complement “requirements standards” for conformity evaluation
2.1) Overall scope of EFC-related standards

- Fee collection (as opposed to fare collection)
- **EFC system architecture** (User, Toll Charger and Service Provider)
- Information exchanges for charging and compliance checking for
  - DSRC-based systems
  - GNSS-based systems (also known as autonomous-based systems)
  - Systems using automatic number plate recognition (ANPR) technologies
  - Systems using integrated circuit cards (ICCs)
- Security of EFC systems and interfaces
- Tests for conformance assessment and examination frameworks
2.1) Principles for EFC standardization

- **Goal:** support agreement, open market and interoperability
- **Mainly technical standardization (not services)**
- **Focusing on interfaces between roles and sub-systems (not on the internal interfaces)**
- **Differences between DSRC-based and GNSS-based EFC**
  - Maturity (10+ years?)
  - No fixed charging infrastructure (but fixed and movable enforcement systems)
  - Degrees of freedom much higher
  - Potentially different media for communication with CS/proxy
- **Why we never were fully top-down (moving target)**
  - Technical developments
  - Evolution of the system architecture to support different scheme types
  - New operational model (from CESARE and EETS) - separation between the Toll charging and Service provision
  - Difficult to get consensus on things under development
2.1) What support do EFC standards bring?

**Framework standards**
- Common understanding, scoping, architecture, terminology etc

**Technical toolbox standards**
- Necessary but not sufficient basis for compatibility
- Why? Changing requirements, evolving or changing technology, lack of experiences, lack of common view, different stakeholder needs
- E.g. “Application interface definition (AID) for DSRC 14906”

**Profile standards**
- Coherent selection of choices in underlying toolbox standards for compatibility and interoperability
- Based on common policies and services agreed/defined by stakeholders
- E.g. “Interoperable application profile (IAP) for DSRC 15509”

**Test standards**
- Assessment of conformity to specification
- E.g. “IAP for DSRC conformity assessment 15876 suite”

**Maintenance of standards**
2.2) EFC system architecture (17573-1)

Objectives

• Overall system reference architecture for EFC systems
• Common technical understanding

Scope

• System architecture and interfaces, roles and responsibilities
• Use diagrams for typical scenarios (mngt of charges, claim and payment settlement ...)

![Diagram of EFC system architecture](image-url)
2.2) EFC system architecture – Enterprise objects
2.2) EFC system architecture – Enterprise viewpoint

Basic roles
2.2) EFC system architecture – Engineering viewpoint
2.3) DSRC-based EFC

OBE

RSE

14906 (toolbox)
DSRC-suite of standards
15509 (profile)

Toll Service Provider
(back office)

12855 (toolbox)
16986 (profile)

Toll Charger
(back office)
2.3) EFC AID for DSRC (14906)

**Scope / properties**
- Transaction model
- 16 functions (e.g. “read”, “write”)
- 46 data sets (contract, vehicle, payment, receipt etc)
- Basis for defining transactions, with one example from the CARDME project

**Impact**
- Harmonized OBUs, basis for national / international tolling service
- 150 million compliant OBE and 70 thousand RSE
2.3) CEN DSRC 5,8 GHz suite

**Complete set of DSRC 5,8 GHz standards**
- Single and high-speed multi-lane tolling
- High reliability, fast connection and low latency
- Small service areas to facilitate compliance checking
- Inexpensive end-user technology

**Impact: single open market**

**Adopted in EU regulations**
- European electronic toll service (EETS, [Directive 2019/520](#))
- Tachographs in road transport ([Regulation No 165/2014](#))
- Max authorized dimensions and weights for road motor vehicles ([Directive 2015/719](#))
2.3) ETSI DSRC test standards

Electromagnetic compatibility and radio spectrum matters - DSRC transmission equipment operating in the 5.8 GHz band (EN 300 674)

- Part 1: General characteristics and test methods for RSU and OBU
- Part 2: Harmonised EN for RSU (sub-part 1) and OBU (sub-part 2) under the “Spectrum article” of the Radio Equipment Directive (RED)

Impact

- Part 1: CEN DSRC-L1 conformance tests specification
- Part 2: DSRC equipment must meet the “essential” requirements to be placed on the European market (indicated by CE marking)
2.3) Interoperability application profile (15509)

**Objectives**

- Interoperability, equipment compatibility, best industry practice
- Support the European Electronic Toll Service (EETS) legislation

**Scope**

- DSRC requirements
- EFC functions, data and security
- Implementation conformance statement (ICS) proforma
- Use of this standard for the EETS, incl relationship to the requirements of EETS legislation
2.3) IAP for DSRC

Relationship to toolbox standards

- EN 15509
  - EFC Interoperability Application Profile
- EN ISO 14906
  - EFC Application Interface Definition
- EN ISO 14816
  - AVEI Numbering and data structures
- EN 12834
  - DSRC Layer 7
- EN 13372
  - DSRC Profiles
- EN 12253
  - DSRC Layer 1
- EN 12795
  - DSRC Layer 2
- EN 12834
  - DSRC Layer 7

CEN/TC 278/WG 1 & ISO/TC 204/WG 5 – Electronic Fee Collection
2.4) GNSS-based EFC

Diagram showing interactions between OBE, RSE, Proxy, Toll Service Provider, and Toll Charger.
2.4) AID for GNSS-based EFC (17575 suite)

Objectives

• Support collection of charges for road usage - for section, areas and cordon-based schemes - modulation of fees
• Support different scheme architecture (thin and smart OBE clients)
• Support the European electronic toll service (EETS)

Parts

• Part 1: Charging
• Part 2: Communication and connection to the lower layers
• Part 3: Context data
2.4) IAP for GNSS-based EFC (16331)

Objectives
- Support interoperability
- Support the EETS

Scope
- AID for GNSS-based EFC systems (17575 suite)
- Info exchanges between TC and SP (12855 / 16986)
- CCC (12813)
- LAC (13141)

IAPs
- **Sectioned** roads tolling
- Sectioned roads tolling or **distanced-based area** charging pricing
- Overlapping sectioned roads tolling or distance or **time-based** area pricing
- Overlapping sectioned roads tolling or distance or time-based area or **cordon** pricing
2.4) Compliance checking of the user (12813)

Objectives

- Compliance checking of the user
  - whether the OBE is mounted in the correct vehicle
  - the classification data transmitted by the OBE
  - the OBE working condition (technical and contractual)
- Support the EETS

Scope

- Data definitions, according and in addition to “AID for DSRC” (14906)
- Supports CEN DSRC, CALM, UNI DSRC and IEEE Wave comm standards
- Lower layers make use of and reference existing standards
- Security concept same as in “IAP for DSRC” (15509)
- Implementation conformance statement (ICS) proforma

The test suite 13143-1/2 can be used to evaluate the conformance of an implementation to 12813
2.4) Localisation augmentation support (13141)

**Objectives**

- Localisation augmentation support
- Support the EETS

**Scope**

- Location reference data
- Supports CEN DSRC, CALM, UNI DSRC and IEEE Wave comm standards
- Lower layers make use of and reference existing standards
- Data origin authentication, integrity and non-repudiation
- Implementation conformance statement (ICS) proforma

The test suite 13140-1/2 can be used to evaluate the conformance of an implementation to 13141
2.4) Secure monitoring - Compliance checking (16702-1)

Objective
- Support for the Toll Charger to check the trustworthiness of the toll declarations from the Toll Service Provider whilst respecting the privacy of the user

Scope
- Secure monitoring concept
- Transactions and data
- Uses and builds onto other EFC standards (12813, 12855, 17575-1...)
2.4) Secure monitoring - Trusted recorder (16702-2)

Objective
- Support for the Toll Charger to check the trustworthiness of the toll declarations from the Toll Service Provider whilst respecting the privacy of the user

Scope
- Secure monitoring concept and stake holder requirements
- Transactions and data
- Uses and builds onto other EFC standards (16702-1, 19299, 12813, 12855, 17575-1...)
2.5) Info exchanges between SP and TC (12855, toolbox)

**Objective:** Support for cost-effective integration of back-office systems

Diagram showing information exchanges between different systems and entities in the context of toll service providers (SP) and toll chargers (TC), with specific focus on the EN ISO 12855 standard.
2.5) Example of data flow based on 12855 (toolbox)
### 2.5) Info exchanges between SP and TC (16986, profile)

**Objectives:** Support interoperability and the EETS

<table>
<thead>
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<th>ADU</th>
<th>DSRC</th>
<th>GNSS, TSP dominant</th>
<th>GNSS, TC dominant</th>
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</table>
2.6) EFC integrated circuit(s) cards-related standards
2.6) Interface for on-board account using ICC (25110)

Objectives
• Support EFC on-board account charging using ICC

Scope
• DSRC – ICC interface protocol bridge / “extension of 14906”
  - Transparent and buffering type (bridge 1)
  - Cashing type (bridge 2)
• Reference model for on-board account system
• Command definitions – RSE – OBE

Referenced toolbox standards
- EN ISO 14906 (EFC API)
- ISO 7816 suite (contact card)
- ISO 14443 suite (contactless card)
- EN 1545 suite (surface transport applications - data elements)
2.7) EFC security

![Diagram showing EFC security]
2.7) Security framework (19299)

**Objectives**
- Security framework
- Support for the EETS

**Scope**
- Threat analysis – asset-based and attack-based assessment
- Requirements specification
- Security measures focusing on the interoperable interfaces
- Trust model and basic key management reqs
2.7) Guidelines for security protection profiles (17574)

Objectives and properties

- Preparation & evaluation of security reqs
- Based on IT security standards
  - Evaluation security criteria 15408
  - Protection profiles 15446
- Product-oriented

Scope

- Guide operators to prepare their PP
- “Best practice” through international registrations of PP
- Japanese OBU used as an example
2.8) Test standards and examination frameworks

CEN/TC 278/WG 1 & ISO/TC 204/WG 5 – Electronic Fee Collection
2.8) Test suites for conformity assessment

Objectives
- Support evaluation of equipment for conformity assessment to the associated requirements standards
- Comparability of results from tests performed at different places and times
- Facilitate communications between parties

A test suite generally entails
- Part 1: Test Suite Structure and Test Purposes (“human-readable part”)
- Part 2: Abstract test suite (“machine-readable part”)

Suites available to evaluate conformity to
- AID for DSRC (14906) - 14907-2 (1 part only, no machine-readable part)
- IAP for DSRC (15509) – test suite 15876
- AID for GNSS-based EFC systems (17575 suite) – test suites 16407, 16401 & 16410
- CCC (12813) – test suite 13143
- LAC (13141) – test suite 13140
2.8) Test procedures user and fixed equipment (14907-1)

Scope and usage
- Defines test procedures and a test plan
- Useful when defining
  - Type approval tests
  - System acceptance tests
  - Prototype tests
- Outside the scope
  - Equipment in the central system and all equipment used for enforcement (e.g. detection, classification, localization and registration)
  - Benchmark figures
2.8) Charging performance framework (17444 suite)

Objectives

- Evaluation of charging performance for discrete and continuous charging schemes to support procurement and service level agreements

Scope

- Charging performance metrics and examination framework
  - Charge reports
  - Toll declarations
  - Billing details
- Invoicing accuracy on the level of user accounts

Outside the scope

- Specific numeric performance bounds, or average or worst-case error bounds in percentage or monetary units
- Evaluation of the expected performance of a system based on modelling and measured data from trial at another place
2.9) Summary

50+ CEN/ISO EFC standard deliverables
- DSRC-based EFC standards
- GNSS-based EFC
- Information exchanges between Service Provision and Toll Charging

Current focus
- Revision of standards for back-office exchanges (12855 / 16986)
- Revision of profile-standards for GNSS-based EFC
- Studies and Technical reports - analysis of emerging needs, trends and road maps
  - Pre-study on the use of vehicle licence plate information and ANPR technologies
  - Integration with related ITS-areas (common payment, traffic management ....)
- Maintenance of standards. Widespread use of EFC-standards in systems -> plenty of feedback to update standards. Support relevant activities to ensure long-term suitability of DSRC tolling technology
3) Recast of the European electronic toll service legislation

Recast of the European electronic toll service legislation

• [EU Directive 2019/520](#) on Interoperability of electronic road toll systems and facilitating cross-border exchange of information on the failure to pay road fees

• Commission [Implementing Regulation (EU) 2020/204](#) on detailed obligations of Toll Service Providers and Toll Charges

• Commission [Delegated Regulation (EU) 2020/203](#) on obligations of users, classification of vehicles, requirements for interoperability constituents and NBs

• [8 CEN / ISO EFC standards](#) are referred to in the EETS legislation
3) Recast of the EETS legislation – main changes

Main changes compared with previous version (Directive 2004/52/EC and Decision 2009/750/EC)

• Cross border enforcement has been added
• Separation of EETS Heavy Duty Vehicles and EETS Light Vehicles
• Clarification of responsibilities (for EETS providers)
• Efforts to remove market entry barriers (e.g. regional EETS) and to promote competition
• ANPR added as an accepted EETS charging technology
• Harmonization of back-office interfaces based on CEN/TS 16986
• Enhanced service definition through references to standards
• The standards explicitly mentioned in the legal acts make them legally binding as part of the legislation
3) EFC standards and the EETS

Not the same scope
- EETS is a single service: Users are free to take advantage of the local and/or the European service
- EFC standards support broader technical needs: used in 50 countries, 140 systems, 150 mio vehicles

EFC standards support the EETS
- by providing technical building blocks...
- ... but does not have the task to deliver “tailor-made” specifications for the EETS
- ... this is up to the owner of the EETS
- non-technical aspects are outside the scope of CEN

Legislators decide on the legal status of standards
3) EFC standards and the EETS

- Context data (TSP specific)
- Charging data (TSP specific)

Toll Service Provider
(back office)

EN ISO 14906
- vehicle parameters
EN 15509 (EN 15876-1)
- CEN DSRC charging
EN ISO 12813 (EN ISO 13143-1)
- Real-time compliance checking of the user
EN ISO 13141 (EN ISO 13140-1)
- Localisation Augmentation support

CEN/TS 16986
(CEN/TS 17154-1)
- Trust objects
- Exception list
- User details for enforcement
- Toll declaration (GNSS)

Other proprietary Toll Charger specific configuration data

Toll Charger
(back office)

Toll declaration (DSRC, video, vehicle measurements ...)

Proxy

OBE

EN ISO 14906
- vehicle parameters
EN 15509 (EN 15876-1)
- CEN DSRC charging
EN ISO 12813 (EN ISO 13143-1)
- Real-time compliance checking of the user
EN ISO 13141 (EN ISO 13140-1)
- Localisation Augmentation support

CEN/TS 16986
(CEN/TS 17154-1)
- Trust objects
- Exception list
- User details for enforcement
- Toll declaration (GNSS)
# Annex - Overview of Standards and Technical Specifications

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<td>CEN ISO/TS 21719-2 OBE personalization using DSRC</td>
<td>ISO/TS 21193 EFC using common media [ASN.1]</td>
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### Annex - Overview of Technical Reports

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<td><strong>TC278 N318</strong> DSRC requirements</td>
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Black = ISO/CEN, Blue = CEN-only, green = ISO-only, *italics* = Working documents
Annex – Architecture and technology independent (1)

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<td>EN ISO 17573-1:2019</td>
<td>EFC - System architecture for vehicle-related tolling - Part 1: Reference model</td>
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<td>CEN ISO/TS 17573-3:2021</td>
<td>EFC - System architecture for vehicle-related tolling - Part 3: Data dictionary</td>
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<td>EFC - Conformity evaluation of implementation to CEN/TS 16986 – Part 1: Test suite structure and test purposes</td>
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## Annex – Architecture and technology independent (2)

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<thead>
<tr>
<th>Standard</th>
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<tbody>
<tr>
<td>ISO/TS 21193:2019</td>
<td>EFC — Requirements for EFC application interfaces on common media</td>
</tr>
<tr>
<td>CEN/TR 16092:2011</td>
<td>EFC - Requirements for pre-payment systems</td>
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<td>CEN/TR 16152:2011</td>
<td>EFC – Personalisation and mounting of first mount OBE</td>
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<td>CEN/TR 16219:2011</td>
<td>EFC – Value added services based on EFC on-board equipment</td>
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<td>CEN/TR 17546:2020</td>
<td>EFC – EETS gap analysis and proposed standards roadmap</td>
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<td>ISO/TR 21190:2018</td>
<td>EFC – Investigation of charging policies and technologies for future standardization</td>
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<tr>
<td>CEN/TR 16690:2014</td>
<td>EFC - Guidelines for EFC-applications based on in-vehicle ITS Stations</td>
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<tr>
<td>ISO/TR 19639:2015</td>
<td>EFC - Investigation of EFC standards for common payment schemes for multi-modal transport services</td>
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Annex – DSRC-based EFC


EN ISO 14907-1:2020  EFC - Test procedures user and fixed equipment - Part 1: Description of test procedures

EN ISO 14907-2:2021  EFC - Test procedures user and fixed equipment - Part 2: Conformance test for the on-board unit application interface

EN 15509:2014  EFC - Interoperable application Profile for DSRC

EN 15876-1:2016  EFC – Evaluation of on-board and roadside equipment for conformity to EN 15509 – Part 1: Test suite structure and test purposes


ISO/TS 16785:2020  EFC - Interface definition between DSRC-OBE and external in-vehicle devices

EN ISO 25110:2017  EFC - Interface definition for on-board account using ICC


CEN/TR 16040:2010  EFC - Requirements for urban DSRC systems

CEN/TR 16968:2016  EFC - Assessment of security measures for applications using Dedicated Short-Range Communication
## Annex – GNSS-based EFC (1)

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<tr>
<td>EN ISO 17575-1:2016</td>
<td>EFC - Application interface definition for autonomous systems – Part 1: Charging</td>
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<td>EN ISO 17575-2:2016</td>
<td>EFC - Application interface definition for autonomous systems – Part 2: Communication and connection to the lower layers</td>
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<td>EN ISO 17575-3:2016</td>
<td>EFC - Application interface definition for autonomous systems – Part 3: Context data</td>
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<td>CEN/TS 16331:2012</td>
<td>EFC – Interoperable application profiles for autonomous systems</td>
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<td>EN ISO 16410-1:2017</td>
<td>EFC – Evaluation of equipment for conformity to ISO 17575-3 - Part 1: Test suite structure &amp; test purposes</td>
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## Annex – GNSS-based EFC (2)

<table>
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<tr>
<td>EN ISO 12813:2019</td>
<td>EFC - Compliance check communication</td>
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<tr>
<td>EN ISO 13143-1:2020</td>
<td>EFC - Evaluation of on-board and roadside equipment for conformity to ISO 12813 - Part 1: Test suite structure and test purposes</td>
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<td>EN ISO 13141:2015/Amd 1:2017</td>
<td>EFC – Localisation augmentation communication</td>
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<td>EN ISO 13140-1:2016</td>
<td>EFC - Evaluation of on-board and roadside equipment for conformity to ISO 13141 – Part 1: Test suite structure and test purposes</td>
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<tr>
<td>CEN/TS 16702-1:2020</td>
<td>EFC - Secure monitoring for autonomous toll systems - Part 1: Compliance checking</td>
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Want to know more or participate?

Coordination of EFC standardization: ISO/TC 204/WG 5 and CEN/TC 278/WG 1

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