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**Electronic fee collection — Charging  
performance framework**

*Perception de télépéage — Cadre de performance d'imputation*

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## 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](http://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](http://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](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 278, *Intelligent transport systems*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition cancels and replaces the second editions ISO/TS 17444-1:2017 and ISO/TS 17444-2:2017, which have been technically revised.

The main changes are as follows:

- the resulting document has been renumbered as ISO/TS 37444;
- various editorial changes have been made to improve the readability of the text;
- a technology-neutral definition of metrics and examination tests has been applied, which also includes support for tolling systems based on automatic number plate recognition (ANPR) technology;
- terminology and references to other documents have been updated.

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](http://www.iso.org/members.html).

## Introduction

### 0.1 General

Electronic tolling systems are complex distributed systems involving critical technology such as dedicated short-range communication (DSRC), camera-based technology (e.g. automatic number plate recognition, ANPR) and global navigation satellite systems (GNSS). These technologies are all subject to a certain behaviour that can affect the computation of the charges. Thus, to protect the interests of the different stakeholders involved, particularly toll service users (SUs) and toll chargers (TCs), it is essential to define metrics that measure the performance of the system in terms of computation of charges, and that ensure that the potential resulting errors are acceptable. These metrics will be a useful tool for establishing requirements for the systems and for examining the system capabilities during acceptance and throughout the operational life of the system.

In addition, to ensure the interoperability of different systems, it is necessary to agree on common metrics for use and on the actual values that define the required acceptable performances. However, these points are not covered in this document.

Instead, this document is defined as a toolbox standard of examination tests, with a method for defining and documenting a specific examination framework to meet specific needs. The detailed choice of the set of examination tests within an examination framework depends on the application and the respective context. Conformance to this document means using the definitions and prescriptions laid out in this document whenever the respective system aspects are subjected to performance measurements, rather than using other definitions and examination methods.

### 0.2 Charging performance metrics

This document also defines a set of charging performance metrics with definitions, principles and formulae, which together make up a reference framework for the establishment of requirements for electronic fee collection (EFC) systems and their later examination of the charging performance.

These charging performance metrics are intended for use with any toll scheme, regardless of its technical underpinnings, system architecture, tariff structure, geographical coverage or organizational model. They are defined to treat technical details that can differ between technologies as a “black box”. They focus solely on the outcome of the charging process, i.e. the amount charged in relation to a pre-measured or theoretically correct amount, rather than intermediate variables from various components as sensors, such as positioning accuracy, signal range or optical resolution. This approach ensures comparable results for each metric in all relevant situations.

The metrics are designed to cover the information exchanged on the front-end (FE) interface and the interoperability interfaces between toll service providers (TSPs) and TCs, as well as information on the end-to-end level.

Metrics for the following information exchanges are defined:

- charge reports (including usage evidence);
- toll declarations;
- billing details and associated event data;
- payment claims on the level of user accounts;
- exception lists;
- end-to-end metrics which assess the overall performance of the charging process.

The proposed metrics are specifically addressed to protect the interests of the actors in a toll system, such as TSPs, TCs and SUs. They can be used to define requirements (e.g. for requests for proposals) and for performance assessments.

Toll schemes take on various forms as identified in ISO 17573-1 and ISO 12855. In order to create a uniform performance metric specification, toll schemes are grouped into two classes based on the character of their primary charging variable:

- charging based on discrete events (charges associated to the fact that a vehicle is crossing or standing within a certain zone);
- charging based on a continuous measurement (duration or distance).

The following are examples of discrete (event-based) toll schemes.

- **Single object charging:** a road section, bypass, bridge, tunnel, mountain pass or even a ferry, charged per passage.

EXAMPLE 1 Most tolled bridges belong to this category.

- **Closed road charging:** a fixed amount is charged for a certain combination of entry and exit on a motorway or other closed road network.

EXAMPLE 2 Many of the motorways in Southern Europe belong to this category.

- **Discrete road links charging:** determined by use of specified road links, whether or not they are used in their entirety.

EXAMPLE 3 Heavy goods vehicle (HGV) charge in Germany.

- **Charging for cordon crossing:** triggered by passing in or out through a cordon that encircles a city core, for example.

EXAMPLE 4 Congestion and infrastructure charging schemes in Stockholm and Gothenburg (Sweden).

The following are examples of continuous toll schemes.

- **Charging based on direct distance measurement:** defined as an amount per km driven.

EXAMPLE 5 HGV charge in Switzerland and US basic vehicle miles-travelled toll systems concepts.

- **Charging based on direct distance measurement in different tariff zones or road types:** defined as an amount per km driven, with different tariffs applying in different zones or on different road types. This is a widely discussed approach, also known as time-distance-place charging, and is under consideration in European countries.

EXAMPLE 6 OReGO, the pilot programme in Oregon, North America.

- **Time in use charge:** determined by the accumulated time a vehicle has been in operation, or alternatively, by the time the vehicle has been present inside a predefined zone.

In all of these toll schemes, tolls can additionally vary as a function of vehicle class characteristics (such as trailer presence, number of axles, taxation class and operating function) and depending on time of day or day of week, such that, for example, tariffs are higher in rush hour and lower on weekends.

With this degree of complexity, it is not surprising to find that the attempts to evaluate and compare technical solutions for SU charging have been made on an individual basis each time a procurement or study is initiated, and with only limited ability to reuse prior comparisons made by other testing entities.

The identification of different types of schemes as proposed in the ISO 17575 series and their grouping in the mentioned two classes is described in [Table 1](#). [Table 1](#) also identifies the examples mentioned above.

**Table 1 — Toll scheme designs grouped according to scheme categories**

Examples	Scheme type	ISO 17575 series category
Single object charging	Discrete	Sectioned roads pricing
Closed road charging	Discrete	Sectioned roads pricing
Discrete road links charging	Discrete	Sectioned roads pricing
Charging for cordon crossing	Discrete	Cordon pricing
Time in use charge	Continuous	Area pricing — time
Cumulative distance charge	Continuous	Area pricing — distance
Charging for cumulative distance in different zones (or by road type)	Continuous	Area pricing — distance

### 0.3 Examination framework

The examination framework that is defined in this document is designed for measuring the metrics defined in [Clause 6](#). The general aim is to achieve a maximum comparability and reproducibility of the results without restricting the technological choices in system design. Specific examination frameworks can be defined for the evaluation and monitoring phases of a project due to the differences in the availability of equipped vehicles.

#### a) Evaluation phase

The evaluation phase encompasses system evaluation and selection, as well as commissioning and ramp-up during implementation. Important aspects of this phase are:

- relatively small sample sizes; and
- well-controlled behaviour of test vehicles.

#### b) Monitoring phase

After the system has gone into operation, its behaviour needs to be monitored for several reasons, such as fine-tuning of the system performance, monitoring of service level agreements (SLAs) between contractual partners (supplier, TC, TSP, etc.). In this phase, the following system aspects can be expected:

- very large sample sizes possible, but with unknown behaviour of the vehicles;
- in principle all measurements from implementation phase possible, too.

### 0.4 Reader's guide

To understand the content of this document, the reader should be aware of the methodology and assumptions used to develop the examination framework; therefore, a suggested reading order is given below.

- a) [Annex B](#) provides details of the underlying considerations for developing the examination framework.
- b) [Annex C](#) provides background statistical information which will enable the reader to determine sample sizes and confidence limits based on the defined performance requirements.
- c) [Clause 5](#) provides the definition of the examination framework for the evaluation of charging performance.
- d) [Clause 6](#) provides definitions of charging metrics and their applicability to the scheme types described above.
- e) [Clause 7](#) contains the toolbox of examination tests for the evaluation of charging performance for the identified scheme types.



- f) [Annex A](#) contains an example template for the documentation of examination tests and their results.
- g) [Annex D](#) contains methods which can be used to reduce the required sample sizes for metrics with high and low probabilities during the evaluation phase.
- h) [Annex E](#) provides examples of specific examination frameworks which have been developed in accordance with the methodology in [5.2](#).

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# Electronic fee collection — Charging performance framework

## 1 Scope

This document defines the charging performance metrics to be used during the evaluation or on-going monitoring of an electronic fee collection (EFC) system and the examination framework for the measurement of these metrics.

It specifies a method for the specification and documentation of a specific examination framework which can be used by the responsible entity to evaluate charging performance for a particular information exchange interface or for overall charging performance within a toll scheme.

The following scheme types are within the scope of this document:

- a) discrete schemes;
- b) continuous schemes (autonomous type of systems).

This document defines measurements only on standardized interfaces.

This document defines metrics for the charging performance of EFC systems in terms of the level of errors associated with charging computation.

This document describes a set of metrics with definitions, principles and formulations, which together make up a reference framework for the establishment of requirements for EFC systems and the subsequent examination of charging performance.

This document defines metrics for the following information exchanges:

- charge reports (including usage evidence);
- toll declarations;
- exception lists;
- billing details and associated event data;
- payment claims on the level of service user accounts;
- end-to-end metrics which assess the overall performance of the charging process.

These metrics focus solely on the outcome of the charging process, i.e. the amount charged in relation to a pre-measured or theoretically correct amount, rather than intermediate variables from various components as sensors, such as positioning accuracy, signal range or optical resolution. This approach ensures comparable results for each metric in all relevant situations.

The following aspects are outside the scope of this document.

- Definition of specific numeric performance bounds, or average or worst-case error bounds in percentage or monetary units.
- Specification of a common reference system which would be required for comparison of performance between systems.
- Measurements on proprietary interfaces.

NOTE It is not possible to define standardized metrics on such system properties. Neither is it possible to define metrics for parts of the charging processing chain which are considered to be the internal matter of an interoperability partner, such as:

- equipment performance, e.g. for on-board equipment (OBE), roadside equipment (RSE) or data centres such as signal range, optical resolution or computing system availability;
- position performance metrics: the quality of data generated by position sensors is considered as an internal aspect of the GNSS front end. It is masked by correction algorithms, filtering, inferring of data and the robustness of the charge object recognition algorithms.
- The evaluation of the expected performance of a system based on modelling and measured data from a trial at another place.

## 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 12855:2022, *Electronic fee collection — Information exchange between service provision and toll charging*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

**3.1 absolute charging error**  
difference between the measured charge (toll) value and the actual value as measured by a reference system where a positive error means that the measurement exceeds the actual value

[SOURCE: ISO/TS 17573-2:2020, 3.1]

**3.2 accepted charging error interval**  
interval of the *relative charging error* (3.22) that the *toll charger* (3.27) considers as acceptable, i.e. as correct charging

[SOURCE: ISO/TS 17573-2:2020, 3.3]

**3.3 average relative charging error**  
ratio between the sum of computed charges (measurement) associated to a set of vehicles during a certain period of time and the actual charge due (reference) minus 1

[SOURCE: ISO/TS 17573-2:2020, 3.21]

**3.4 billing detail**  
information needed to determine or verify the amount due for the usage of a given service

[SOURCE: ISO/TS 17573-2:2020, 3.25]

**3.5****charge object**

geographic or road-related object for the use of which a charge is applied

[SOURCE: ISO/TS 17573-2:2020, 3.31]

**3.6****charge object detection**

event marking the usage of a *charge object* (3.5)

[SOURCE: ISO/TS 17573-2:2020, 3.32]

**3.7****charge parameter change**

event occurring within a tolling system, that is relevant for charge calculation, such as change of vehicle category, but not for the detection of a *charge object* (3.5) itself

[SOURCE: ISO/TS 17573-2:2020, 3.34]

**3.8****charge report**

information containing road usage and related information originated at the *front end* (3.15)

[SOURCE: ISO/TS 17573-2:2020, 3.35]

**3.9****charging performance metrics**

specific calculations used to describe the charging performance of a system

[SOURCE: ISO/TS 17573-2:2020, 3.37]

**3.10****continuous toll scheme**

toll scheme where the charge is calculated based on the accumulation of continuously measured parameter(s)

[SOURCE: ISO/TS 17573-2:2020, 3.50, modified — EXAMPLE removed.]

**3.11****data analysis**

parameter estimation and inference based on *samples* (3.24)

**3.12****discrete toll scheme**

toll scheme where the charge is calculated based on distinct events associated with the identification of *charge objects* (3.5) such as crossing a cordon, passing a bridge and being present in an area

Note 1 to entry: Each event is associated with a certain charge.

[SOURCE: ISO/TS 17573-2:2020, 3.62, modified — Note 1 to entry added.]

**3.13****evaluation**

systematic process of determining how individuals, procedures, systems or programs have met formally agreed objectives and requirements

[SOURCE: ISO/TS 17573-2:2020, 3.75]

**3.14****false positive**

event that was erroneously detected, but did not take place

**3.15  
front end**

part of an EFC system which consists of on-board equipment (OBE) and possibly of a proxy where road tolling information and usage data are collected and processed for delivery to the back end

[SOURCE: ISO/TS 17573-2:2020, 3.85]

**3.16  
interval estimation**

calculation of lower and upper bounds for unknown parameters, assuring a predefined coverage probability of the true value

**3.17  
missed recognition**

usage of a *charge object* (3.5) that is not recorded by the system

**3.18  
monitoring**

collection and assessment of status data for a process or a system

Note 1 to entry: This can be used to observe metrics during operation.

[SOURCE: ISO/TS 17573-2:2020, 3.120, modified — Note 1 to entry added.]

**3.19  
overcharging**

situation where the calculated charge is above the *accepted charging error interval* (3.2)

[SOURCE: ISO/TS 17573-2:2020, 3.130]

**3.20  
payment claim**

statement made available to the payer by the payee to justify the amount due

Note 1 to entry: The statement can include the concluded *billing detail* (3.4).

[SOURCE: ISO/TS 17573-2:2020, 3.133]

**3.21  
population**

totality of items under consideration

[SOURCE: ISO/TS 17573-2:2020, 3.142]

**3.22  
relative charging error**

ratio between the *absolute charging error* (3.1) and the reference value

[SOURCE: ISO/TS 17573-2:2020, 3.154]

**3.23  
representative trip**

*trip* (3.31) that is of a distance larger than a defined threshold and so is to be considered by the related metrics

**3.24  
sample**

subset of a *population* (3.21) made up of one or more of its individual parts

[SOURCE: ISO/TS 17573-2:2020, 3.164]

**3.25****specific examination framework**

particular instance of a set of examination tests defined by an entity to determine the performance of specific selected charging metrics during either *evaluation* (3.13) and/or *monitoring* (3.18)

**3.26****successful charging**

situation where the user has been correctly charged according to the rules of the system

[SOURCE: ISO/TS 17573-2:2020, 3.177]

**3.27****toll charger**

entity which levies toll for the use of vehicles in a toll domain

[SOURCE: ISO/TS 17573-2:2020, 3.194]

**3.28****toll declaration**

statement to declare the usage of a given toll service to a *toll charger* (3.27)

[SOURCE: ISO/TS 17573-2:2020, 1.199]

**3.29****toll service provider**

entity providing toll services in one or more toll domains

[SOURCE: ISO/TS 17573-2:2020, 3.206]

**3.30****toll service user**

customer of a *toll service provider* (3.29), i.e. one liable for toll, owner of the vehicle, fleet operator or driver depending on the context

[SOURCE: ISO/TS 17573-2:2020, 3.207]

**3.31****trip**

part of the space-time trajectory of a vehicle within a toll domain

[SOURCE: ISO/TS 17573-2:2020, 3.220]

**3.32****undercharging**

situation where the calculated charge is below the *accepted charging error interval* (3.2)

[SOURCE: ISO/TS 17573-2:2020, 3.225]

**3.33****user account**

centrally or on-board stored transport-related service rights of the user in relation to a service provider

[SOURCE: ISO/TS 17573-2:2020, 3.228]

**3.34****user complaint**

complaints from users related to a specific service provision

[SOURCE: ISO/TS 17573-2:2020, 3.229]