



BSI Standards Publication

Public transport – Operating raw data and statistics exchange

National foreword

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English Version

Public transport - Operating raw data and statistics exchange

Transports publics – Échange de données brutes
d'exploitation et de données statistiques

Öffentlicher Verkehr - Betriebliche Rohdaten und
Austausch statistischer Daten

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European foreword

This document (CEN/TR 17370:2019) has been prepared by Technical Committee CEN/TC 278 “Intelligent transport systems”, the secretariat of which is held by NEN.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document is the Technical Report (TR) of Operating raw data and statistics exchange (OpRa) that contains information needed to define precisely the contents of what could be the scope of the following Technical Specification (TS) or European Norm (EN).

0 Introduction

0.1 General

The Public Transport (PT) sector, particularly for Public Transport Operators (PTO) and Public Transport Authorities (PTA), has identified the necessity to develop a data strategy, based on the cost and value, focusing on the strategic benefits of data. It is crucial that mobility stakeholders are not only able to compete against potential new market entrants, but also need a suitable environment to develop new business models and services. Public transport is becoming a data-enabled or data-driven business and should answer different local conditions.

This led to the need to standardize data analysis in Public Transport to understand formally how information can be created as added value and indicator calculation can facilitate moving from a qualitative analysis of the PT service towards a quantitative one.

In this perspective, OpRa (Operating raw data and statistics exchange) defines a minimum set of Public Transport raw data needed as PT quantitative analysis enabling factor.

This document is an informative document that describes the approach followed to perceive this goal and the results got.

0.2 Transport modes

OpRa takes most public transport modes, except air transport, into account. This specifically includes rail, bus, metro, tramway, trolleybus, ferry, coach, funicular railway, suspension railway, and rack railway.

0.3 OpRa management information

Management information deals with functions analysing production data in order to evaluate the service quality or to take corrective measures in planning and managing operations. In PT, for instance, the study of operational data (e.g. observed run times, passenger load) collected during service operations is an input for strategic planning (e.g. how and when to amend the schedules), tactical planning (e.g. when to undertake a certain control action), quality follow-up, etc.

Management information uses, therefore, two main types of data:

- data resulting from the planning stages, i.e. theoretical data on the production orders (e.g. timetables, run times, driver rosters, etc.);
- data describing the daily actual production (e.g. observed passing times, actual number of passengers, missed interchanges, modifications operated to the plan, etc.).

Advances in technology, in particular as regards data storage, allow the provision of all the necessary underlying data in production databases, against which the desired requests can be made by PT managers. Consistent data structures for management data will make the design of such requests easier, and offer the flexibility required to OpRa exchange PT raw data, in order to enable indicators calculation. Raw data is identified according to specific use cases and, where applicable, defined and described in Transmodel format. In this perspective, the exchange will be performed using similar NeTEx modalities, for compatibility reasons.

0.4 OpRa exchanging data modality

Similarly, to NeTEx, the primary software resource from implementing an OpRa interface will be based on XML schema; at this stage, a full schema has not been designed yet.

Two main variants of the schema will be available each providing a different protocol for embedding the same content model subschemas.

- a) **Simple OpRa documents exchange:** (see *NeTEx_publication.xsd*). A schema to use with NeTEx documents input or output by a system that are exchanged as files using FTP, email etc.
- b) **OpRa document exchange using SIRI HTTP requests:** (see *NeTEx_siri_SG.xsd*). A schema that embeds the OpRa elements in a sequence of HTTP messages that define request/response and publish/subscribe interchanges for exchanging data. Requests use OpRa elements to specify the desired data. Responses wrap in version frames. The messages are specializations of the SIRI framework.

0.5 Motivation

Measured Public Transport data describing the public transport network fulfilment are essential for studies, control, service improvement and contractual relations between stakeholders. It is important that they can be shared among PTO, PTA, engineering and design office, researchers, and other actors in a clear and unambiguous way, in order to provide accurate and intelligible information.

Furthermore, the OpRa covered scope is fully complementary to other existing exchange standards and allows covering one of the small remaining gaps of public transport standardization, with particular references to Transmodel, NeTEx and SIRI.

NeTEx (CEN/TS 16614-1 to 3) is an exchange protocol dedicated to scheduled public transport data, based on the Transmodel (EN 12896) conceptual data model. NeTEx supports the exchange of information relevant to public transport services for passenger information and AVM systems and is divided into three parts:

- Part 1: network topology exchange;
- Part 2: timetables exchange;
- Part 3: fare information exchange.

SIRI (EN 15531-1 to 5) is complementary with NeTEx and provides operators and manufacturers with a standard framework for exchanging data concerning public transport real-time information, along with a set of functional services for specific types of real-time data. As for NeTEx, the underlying conceptual definitions used by SIRI are provided by Transmodel. SIRI and NeTEx share the same communication protocol.

Using these standards, scheduled and real-time information can be made available for passenger information, and for operations and for process review. However, there is still one final aspect missing, just after real-time: to provide information about what has actually been performed, with the same overall view as for scheduled information. Such data allows a feedback loop to improve existing services.

The OpRa work is therefore about operating raw data and statistics, regularly requested by PTA, aims to meet that need.

0.6 CEN Standards context

OpRa work has been developed under the aegis of CEN draws on a number of existing national Public Transport Service scenarios and EU standards.

The keystone is the Transmodel standard, a conceptual model that names and represents PT info concepts for a wide set of functional areas and can be used to compare and understand different models. Transmodel project outputs have been used both to underpin a number of CEN concrete data standards such as NeTeX, SIRI or IFOPT¹. It underpins many national standards to allow for harmonization and interoperability. Transmodel generic model has been used to develop OpRa and OpRa-specific requirements itself being updated to include OpRa additions provided also some of Transmodel enhancements (present in prEN 12896-8, concerning Management Information and Statistics).

CEN (Comité Européen de Normalization) is Europe's standardization body. It divides its work into committees covering different aspects of industry and technology. OpRa work is formally produced by Technical Committee 278, Work Group 3, Sub-Group 10. Other TC 278 WG 3 sub-groups handle the related standards, in particular, Transmodel (SG4 Reference data model), SIRI (SG5 Service Interface for Real-time Information) and NeTeX (SG9 Network and Timetable EXchange).

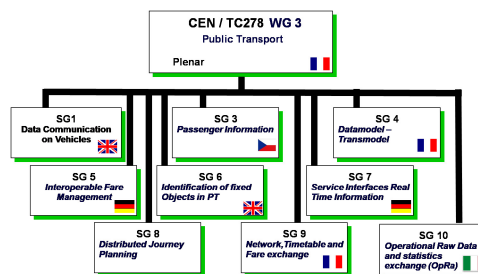


Figure 1 — CEN TC 278 WG 3 Sub-groups

0.7 CEN process and participants

The CEN process requires a working sub-group to develop a candidate specification, which is then sent to national mirror groups for review and comment, with voting stages for approval and adoption. Work on OpRa has involved delegates from France, Hungary, and Italy. Evolution of EU PT standards and OpRa for rail with TAP/TSI compatibility.

The following countries have shown interest for the activation of OpRa work:

- 1) Austria (ASI);
- 2) Czech Republic (UNMZ);
- 3) Denmark (DS);
- 4) France (AFNOR);
- 5) Hungary (MSZT);
- 6) Italy (UNI);
- 7) Netherlands (NEN);

¹ IFOPT has been included in Transmodel Part 2: Public Transport Network (EN 12896-2) and is no more a standalone standard.

- 8) Norway (SN);
- 9) Slovakia (SOSMT);
- 10) Slovenia (SIST);
- 11) Spain (UNE);
- 12) United Kingdom (BSI).

The following map shows the distribution of the stakeholders by country, based on whether they are already active or just interested in the results.



Figure 2 — OpRa stakeholders' involvement

The development of OpRa has drawn on PT national scenarios, in particular to identify needs and validate the OpRa detailed use cases by establishing mappings with studied national PT scenarios.

The development of OpRa also coincided with an interest by the European Rail Authority (ERA), UITP and other stakeholders in seeking a degree of data interoperability between different modes of Public Transport such as rail, metro and bus, that is, the ability to exchange PT raw data about routes, timetables and fares between systems and to supply external third-party users.

0.8 Evolution of EU PT standards and OpRa

This document describes the results of preliminary analysis phase covering the following main topics:

- national scenarios for Public Transport raw data and statistics exchange (needs and usage);
- Public Transport Quality of Service (QoS) in EU projects;
- use cases definition and classifications;
- compliance with CEN TC 278 WG 3 standards (Transmodel).

The subsequent work consists in the definition of a Technical Specification (TS) for OpRa data exchange format and associated services. In this perspective, it has been proposed to insert this standardization activity among those included in the *EU ICT Rolling Plan 2019*.

0.9 Further information

In the case of long-distance train, OpRa work takes into account the requirements formulated by the ERA (European Rail Agency) — TAP/TSI (Telematics Applications for Passenger / Technical Specification for Interoperability), entered into force on 13 May 2011 as the Commission Regulation (EU No 454/2011), and based on UIC directives.

1 Scope

1.1 Introduction

The OpRa work scope is the definition of a minimum set of Public Transport raw data needed as PT quantitative analysis enabling factor. To obtain this considering all the several aspects involved in this complex domain, the work has been conducted through the following phases:

- 1) assessment;
- 2) use cases definition and classification;
- 3) indicators definition;
- 4) raw data identification.

OpRa work does not go into the field of service quality measurement and reporting: service quality analysis will of course use data provided by OpRa, but quality definition remains a contractual level issue between a Public Transport Authority and a Public Transport Operator or an operator's internal choice for a purely private service. OpRa mainly only reports unbiased actual data (i.e. measured or observed), described and aggregated in a shared and understandable way.

The OpRa work documented in detail in this document is coherent with EU Directive 2010/40. In particular, it relates to the Article 4² of the Delegated Regulation EU 2017/1926 [33], as regards the historic data. OpRa proposes to complement NeTEx (dedicated to the static scheduled information), for the historic data based on the underlying conceptual data reference model Transmodel EN 12896, similarly to the requirement of the Delegated Regulation EU 2017/1926 referring to the static scheduled information³.

1.2 Assessment phase

The **assessment phase** has been conducted studying the following aspects:

- national scenarios for public transport raw data and statistics exchange, to identify indicators needs and usage;
- public transport KPI definition in research projects to consider what has been already done in literature and research;
- relations with public transport EU norms, to be coherent with already existent PT norms.

Moreover, involved actors and stakeholders have been identified like: **Public Transport Authority** (PTA), **Public Transport Agencies**, **Public Transport Operator** (PTO), **system integrators** and

² Transport authorities, transport operators, infrastructure managers or transport on demand service providers shall provide the static travel and traffic data and historic traffic data listed in point 1 of the Annex of the different transport modes, by using: (a) for the road transport, the standards defined in Article 4 of Delegated Regulation (EU) 2015/962; (b) for other transport modes, the use of one of the following standards and technical specifications: NeTEx CEN/TS 16614 and subsequent versions, technical documents defined in Regulation (EU) No 454/2011 and subsequent versions, technical documents elaborated by IATA or any machine-readable format fully compatible and interoperable with those standards and technical specifications; (c) for the spatial network the requirements defined in Article 7 of Directive 2007/2/EC.

³ 16) For what concerns the exchange of static scheduled data (such as public transport, long distance coach and maritime including ferry), the relevant data in the national access point should use the CEN data exchange standard NeTEx CEN/TS 16614 based on the underlying conceptual data reference model Transmodel EN 12896:2006 and subsequent upgraded version.

passengers, analysing public transportation *Planning and Operation process*, that have been divided into five main stages to group all the activates that characterize the Public Transport Service:

- **strategic planning:** definition of network elements (lines, stops), main service parameters (vehicles sizes, operation intervals, service intervals for important time demand types), and guaranteed interchanges are planned;
- **tactical planning:** operators plan their resource usage (vehicles, rolling stock, personnel), with detailed timetables for each resource unit;
- **before travel:** all planned networks and timetables are published. Passengers and other types of clients can plan their use of the offered transportation services via printed and electronic media, and make their reservations as needed;
- **in-travel:** the transportation service is conducted. Real-time information exchange is available while this takes place and can be recorded;
- **study and control:** in this stage, operators and authorities review the history of actual operations, which could lead to improvements through operational changes, or an optimization of strategic and tactical planning.

The PTA and PTO are interested in all the defined stages, meanwhile from the passenger point of view; only the last three stages are relevant (all the preparation work being hidden).



Figure 3 — Public Transport Service phases

During the assessment the most relevant research projects results have been considered and a deep analysis of the roles and usage of Public Transport Standards have been completed to guarantee a coherent approach of OpRa.

The first four stages are under the scope of NeTEx (Network Timetable Exchange) and SIRI (Service Interface for Real Time Information) and the last stage is the additional scope to be covered by OpRa. All these standards are compliant with the European Public Transport Reference Data Model (Transmodel).

NeTEx supports data exchange for the **Strategic Planning** and **Tactical Planning** stages, with data more than 24 h before validity date. In the **Before Travel** stage, NeTEx can be used to publish all planned data to client systems. Meanwhile SIRI supports “**in-travel / in-operation**” data exchange.

The **OpRa** scope is mainly concentrated to support data exchange for the **Study and Control** stage and it mainly focus on actual and measured information, i.e. information that cannot be changed anymore in the future. The OpRa covered concepts are based on following Transmodel domains:

- operations monitoring and control (Part 4);
- management information and statistics (Part 8).

1.3 Use cases definition and classification phase

To identify the set of raw data, a clear definition of use cases that, based on the assessment phase results, describes the indicators definition and usage to satisfy the Public Transport Study and Control phase is needed.

In this complex and articulate scenario, the work bring to a definition of several use cases this led to the needs to aggregate them and classify accordingly.

1.4 Indicators definition phase

For each defined use case an indicator has been formally defined, including its formulae. It has been advised that some indicators could have particular importance in for the Quantitative Analysis and in this perspective they could be considered Key Process indicators (KPI), for the purpose of this OpRa work, indicators and KPI are used as synonyms.

1.5 Raw data identification phase

After use cases and indicators have been defined, the work enter in the phase of raw data identification for the calculation of the indicators included all use cases. Due to the high level of complexity of the results, a traceability matrix has been identified.

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.

EN 12896-8:2018 ⁴, *Public Transport — Reference Data Model — Part 8: Management Information and Statistics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in prEN 12896-8 and the following apply.

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

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

3.1 attribute

property of an entity

3.2 conceptual data model

description of a real-world domain in terms of entities, relationships, and attributes, in an implementation independent manner and providing a structure on which the rest of the development of an application system can be based

⁴ Under preparation. Stage at the time of publication: prEN 12896-8:2018.

3.3**conceptual level**

conceptual data model in the context of data modelling

3.4**database**

collection of data; often used in the sense of the physical implementation of a data model

3.5**data model**

real-world domain in terms of data and relationships

3.6**entity**

object (data) that has its own existence (as opposed to an attribute)

3.7**function**

a sub-activity of a functional area

3.8**functional area**

arbitrarily defined set of activities used to define the objectives and limits of the data model

3.9**interoperability**

ability of (sub) systems to interact with other (sub) systems according to a set of predefined rules (interface)

3.10**logical data model**

data design that takes into account the type of database to be used but does not consider the means of utilization of space or access

3.11**logical denormalized model**

relational data model that is not fully normalized, i.e. does not completely follow the normalization rules and thus could be redundant

3.12**logical level**

logical data model in the context of data modelling

3.13

management information

all activities allowing the company management to collect the information necessary to meet problem-solving needs

Note 1 to entry: Data of operational systems are filtered and aggregated for the purpose of management information, and are made available to the user interactively, or in form of pre-defined reports and summaries. Such functions are in principle related to all functional areas of a company, with particular reference to the management of statistical results.

3.14

operations monitoring and control

all activities related to the transportation process, i.e. real-time functions related to the driving and transportation of passengers according to given instructions, including the monitoring of the driving process and its control in case of deviations, as well as all activities that support the driving process (traffic light priority, track switching, bay selection, advance/delay advice, etc.)

Note 1 to entry: Such functions are often assisted by computer-aided tools, known as Automated Vehicle Monitoring (AVM).

3.15

passenger information

all activities related to informing the users either on the planned or on the actual transportation services

3.16

real-time control

see operations monitoring and control

3.17

relational data model

type of logical data model giving the information as series of tables (relations) and attributes

Note 1 to entry: The relational data model has the following characteristics: 1) all attribute values are atomic, 2) all "tuples" (rows/occurrences) are distinct, 3) no part of the primary key may be null, 4) foreign key values have to correspond to an existing primary key in another relation or be null.

3.18

scheduling

see tactical planning

3.19

strategic planning

all activities related to definition of network elements (lines, stops), main service parameters (vehicles sizes, operation intervals, service intervals for important time demand types), and guaranteed interchanges planned

3.20

tactical planning

all activities related to the tactical planning of transportation, splitting into vehicle scheduling, driver scheduling, and rostering

3.21

UML

Unified Modelling Language

3.25**domain specific terms and definitions**

terms specific to the management information and statistics domain and which are also data entity names

Note 1 to entry: These terms are defined in Annex A and are mostly not repeated here.

3.25.1**indicator**

relates to a set of data (planned or measured) and could be either qualitative or quantitative

3.25.2**granularity**

determines the smallest unit for an indicator

3.25.3**formula**

describes the method to calculate indicators that are based on other indicators or on a set of raw data

4 Symbols and abbreviations

API	application programming interface
AVL	automated vehicle location
AVLS	AVL system
AVMS	automated vehicle management system
CEN	Comité Européen de Normalization
DRT	demand responsive transport
FTS	flexible transport service
IFOPT	identification of fixed objects in public transport
ISO	International Standards Organization
KPI	key process indicator
NeTEx	Network and Timetable Exchange
OpRa	Operating Raw Data and statistic exchange
PT	public transport
PTA	public transport authority
PTO	public transport operator
QoS	quality of service
SIRI	service interface for real-time information
TR	Technical Report
UML	Unified Modelling Language
UC	use case
WGS	World Geodetic Standard
WSDL	Web Services Description Language
XMI	XML Metadata Interchange
XML	Extensible Mark-up Language
XSD	XML schema document

5 National scenarios for Public Transport raw data and statistics exchange

5.1 General

A deep and detailed study of PT world has been conducted, focusing on current or desired usage of raw data and statistics on information exchange processes among stakeholders (mainly authorities, operators and system providers) in several EU countries. Particular attention has been posted on the identification of all possible measured data and measured data aggregation and statistics exchanges.

All the aspects have been described in terms of Public Transport National scenarios, including high-level description of the role of indicators in PT Governance. Thanks to this contribution, national requirements have been collected and analysed, focusing on data input for PT network study including ERA, UITP and UIC.

5.2 France

5.2.1 General

Several scenarios implying the use of raw data are considered in France:

- reporting from rail companies to authorities in French regions (this scenario is the one having provided most of the French use case as input to OpRa);
- reporting of bus operators to local authorities (from city to region);
- internal use at operator level in order to improve the quality and the economy of the service;
- security analysis.

5.2.2 Rail reporting

Strong needs were reported from ARF (Association des Régions de France) and were used as input for OpRa. French regions are in charge of organizing the rail transport within the regions (mainly TER), with the SNCF as operator for now, but also having in mind the incoming market opening. There are some strong contractual reporting requirements (rail operator reporting to the regional authority) in order for the region to check how the ordered service compares to the actual one. Furthermore, regions are facing unstable data formats and unclear definition when collecting operational data, and this needs to be solved for the current situation, and even more in the context of an opened market.

The main identified expectations are:

- clear definitions of exchanged concepts;
- a generic list of concepts in which they could pick up what they need for operational reporting and indicator building: the selected concept could then unambiguously be inserted in call for tender. The generic list needs of course to be available for authorities and operators;
- a well-defined and stable data format to exchange information related to the above concepts;
- rules that can be inserted in call for tenders and that can be verified (verify and test the conformance of data sets to the expected concepts and exchange protocol).

Examples of needs:

- identify the number of late trains per station, clearly differentiating cancelled trains and late trains;
- collect information about disruptions, differentiating incidents due to the infrastructure, due to external events (weather, passenger), due to the operator, to strikes, etc.
- comparison of data sets (reporting) produce at different dates;
- being able to easily import the operational reporting in tool (allowing visualization, comparison and statistics);
- to have the same type of information for several region, allowing comparison across regions;
- to have a clear view of the scheduled service including: vehicle type, number of vehicles, distances, number of passenger per train (expected, maximum), etc., and later on the corresponding observed values so they can be compared to each other;
- getting the information about substitution offer and when they are used;
- differentiate distance run by train (kilometres) and distance run by coaches;
- to be able to collect to have ticketing information (sold tickets and travel cards, km and trips per travel cards, etc.);
- to be able to focus on subparts of Vehicle Journeys (for trains crossing several regions);
- etc.

5.2.3 Local public transport reporting

Operational reporting is highly important for rail, but is equally important at local level (cities, urban area, etc.). This will mainly involve relation between authorities and bus operators, but also tram and metro operators. Therefore, even if there are some obvious commonalities with the reporting expected from rail operator, this local context has a set of particularities.

This local market is already fully opened and requires to clearly set the expectations in call for tenders, and then control through the provision of operational data that the service is consistent with the requirement (with possible financial adjustments).

Among the particularities of this local market, it may be mentioned a higher focus on distance (service with passengers and dead-run without passengers, with a clear distinction between both) and passenger count.

For example:

- identification of the percentage of “service kilometres” and “dead-run kilometres”;
- comparison of run kilometres with the corresponding approximate route distance;
- number of validated (used) tickets (fare product, whatever media they are stored on) per period and per fare product;

- amount of ticket (fare product) sales per period and per fare product;
- passenger use of the network (origin, destination, number of travel per period, etc.);
- etc.

5.2.4 Quality, economic and sociologic management

The expectation concerning Operational raw data are not only to provide a way to control the operator's work but also to improve the scheduling, meaning that there are also operator's needs for such data.

For example:

- frequently late bus due to traffic congestions (should probably be rescheduled);
- vehicle load information can obviously be used for a better vehicle type choice, are for a better scheduling;
- etc.

Studies are also recognized as being a huge consumer of Operational raw data for:

- sociological studies;
- mobility studies;
- studies on possible use of new transport mode (and could the help or be complementary to regular PT for example);
- environmental studies;
- economic studies;
- security studies;
- etc.

5.2.5 Security analysis

A less obvious but equally important use of Operational raw data reported by RATP (main bus and metro operator in Paris) is security and assessment of quality of service as perceived by passengers (which is often different from the measured quality).

In this context, additional information shall be gathered. For example:

- passenger counting in station's corridor (using specific counting devices);
- passenger counting at validation gates (complementing the ticketing validation count and doing);
- passenger counting: the difference between the count and the validation provides a pretty clever count of fraud at validation gate;
- they use the maximum flow information at gates, and in corridors, and compare it to the current flow;
- measurement of the stopping time between stations (not only at stops) which is important for the perceived quality;

- comparison of origin and destination required on journey planners to the one actually done on the network;
- collection of Origin-Destination for which no answer is provided by the journey planner;
- collection, on a driver base all, of the mean speed, distance, and number of journeys per operational day;
- collection of the number of fines and fraud detected by controllers.

5.3 Hungary

In Hungary, regional and long-distance public transport is awaiting a major overhaul project currently in preparation and tendering phase that is looking to improve institutional, central, on-board, on-site and online equipment and capabilities.

The project can be divided into 3 sub-projects:

- a central node that is responsible for organizing and collecting data, and provides multiple centralized services for public transport actors (journey planning, timetable planning, etc.);
- field equipment overhaul (on-board units, ticketing machines, controllers' equipment);
- customer end point systems (e.g. sales).

Raw data exchange comes into play when actual service is reported towards customers and Public Transport organizers (PTAs) for service level evaluation and accounting purposes. Having a standardized exchange format would assist in creating a thorough SLA environment.

Projected data types covered by OpRa scope in the Hungarian transportation system management are the following:

- actual service data (comparable with the planned service data);
- usage data (alighting/boarding passengers' count, utilization rate, load factor, average performance indicators);
- quality of service data (SLA contractual requirements), including station equipment quality, rolling stock and vehicle capabilities (especially accessibility-related information), cleanliness, etc.

Another future use will be to exchange operational raw data towards other professionals through the National Access Point. We can estimate that — based on the current EU regulations, NeTEx capabilities have to be deployed until 2023 — the NAPs will evolve towards exchanging actual (finished) service information, where OpRa can fit into the exchange standard role.

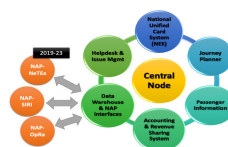


Figure 4 — PT Hungary scenario

5.4 Italy

In Italy, several actors are involved in the Public Transport Governance process from the Administrative aspect until the Operation one.

In particular, the following actors are involved:

- **Public Authority** at several levels (Central and delegated ones) in charge to manage contracts and verify results of the PT Service respect contract Service Level Agreement (SLA).
- **Public Transport Agencies**, delegated to control the PT services according to contracts.
- **Public Transport Operator** in charge to provide PT Service in accordance with a contract with having revenue fitting the contract.
- **System Integrators** that provide hardware devices and software platforms and applications to facilitate digitalize the operations of PT Service.

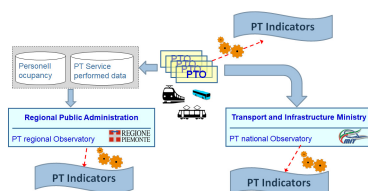


Figure 5 — Italian PT scenario

All the involved actors are interested in calculation and evaluation of specific indicators, mainly relevant to a certain process. PTOs are interested in monitoring and controlling the performance of the Service, to control costs and improve the service. The authorities have the institutional goal to create and control that PTOs perform in respect to the established contract, typically this is done at two levels, the former by Local Authorities like Regions or delegated entities (Agencies) and the latter at national level, in a more aggregated way.

In this perspective, several indicators are calculated from several actors. Recently, the Italian Ministry decided to optimize this set of processes and to normalize the indicators definition and clearly identify the inputs data to be used for calculation.

This led the country to participate at OpRa working group, in order to follow the best way in the formalization and exchange to input data to be used for indicators calculation.

Following table shows an example of some indicators used and calculated by Ministry.

Table 1 — Italian indicators example (BUS/TRAM/METRO)

Raw data	Modality of transport	Description	Type
Total distance (BUS km)	BUS / TRAM / METRO	Total distance performed — Sum of the km of each performed journey	Decimal (3 digits) [0, ∞)
Transported passengers	BUS / TRAM / METRO	Passengers quantity (Q)	Integer
PTO employee	BUS / TRAM / METRO	Employee quantity	Integer
Q. of “VEHICLE_JOURNEY” passed at the STOP_POINT (BUS STOP)	BUS / TRAM / METRO	Vehicle journey quantity	Integer [0, ∞)
Q. of passengers drop in vehicle at STOP_POINT	BUS / TRAM / METRO	Passengers quantity	Integer [0, ∞)
Q. of passengers drop off at STOP_POINT	BUS / TRAM / METRO	Passengers quantity	Integer [0, ∞)

Table 2 — Italian indicators example (TRAINS)

Raw data	Modality of transport	Description	Type
Total distance (TRAIN km)	TRAIN	Total distance performed — sum of the km of each performed journey	Decimal (3 digits) [0, ∞)
Total distance (BUS km)	TRAIN	Total distance performed — sum of the km of each performed journey	Decimal (3 digits) [0, ∞)
PTO employee	TRAIN	Employee quantity	Integer
Q. of “VEHICLE_JOURNEY” passed at the STOP_POINT (STATION) Monday-Friday	TRAIN	Vehicle journey quantity	Integer [0, ∞)
Q. of “VEHICLE_JOURNEY” passed at the STOP_POINT	TRAIN	Vehicle journey quantity	Integer [0, ∞)
Q. of passengers drop in vehicle at STOP_POINT	TRAIN	Passengers quantity	Integer [0, ∞)
Q. of passengers drop off at STOP_POINT	TRAIN	Passengers quantity	Integer [0, ∞)

The Ministry is also interested in evaluating economic aspects relevant to the Service and the PTOs and as part of signed contracts to require having information about sold tickets, incoming revenues, outcomes, etc.

5.5 The Netherlands

5.5.1 General

In The Netherlands, the governance of the Public Transport lies with the Ministry of Transport, twelve regional public administrations (provinces) and two metropole areas. These PT Authorities manage the

contracts for one or more areas (concessions). The actual PT services are provided by PT Operators in accordance with the contract and Service Level Agreement. This includes both planning and exploitation. A concession is awarded to a PT Operator for a number of years, as illustrated in the figure published by CROW.

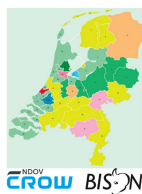


Figure 6 — The Netherlands concessions

The Dutch PT organisations (Authorities, Operators, NAPs) collaborate in CROW-NDOV in order to monitor and improve the quality of PT information for travellers. The management of the information exchange standards — timetables and real time information — lies with BISON (Beheer Informatie Standaarden OV Nederland). There are three National Access Points (loketten) that combine and publish the data provided by the different Operators, and a National Stop Database.

Fare collection is mostly based on a smart card (OVchipkaart), which can contain many different fare products. Since travellers are expected to check in and check out of a vehicle, there is a large amount of detailed information about the actual use of the PT services.

5.5.2 Monitoring

Most PT companies monitor the performance of their own PT service using many different elements. For example, GVB (Amsterdam) combines data from the following sources:

- OVchipkaart;
- Vehicle monitoring systems;
- Traffic control system;
- Counting systems in the vehicles;
- Administration of cancellations;
- Personnel planning system;

and is interested in (among others) the following quantities:

- number of people boarding and alighting;
- total amount of vehicle kilometres and vehicle hours;
- cancellations on journey / stop point / line level;
- sale and usage of fare products (and the corresponding revenue).

Furthermore, on a national level CROW-NDOV also monitors a number of Key Performance indicators (KPI) of the different PT operators in a national dashboard.

5.5.3 Reporting

In order to facilitate the tenders for concessions, uniformly evaluate the performance of Operators and aggregate the results to the national level, an Information Profile has been defined detailing the relevant quantities: MIPOV2008 (Model InformatieProfiel Openbaar Vervoer). This selection of data are based on the use of the OVchipkaart. An Addendum2011 has added some support for non-OVchipkaart data and ways to manage incomplete data.

The following table illustrates the MIPOV2008 data, including the expected detail level (filters). Italic items are optional. "Planning" data should be delivered at least one month before the timetable is valid, "Quality" and "Demand" reports monthly or quarterly (depending on the SLA), separately for each concession. The data include all modes of PT (train, bus, tram, metro, ferry).

Table 3 — PT raw data in the Netherlands scenario

	Raw data	Unit	Filters					
			Mode	Line (part)	Day type	Formula	Period	Other filters
Planning	Basic timetable elements		x	x	x			
	Total time in timetable	hours	x	x		x		
	Total distance in timetable	km						
	Frequency	journeys/h	x	x	x	x		
Quality	Cancelled/delayed journeys	amount and hours	x	x	x	x	x	size of delay
	Journeys too early/ late at timing point	%	x	x	x	x		(part of) day
	Journey with wrong headway interval	%	x	x	x	x	x	line group
	Number of incidents		x	x				incident category
	Successful interchanges	%			x			station, interchange
	Complaints (amount and processing time)	days	x					
	Total number of complaints		x	x				complaint category
Demand	Reinforcement journeys	amount and hours and km	x	x	x			
	Number of passengers boarding		x	x	x	x	x	
	Number of passengers alighting		x		x	x	x	journey part
	Max occupancy of vehicle	persons	x	x	x	x	x	
	Total distance travelled	km	x	x	x	x		type of ticket
	Total revenue	euro	x					type of ticket
	Detailed revenue	euro	x	x	x	x		
	Total passengers 'from — > to'	(matrix)			x			group of stop points
	Average passengers per day "from —> to"	(matrix)		x				group of stop points
Other	On demand journeys	hours	x	x	x	x		
	Number of vehicles		x			x		vehicle role
	Average vehicle age	years	x					type of vehicle
	Average passengers boarding/alighting		x	x	x	x	x	stop point
	Average passengers "from —> to" (large area)	(matrix)			x			postal code

5.6 Slovenia

5.6.1 General

In Slovenia, governance of Public Transport is organized at national (inter-urban, international) and city level. Cities with more than 100,000 citizens are obliged to manage Public Transport with their local budget. Public Transport at the national level is a responsibility of the Ministry of Infrastructure (<http://www.mzi.gov.si/en/>), which is the main Public Transport authority. The responsibility is shared between its different organizational units:

- **Sustainable mobility and transportation policy sector:** strategic development of Public Transport policy, integration of public passenger transport (IJPP, <https://ijpp.si>), guidelines for sustainable mobility (cyclist-friendly infrastructure, infrastructure for pedestrians, park&ride, Slovenian platform for sustainable mobility), multimodal mobility for people with disabilities, passenger rights. In 2016 the sector managed the implementation of a national Integrated Public Passenger Transport system (IJPP, <https://ijpp.si>). It integrates all Public Transportation operators in Slovenia to provide a unified ticketing and automated fare collection system. With 37 bus operators and one national railway operator, the IJPP deploys more than 1 500 automated fare collection and validation terminals throughout the country. By using unified ticketing users can travel across the country, regardless of the transportation provider. Initial deployment scenario involved only middle school and student population for system test and validation. The initial deployment period enables public transport operators to migrate existing technology and adopt to the IJPP standard for wider public use.



Figure 7 — Logo of the Integrated public transport project in Slovenia

- **Sector for road traffic and logistics:** responsible for management of inter-urban public passenger transport at national level. Public Transport in Slovenia is considered an economic public service for which Public Transport operators are awarded concessions through a public tendering process. Before the tendering process starts, Public Transport demand is identified, and initial timetables are proposed for individual concession areas. The timetables are part of the concession contracts with public transport operators. The timetables may be updated twice a year in response to changed demand.
- **Slovenian Infrastructure Agency:** the agency manages main and regional public roads and cycling routes. It is also responsible for the construction, upgrade, reconstruction and maintenance of public railway infrastructure. The public railway infrastructure is owned by the Republic of Slovenia. The operator of the public railway infrastructure is SŽ, d.o.o., as per the Railway Transport Act.
- **National Traffic Management Centre (NTMC):** the Centre is mandated to integrate services for traffic monitoring including information delivery and traffic management. The Centre will also manage the project “National Access Point Slovenia Programme Support Action (PSA) for the implementation of Union-wide multimodal travel information services on the TEN-T network” which will result in the implementation of a Slovenian NeTex National Profile and a Slovenian National Access Point with static and dynamic public scheduled transport data sets.

5.6.2 Collecting and reporting of Public Transport raw data (operational statistics)

Public Transport concession operators have to report to the Ministry of Infrastructure about operational statistics on a monthly and yearly basis. There are 8 monthly and 15 yearly concession reports:

Table 4 — PT raw data in the Slovenia scenario

Data about planned and actual kilometres	• Number of registered (planned) kilometres (per concessionaire, per sub-contractor); • Number of actual kilometres driven (per concessionaire, per sub-contractor); • Table with detailed data for individual lines • Line ID, Line name, • Number of registered (planned) kilometres, • Number of actual kilometres driven, • Comment (if registered versus actual differs).
Income from sold fare products	• Table with detailed data per line • Line ID, Line name, • Number of registered (planned) kilometres, • Number of actual kilometres driven, • Income from sold fare products.
Income from public sources	• Table with detailed data per line • Line ID, Line name, • Number of passengers luggage items • Number of unattended luggage items • Income from passengers luggage items, • Income from unattended luggage items
Income from other public sources	• Table with detailed data per line • Line ID, Line name, • Number of concession passengers, • Income from concession passengers, • Income from community funding, • Income from other public sources (contracts with schools, army, etc.).
Income from other non-public sources	• Table with detailed data per line • Line ID, Line name, • Number of passengers, • Income from contracts with 3rd companies, • Income from other sources (contracts associations, advertisement, climate fund, etc.).
Statistics about fares and passengers	• table with detailed data per line • Line ID, Line name, • Number of one-way fares sold, • Number of return fares sold, • Number of weekly fares sold, • Number of monthly fares sold, • Number of 6-monthly fares sold, • Number of yearly fares sold.
Statistics about clearing between concessionaires	• Table with detailed data per line • Line ID, Line name, ID of Partner PTO, • Income from fares, • Total income for the line.

Statistics about services under concession contract	• Drivers • Total number of drivers, Number of concessions drivers, Average age of concession drivers, Number of all employees, Max. number of needed daily drivers; • Vehicles • Number of all vehicles, Number of all concession vehicles, Number of all concession vehicles in operation, Average age of concession vehicles, Total concession passengers seats, Total concession passengers stands; • Kilometres • Number of concession only kilometres driven, Number of non-concession kilometres driven, Total number of kilometres driven with concession vehicles, Total number of kilometres driven with all vehicles; • Lines and passengers • Total number of departures, Total number of all concession passengers.
Statistics about eligible costs per concessionaire	• Fuel cost, • Amortization value of vehicles, • Maintenance cost for vehicles, • Labour (drivers) cost, • Insurance cost (drivers, passengers), • Cost for stop- and parking- places.
Statistics about vehicle pool	• Vehicle ID, Registration number (plates), Date of first registration, Vehicle brand and model, Passengers capacity — seats, Passengers capacity — stands, Initial value of vehicle, Current value of vehicle

5.7 Slovakia

In Slovakia, the operation of Public Transport depends on the competence and responsibility for operation of Public Transport in a covered geographical area. There are 3 main levels (national, regional and city). Hence, there are different actors with different roles in the Public Transport Governance process.

The following actors are involved in the Public Transport Governance process:

- **Public Transport Authority (PTA)** at several levels (national, regional and city levels) in charge to manage contracts and verify results of the PT Service against the Service Level Agreement (SLA). There is the difference between rail and bus regional transport. The rail services are contracted by Ministry of Transport, the regional bus service is contracted by a Regional authority. The cities are responsible for contracting the urban public transport. The nationwide long-distance bus transport is liberalized/free market.
- **Public Transport Operator (PTO)** in charge to provide PT Service in accordance with a contract with having revenue fitting the contract.

- **Public Transport Agencies**, delegated to control PT services against the contracts. They can be responsible for city or regions.



Figure 8 — Slovak PT scenario

In the Slovak scenario, the PTO is providing PT indicators based on the area they are covering. The output from PT indicators database goes to the main responsible public authority to analyse and evaluate the performance of Public Transport. The indicators/performances that should be reported by each PTO are specified by a contract.

The example of PT indicators related to urban/city transport presents the following table.

Table 5 — Slovak indicators example

Indicator	Transport mode	Description	Type
number of planned PT trips	bus/Tbus/tram/bus,train	number of planned PT trips according the contract	integer
number of real PT trips	bus/Tbus/tram/bus,train	number of real PT trips according the contract	integer
length of PT line	bus/Tbus/tram/bus,train	length of PT line in km	integer
operation speed	bus/Tbus/tram/bus,train	average speed during the operation of PT	decimal
planned vehicle travel time	bus/Tbus/tram/bus,train	planned vehicle travel time according timetable	decimal
real vehicle travel time	bus/Tbus/tram/bus,train	real vehicle travel time according timetable	decimal
total distance	bus/Tbus/tram/bus,train	total distance operated by PT vehicle	integer
capacity of vehicle	bus/Tbus/tram/bus,train	capacity of particular PT vehicle	integer
total vehicle kilometres	bus/Tbus/tram/bus,train	total number of vehicles x kilometres	real
total seat kilometres	bus/Tbus/tram/bus,train	total number of vehicles capacity x kilometres	real
quantity of stops/stations	bus/Tbus/tram/bus,train	total number of stops/stations	decimal
total number of boarding	bus/Tbus/tram/bus,train	total number of boarding passengers per each stops	decimal
total number of alighting	bus/Tbus/tram/bus,train	total number of alighting passengers per each stops	decimal

In addition, it is possible to collect data on the revenues and cost, but in most cases, the data are considered as sensitive and hence kept confidential. They are available only to the public authorities, which are checking the eligibility of the costs to subsidies. An example of the data is provided in Table 6.

Table 6 — Slovak PT indicators related to cost and revenues — example

Indicator	Transport mode	Description	Type
operational cost per 1 km of PT line	bus/Tbus/tram/bus,train	operational cost per 1 km of particular PT line	decimal
total operational cost of 1 PT line	bus/Tbus/tram/bus,train	total operational cost of 1 PT line	decimal
total operational cost per network	bus/Tbus/tram/bus,train	total operational cost per served network	decimal
revenue per 1 km of PT line	bus/Tbus/tram/bus,train	revenue per 1 km of particular PT line	decimal
total revenue of 1 PT line	bus/Tbus/tram/bus,train	total revenue of 1 PT line	decimal
total revenue per network	bus/Tbus/tram/bus,train	total revenues per served network	decimal

Based on the PT indicators mentioned above it is possible to provide an operational and economic analysis of a PT system. The public authorities will have a strong tool to evaluate a level of operation and trends in PT ridership in a particular area.

5.8 Spain

Spain is a decentralised state composed by 17 Comunidades Autónomas (CA) and two autonomous cities.

After the approval of the 1978 Constitution, Spain grants the right of each region of having its own autonomy statute, from 1978 to 1983 all CA have been created its own autonomy statutes, and from that date, all of them have incorporated the competences in transport matters.

At state level, the situation is ruled by the law 16/1987 modified in 2013. This law replaces a previous law of 1947 and establishes a new model of short-term contract services instead of long-term administrative concessions that operators buy, which allows the operation of predefined lines and routes.

The actors involved are:

- Ministerio de Fomento, central government ministry controlling the contracts of the inter-region services.
- CA governments, Local governments, they have the responsibility of transport regulation in their areas; in some cases they have created authorities or consortia to manage PT. Other cases they control directly PT service.
- Public Transport authorities and consortia: they are agencies that have delegated functions to control PT in their area. Their activity is focused in provide information to the user, evaluate the service performance, propose changes/ new contracts, establish the fare policy and making the clearinghouse between PT operators.
- Public Transport Operators, public or private companies in charge to operate Public Transport according to service contract.
- System integrators, provides software applications and hardware to the operators to perform the service.

Regarding the indicators, Ministerio de Fomento for their internal analysis is requesting the operators the following data every 3 months.

Table 7 — PT raw data in Spain

Name	Description
Passengers displaced	Total number of passengers transported
Traffic volume 1	Number of passengers per kilometre
Traffic volume 2	Number of vehicles per kilometre
Total collection	Total amount (€) collected

Today there are still many Operators with the old long-term contracts (according to 1947 law) that are pending to renew or will expire in the following near.

Because this scenario, the CAs last years are developing plans to restructure and modernize Public Transport organization, and because of that it is important to define indicators to control contract renews in basis of the performance of the service, demand performance and government strategy.

The most advanced in this matter is Consorcio de Transportes de Madrid (CRTM), who has defined the indicators to evaluate service quality and remunerate operators in basis to it.

In this way CRTM have defined a quality related attribute to the indicators:

- if it has a positive, negative or neutral effect in the remuneration (PN);
- only negative or neutral effect (NN);
- it is a recommendation that in future can be PN or NN (R).

The indicators according to the Quality plan 2010 are:

Table 8 — PT indicators in Spain

Name	Description	Attribute
Accomplishment of the offer	For each journey, difference (minutes) between the real start time and the planned start time.	PN
Occupancy	Maximum level of vehicle occupancy (%). For each journey, the maximum number of passenger at same time inside the vehicle / vehicle capacity.	PN
Ticketing machines failures	% of time of a ticketing machine installed in a vehicle is not available.	NN
Fleet tracking system failures	% of fleet management system working time versus theoretical service time.	NN
Contingency plan	Existence of a contingency plan	NN
Protocol to verify elements available	Existence of a verify protocol to ensure the correct working status of every vehicle element.	NN
Operation of ramps and platforms	% of vehicle ramps and platforms in correct status for each working day.	PN
Training of drivers and personal	Driver manual includes CRTM recommendations.	NN
Transport facilities	Provision of reserved spaces or transportation facilities for packages (shopping carts, bicycles, etc.)	R
Vehicle information	All the mandatory information on the vehicle is present (id, line, destination, current fares, contact data, etc.).	NN
Driver information	Driver is able to inform about stops, route, timetable and fares of the line he is doing.	PN

Name	Description	Attribute
Stops information review	All the mandatory information in the stops is present (stop number, fare zone, etc.)	PN
Cleaning and conservation of stops	Cleaning the surrounding environment and the stop Painted and similar that prevent the reading of information available at the stop Damages such as broken windows, seats, etc. Absence or fall of the post Missing or broken furniture	PN
Information on scheduled modifications	On board, operator supplies information to the user about changes in routes, stops, and stop times.	NN
Dynamic information in stops	% of working day that information of waiting times is not available or not correct.	PN
Real time information	% of working day that real time information (timetables, waiting times) is not available in the web/mobile app.	PN
Cleaning protocol	Existence of a cleaning protocol	NN
Operation of air conditioning	% of inspections where the air conditioning is working with the satisfactory temperature and air quality inside the vehicle.	NN
State of cleaning and conservation	% of inspections where the state of cleanliness and conservation is satisfactory	PN
Protocol of inspections and maintenance	Existence of a protocol for inspections and maintenance with the minimum content of mandatory items of CRTM	NN
Accident rate	Accidents by year classified by: 1. Driver responsibility 2. Third party liability 3. To be determined	PN
Incident rate	Number of registered incidents by million users of the service	NN
Security certifications	Possession of specific certifications regarding safety	R
Not mandatory systems	Provision of additional non-mandatory systems or procedures that guarantee or improve the safety of users (i.e. cctv)	R
Environmental impact protocol	The operator delivers both the protocol and the registers confirming the development of the actions indicated in it	NN
Environmental impact certifications	Provision of specific certifications in subject environmental	R
Customer service protocol	Existence of a customer service protocol	NN
Complaints book	% of vehicles with the complains book available	NN
Complaint registration	Website includes a link to CRTM complaint application	NN
Complaint rate	Claims received for million users	PN
Complaint management	Average time (days) of delivery of a claim and its corresponding report	PN
Follow-up of complaints	Existence of a registry and follow-up of recorded deviations and an internal action plan for correct the correctable aspects of the service	R
Contact phone	% of inspections where phone service is working	PN

Name	Description	Attribute
Web	% of contents of CRTM mandatory items: — Fares — Timetables — Company services (lost objects, etc.) — Means of contact with the company — Link to the CRTM website — Link to the application of complaints and suggestions CRTM — Notices of changes / modifications of the services — Other relevant developments of the transport system of Madrid	PN
Services letter	Existence of a service letter reflecting the service commitments operating company and, in addition, it advertising the annual compliance with these commitments, encouraged by CRTM to through a content manager	PN
Fraud control	Existence of a fraud control plan	NN
Corporate social responsibility	% of invest in social programs compared to the total income	PN
User satisfaction	Index from CRTM user surveys	PN
Valuation surveys	Existence of operator survey plan	R

6 Public Transport KPI definition in research projects

6.1 General

A deep and detailed study of PT world has been conducted, focusing on current or desired usage of raw data and statistics on information exchange processes among stakeholders (mainly authorities, operators and system providers) in several research projects, conducted among those that worth scope relevant for PT QoS.

In particular, the following have been analysed:

- 1) **EBSF** — European Bus System of the Future **(2008 to 2013)**;
- 2) **MEDIATE** — Methodology for Describing the Accessibility of Transport in Europe **(2008 to 2010)**;
- 3) **CONDUITS** — COordination of Network Descriptors for Urban Intelligent Transportation Systems **(2009 to 2011)**;
- 4) **METPEX** — a MEasurement Tool to determine the quality of Passenger Experience **(2012 to 2015)**;
- 5) **TIDE** -Transport Innovation Deployment for Europe **(2012 to 2015)**;
- 6) **D3IMPACT** -Data-driven decisions for intelligent management of public transportation **(2015 to 2016)**;
- 7) **CELISO** -Low-cost and high-performance pocket Automated Vehicle Monitoring system for Public Transport **(2016)**.

6.2 EBSF — European Bus System of the Future (2008 to 2013)

The development of a new generation of bus systems was the goal of the European Bus System of the Future (EBSF) project, funded by the European Commission within the 7th Framework Program. To accomplish this, a series of very different innovative solutions for buses (such as new vehicle layouts, advanced remote maintenance systems, improved on-board communication systems, more performing bus stops and eco-efficient engines) were simultaneously tested in seven use cases (UCs) in Europe (Bremerhaven, Brunoy, Budapest, Gothenburg, Madrid, Rome and Rouen). The EBSF is funded on the consideration that bus still remains the most universal solution for balanced and sustainable urban development from an economic, environmental, and social standpoint [22].

Through the application of the “system approach”, the project aimed at designing and validating a new breakthrough generation of urban bus systems, which will stimulate European cities to ensure a higher quality of the existing services and making public transport more attractive.

The experts of the project Consortium have identified the main factors influencing the evolution of bus systems in Europe. These main factors have been translated in the six strategic concepts, which define the EBSF vision:

- responding to passengers’ needs;
- responding to social and environmental needs;
- responding to the needs of cities;
- promoting political support and relevant legislation;
- securing global leadership;
- call for strategic research agenda for urban bus systems [16].

6.3 KPI description

A specific evaluation methodology was applied to assess the efficiency of the tested solutions, comparing “before” and “during” situations, through a comprehensive set of Key Performance indicators (KPIs), divided into four evaluation categories, each corresponding to more areas of investigations:

- productivity of the system,
- environmental performance,
- quality of the service,
- customer satisfaction.

The KPIs were collected both through direct measurements of the technical performance of each tested solution, and via questionnaires submitted to the involved actors (operators, drivers, passengers) for all the issues concerning perception and acceptance. A full-featured, web-based software was available to store and process the KPIs data. KPIs were both common, if applied to more UCs, or specific, when tailored for a single one. Since the tested measures, as well as the testing environments, duration, and conditions were very different, a simple “before/during” comparison at each UC was not sufficient to assess the efficacy and the benefits of the whole package of EBSF innovations. To this aim, a cross-site evaluation, i.e. a further comparative assessment, was carried out: the core of this phase was to evaluate the different impacts for each area of evaluation or each KPI, and homogenize them through a number of utility functions. Therefore impacts to be measured required first to convert the variation of a given KPI between the before and during scenarios into a homogeneous value scaled from 0 (no change) to 1

(maximum change), and then to assign a weight to the different areas of investigations in order to quantify its importance in the development of each EBSF innovation.

Selected KPIs measured the performance of every innovative solution in each UC, comparing results before the implementation (ex-ante) and while testing it (during). Surveyed variations [Table 9] allow highlighting two categories of results:

- a) performance that fully improved in all the UCs;
- b) performance that either improved or worsened, or did not vary at all.

Theoretically, category a) performance can be assumed as points of strength, whereas those of category b) as elements of uncertainty. It is also worth noticing that none of the KPIs recorded negative performance in all the UCs, which allows to state that no general elements of weakness can be detected [16].

Table 9 — KPIs and ex ante-during comparison of results

a) KPIs Evaluation Category	b) Areas of investigation	c) KPI Name	d) KPI Units	e) Variation $[(V_d - V_a)/V_a] \times 100$ Va = ex ante value; Vd = during value						
				UC1	UC2	UC3	UC4	UC5	UC6	UC7
Customer Satisfaction and attractiveness of bus systems	Comfort, cleanness and quality feeling/perception	Perceived quality of service	Passengers survey (1 to 10 scale)	13	5	6		4		
		Perceived comfort level on board			8			25		
		Customer perception of image		16				5		
	Information to passengers, relational and behavioural issues	Accessibility of real time information	%	11		100				
		Availability of information for connecting to other PT services	Passengers survey (1 to 10 scale)	4		20				
		Drivers situation	Drivers survey (1 to 10 scale)					10		
		Accessibility to drivers						-3		
Urban environment and integration	Environmental issues	Energy consumption	Litres*1 000/passkm	3	-17		0	-8	12	0
	Urban development and quality of life	Mobility of inhabitants	Trips/inhabitants			6				
	Accessibility to vehicles and infrastructures	Accessibility for users with special needs	Seconds						-9	
Productivity of the system	Economic and operation issues	Operating Costs	Euro/km	0	-17					0
		Passengers demand	Pass/month	-4	9	-10			30	
		Passenger capacity	Places*km		3			8	0	
	Pricing and commercial policies	Service efficiency	%	0		-1		9		0
	Maintenance	Technical maintenance of the bus	Days out of service	0	91	0	6	0	0	-52
		Days in Workshop			-75					-60
		Vehicle failure	Number/10 000 km		-90		-15			35
		Ratio of non-working vehicles	%							-26

a) KPIs Evaluation Category	b) Areas of investigation	c) KPI Name	d) KPI Units	e) Variation [(Vd-Va)/Va]x100 Va = ex ante value; Vd = during value						
				UC1	UC2	UC3	UC4	UC5	UC6	UC7
Quality of the bus service	Safety and security	Customer perception of buses safety	Passengers survey (1 to 10 scale)		-4			4		
		Drivers level of training	Drivers survey (1 to 10 scale)					8		
	Service performance	Dwell time	Seconds		-13			-6		
		Bus frequency			-4					
		Commercial Speed	Km/h		4			0	0	0
		Bus punctuality			52	3		6		
	Modal integration and additional/flexible services	Level of modal integration services		%			-2			
		Performance levels improved in all the UCS								
	Performance levels which either improved or worsened, or did not vary at all									
	Not applicable									

Focusing on category b), the amount of yellow cells corresponding to performance levels with different outcomes among the UCS [Table 9] stresses that uncertainty prevails, although with different degrees of significance. More specifically:

- Performance with no strong variations, corresponding to KPIs Commercial speed, Technical Maintenance of the bus and Operating costs;
- Performance with negligible improvements, corresponding to KPIs Service efficiency and Energy consumption;
- Performance with significant improvements, corresponding to KPI Passenger capacity;
- Performance with contrasting outcomes;
- Performance corresponding to KPIs Customer perception of the bus safety, Vehicle failure and Passenger demand [16].

KPIs belonging to category a) are: Dwell time, Bus punctuality, Perceived comfort level on board, Perceived quality of service, Customer perception of image, Accessibility of Real Time Information, Availability of information for connecting with other PT service and Days in Workshop. It is worth noticing that the results of three KPIs concerning “perception” were achieved through the passengers’ assessment, which implies that customers favour and satisfaction can be considered as fully achieved within EBSF. The most efficient performance were achieved in the evaluation category Productivity of the system (with areas of investigation: Maintenance, Pricing and commercial policies, and Economic and operational issues) and Customer Satisfaction and attractiveness of bus systems one (with areas of investigation: Information to passengers and Comfort, cleanness). A minor role is played by the evaluation category Quality of the bus system (with the only strong area of investigation: service performance), whereas Environmental issues are the only whose seem to be of no relevance, due to the majority of negligible results among the involved UCS [16].

6.4 MEDiate — Methodology for describing the Accessibility of Transport in Europe (2008 to 2010)

6.4.1 General

The Mediate project, METHodology for DescribIng the Accessibility of Transport in Europe, is a Coordination and Support Action within the 7th European Commission Framework Programme, running from December 2008 to November 2010.

The overall objective for Mediate is to identify and select a set of common indicators in order to measure accessibility in public urban transport in Europe.

The project has the following specific objectives:

- to review relevant initiatives and methodological approaches used to identify and describe accessibility in public transport systems;
- to identify and selected common indicators to measure accessibility to public transport.

6.4.2 KPI description

The purpose of this project was to identify indicators to be used as a basis for a common set of standardized indicators at the European level. The indicators [20] were selected to enable local authorities and operators to investigate the accessibility of the public transport system at local and regional level. They may also be used by individual operators, user organizations or others. The indicators can monitor the effectiveness of measures directed at accessibility, pointing out areas of strengths and areas, which are in immediate need of improvement. With repeated investigations, the indicators suggest whether development is sustainable, investments are well spent and contracts followed up, and point out the next core areas to focus on.

A set of common indicators has the following benefits:

- It provides a framework to help actors look for relevant information and recognize what information is missing.
- It gives stakeholders insight to the current accessibility situation and the strengths and weaknesses of the transport system.
- It makes transport providers and authorities aware of the complexity of accessibility.
- The indicators are instruments in target-oriented management and measure the effectiveness of budgets directed at accessibility.

The indicators are briefly presented in the table below.

Table 10 — Key Process indicators

Key indicator	Fact finding and assessment
Policy and investment	
1. Accessibility plan	Provision of updated urban accessibility plan and strategy, and political commitment at local, regional and national level.
2. User involvement	The involvement of older and disabled people in relation to a variety of barriers, in all stages planning, implementation, monitoring, and evaluation.
3. Integrated accessibility policy	How the principle of accessibility for all is integrated at all policy stages by all actors: in physical planning, maintenance, procurement, service level agreements, supplier requirements, funding and investment, and the involvement of stakeholders.
Service operations and standards	
4. Meeting user needs	The consideration of all users in all policy stages: personal security policy, complaints and customer satisfaction monitoring, staff training and staff availability.
5. Accessibility maintenance	How plans, routines and monitoring ensure accessibility is maintained.
6. Fare policies and available services	Fare policies, reimbursement procedures and affordability for older and disabled people. The availability of door-to-door transport and special services.
Information, ticketing, vehicles and built environment	
7. Accessible information	Provision of information before and on trip, offering a choice of channels, including information on accessibility in relation to user requirements, disruptions, and emergency procedures. Travel training provision to a broad user group covering a wide range of barriers.
8. Accessible ticketing	Ease of purchasing and validating tickets, provision of simple intuitive systems and multimodal tickets for the whole journey.
9. Accessible vehicles and the built environment	The joint efforts of actors in making access to the public transport system barrier free and easy to find. The percentage of platforms with audio and visual announcements and level access from the pedestrian environment to the platform and vehicle. The percentage of vehicles with a low floor, kneeling mechanisms/ramps, designated place(s) for wheelchair users, and audio and visual announcements.
Seamless travel	
10. Seamless travel	The ease with which older and disabled people are able to travel by public transport on trips which include more than one line or mode, considering information, ticketing, security systems and physical access.

A self-assessment tool has also been developed. Its purpose is to give an indication of the actual quality level of accessibility of public transport, as well as to help authorities and public transport operators determine what will best improve accessibility. This tool has been designed based on the philosophy of Total Quality Management (TQM), recognizing that the development and implementation of accessibility in urban public transport is a dynamic process consisting of consecutive phases that bring accessibility to a higher level of development [20].

6.5 CONDUITS — Coordination of Network Descriptors for Urban Intelligent Transportation Systems (2009 to 2011)

6.5.1 General

With the aim of achieving a common and more holistic approach to the assessment of ITS and traffic management measures, the EU-funded CONDUITS project (2009 to 2011) [21] defined a set of key performance indicators (KPIs) across the main policy areas of traffic efficiency, pollution reduction, road safety, social inclusion and land use. Selected KPIs were then tested in Paris (FR), Rome (IT), Munich (DE), Tel Aviv (IL) and Ingoldstadt (DE).

Four strategic themes of urban traffic management and ITS, were tackled:

- traffic efficiency;
- traffic safety;
- pollution reduction;
- social inclusion and land use.

The proposed methodological evaluation framework is simple to be applied and elaborated for two main reasons:

- national and local authorities can apply the KPIs without great difficulty and with resources readily available when commercial software and devices are used;
- municipalities can market the results to the general public, who in turn can easily understand them in simple terms.

6.5.2 KPI description

6.5.2.1 General

The first part of the project sets the context of performance measurement in the field of urban traffic management and ITS. At first, the concept of performance measurement is defined, outlining the principles of performance measurement and relating them to the cities' needs from an evaluation framework. Then, the steps involved in the development of new performance measures are presented, which include the definition of goals and objectives, the selection of appropriate dimensions, the identification of the selection criteria and the description of data requirements.

Defining the concept of performance measurement, the principles of performance measures are outlined first, making the disambiguation between a performance measure and a performance index. Then, the needs from performance measurement in urban traffic management and ITS are identified [22].

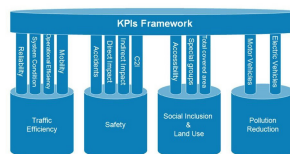


Figure 9 — KPIs Framework

The project gives definitions and identifies the relevant application areas for performance measurement in each of the four strategic themes of urban traffic management and ITS (traffic efficiency, traffic safety, pollution reduction, and social inclusion and land use), in line with the European Commission's strategy on the future of transport, as presented in the 2001 and 2011 white papers [21].

6.5.2.2 Traffic efficiency

The vast majority of urban traffic management policies and solutions, including those involving ITS, have the improvement of traffic efficiency as their objective. While the implementation of a specific policy or technology may have several objectives across the spectrum of urban traffic management, traffic efficiency usually figures high among them. This makes the quantification of the performance in terms of traffic efficiency very important.

The term traffic efficiency may cover a variety of aspects. In this context, traffic efficiency is constituted by the following four sub-categories: mobility, reliability, operational efficiency, system condition, and performance [21].

6.5.2.3 Traffic safety

Despite considerable improvements in recent years, safety is still a key issue within transport planning, as many people are involved in road accidents every day, often suffering injury or death. A variety of measures aiming at reducing traffic accidents have been introduced throughout the last decades; these include in-vehicle fixtures and fitments (seatbelts, airbag, headrests, etc.), as well as on-road traffic engineering features (pedestrian crossings, traffic calming, etc.), with ITS playing a prominent role in both categories (e.g. collision control, variable speed warning signs, etc.). As is expected, the improvement of traffic safety is a priority for city authorities, and the quantification of a city's performance in that aspect is essential [21].

6.5.2.4 Indices for pollution reduction

In order to quantify improvements resulting from the implementation of an urban traffic management or ITS solution in terms of their impact on the environment, an assessment of emissions levels by appropriate vehicle fleets before and after the application is required. Such an assessment is suggested to be carried out with the aid of available emissions simulation models, suited for different types of vehicle fleets under consideration [21].

6.5.2.5 Index for public transport usage of special groups

Several traffic management and ITS applications target the empowerment of special population groups, and particularly the mobility-impaired, to use Public Transport. Comparing the usage of Public Transport by special groups with the average of the population is not applicable in this case, due to the different modal choice patterns of people with mobility impairments. A practical way to assess this modal choice behaviour is the comparison of the potential public transport demand to the realized demand 0.

The public transport usage of special group g , PTU_g , is defined as follows:

$$PTU_g = \frac{PTT_{g,real}}{PTT_{g,pot}}$$

where

- $PTT_{g,real}$ is number of Public Transport users of special group g ;
- $PTT_{g,pot}$ is number of people of special group g with access to Public Transport.

PTU_g represents the percentage of people of special population group g that actually use Public Transport, to the total of group g that has access to Public Transport services. The reference area of the indicator is, as in the social mobility, a geographical space, which can contain the whole city territory, but can also be narrowed down to the area in which the targeted applications are deployed.

PTTg,real can be obtained by two methods. If the user group of the application is distinct, then the application delivers the necessary data. This is the case mostly for personalized ITS systems, such as personal mobility assistants. If the actual circle of users is unknown, however, the necessary data can be acquired by extensive passenger surveys. The value of PTTg,pot can be approximated through GIS databases. Since it is impossible to know the exact location and demand pattern of all people of group g , their percentage in the population can be used to calculate their theoretical distribution in the area concerned.

In the special case of mobility-impaired users, if the data concerning the public transport system are attributed with barrier information, then the number of potential passengers with access to a barrier-free public transport system can be elaborated and used as the value of PTTg,pot. While there is uncertainty within this approach, since the OD-matrix of the potential passengers is not known and a non-use of public transport can be the result of lacking suitable connections rather than barriers, it can still be used in the absence of a more exact approach given the means of public authorities.

PTUg is dimensionless taking values from 0 to 1, and for specific case studies it may also be used as a performance index. However, for the complete assessment of public transport usage by special groups, the various PTUg values for different population groups can be cumulated into a combined KPI, representing the average public transport usage of all special population groups (set G). The resulting average public transport usage KPI, I_{PTU} , is defined as follows:

$$I_{PTU} = \sum_{g \in G} \frac{|G|}{w_g} \cdot PTU_g$$

where

w_g is weight representing the importance of special group g .

It should be noted that even though IPTU (and PTUg) is dimensionless, it cannot be combined with the social mobility KPI, as they refer to different sizes of total population [21].

6.6 METPEX — a MEasurement Tool to determine the quality of Passenger Experience (2012 to 2015)

6.6.1 General

METPEX is a research project funded in the context of the 7th Framework Programme of the EU, aiming to develop and evaluate a standardized tool to measure passenger experience across whole journeys. METPEX stands for MEasurement Tool to determine the quality of Passenger EXperience and its results will be used to inform policy makers in providing inclusive, passenger-oriented integrated transport systems that are accessible by all citizens [23].

The METPEX consortium is coordinated by Coventry University and brings together 16 European partners, from 12 countries (Ireland, Belgium, Spain, Switzerland, Italy, Greece, Sweden, Romania, France, Portugal, and Lithuania) [24].

Two central arguments of METPEX were:

- travellers would only be attracted to public/active forms of transport if they are perceived to be of high quality;
- the whole journey experience needs to be the focus of attention as this corresponds to mobility patterns.

METPEX aimed to develop a set of KPIs, which could be used by transport operators and authorities, local authorities and other interest groups to measure the quality of the whole journey experience.