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Public transport — Reference data model

Part 8: Management information & statistics

National foreword

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Partie 8 : tableaux de bord et statistiques

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Managementinformationen und Statistiken

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Contents

Page

European foreword.....	7
Introduction	8
1 Scope	9
1.1 General Scope of the Standard.....	9
1.2 Functional Domain Description	10
1.3 Particular Scope of this Document.....	10
2 Normative references	10
3 Terms and definitions	11
3.1 General Terms and Definitions:	11
3.2 Domain Specific Terms and Definitions:	13
4 Symbols and Abbreviations.....	14
5 Management Information and Statistics Domain.....	14
5.1 Introduction	14
5.1.1 Information Needs	14
5.1.2 Calculation of indicators.....	15
5.1.3 Functions Covered	17
5.1.4 Limitations of the Model.....	18
5.2 Management Information and Statistics Data Model.....	19
5.2.1 Loggable Objects Model	19
5.2.2 Logging Time and Place	19
5.2.3 Recorded Objects	20
5.2.4 Recorded Use of Services.....	24
5.2.5 Examples of use of the LOGGABLE OBJECT pattern	25
Annex A (normative) Data Dictionary	31
A.1 Introduction	31
A.2 Data Dictionary — Management Information and Statistics.....	31
A.2.1 BOARDING AND ALIGHTING	31
A.2.2 BOARDING BASED PASSENGER COUNT	31
A.2.3 DATED JOURNEY INFORMATION RECORDING	31
A.2.4 INTERCHANGE STATUS	32
A.2.5 LOCATED EVENT	32
A.2.6 ONBOARD DEVICE BASED PASSENGER COUNT.....	32
A.2.7 RECORDED LEG	33
A.2.8 RECORDED STOP	33
A.2.9 RECORDED TRIP	33
A.2.10 TICKETING BASED PASSENGER COUNT	33
Annex B (normative) Additional Common Concepts — Extension to EN 12896-1:2016, <i>Public transport – Reference data model – Part 1: Common Concepts</i>	34

B.1	Methodology and Conventions	34
B.1.1	Methodology for conceptual modelling.....	34
B.1.1.1	General	34
B.1.1.2	Packages.....	34
B.1.1.3	Package Prefixes and Package order.....	35
B.1.1.4	Part Prefixes and diagram names.....	36
B.1.1.5	Class diagrams	36
B.1.1.6	Class Diagram Presentations.....	37
B.1.1.7	Use of Colour.....	37
B.1.2	MODEL Class Diagrams.....	38
B.1.2.1	General	38
B.1.2.2	Classes and attributes	39
B.1.2.2.1	General.....	39
B.1.2.2.2	Attribute visibility.....	39
B.1.2.2.3	Attribute names	40
B.1.2.2.4	Attribute types	40
B.1.2.2.5	Multiplicity of Attributes	40
B.1.2.2.6	Common attributes.....	40
B.1.2.2.7	Simple Diagram Example	40
B.1.2.3	Relationships.....	42
B.1.2.3.1	General.....	42
B.1.2.3.2	Association relationships.....	42
B.1.2.3.3	Reflexive associations	42
B.1.2.3.4	Aggregation relationship.....	43
B.1.2.3.5	Generalization relationship	44
B.1.2.3.6	Multiplicity (Cardinality) of Relationships.....	45
B.1.2.3.7	Presence of Relationships on a given diagram.....	45
B.1.2.3.8	Relationships and navigability.....	46
B.1.2.3.9	Positional semantics for laying out classes and relationships	47
B.1.2.3.10	Explicit Frames.....	47
B.1.3	Summary of Rules for Transmodel Presentation.....	48
B.1.3.1	Presentation of Class Structure diagrams	48
B.1.3.2	Rules for naming and presenting classes.....	48
B.1.3.3	Rules for use of role names	49
B.1.3.4	Rules for use of multiplicity	50
B.1.3.5	Rules for relationship qualifiers	50

B.1.3.6 Rules for presenting relationships	51
B.1.3.7 Rules for Placing Role names.....	51
B.2 Extensions to the Common Concept MODEL.....	52
B.2.1 General.....	52
B.2.2 Additional Common Concepts	52
B.2.2.1 Additional Generalizations.....	52
B.2.2.1.1 Generic Type of Value – Conceptual MODEL	52
B.2.2.1.2 Generic Assignment – Conceptual MODEL.....	53
B.2.2.1.3 Generic Section – Conceptual MODEL.....	54
B.2.3 Extensions to the Generic Framework	55
B.2.3.1 General.....	55
B.2.3.2 Alternative Text – Conceptual MODEL.....	55
B.2.3.3 Generic View – Conceptual MODEL.....	56
B.2.3.4 Generic Loggable Object – Conceptual MODEL.....	57
B.2.3.5 Event Model – Conceptual MODEL.....	57
B.2.4 Extensions to the Reusable Components.....	58
B.2.4.1 Employee Model – Conceptual MODEL	58
B.2.4.2 Message Model – Conceptual MODEL.....	59
B.2.4.2.1 Messages	59
B.2.4.2.2 Publication Scope	60
B.2.4.3 Role Model – Conceptual MODEL.....	61
B.2.4.3.1 Generic Roles.....	61
B.2.4.3.2 Service Organization Roles	62
B.2.4.3.3 Employee Roles	62
B.2.4.3.4 Administrative Organization Roles.....	63
B.2.4.3.5 Technology Organization Roles.....	64
B.2.4.3.6 Messaging Roles	65
B.2.4.3.7 Transport Customer Roles	66
B.2.4.4 Security List – Conceptual MODEL	66
B.2.4.5 Transfer Time – Conceptual MODEL	67
B.2.5 Data Dictionary	67
B.2.5.1 General.....	67
B.2.5.2 ADMINISTRATIVE ORGANIZATION ROLE.....	68
B.2.5.3 ALTERNATIVE TEXT	68
B.2.5.4 ASSIGNMENT	68
B.2.5.5 BLACKLIST	68

B.2.5.6 CLASS ATTRIBUTE	69
B.2.5.7 CONDUCTOR ROLE.....	69
B.2.5.8 CUSTOMER SERVICE PROVIDER ROLE	69
B.2.5.9 CUSTOMER SERVICE ROLE.....	69
B.2.5.10 DATA COLLECTOR ROLE	70
B.2.5.11 DRIVER ROLE	70
B.2.5.12 EMPLOYEE.....	70
B.2.5.13 EMPLOYEE ROLE.....	70
B.2.5.14 EVENT	71
B.2.5.15 GENERAL EVENT	71
B.2.5.16 GENERAL OBSERVER ROLE	71
B.2.5.17 GENERAL SECTION	71
B.2.5.18 LOG	72
B.2.5.19 LOG ENTRY	72
B.2.5.20 LOGGABLE OBJECT	72
B.2.5.21 MESSAGE.....	72
B.2.5.22 MESSAGE PART	73
B.2.5.23 MESSAGE PRIORITY.....	73
B.2.5.24 ORGANIZATION ROLE.....	73
B.2.5.25 PT SCOPE	73
B.2.5.26 PUBLICATION APPROVER ROLE	73
B.2.5.27 PUBLICATION DECISION	74
B.2.5.28 PUBLICATION SCOPE.....	74
B.2.5.29 PUBLICATION WINDOW	74
B.2.5.30 PUBLISHING ACTION.....	74
B.2.5.31 PUBLISHING CHANNEL	75
B.2.5.32 QUALIFICATION	75
B.2.5.33 REGISTRAR ROLE	75
B.2.5.34 SECTION.....	75
B.2.5.35 SECTION IN LINK SEQUENCE	76
B.2.5.36 SECURITY LIST.....	76
B.2.5.37 SECURITY LISTABLE.....	76
B.2.5.38 SECURITY LISTING	76
B.2.5.39 SECURITY MANAGER ROLE	76
B.2.5.40 SERVICE OPERATOR ROLE	77
B.2.5.41 SITUATION AUTHOR ROLE	77

B.2.5.42 SPECIFIC OBSERVER ROLE.....	77
B.2.5.43 STATION EMPLOYEE ROLE	77
B.2.5.44 TECHNOLOGY ORGANIZATION ROLE.....	78
B.2.5.45 TRAFFIC INFORMATION OFFICER ROLE.....	78
B.2.5.46 TRANSFER TIME.....	78
B.2.5.47 TRANSPORT USER ROLE.....	78
B.2.5.48 TRAVEL DOCUMENT CONTROLLER ROLE	79
B.2.5.49 TRAVEL DOCUMENT CONTROLLING ORGANIZATION ROLE	79
B.2.5.50 TRAVEL ORGANIZATION ROLE	79
B.2.5.51 TYPE OF AUDIENCE	79
B.2.5.52 TYPE OF EVENT	80
B.2.5.53 TYPE OF MESSAGE	80
B.2.5.54 TYPE OF MESSAGE PART CONTENT	80
B.2.5.55 TYPE OF QUALIFICATION.....	80
B.2.5.56 TYPE OF SECURITY LIST	81
B.2.5.57 TYPE OF VALUE.....	81
B.2.5.58 View	81
B.2.5.59 WHITELIST	81
Annex C (informative) Data Model Evolutions.....	83
C.1 Change Requests.....	83
C.2 Source of Text.....	83
C.3 Diagram Status	83
Bibliography.....	85

European foreword

This document (EN 12896-8:2019) has been prepared by Technical Committee CEN/TC 278 “Intelligent transport systems”, the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2020, and conflicting national standards shall be withdrawn at the latest by March 2020.

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.

The series is composed of the following documents:

- *Public transport – Reference data model – Part 1: Common concepts;*
- *Public transport – Reference data model – Part 2: Public transport network;*
- *Public transport – Reference data model – Part 3: Timing information and vehicle scheduling;*
- *Public transport – Reference data model – Part 4: Operations monitoring and control;*
- *Public transport – Reference data model – Part 5: Fare management;*
- *Public transport – Reference data model – Part 6: Passenger information;*
- *Public transport – Reference data model – Part 7: Driver management;*
- *Public transport – Reference data model – Part 8: Management information & statistics; and*
- *Public transport – Reference data model – Part 9: Informative documentation [CEN/TR].*

Together these create version 6 of the European Standard EN 12896, known as “Transmodel”, and thus replace EN 12896:2006, known as “Transmodel v5.1”.

In comparison with EN 12896:2006, the technical modifications made are presented in CEN/TR 12896-9, *Public transport – Reference data model – Part 9: Informative Documentation*.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Part 1 of this European Standard presents the following items:

- Rationale for the Transmodel Standard;
- Use of the Transmodel Standard;
- Applicability of the Transmodel Standard;
- Conformance Statement;
- Transmodel Origins;
- Reference to the Previous Version and Other Documents.

The data structures represented in Part 1 are generic patterns that are referenced by different other parts.

Part 2 of this European Standard presents space-related data structures.

Part 3 presents time-related data structures and replaces the sections of EN 12896:2006 referring to the time-related Tactical Planning Components and to Vehicle Scheduling.

Part 4 presents data referring to daily operations (i.e. to operational days), different from those planned for day types (space-related data structures and tactical planning components) and including operational raw data referring to operations follow-up.

Part 5 presents fares structures including sales, validation and control.

Part 6 presents Passenger Information (planned and real-time).

Part 7 presents Driver Management including Driver Scheduling (day-type related driver schedules), Rostering (ordering of driver duties into sequences according to some chosen methods) and Driving Personnel Disposition (assignment of logical drivers to physical drivers and recording of driver performance).

Part 8 (this part) presents Management Information and Statistics.

1 Scope

1.1 General Scope of the Standard

The main objective of the present standard is to present the Reference Data Model for Public Transport, based on:

- the Reference Data Model, EN 12896, known as Transmodel V5.1;
- EN 28701:2012, *Intelligent transport systems – Public transport – Identification of Fixed Objects in Public Transport (IFOPT)*, although note that this particular standard has been withdrawn as it is now included within Parts 1 and 2 of this standard (EN 12896-1:2016 and EN 12896-2:2016) following their successful publication;

incorporating the requirements of:

- EN 15531-1 to -3 and CEN/TS 15531-4 and -5: *Public transport – Service interface for real-time information relating to public transport operations (SIRI)*;
- CEN/TS 16614-1 and -2: *Network and Timetable Exchange (NeTEx)*, in particular the specific needs for long distance train operation.

Particular attention is drawn to the data model structure and methodology:

- the data model is described in a modular form in order to facilitate the understanding and the use of the model;
- the data model is entirely described in UML.

The following functional domains are considered:

- Network Description: routes, lines, journey patterns, timing patterns, service patterns, scheduled stop points and stop places;
- Timing Information and Vehicle Scheduling (runtimes, vehicle journeys, day type-related vehicle schedules);
- Passenger Information (planned and real-time);
- Fare Management (fare structure, sales, validation, control);
- Operations Monitoring and Control: operating day-related data, vehicle follow-up, control actions;
- Driver Management:
 - Driver Scheduling (day-type related driver schedules),
 - Rostering (ordering of driver duties into sequences according to some chosen methods),
 - Driving Personnel Disposition (assignment of logical drivers to physical drivers and recording of driver performance);
- Management Information and Statistics (including data dedicated to service performance indicators).

The data modules dedicated to cover most functions of the above domains will be specified.

Several concepts are shared by the different functional domains. This data domain is called “Common Concepts”.

1.2 Functional Domain Description

The different functional domains (enumerated above) taken into account in the present document, and of which the data have been represented as the reference model, are described in EN 12896-1:2016, *Public transport – Reference data model – Part 1: Common Concepts*.

1.3 Particular Scope of this Document

The present document entitled *Public transport – Reference data model – Part 8: Management information & statistics* describes how to structure data which refers to the planning stages (e.g. timetables, run times, driver rosters, etc.) and/or to the daily actual production, and which is registered for different purposes, in particular to build service performance indicators. The data model is based on a generic design pattern, Generic Loggable Objects Model (provided in the Additional Common Concepts part – Annex B), and incorporates the following data packages:

- Logging Time and Place, providing additions to the Generic Loggable Objects Model,
- Recorded Objects,
- Recorded Use of Services,
- Service Journey Performance.

The last three packages show how the recorded data contributes to the implementation of indicators.

This document itself is composed of the following parts:

- Main document (normative),
- Annex A (normative), containing the data dictionary, i.e. the list of all the concepts and attribute tables present in the main document together with the definitions,
- Annex B (normative), providing a complement to EN 12896-1:2016, particularly useful for Parts 4 to 8 of the Public Transport Reference Data Model;
- Annex C (informative), indicating the data model evolution from the previous version.

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 12896-1:2016, *Public transport – Reference data model – Part 1: Common concepts*

EN 12896-2:2016, *Public transport – Reference data model – Part 2: Public transport network*

EN 12896-3:2016, *Public transport – Reference data model – Part 3: Timing information and vehicle scheduling*

ISO 4217:2015, *Codes for the representation of currencies*

ISO 80000-1:2009, *Quantities and units – Part 1: General*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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 General Terms and Definitions:

3.1.1

attribute

property of an entity

3.1.2

conceptual data model

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

3.1.3

conceptual level

conceptual data model in the context of data modelling

3.1.4

database

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

3.1.5

data domain

data structure (in this European Standard, part of the Reference Data Model for Public Transport) made up of data related to each other, through the fact that there is a functional area or group of functions using this data set as a whole

3.1.6

data model

description of a real-world domain in terms of data and relationships

3.1.7

entity

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

3.1.8

fare management

all activities related to the collection of money from passengers

3.1.9

function

activity which, in this European Standard, is a sub-activity of a functional area

3.1.10

functional area

arbitrarily defined set of activities, used, in this European Standard, to define the objectives and limits of the data model

3.1.11

interoperability

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

3.1.12

logical data model

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

3.1.13

logical denormalized model

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

3.1.14

logical level

logical data model in the context of data modelling

3.1.15

management information

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

3.1.16

object-oriented data model

data structure expressed according to principles that allow for a direct implementation as an object-oriented database, where information is represented in form of objects, i.e. respecting the principle of encapsulation meaning in particular that each data are accessed or modified through operations (methods) belonging to it

3.1.17

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 such as traffic light priority, track switching, bay selection, advance/delay advice, etc.

3.1.18

passenger information

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

3.1.19

personnel disposition

all activities related to the mid-term and short-term management of drivers

3.1.20

real-time control

see Operations monitoring and control

3.1.21**relational data model**

type of logical data model giving the information as series of tables (relations) and attributes, and possessing the following characteristics:

- a) all attribute values are atomic;
- b) all “tuples” (rows/occurrences) are distinct;
- c) no part of the primary key may be null; and
- d) foreign key values must correspond to an existing primary key in another relation or be null

3.1.22**scheduling**

see Tactical Planning

3.1.23**tactical planning**

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

3.2 Domain Specific Terms and Definitions:

NOTE The following terms specific to the Management Information and Statistics domain are used. Terms which are also data entity names are defined in the data dictionary in Annex A and are mostly not repeated here.

3.2.1**aggregation frame**

data structure within which the data values are grouped and used for a formula to provide an indicator

3.2.2**indicator**

set of data (calculated or measured) which may be either qualitative or quantitative that is used to provide information on the status (may be a measure, a functional state, etc.) or the quality of a service or a function

3.2.3**indicator type**

category of a given indicator, e.g. time, length, passenger count, price, vehicle, etc.

3.2.4**indicator unit**

measurement unit (e.g. metres, seconds, passengers, etc.) in which a specific indicator is measured

3.2.5**formula**

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

3.2.6**granularity**

input for calculation processes representing the smallest unit(s) to generate output indicator(s)

3.2.7

O/D matrix

tabular structure describing data by origin/destination parameters (e.g. daily traffic volume between zones)

3.2.8

indicator parameter type

category of a given indicator parameter, e.g. time, length, passenger count, price, vehicle, etc.

3.2.9

indicator parameter unit

measurement unit (e.g. meters, seconds, passengers, etc.) in which a specific indicator parameter is measured

4 Symbols and Abbreviations

IFOPT	Identification of Fixed Objects in Public Transport
ISO	International Organization for Standardization
IT	Information Technology
O/D	Origin / Destination
PT	Public Transport
PTO	Public Transport Operator
SI	International System of Units (abbreviated from the French <i>Système international</i>)
SIRI	Service Interface for Real-time Information
TM	Transmodel
UML	Unified Modelling Language

5 Management Information and Statistics Domain

5.1 Introduction

5.1.1 Information Needs

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 public transport, 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 to data storage, allow the provision of the necessary data in production databases, against which the desired requests can be made by public transport

managers. Consistent data structures make the design of such requests easier, and offer the flexibility required to meet a large variety of needs.

5.1.2 Calculation of indicators

The number of different ways of processing PT data in order to issue relevant and synthetic information reports for managers is almost infinite. The criteria for doing so will depend on local conditions, on the level of management, on the time scale of the analysis, etc. The objective of the reference model is not to describe the processing methods, but to offer data structures able to fulfil their manifold requirements.

The result of raw data processing provides different types of indicators, each specialized for reporting information on a specific aspect of public transport (Service Demand, Commercial Speed, etc.).

An *indicator* relates to a set of data (planned, measured, or a combination of both) and may be either qualitative or quantitative. Indicators of lower level objects may be overridden by higher level objects (e.g. an indicator related to the ROUTE can override the aggregation - summary, average, etc. - of indicators related to ROUTE LINK).

Indicators may be of several *indicator types*, for example, they may describe the time, length, passenger count, price, vehicle, etc.

An *indicator unit* is used to describe the measurement unit of quantitative indicators. Unit names shall follow standards ISO 4217:2015 for currency codes, and ISO 80000:2009 for SI units.

A set of parameters may be associated with any indicator to represent the scope of that particular indicator (for example, a TIME BAND and a DAY TYPE for a passenger count indicator).

Indicator parameter type describes categories of the indicator parameter: time, length, passenger count, price, vehicle, etc.

Indicator parameter unit describes the measurement unit of quantitative indicator parameters. Unit names shall follow standards ISO 4217:2015 for currency codes, and ISO 80000:2009 for SI units.

A *formula* describes the method to calculate indicators that are based on other indicators and/or on a set of raw data.

An *aggregation frame* describes a data structure within which the data values are grouped and used for a formula to provide an indicator.

A *granularity* entity determines the smallest unit(s) in a calculation process which generates indicator(s).

A calculation process that generates the indicators is characterized by indicator parameters, formula, aggregation frame and granularity unit.

The main elements used to calculate indicators are presented in the figure below.

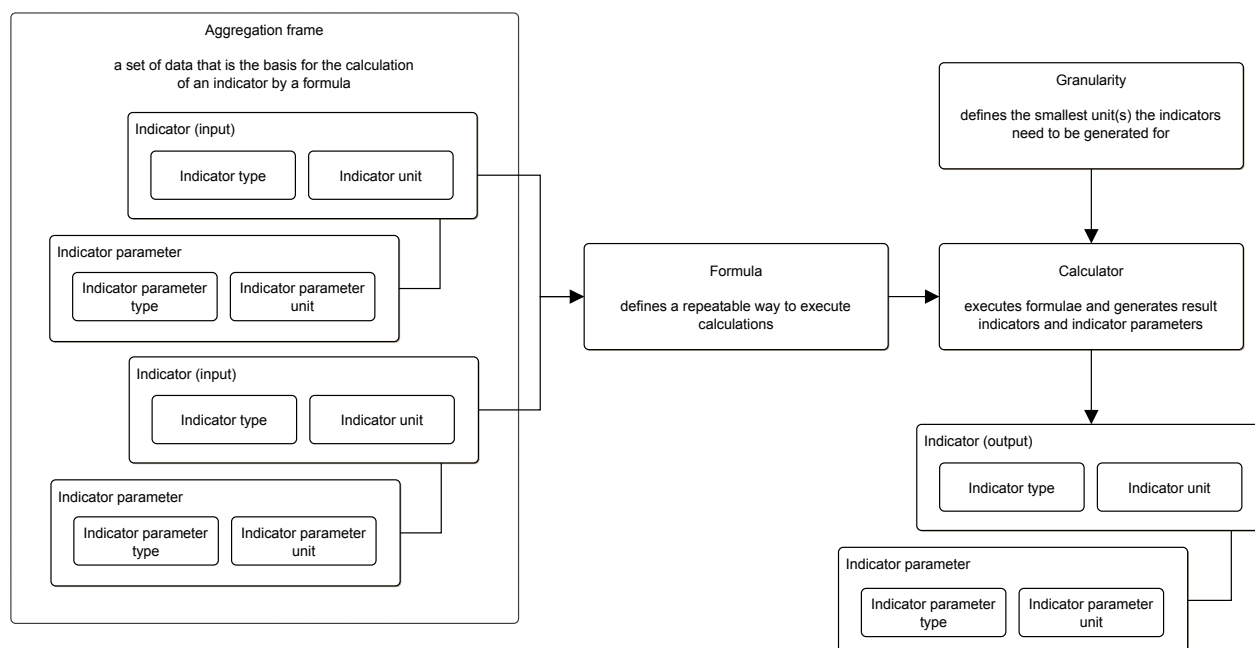


Figure 1 — Calculation of indicators

This figure also indicates that indicators might be generated by a previous (nested) calculation, and might be used in another calculation process.

For example, the calculation of the length of a tram network for each infrastructure operator (assuming there are more than one) may be modelled as follows:

- indicator (input): length of the projection of ROUTE LINKs on the infrastructure, parameterized by infrastructure operator;
- aggregation frame: defines a set of ROUTE LINKs that make up the network;
- granularity: defines that the indicators shall be grouped by infrastructure operator;
- formula: calculates the sums of the length of each item in the aggregation frame;
- calculator: executes the formula for each infrastructure operator;
- indicator (output): total length of the network, parameterized by infrastructure operator.

A typical use of indicators is when the actual service has to be compared to the planned service. To ensure the same indicator parameters are used in the comparison, a common granularity definition might be needed to govern the calculation processes and provide the same level of detail for both actual (measured) and planned service indicators. This is illustrated by the figure below.

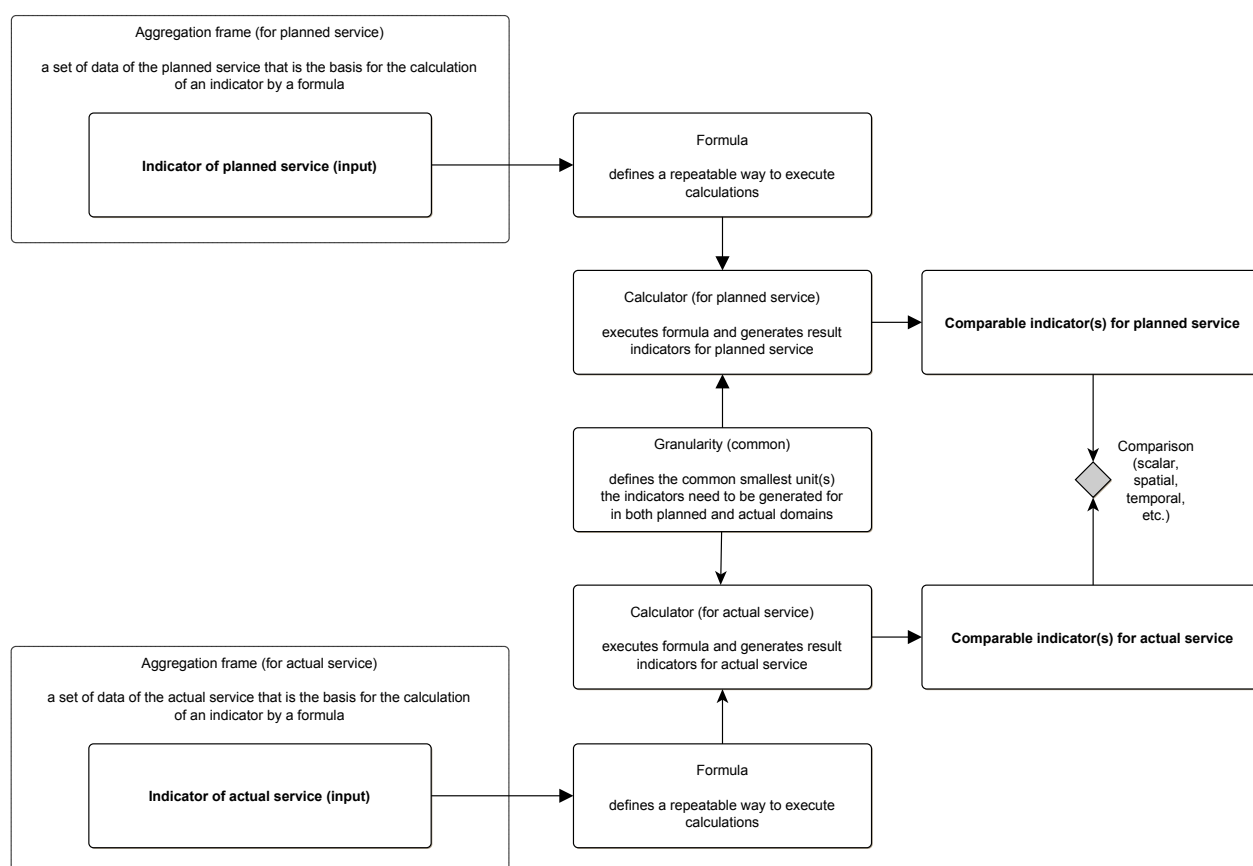


Figure 2 — Comparison of planned and actual service indicators

5.1.3 Functions Covered

The following functions as defined in Operating Raw data and statistics exchange are covered by Transmodel v6:

- Service dimensions:** this function considers all the information to evaluate the dimension of the service in terms of number of lines, journeys, available seats, etc.
- Commercial speed:** this function considers all the information needed to evaluate the commercial speed of the fleet.
- Service spatial coverage:** this function considers all the information relevant to the characteristics of the service offer in terms of spatial coverage of the territory where the service is performed.
- Service temporal coverage:** this function considers all the information relevant to the characteristics of the service offer in terms of temporal coverage of the territory where the service is performed.
- Service interchange nodes:** this function considers all the information relevant to the characteristics of the service offer to evaluate the interchanges at specific PLACES.
- O/D zones connections:** this function considers all the information relevant to the characteristics of the service demand to evaluate connections among different ZONES.

- g) O/D Matrix: this function considers all the information relevant to the characteristics of the service demand to evaluate movement of passengers among different ZONES.
- h) O/D zones moving cause: this function considers all the information relevant to the characteristics of the service demand needed to evaluate movement causes of passengers among different ZONES (school, work, etc).
- i) Demand Dimensions: this function considers all the information relevant to the characteristics of the service demand to evaluate the number of passengers that use the public transport service.
- j) Load factor: this function considers all the information relevant to the characteristics of the service demand to evaluate the load of VEHICLES.
- k) Service performed distance: this function considers all the information to calculate performed distance.

An important source of information for the management of a public transport company is the evaluation of the current timetables. The key questions that can be answered from this evaluation are:

- to what extent is the timetable practicable with the available means?
- does it suit the demand requirements?
- is the desired level of quality reached?

This process includes the analysis of service journey performance, the study of observed passing or run times and stopping times at stop points, the detection of sections where vehicles are slowed down by the traffic, the analysis of regular disturbances and modifications to the service, the study of missed interchanges, etc.

Another important input comprises data on the use of the network by travellers. Such information can provide a significant contribution to an improved knowledge of passenger demand and behaviour, as well as indicating how to adapt the supply to satisfy such factors. This may include the analysis of the number of boarding and alighting passengers at stop points, the vehicle occupancy on service links, the origin and destination places of passenger trips, possible interchanges, etc.

5.1.4 Limitations of the Model

The following functions defined in Operating Raw data and statistics exchange are not covered by Transmodel v6:

- a) Fleet dimensions: this function considers all the information to calculate the dimension of the fleet (number and kind of vehicles, etc.).
- b) Service safety: this function considers all the information to evaluate the safety of the PT service in terms of, for example, accidents that have occurred, etc.
- c) Service pollution emissions: this function considers all the information to evaluate environment impacts due to the emission of pollutants.
- d) Service incoming funds; this function considers all the information to calculate the economy aspects of the PT service (public funds, revenues from sold tickets, etc.).
- e) Service costs: this function considers all the information to calculate expenses to maintain and to sustain the PT Service.

- f) PTO dimensions: this function considers all the information to calculate the characteristics of a PTO (like number of employees, drivers, etc.).

The reference model describes only elementary data (e.g. number of passengers boarding a particular vehicle at a defined stop points). The various possible aggregations of such data, which depend to a large extent on the manager own requirements, are not described.

There are numerous other areas of interest with respect to management information, for instance the analysis of driver work, the mechanical behaviour of vehicles, and revenue patterns. However, these areas are not covered by the current version of the reference model.

5.2 Management Information and Statistics Data Model

5.2.1 Loggable Objects Model

The Generic Loggable Object MODEL present in the Additional Common Concepts Package (Annex B) presents the basic pattern on which is based the data structure for registered data. The LOGGABLE OBJECT represents an ENTITY being monitored for significant events and changes of state; successive states and events affecting the entity are recorded as a set of LOG ENTRIES, making up a temporal trace that can be analysed for management purposes or examined for audit purposes. LOGGABLE OBJECT is a design pattern uses widely in Transmodel.

Note that this design pattern is sometimes explicitly used (for example in VEHICLE MONITORING in Part 4, EN 12896-4) but is available for being used on any object whenever there is a use case for it. This is especially true for Management Information and Statistics: this pattern can be applied to any Transmodel object being of use for Management and Statistics.

A LOG ENTRY is the single record of an event and may contain measurements as well as a record of the current state of some or all of the attributes of a LOGGABLE OBJECT, supplied by a DATA SOURCE. LOG ENTRIES occur in temporal sequence, together making up a LOG.

LOGs will typically be archived or purged once their data are no longer of interest.

An EVENT can be described as something happening to a LOGGABLE OBJECT, i.e. a change of the attributes or the status of a LOGGABLE OBJECT. The EVENT itself is not necessarily represented in the implementation system. The LOG ENTRY is the class in the model designated to represent the EVENT, recording only its salient aspects.

5.2.2 Logging Time and Place

An EVENT can signify changes occurring to an ENTITY in both temporal and spatial dimensions. When an EVENT has spatial attributes, it becomes a LOCATED EVENT and has geographical attributes that can refer to:

- the ZONE in which the LOCATED EVENT is located.
- the POINT where the LOCATED EVENT occurs.
- the LINK on which the LOCATED EVENT is located.

A ZONE can be represented by its functional centroid, an instance of POINT; a LINK can be referenced by its start POINT and end POINT. A LOG ENTRY may also reference the actual ZONES, POINTs or LINKs if this is relevant for analysis.

The temporal dimension of a LOCATED EVENT should always conform to ISO 8601:2004. In addition to the timestamp of the EVENT, it also provides the date and time at which the event has been received.

The LOG ENTRY will record, among other attributes, the identifier of the LOGGABLE OBJECT, the timestamp and the spatial attributes.

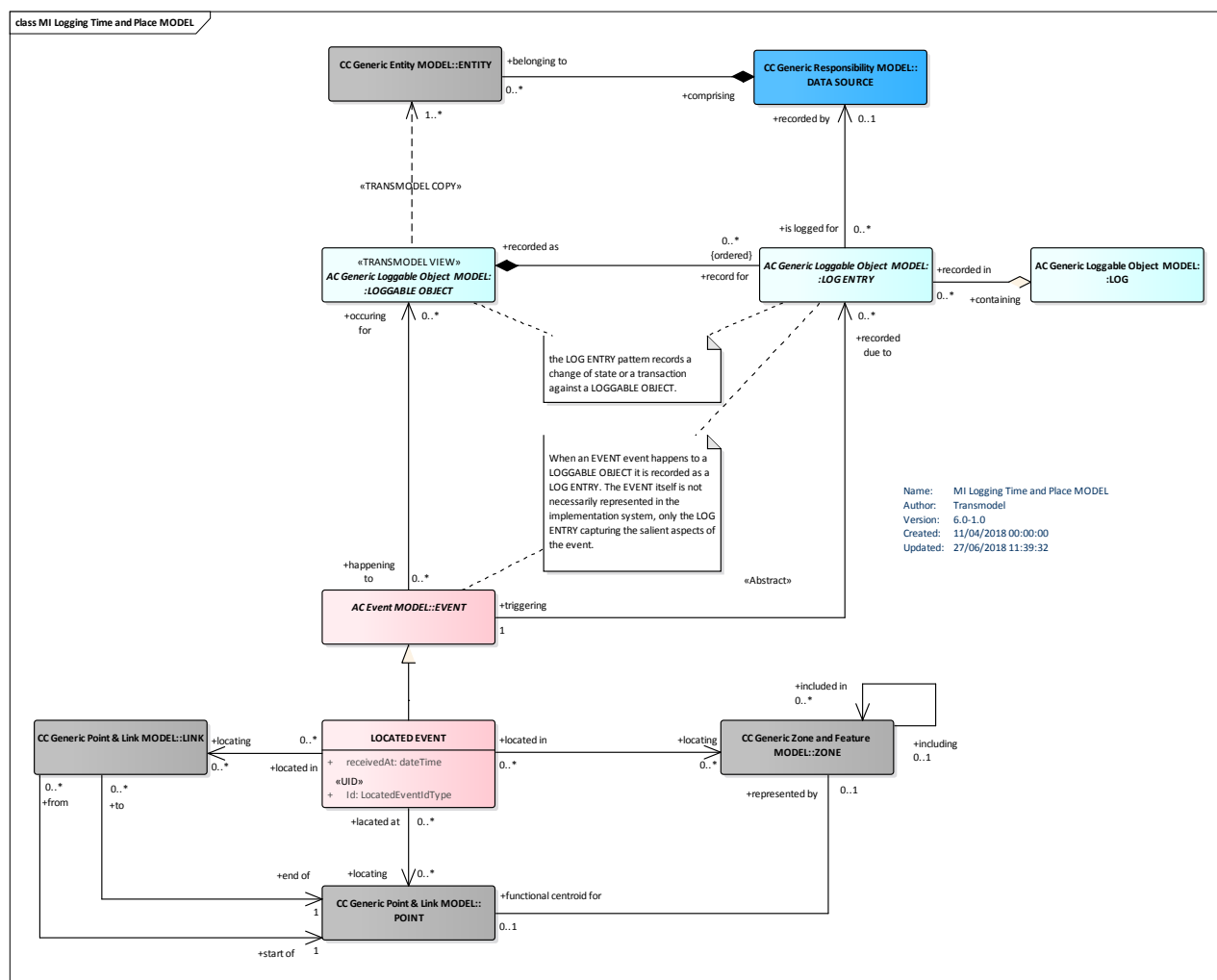


Figure 3 — Logging time and place MODEL

5.2.3 Recorded Objects

5.2.3.1 Recording Service and Vehicle Performance Events

The record of events related to the performance of vehicle journeys, in particular service journeys, on each day of their operation is an important source of information for management information. The main information to record is the following:

- actual passing times at points along the route;
- the number of passengers boarding and alighting and the time taken to do so;
- the occurrence of impeded time;
- interchange realization;
- the occurrence of disturbances.

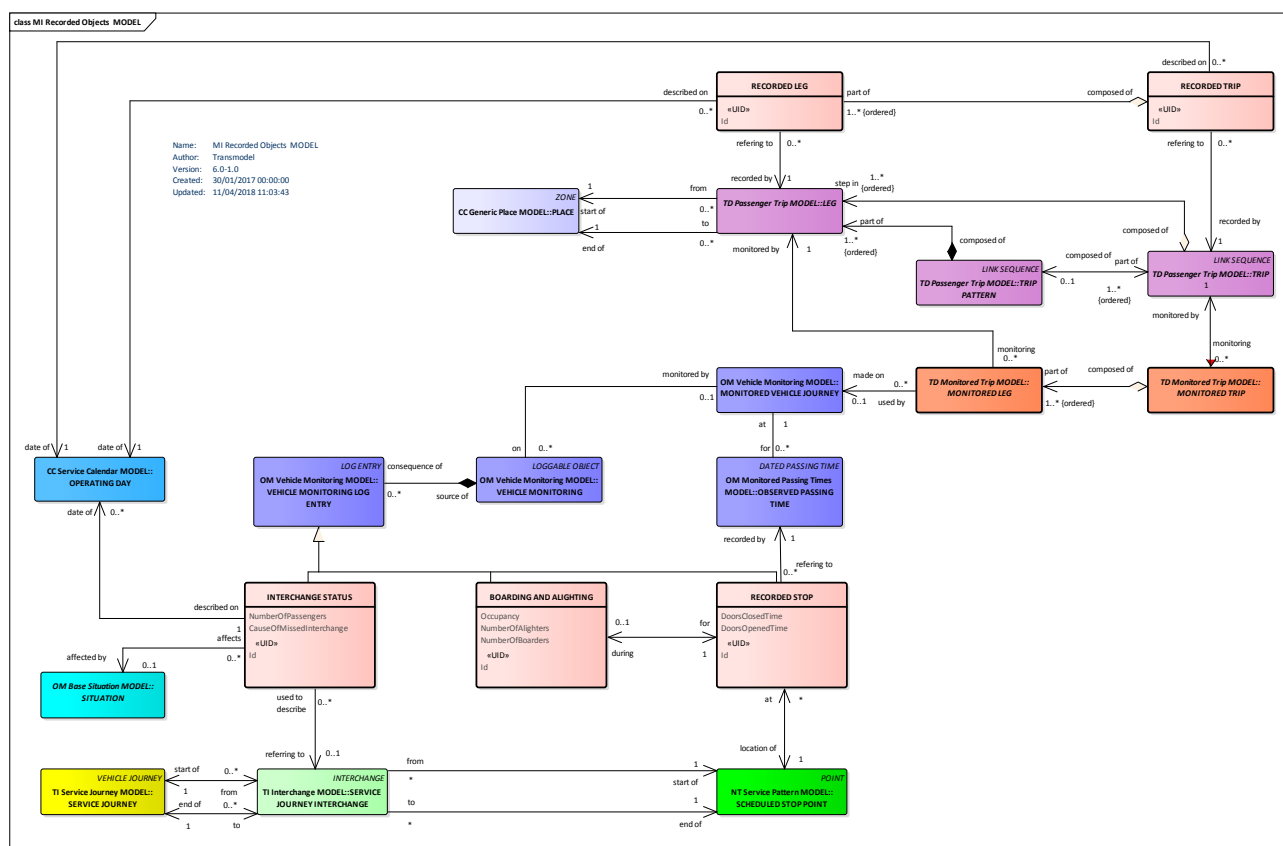


Figure 4 — Recorded Objects MODEL

5.2.3.2 Journeys

The data for the subsequent evaluation of service journeys is collected during operations through recording MONITORED VEHICLE JOURNEYS (as described in EN 12896-4). Such journeys are observed actual journeys, as recognized by a monitoring system, operated on the OPERATING DAY on which the data are collected. The term “monitoring” should be understood in a wide sense that embraces both automated and manual survey means.

However, it is of a great importance for management information to be able to relate, as far as possible, any such monitored journeys to the plan assigned to them, in order to compare the actual production performance against the original plan. Therefore, a MONITORED VEHICLE JOURNEY will relate, in most cases, to a DATED VEHICLE JOURNEY. The latter represents the latest valid plan assigned to the considered vehicle.

Most DATED VEHICLE JOURNEYS will be NORMAL DATED VEHICLE JOURNEYS, which means that they are copied from a schedule designed for a DAY TYPE to be applied on the particular OPERATING DAY. Others are extra DATED VEHICLE JOURNEYS, created by a CONTROL ACTION to meet a specific set of circumstances.

Any DATED VEHICLE JOURNEY may have been amended by CONTROL ACTIONS (e.g. by shortening of the ROUTE, an added departure lag, etc.).

5.2.3.3 Recorded Passing Times

The passing time of a vehicle is recorded as an OBSERVED PASSING TIME. It refers to a given MONITORED VEHICLE JOURNEY and is recorded at a particular POINT. An OBSERVED PASSING TIME is a specialization of DATED PASSING TIME.

The POINT in question may be a SCHEDULED STOP POINT, a TIMING POINT or any other type of POINT defined for a measurement purpose. For instance, in order to evaluate the influence of the traffic on a bus line, passing times may be recorded at the entry point then at the exit point of a complex road junction. OBSERVED PASSING TIMES may be recorded at TIMING POINTs in order to check whether standard run times are appropriate, or at STOP POINTs to check the service punctuality as a quality indicator.

If the vehicle stops at a POINT, an OBSERVED PASSING TIME may record an arrival time or a departure time, or both; alternatively, it may record simply a passing time. If the vehicle stops, the waiting time (i.e. the period during which the vehicle is not moving) may also be recorded.

5.2.3.4 Recorded Stops

It is of interest to record when a vehicle actually stops at a SCHEDULED STOP POINT and opens the doors to allow passengers to board or alight. This information is useful in particular on networks where vehicles only stop when a passenger (onboard or waiting at the stop point) requests it to do so. The duration of the period during which the doors are open is also of interest, as it can be used to refine the schedules or to consolidate demand data. This duration of the period that the doors are open is often different from that of the time the vehicle is actually halted at the stop.

The entity RECORDED STOP is used to describe the above information. It is referencing an OBSERVED PASSING TIME, extending the information captured. RECORDED STOPs may only be created for a SCHEDULED STOP POINT. Note that, when the vehicle has several doors, the DoorsOpenedTime is the time of opening of the first door and the DoorsClosedTime is the time when the last door is closed. A RECORDED STOP follows the LOGGABLE OBJECT design pattern (and therefore inherits from LOGGABLE OBJECT).

5.2.3.5 Boarding and Alighting

During a RECORDED STOP, i.e. when a vehicle stops at a STOP POINT on a service journey, passenger movements may take place. A passenger movement can be either boarding a vehicle or alighting from a vehicle.

The most usual practice is to record the number of alighting and boarding passengers at a defined STOP POINT. Such information may be obtained thanks to manual surveys or specific sensors (e.g. infrared sensors, NFC scanners, or counting steps). In spite of a certain lack of accuracy, such sensors enable the collection of data for online control (degree of occupancy of a vehicle) or for statistical investigations as to actual demand. The accuracy is sometimes improved by sensors measuring the current load (occupancy) of a vehicle between two stop points, or by data provided by fare collection devices. Often, only a subset of the possible information can be recorded regularly.

The observed number of boarding and alighting passengers at a SCHEDULED STOP POINT is stored in the entity BOARDING AND ALIGHTING, which corresponds to a given RECORDED STOP. BOARDING AND ALIGHTING follows the LOGGABLE OBJECT design pattern (and therefore inherits from LOGGABLE OBJECT).

The occupancy of a vehicle on every SERVICE LINK may be derived from the counts of boarding and alighting passengers at both SCHEDULED STOP POINTs bordering it. LINK data are therefore not explicitly represented in the reference model but can be computed from it. Users wanting to use the occupancy data separately should implement the corresponding entity.

The number of passengers possibly left at the stop, because of a too high occupancy level already in the vehicle, is not described by the current version of the model but could be added as an extra attribute.

5.2.3.6 Impeded Time

The evaluation of the running times and the speed of vehicles is an important tactical planning function, in particular for bus lines on which vehicle running is influenced by the general traffic. Statistical

investigations on OBSERVED PASSING TIMES are an important source of information for this function (e.g. measurement of the time taken to cross a frequently congested road junction). It may be completed by a record of situations where the vehicle is not moving, due to congestion for instance.

Such a recording of impeded periods may also be carried out using a monitoring system. This function will typically use three types of threshold to trigger observations:

- a maximal speed under which the vehicle is considered as impeded (e.g. 5 km/h);
- a minimum duration to trigger an impediment statement (e.g. wait at least a minute before recording that a vehicle is still impeded);
- a minimum speed a vehicle should reach to declare the end of an impediment.

The entity IMPEDED TIME describes the event of such a vehicle impediment during a MONITORED VEHICLE JOURNEY. An IMPEDED TIME occurs on a LINK (e.g. an INFRASTRUCTURE LINK). Attributes of this entity are the 'start time' and the 'end time', the 'distance from the link start point' and the possible 'distance covered' under the maximal speed.

5.2.3.7 Status of Planned Interchanges

In networks covering a large area or served by different transport modes, travellers are likely to have to interchange between services to reach their final destination. Many networks will organize the operational planning and control in order to facilitate such interchanges.

Planned interchanges may be optimized by trying to minimize the waiting time for the second service, for instance. There are various levels of complexity in planning such an optimization, as described in EN 12896-3:2016, 5.3.7. Many planned interchanges will be advertised, in order to improve the trip organization by passengers. Some of them will even be guaranteed. Thanks to a monitoring system, information on the actual status of interchanges (e.g. whether an interchange will be missed) may be provided to passengers. Such passenger information regarding interchanges is described in EN 12896-4.

Whenever interchanges are taken into account for planning and control of operations, it is of a high importance for service quality management purposes to measure the actual performance of the realization of the planned interchanges. Such a measurement is mainly based on the recording of INTERCHANGE STATUS data. Any time a SERVICE JOURNEY INTERCHANGE is planned, an INTERCHANGE STATUS record will exist. However, many companies will register only the missed interchanges. Such cases may be analysed using the 'number of passengers' involved and the 'reason for missing', stored as attributes, which supposes in most cases a manual entry.

A SERVICE JOURNEY INTERCHANGE describes a specific interchange of two individual service journeys. Less sophisticated interchange management may be used in the planning of operations. For instance, planning may simply take into account the general CONNECTION LINK times for any journey or may organize broad JOURNEY MEETINGS. In such cases, it will in general not be possible to register precise INTERCHANGE STATUS records. The follow-up of the interchange realization may, however, be based on computation of OBSERVED PASSING TIMES at the interchange STOP POINTS, which will then be compared to the planned data.

5.2.3.8 Disturbances

The analysis of disturbances affecting the network functioning is of a high interest for operations management. Such disturbances are caused for instance by traffic jams, accidents, road works, demand peaks, passenger illnesses, etc. It is often possible to identify the cause of a disturbance. In other cases, only the effects may be recorded (e.g. an observed delay, without any obvious reason).

Any disturbance affecting operations may be recorded in the entity OPERATIONAL EVENT (described in EN 12896-4). The main types of OPERATIONAL EVENTS are ALARMS (these may either be logged

manually or recorded automatically when a system detects a threshold is exceeded) and INCIDENTs (often recorded in a logbook). A more detailed classification may be specified by a TYPE OF EVENT (inherited from EVENT, described in Additional Common Concepts – see Annex B).

In addition, a disturbance can be related to a SITUATION (an incident or deviation affecting traffic or travel circumstances, which can be any event e.g. some weather condition, passenger illness, a car accident on the ROUTE used by the bus, etc.), having some PT SITUATION CONSEQUENCE on the network (delays, cancellations, etc.).

The staff in charge of controlling operations may make CONTROL ACTIONs, modifying the latest valid plan (e.g. DATED VEHICLE JOURNEYs). Such a CONTROL ACTION may be associated to one or several OPERATIONAL EVENTs and SITUATIONs, in order to classify the modifications by their causes. This allows for a historic analysis of the efficacy of different actions on the running of the network.

5.2.4 Recorded Use of Services

5.2.4.1 Introduction

One of the most difficult data collection tasks in public transport is to obtain information on the observed demand, in particular on the origin and destination of passenger trips. Such information is crucial for strategic planning (e.g. network design) and for tactical planning (e.g. choice of vehicle types or planning of interchanges). As the fare system of many networks is not based on the specification of precise origins and destinations, the only way to collect such data was, for some decades, to carry out surveys on passenger behaviour. The progress of fare collection techniques allows some systems to provide, in addition to their basic functions, more precise information on passenger trips.

5.2.4.2 Actual Passenger Trips

The management information part of the reference model includes concepts describing the actual consumption of the transport services by travellers, regardless of the means used to collect this information. It refers to the generic concepts (developed in EN 12896-6) of trips (traveller movements between two places), PT TRIPS (parts of trips restricted to the PT network, i.e. between stop points) and LEGs (parts of trips on the same PT vehicle).

A RECORDED TRIP is an actual trip undertaken by a passenger, from a certain origin place to a certain destination place, on a specific OPERATING DAY. In many cases, the origin and destination places will be expressed as a type of PLACE (STOP PLACE, POINT OF INTEREST, ADDRESSABLE PLACE, etc.). However, due to system limitations, they will be sometimes described with less precision, as TARIFF ZONES or FARE SECTIONS.

A RECORDED TRIP may be composed of one or more RECORDED LEGs. RECORDED LEGs are those parts of the whole trip that are carried out on one single vehicle, without transfers or other interruptions. RECORDED LEGs may be recorded as being made between PLACES (and subtypes), TARIFF ZONES or FARE SECTIONS.

The relationship between RECORDED LEG and RECORDED TRIP is optional, as the information necessary to specify which rides a trip may be composed of is not always known, depending on the technical system used. In some cases, only the rides may be registered, while in other cases only the trips are known.

A RECORDED LEG may, when on public transport, be related to a known MONITORED VEHICLE JOURNEY. Such a journey may have been detected and therefore be known already during the registration process, or it may be derived by calculation and stored afterwards. In some cases, it may be not specified at all. The given MONITORED VEHICLE JOURNEY may be recognized by the monitoring system as being the realization of a planned DATED VEHICLE JOURNEY. Such processes may allow the identification of the JOURNEY PATTERN over which a RECORDED LEG was made.

For a RECORDED LEG, the actual times of passenger boarding and alighting may be recorded. If onboard fare collection equipment is available, it enables the registration of the boarding time on the vehicle (derived from the control time). If such equipment is not available, the boarding time can be determined, with less accuracy, from the OBSERVED PASSING TIME at the concerned SCHEDULED STOP POINT. In a similar way, the precise alighting time can be determined from a ticket control when the passenger leaves the vehicle or from an OBSERVED PASSING TIME.

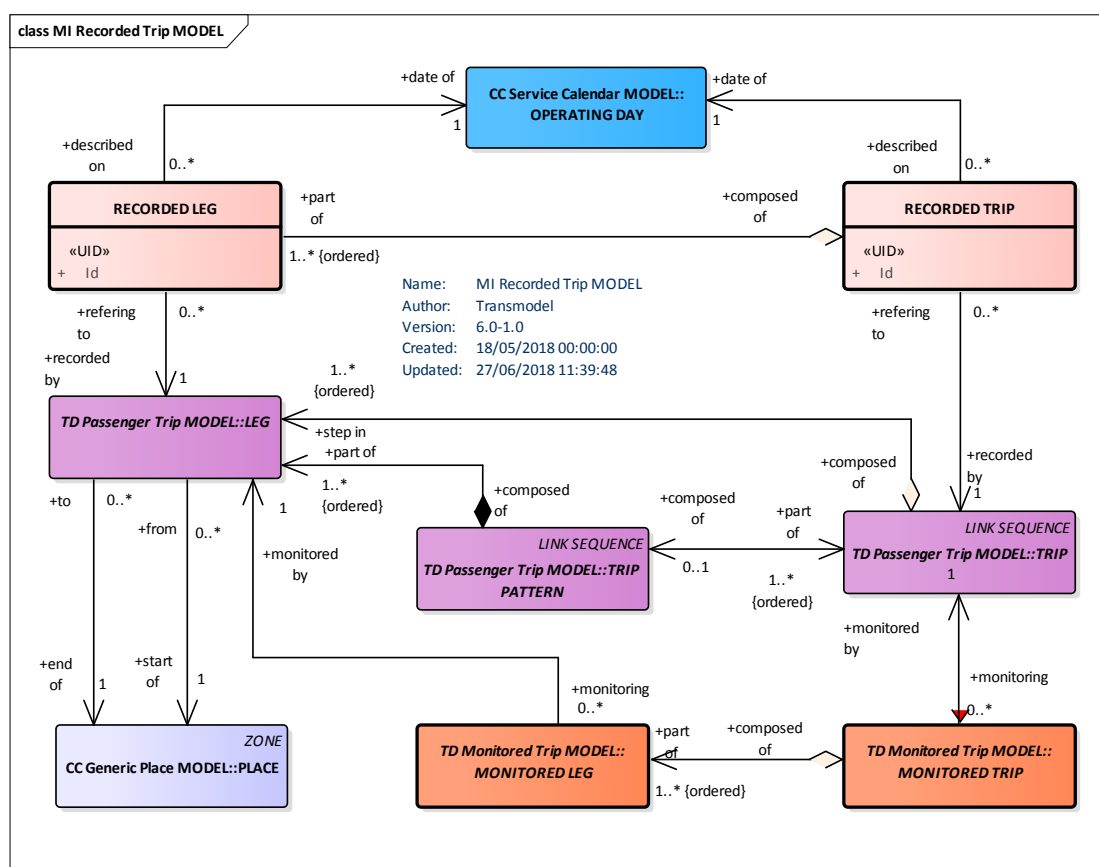


Figure 5 — Recorded Trip MODEL

5.2.5 Examples of use of the LOGGABLE OBJECT pattern

5.2.5.1 Introduction

The following sections describe some possible use of the Generic Loggable Object MODEL (Annex B) and Logging time and place MODEL. They constitute examples of use of this generic pattern and real-life situations may differ depending on the operational context.

There is a great variety of equipment available in public transport to record operational events, each with its own characteristics. Several generations of onboard or ground measurement devices are installed in PT networks. The most recent are integrated into monitoring (AVM) or payment systems, which cover many other functions than collecting data. In numerous cases, manual surveys are still necessary, in particular as regards to the traveller movements. Each implementation will require some form of data acquisition, utilizing the various forms of equipment available as appropriate for the application.