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Public transport — Reference data model

Part 5: Fare management

National foreword

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European foreword

This document (EN 12896-5:2019) 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of an identical text or by endorsement, at the latest by March 2020, and conflicting national standards shall be withdrawn at the latest by March 2020.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 (this part) 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 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: *Public transport – 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 standard, 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 5: Fare Management* addresses Fare Information for Public Transport and incorporates the following data packages:

- Fare Structure;
- Access Right Assignment;
- Fare Pricing;
- Sales Description;
- Sales Transaction;
- Fare Roles;
- Validation and Control;
- Explicit Frames for Fares.

This document itself is composed of the following parts:

- Main document (normative) representing the data model for the concepts shared by the different fare domains covered by Transmodel,
- 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 the "Common Concepts" domain, particularly useful for parts 4 to 8 of the Public Transport Reference Data Model,
- Annex C (informative), indicating the data model evolutions from previous versions of Transmodel (EN 12896:2006).

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*

EN 12896-6, *Public transport – Reference data model – Part 6: Passenger information*

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:

NOTE The following generic terms are used.

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

Note 1 to entry: Often used in the sense of the physical implementation of a data model.

3.1.5

data domain

data structure (in this European Standard, a 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

Note 1 to entry: In this European Standard, 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 utilisation of space or access

3.1.13

logical denormalised model

relational data model that is not fully normalized, i.e. does not completely follow the normalisation 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 is 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 fares 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**access right**

right to consume a Public Transport service or other service provided along with the transport

3.2.2

account based ticketing

fare collection paradigm which manages ticket issuing and validation through individual customer accounts held online and controlled by means of a token used on paper or electronic materialisations of a travel document

3.2.3

activation

triggering of the use of access rights and initiation of consumption

3.2.4

anonymous customer

CUSTOMER whose identity is not visible from their TRAVEL DOCUMENT, but who may be nevertheless be a registered customer using an anonymous token, in contrast to an impersonal customer, of whom the service operator has no individual knowledge

3.2.5

automated fare collection system

fare collection system capable of automatically determining which products the customer must purchase according to the travel he consumes

3.2.6

base price

price that is provided as an absolute amount and from which other prices may be derived

3.2.7

blacklist

revenue protection mechanism taking the form of a security list identifying travel documents, media, etc. for which the validity has been cancelled temporarily (denial) or permanently (refusal) and which will be used to block access to services for customers bearing documents associated with items on the list

3.2.8

booking

placing of a reservation to use a specific transport service, but not necessarily entailing a purchase of a ticket

3.2.9

cancellation

marking of a TRAVEL DOCUMENT as having been used

3.2.10

capping

setting of an upper limit on the price of the consumption of access rights

3.2.11

card centric

form of media centric ticketing where the media is a smart card

3.2.12

classical ticketing

non-electronic fare management and ticketing using paper and passive media travel documents, usually for a single operator

3.2.13

control

checking of a passenger's entitlement to consume access rights, involving identification of the traveller and/or the travel rights

3.2.14

consumption

using up of access right by a transport customer as a result of travel

3.2.15

credentials

data or other mechanisms used to authenticate an actor to a system as a legitimate participant

3.2.16

derived price

price that can be computed from another base price using pricing parameters

3.2.17

distributor

party who sells products on behalf of other product owners

3.2.18

dynamic price

price that is fetched at run time from a pricing engine as opposed to a static or derived price

3.2.19

easement

change to the normal access rights given to passengers because of a disruption to the network

3.2.20

embargo date

date before which information about a price or product is not to be released to the public

3.2.21

entry

record of an interaction with the system performed by an agent such as a CUSTOMER or ORGANISATION

3.2.22

event

any event, occurring on an OPERATING DAY and recorded in the system as some form of LOG ENTRY, having some consequences on entities

3.2.23

fare

from the customer perspective, the amount that a customer has to pay for a journey or for acquiring a specific fare product

3.2.24

fare set

particular version of all aspects of the fare structure, i.e. of the rules and associated parameter values, also called a 'tariff'

3.2.25

fare structure

set of parameters that determine the basic tariffs

3.2.26

fare token

materialisation of a TRAVEL DOCUMENT token as an anonymous physical object such as coin-like objects that are captured at validation and subsequently reused, or ephemeral paper representations that are cancelled

3.2.27

flat fare

fare that does not increase in proportion to distance or other measure of consumption (and so typically cannot be derived by calculation)

3.2.28

fulfilment

delivery of a TRAVEL DOCUMENT to the customer once it has been ordered or purchased

3.2.29

graduated fare

type of progressive fare, i.e. one that increases in proportion to consumption, where the increase is based in a distance increment

3.2.30

identity token

secure, machine-readable instantiation in media of an identity

3.2.31

impersonal customer

CUSTOMER whose identity is not known in any way to the operator, for example the purchaser of a paper metro ticket

3.2.32

interlining trip

customer trip made using a single medium and/or fare product that starts in one PT network and ends in another, in contrast to a local trip or a roaming trip

3.2.33

interoperable fare management system

fare system which is interoperable with other fare systems, possessing all the functions involved in the fare management process such as management of application, products, security and certification, registration, and identification to enable customers to travel with participating service operators using a single portable electronic medium

3.2.34

inventory controlled product

FARE PRODUCT whose supply is constrained by the service provider, such that only a set quota of capacity is available on a given journey

3.2.35

local trip

trip made entirely within the home network of a fare product

3.2.36**local use fare product**

FARE PRODUCT which can only be used on the operator's own network, in contrast to a roaming product

3.2.37**marking**

stamping or defacing a travel document to indicate that it has been activated and its rights consumed or partially consumed

3.2.38**media**

physical support containing a machine readable/writable data/processor application, such as transport industry smartcards, payment industry contactless cards, public sector issued cards, mobile phones or paper (for barcodes), new formats such as watches and key fobs, plus NFC mobile

3.2.39**media centric ticketing**

ticketing paradigm under which the product sold is held entirely on some form of local media and any validation and charging is done immediately against the card's contents

3.2.40**pay as you go**

type of reusable fare product giving the right to travel where the user is charged for access rights at the point of consumption or sometime after completing consumption

3.2.41**post-paid ticketing**

type of fare management according to which the user is charged at some time after using the transport service

3.2.42**prepaid ticketing**

type of fare management according to which the user is charged for either a fare product (ticket) or a deposit prior to riding

3.2.43**price**

value of fare or tariff

3.2.44**progressive fare**

fare that increases in proportion to consumption of space and/or time

3.2.45**registration**

enrolment of a customer as a user of a fare system

3.2.46**retailer**

actor who sells products directly to the end customer (as opposed to a distributor)

3.2.47

roaming fare product

fare product that is issued by one operator but valid on the network of another operator (in contrast to a local product)

3.2.48

roaming trip

customer trip using a single medium and/or fare product from one operator made entirely inside another operator's PT network, in contrast to a local trip or an interlining

3.2.49

role

part a particular actor such as a CUSTOMER or an ORGANIZATION takes when interacting with a system

3.2.50

static price

price that is precomputed and explicitly distributed, as opposed to a derived or dynamic price.

3.2.51

status of consumption

status indicating whether a given access right included in a customer purchase has been activated, consumed, etc.

3.2.52

tap

industry term for the record of a customer's interaction with the system that may be collected for interoperable fare management including, in particular, any sort of VALIDATION ENTRY returned with specific data from validation devices to the back office in Account Based Systems

3.2.53

usage-based product

FARE PRODUCT where the calculation of price is made after travel according to the amount of travel consumed

3.2.54

validation

verification that an access right is valid, has been or is being consumed, and that this consumption is allowed, achieved by checking the validity of the passenger's travel rights and comparing them to the parameters collected by the previous inspections and/or inspection context

3.2.55

whitelist

revenue protection mechanism that takes the form of a security list identifying travel documents, media, etc. which have been explicitly authorised as valid for use

4 Symbols and Abbreviations

ABT Account Based Ticketing

AFC Automated Fare Collection

AR Access Right

DRT	Demand Responsive Transport
EMV	Europay MasterCard Visa standards for payment cards
FM	Fare Model
FP	Fare Pricing
FTS	Flexible Transport Service
FS	Fare Structure
FSM	Full Service Model
GIS	Geographic Information System
IFM	Interoperable Fare Management
IFOPT	Identification of Fixed Objects in Public Transport
ISO	International Organization for Standardization
IT	Information Technology
NeTEx	Network and Timetable Exchange
NFC	Near Field Communication
OCR	Optical Character Recognition
PT	Public Transport
PTO	Public Transport Operator
SD	Sales Description
ST	Sales Transaction
SIRI	Service Interface for Real-time Information
TM	Transmodel
UML	Uniform Modelling Language
URI	Uniform Resource Identifier
URL	Universal Resource Locator
VC	Validation and Control
VDV	Verband Deutscher Verkehrsunternehmen (D)
WGS	World Geodetic Standard

5 Public Transport Fares Domain

5.1 Scope & Overview

5.1.1 Functional Domains of a Fare Model

The fare collection process in public transport may be considered as being composed of the following functional areas:

- Fare policy definition:
 - Characterisation of different fare structures through spatial and/or temporal parameters (e.g. sections, zones, time periods, etc.).
 - Specification of the access rights allowed on a network, i.e. access to services provided on a transport network (e.g. trip on the metro network, trip on the bus network, access to the 1st class waiting area, etc.) within a fare structure and the ways of using them (e.g. trip on the metro network during a time period of 2 hours, without successive on-board validations, trip on an open bus network during 1h30 with mandatory on-board validations and with the obligation to show an entitlement to use this right).
 - Specification of marketable combinations of access rights, called fare products (e.g. service consumption rights granted through a simple ticket), being possibly combinations of access rights determined by different fare structures for example a return ticket, a day pass, a season ticket, etc.
 - Description of sale principles applied to the fare products (e.g. specification of fare products sold as a package, and parameters describing the purchase rights, as for instance the obligation to show an entitlement to purchase a certain fare product).
- Sales organisation:
 - Management of the sales network (not covered, some basic retail and distribution elements relevant for passenger information added).
 - Sales operations, including fulfilment (partly covered).
 - Management of customers (partly covered).
 - Collecting funds or accounting (not covered).
- Pricing:
 - Pricing parameters specification (partly covered).
 - Exact price calculation (not covered).
- Consumption control:
 - Access right validation & control (covered).
 - Fraud management and revenue protection measures (partly covered).

- Collection and aggregation of consumption data (partly covered).
- Settlement
 - Management of revenue sharing and clearing house activities (not covered).
- Provision of information on fares.
 - Provision of fare data in forms suitable for integration with passenger information systems and operational processes, e.g. control (covered – see also EN 12896-6).

The part of the reference model described in the present subclause is made up of most data necessary for operating the above functions. However, the functions referring to the management of the sales network and the management of funds are not covered, while the management of customers is only partly covered.

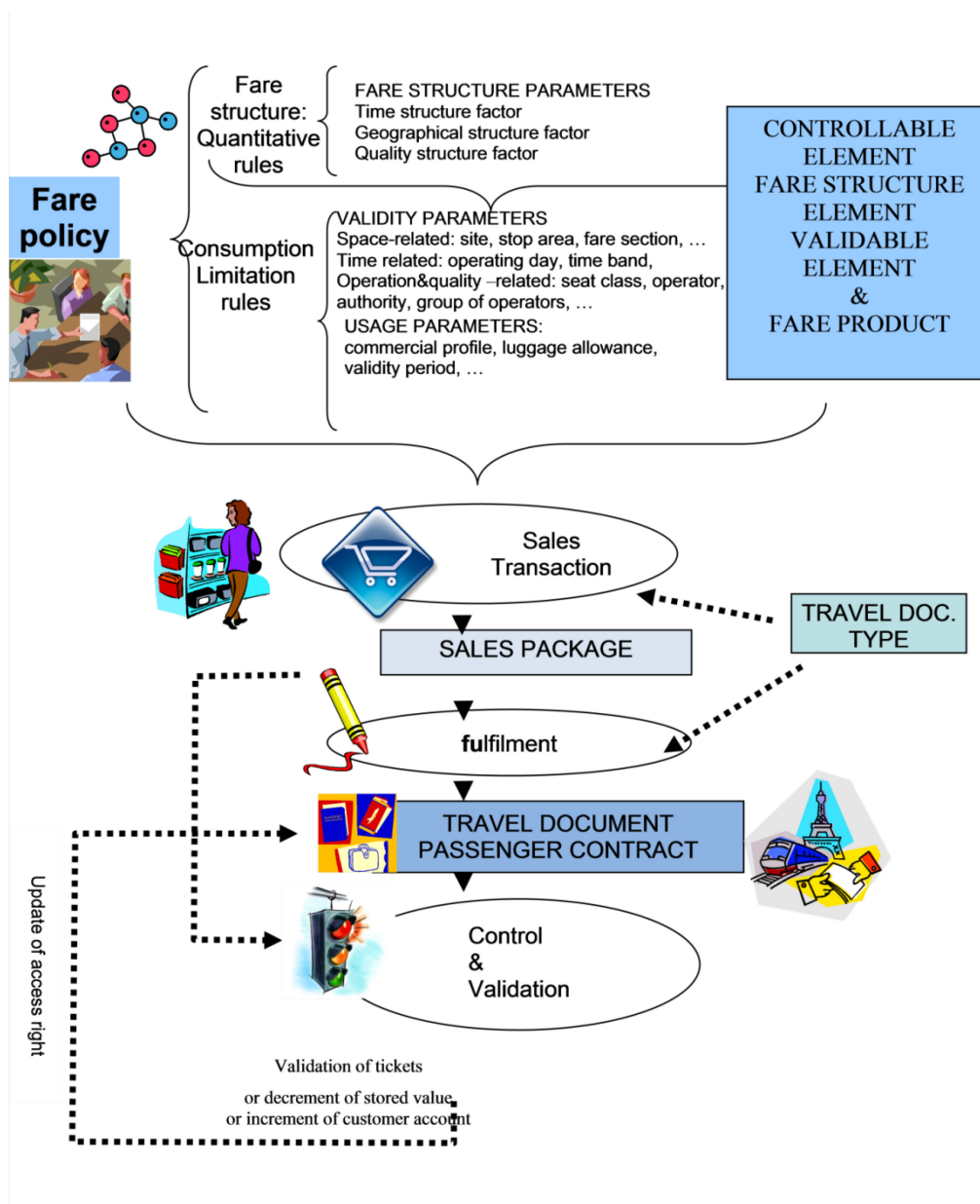


Figure 1 — Fare collection activities overview

5.1.2 Variety and Complexity of Fare Systems

There is an increasingly large range of solutions, methods and equipment for fare collection in the field of public transport. Traditional fare systems, as used for many decades in public transport, are relatively simple to describe. Such fare systems concern only one service (i.e. public transport), are often provided by only one operator, a single type of travel document is generally used (e.g. throw-away ticket), and the fare structure is unique, etc.

The current progress of technology is transforming such conventional systems: for example, with reloadable tickets, remote (hands-off) payment, electronic purse, pay- as- you-go charging, apps in personal devices, etc. Moreover, such techniques enable the emergence of integrated payment systems, which federate different service providers, offering different services (public transport associated to car parking, road tolling or shop or spectacle discounts etc.) and different means of payment or consumption documents (e.g. electronic cards). Such modern techniques are likely to coexist for a while with the older.

The concepts presented in this fares model are described with reference to public transport operation. However, they have been designed, as far as possible, to be applicable to other types of services. This is typically the case for car parking or road tolling and, more generally, to any service based on access rights and access controls.

5.1.3 Impact of Control and Validation Technologies

The capabilities of the control and validation technologies that are available on a network have a significant bearing on the range of products that may be offered by an operator. **Classical fare systems** are typically paper based and limited to simple pre-purchased products at a fixed price. **Media centric systems** on smart cards allow for pay as you go products that debit the user from stored value on the card at the time of travel; typically requiring appropriate equipment throughout the network. **Account based systems**, where the user's travel is recorded into a back-office system and accounted for post hoc, may offer even more sophisticated usage-based products, for example applying additional rules such as volume usage discounts and capping.

5.1.4 Ticketing Paradigms: Account Based Ticketing & Media Centric Ticketing

Account Based Ticketing (ABT), under which the user holds an on-line account to which fares are charged, has been an area of notable growth, enabled by the widespread availability of internet-based devices for the end user. Account-based ticketing supports conventional tickets bought in advance, but also new types of usage-based products with the price calculated after travel, either using payment on exit or payment based on the itineraries used within a given period. An essential feature is the issuing of a unique identity token to embed in the Travel Document with which to reconcile transactions made on the account. The token may be designed not to reveal the user's actual identity so that passengers can travel anonymously. ABT allows the use of general purpose consumer technologies such as payment cards or mobile devices to act as travel documents.

ABT can be contrasted with card or **Media Centric Ticketing**, under which the product sold is held on some form of local media and any validation and charging is done immediately against the card's contents. Systems that provide media centric products may also involve registration and customer accounts (for example to manage issuing the card and the customer may be registered, but access to an account is not necessary for the use of the card). Both systems support pay as you go travel, and furthermore may support an increased sophistication as to the pricing policies that are used as they can take into account the user's overall consumption and not just each individual journey. Media applications may be hosted on dedicated card platforms issued by public transport operators, or within general purpose smartcards able to host other types of applications.

Hybrid Media/ABT systems are also possible, for example a card-based system that automatically recharges from e.g. a bank account that is linked to the customer's payment card.

ABT & Media centric system interactions can include:

- Register customer account for the customer
- Register EMV media to charge against a customer account
- Recharge customer account (add credit to a customer account)
- Issue media to passenger
- Install application on passenger's device

- Recharge media (apply credit to local store on card)
- Check-in at start of journey by passenger
- Check-in at way point by passenger
- Check-out at end of journey by passenger
- Compute travel charge and adjust customer account
- Adjust balance on card on check-in/check-out
- Deregister account for customer

Account based systems require the customer to register with a system. European data privacy laws require the capability for a customer to deregister and have their personal details removed from the system.

Some forms of travel, such as that made in groups, do not sit well with ABT, as there can be significant effort to associate the tokens of all the travellers to the group transport product. For this and similar cases, it can be expected that there will always be a residual level of conventional ticketing, even if regular travel is priced using a usage-based method.

5.1.5 Interoperability

Modern fare systems are increasingly required to support interoperability – the ability to use the same media (and even fare products) across the different networks of different operators, sometimes across international borders. Products may thus be designed to support a variety of different operational scopes:

- **Local** trips: Trips made entirely on the home network of an operator with the operator's own media and products
- **Roaming** trips: Trips made entirely on a network using the media (and possibly products) of a different operator.
- **Interlining** trips: trips that span two different networks, i.e. that have both local and roaming legs.

5.1.6 Abstract Modelling

Due to the above considerations, a generic description of the subject domain systems for fares and the data they use is necessarily complex. This explains why a rather abstract representation is used in Transmodel that represents the fare domain with a number of separate (and in some cases non-intuitive), highly reusable abstractions instead of a simple representation using more literal and familiar classical fare objects. For instance, a concrete allowed access right such as “a ride on a bus” will be described by a much more abstract concept such as a “controllable element”, or a “ticket” sold on the network by a “travel document” concept that is able to integrate with other types of media (the physical materialisation of the ticket being just one aspect of the informational import of a ticket). This abstract modelling, of which the concrete applications are not necessarily explicit, is aimed at allowing the integration of a large variety of data structures, within the same data base or even on the same fare support (e.g. an electronic card). This same modelling may be applied, for instance, to car parking, therefore allowing integrated “park and ride” fare systems.

5.1.7 Modelling Approach - Access Rights

The essential characteristic of the reference fare data model is that it is based on *access rights* (i.e. service consumption rights), rather than directly on products or prices.

An access right granted to a customer is any part of a service that a user is entitled to consume, and of which the service provider (or another organisation) is able to control the consumption. A large variety of prices may be attached to a particular access right, and it may be sold in a wide range of marketable combinations. It is possible therefore to describe a price or a marketable package by starting from the access right description, but the opposite is not true, or at least would result in a great complexity. The definition of the access rights to a public transport service (or analogous services), together with the definition of the ways of controlling these rights, are more stable and simpler to describe than the almost infinite number of pricing and marketing systems.

- Various access rights may be combined in order to form immaterial “fare products” (e.g. a “single ride” granted by a fare product called “simple ticket”, or “multiple trips during one month” granted by a fare product called “monthly pass”), which are marketable sets of access rights. One or several fare products may be associated to a “travel document” and materialised (e.g. a paper single ticket allowing only a “single ride” or an electronic card containing various fare products). Combinations of fare products and travel documents are sold to customers as “Sales Offer Packages”. Each sold package is part of an individual “contract” with a particular customer.
- Controls are applied to access rights present on travel documents or in contracts, aimed at validating the consumption. The fact that fare products may represent “compound access rights” and that their elementary “components” have to be validated at a certain point or under some conditions, makes it necessary to be able to determine the elementary components of access rights (called in Transmodel CONTROLLABLE ELEMENTs, FARE STRUCTURE ELEMENTs, VALIDABLE ELEMENTs).

Pricing parameters are applied to access rights (either in a planning stage or, in the case of yield managed fares, in real time, according to specific principles), fare products and sales offer packages, in order to calculate the end price to be paid by the user.

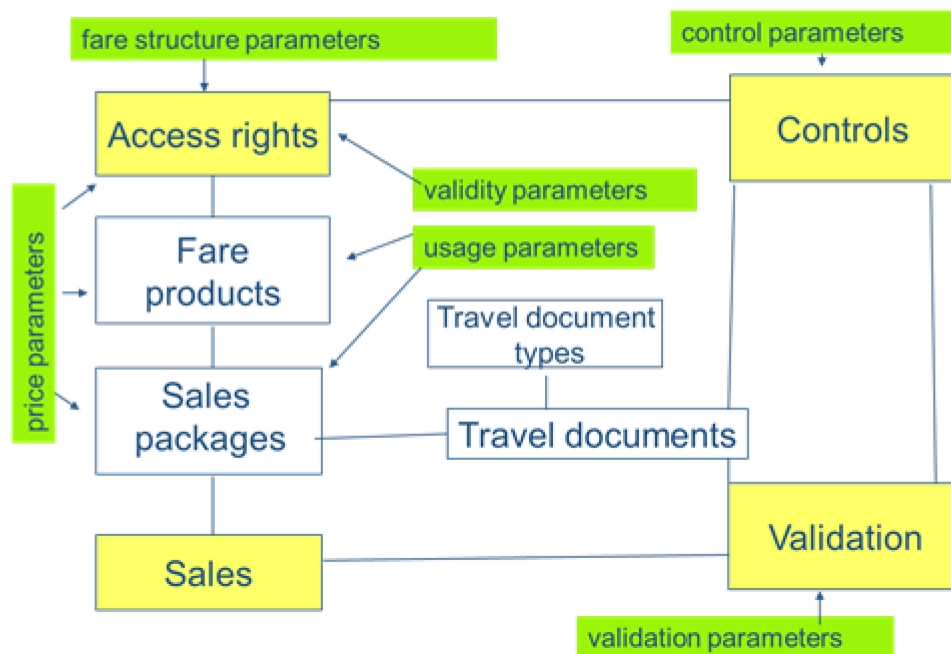


Figure 2 — Fare collection main processes and concepts

5.1.8 Possible Simplifications for Implementations

The fare collection reference model contains a large number of entities, describing in detail the above main concepts. However, a traditional fare system does not need such a complexity, which will be only required for the more complex integrated payment systems. Not all of the entities will therefore need to be implemented in simpler applications; some of the concepts separated for precision being merged into simpler objects for a concrete implementation.

The difference between the simplest and the most complex use cases found in the fare collection domain is more marked than for other parts of the reference model.

5.1.9 Further Evolution of Fare Systems

Fare structures for complex networks – and the fare management systems to service them – represent a significant investment and once established, tend to be relatively stable, with only evolutionary changes to services and routes being made within an established overall structure; for example, the addition of new stops or services on existing routes. There is a continuing need however to periodically re-price existing fares, and it is therefore important to separate price data from fare structure data and to give it a well-defined validity period.

There is also a need over time to introduce new fare products to increase yields from the network; these will typically be constrained to the existing fare collection infrastructure but may include products with specific limitations targeted at different users and different travel times, for example, promotion passes for tourists. Many operators thus support two sets of products: a stable regular set of standard products and fare offerings covering all the network, and an ad hoc set of promotional products intended to generate additional custom at particular times. These will normally have more restrictive commercial conditions. The ability to represent complex fare conditions in a computable form (that can also be explained to users) is therefore also an important requirement.

5.1.10 Use of Fare Data in Passenger Information services

This document is concerned mainly with describing a conceptual model for fares that is independent of any implementation or any specific implementation technology or API. One of the uses of such a model is to design online queries about fare sand fare products that make use of data elements from such a model. For an indication of how the reference model elements relate to typical fare queries, see the Transmodel v6 Part 6, *Passenger Information* standard (EN 12896-6), where fare zone, trip fare and fare product queries are outlined.

5.2 Fundamental Concepts

5.2.1 Access Rights

The model considers in particular the access rights needed by a passenger to use a public transport service.

The definition of the access rights is linked to:

- the definition of theoretical access rights, describing elements of the service that can be offered for consumption (e.g. the possibility to carry out a ride on a service journey from one stop point to another on one single vehicle, the possibility to access a closed system such as a metro network, i.e. to access the metro system and carry out a trip on several vehicles etc.). Such elementary access rights may be combined in various marketable combinations. They are in effect a set of rules, determined predominantly by space, time or quality related parameters – and termed in this document ‘fare structure parameters’.
- the definition of validity (limitation) rules, specifying the specific conditions to consume the generic or combined elements with use of validity parameters (e.g. Particular tariff zone, particular line, specific operator, etc.) or usage parameters mainly linked to the characteristics of the practical use of the right, e.g. linked to the type of user (user profile, commercial profile, the maximum duration of a particular trip or set of trips, to the accompanying objects, such as luggage allowance, specific permissions, such as interruption of the use of the right, use of specific route, etc.);
- the definition of means to materialise the access rights on travel documents (e.g. a throw-away ticket, an electronic travel card, etc.) and to control their consumption (e.g. using validators, turnstiles, manual controls, etc.).

5.2.2 Access Rights Specification

The definition of fare structure elements is based on generic, mostly quantitative, rules that influence the access rights regulating the consumption of transport services, and thus the price a passenger has to pay for a specific consumption: limitation of the duration or the length of trips, the number of zones crossed, etc.

These rules describe the use of the transport system in terms of space, time and service quality (see subclause 5.6 Fare Structure). Therefore, space-based, temporal and quality parameters will be specified and attached to specific FARE STRUCTURE ELEMENTs by the fare structure.

The rules determining the access rights can be classified under two main categories:

- Global rules, determined by “fare structure parameters”, used to determine the validity of a range of generic access rights providing the basis for calculating the price of their consumption. Such a set of rules is classically called “fare structure”. A fare structure is mainly used to define generic pricing

rules (for instance, the main types of public transport fare structure are known as “graduated fares” and “flat fares”). In a wider context, fare structure rules are also used to limit validity, even when the consumption is free of charge (e.g. limitation of the duration or the length of a trip, limitation of the number of zones crossed, etc.). Examples of Fare structure parameters are: GEOGRAPHICAL INTERVAL, GEOGRAPHICAL UNIT, TIME INTERVAL, etc. (see subclause 5.6);

- Validity limitation rules which consist in assigning certain “limiting parameters” to specific access rights. For instance, a ride may be limited to a specific area, a trip limited by the latest possible start time, a pass valid only for students, etc. Such limitations are expressed by two categories of parameters:
 - “validity parameters”, which affect the physical scope of access rights (mainly in space or time); examples of validity limiting parameters are GROUP OF LINEs, DAY TYPE, etc.
 - “usage parameters”, which affect the actual use of access rights, such as USER PROFILE, FREQUENCY OF USE, TRANSFERABILITY, etc.

A particular version of the fare structure fixes the values of the different parameters: this set of rules together with well-defined parameter values builds a TARIFF.

5.2.3 Fare Products

Finally, the access rights are advertised to the public.

A FARE PRODUCT is an immaterial marketable element made available to the public. It can be purchased and enables the owner to consume public transport or other services at specific conditions. It may consist of specified access rights (PRE-ASSIGNED FARE PRODUCT) or other products (discounts, amount of price unit, etc.).

In other words: the set of access rights granted by a travel document represent a FARE PRODUCT. It is a set of VALIDABLE ELEMENTs that are determined by fare structure parameters, validity parameters and usage parameters and may be considered as being combinations of FARE STRUCTURE ELEMENTs (and/or CONTROLLABLE ELEMENTs).

Each access right component level (CONTROLLABLE ELEMENTs, FARE STRUCTURE ELEMENTs VALIDABLE ELEMENTs) is characterised by the type of limitation rule that can be applied to access right components belonging to this level. The distinction between all three levels is only required for the most complex fare systems.

To be comprehensive, the concept of a CONTROLLABLE ELEMENT is introduced in the reference data model. CONTROLLABLE ELEMENTs represent the most elementary components that are determined by the fare policy and are mainly dedicated to the “control process”.

5.2.4 Sales Offer Packages

Access rights are not the only consideration in defining and marketing travel products. There may be different prices and conditions according to the sales DISTRIBUTION CHANNEL (in-station counter, online, on-board conductor) or the TRAVEL DOCUMENT i.e. media used (Smart card, app, paper ticket, etc.) - or other commercial factors. One or more FARE PACKAGES may be assembled into one or more SALES OFFER PACKAGES with various distribution and additional commercial conditions attached.

A SALES OFFER PACKAGE is defined as a package to be sold as a whole, consisting of one or several FARE PRODUCTs materialised thanks to one or several TRAVEL DOCUMENTs.

5.2.5 Overview on Access Rights Levels, Parameter Types and Associated Concepts

5.2.5.1 Access Rights and Parameters

A fare structure is defined through a set of elements that represent access rights to the transport system. The access rights are determined through a range of rules that enable price calculation. The rules are basically of two types:

- global (mostly quantitative) rules, determined through fare structure parameters; and
- particular (consumption) limitation rules, determined through validity and usage parameters.

Global, quantitative rules are, sometimes combined with validity limitation rules.

5.2.5.2 Levels of Access Right

In terms of data model concepts, the description of access rights is organised in a hierarchy of three levels:

- CONTROLLABLE ELEMENTs,
- FARE STRUCTURE ELEMENTs
- VALIDABLE ELEMENTs.

A fare structure is defined through FARE STRUCTURE ELEMENTs that may be represented, for some needs and in some cases, as sequences of CONTROLLABLE ELEMENTs.

FARE STRUCTURE ELEMENTs may build sequences to be validated “in one go” (VALIDABLE ELEMENTs) i.e. as a set, without the possibility to use a single component as an isolated access right. In many cases a FARE STRUCTURE ELEMENT is already a VALIDABLE ELEMENT.

A FARE PRODUCT is an immaterial marketable element (access right, discount right, etc.), made available to the public. PREASSIGNED FARE PRODUCTS represent the access rights determined by a (or a sequence of) VALIDABLE ELEMENT(s).

FARE STRUCTURE ELEMENTs are typically determined through global rules, that may be combined with validity limitation rules.

To VALIDABLE ELEMENTs (in some cases to FARE STRUCTURE ELEMENTs as mentioned above) and to FARE PRODUCTs limitation rules apply, i.e. rules that either limit the validity by specific parameters:

- on one hand, by validity parameters (e.g. particular DAY TYPEs, a particular LINE, a specific OPERATOR, etc.),
- on the other hand, by usage parameters, linked to the actual usage of the access rights (e.g. particular user profiles, luggage allowance, booking possibility, necessity to provide a particular entitlement, etc.).

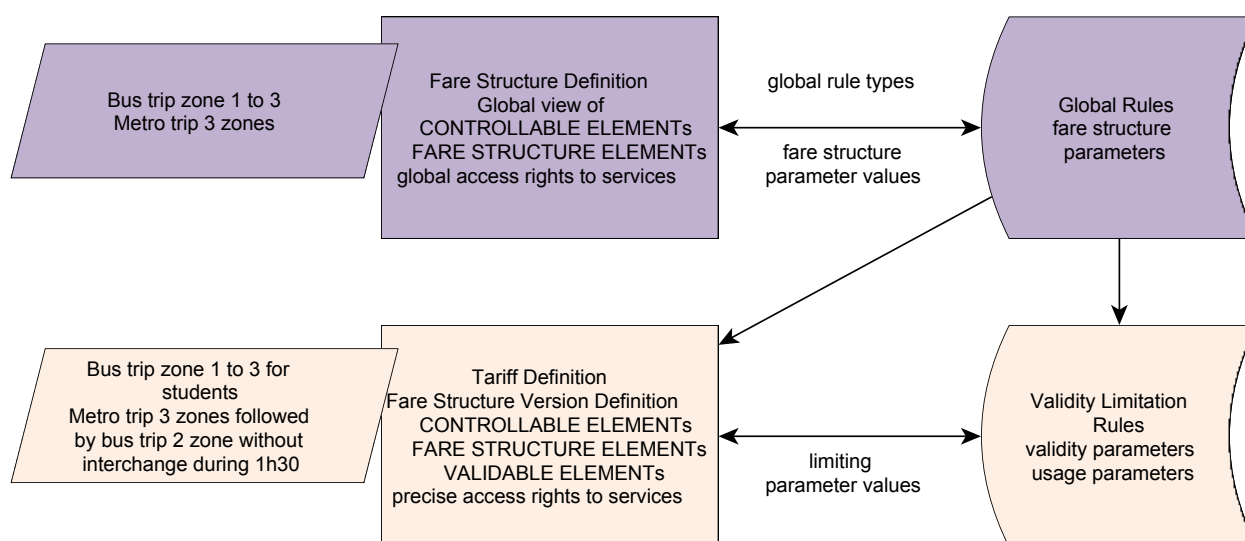


Figure 3 — Overview of the different parameters determining the components of access rights and examples

5.2.6 Customers and Contracts

If a purchase of a FARE PRODUCT takes place, a FARE CONTRACT is in effect agreed between a customer and the PRODUCT OWNER that the travel services will be provided, this consumption being ruled by the contract liabilities and conditions of carriage. Such an agreement may be explicitly represented by the FARE CONTRACT entity, but it is implicit even if the customer is impersonal (that is, unknown to the operator as an individual), or anonymous (that is, known only through an anonymous token).

Both classical, media centric and ABT systems can make use of the concept of a CUSTOMER ACCOUNT, a registration of the TRANSPORT CUSTOMER as a user known to the system. Transmodel uses TRANSPORT CUSTOMER to represent a user of services in any sense; a TRANSPORT CUSTOMER may in fact undertake both a CUSTOMER ROLE (i.e. act as purchaser or consumer of retail services) and a PASSENGER ROLE (i.e. act as a consumer of travel services). However, it is possible that different individuals undertake the two roles, as when an individual buys a ticket for another – or when a passenger does not have a valid ticket.

5.2.7 Travel Documents, Customers, Contracts and Sales Offer Packages

A FARE PRODUCT is immaterial (i.e. is agnostic as to how it will be physically manifested), which means that the same FARE PRODUCT can be materialised on various TRAVEL DOCUMENTs according to a particular type of medium. For instance, a monthly pass may be incorporated on a specific ticket or stored on an electronic card. The available media types can be described as TYPEs OF TRAVEL DOCUMENT.

An electronic TRAVEL DOCUMENT can be represented as a MEDIUM APPLICATION INSTANCE that resides on a MEDIUM ACCESS DEVICE (phone smart, card, etc.). The available types of device supported can be described as TYPEs OF MEDIUM ACCESS DEVICE. In Account Based Ticketing, the representation on the medium may be minimal – possibly just a security token or the identifier of an EMV card – the actual TRAVEL DOCUMENT details being stored online as part of a CUSTOMER ACCOUNT.

A FARE CONTRACT is immaterial, which means that is independent of the TRAVEL DOCUMENTs on which the whole FARE CONTRACT or a subset of it may be loaded.

The FARE PRODUCTS are associated with TRAVEL DOCUMENTs in order to form packages suitable for selling. A SALES OFFER PACKAGE is defined as a package to be sold as a whole, consisting of one or several FARE PRODUCTS materialised thanks to one or several TRAVEL DOCUMENTs.

The detailed contents of a TRAVEL DOCUMENT may be represented by an associated CUSTOMER PURCHASE PACKAGE which describes the SALES OFFER PACKAGE and any parameters that describe the specific access rights selected from it.

5.2.8 Distribution and Fulfilment

Sales of particular products may be restricted to specific DISTRIBUTION CHANNELs in specific territories, for example, from operators, third parties, online, etc.

Fulfilment, the delivery of the TRAVEL DOCUMENT to the user, may take place at the time of purchase, or involve subsequent steps to download or install to some form of media. For example, an online purchase of a product may be self-printed, collected at a ticket on departure machine at a station, added to a user's account for online retrieval, loaded onto the user's card when she checks in at a barrier, etc.

The available DISTRIBUTION CHANNELs, FULFILMENT METHODs for a SALES OFFER PACKAGE may be described using a DISTRIBUTION ASSIGNMENT, and the specific values used on a purchase can be recorded on a CUSTOMER PURCHASE PACKAGE.

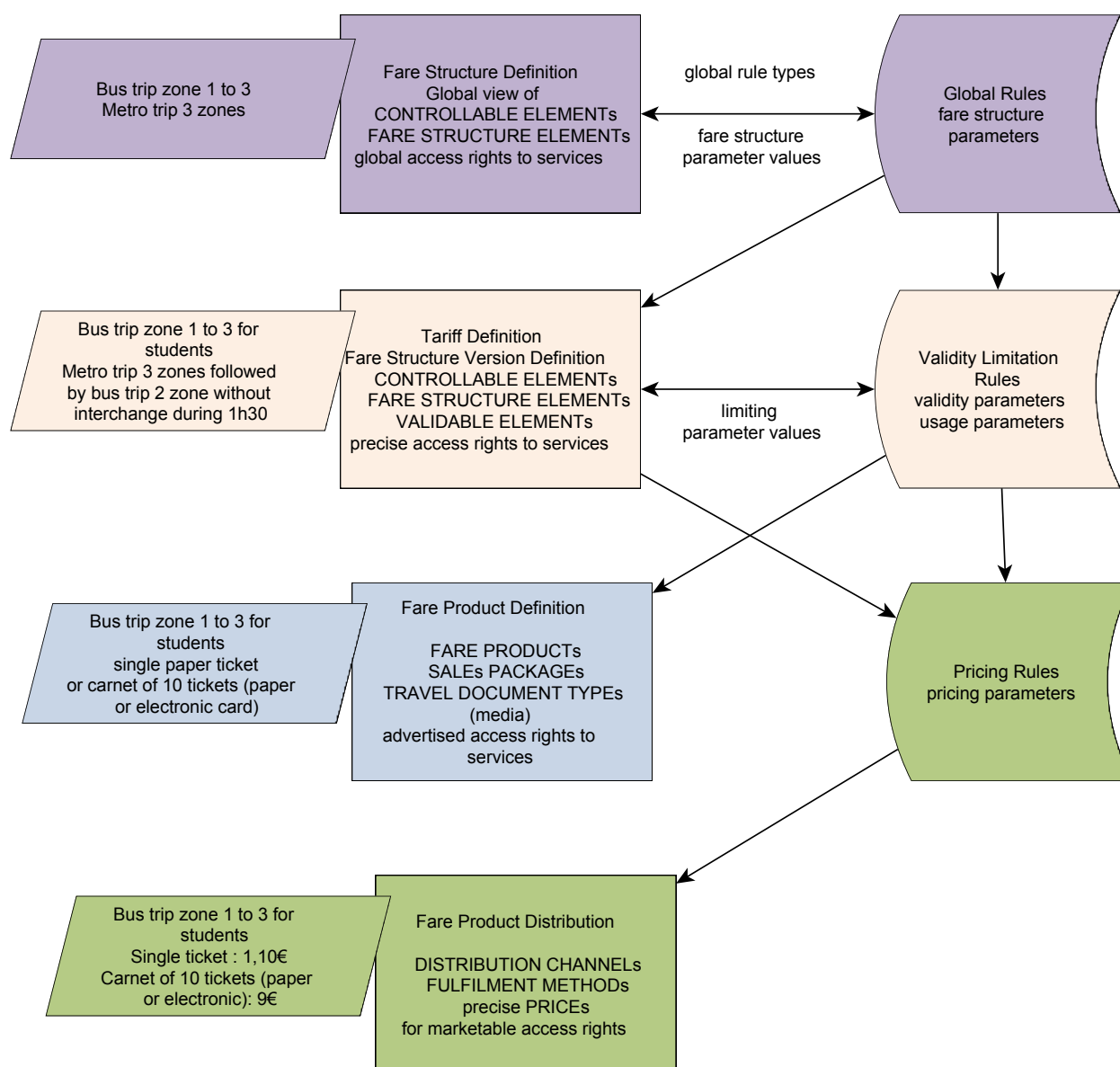


Figure 4 — Overview on Rules Types, Parameters and Concepts

5.2.9 Sales Transactions

TRAVEL DOCUMENTs are usually allocated to customers on the occasion of a SALE TRANSACTION.

A SALE TRANSACTION is a log entry recording an individual sale event. There are a number of different types of sales event including:

- Sale of one fixed SALES OFFER PACKAGE as a CUSTOMER PURCHASE PACKAGE, which means the sale of one or several FARE PRODUCTs that relate in a fixed way on one or several TRAVEL DOCUMENTs (e.g. classical tickets);
- Sale of one reloadable SALES OFFER PACKAGE as a CUSTOMER PURCHASE PACKAGE, which means that the sold FARE PRODUCTs are loaded on a TRAVEL DOCUMENT allowing such a loading on a MEDIUM ACCESS DEVICE (e.g. magnetic or electronic card), as described by a MEDIA APPLICATION INSTANCE;

- Refund or exchange of FARE PRODUCTS; this is meaningful in particular when a commercial offer allows the customer to replace an already purchased CUSTOMER PURCHASE PACKAGE by a more attractive one.
- The initial contracting procedure with a customer; this is meaningful in particular when such a procedure contains the CUSTOMER registration, before any product sale.

5.2.10 Prices

5.2.10.1 General

There is a large variety found as to the methods used to calculate the price to be paid for a fare. There is probably no generic solution to model all possible price generation algorithms. Therefore, the data model includes a set of pricing entities, which provide the factors necessary to calculate the price in each of the cases. Specific algorithms are responsible for applying the local price calculation rules to this basic data, but which are not themselves modelled in detail.

Prices may thus either be distributed as a set of base prices and the pricing parameters, or as fully resolved derived prices for every required fare structure element and access right.

The method used to derive a price from another price can be indicated on the price by a PRICING RULE, which can include a discount applied (DISCOUNTING RULE) and limits as to the minimum and maximum prices to be charged that are in effect (LIMITING RULE), as well as recording any tax applied.

5.2.10.2 Separation of Prices from Structure

In the models for both the Fare Product and the Fare Structure, the actual price values are kept logically distinct from the elements that they price. This permits the use of successive revised prices sets with the same fare product and fare structure, and also the separate exchange of prices and price updates without having to transmit all the base product data.

5.2.10.3 Fixed versus Yield Managed prices

5.2.10.3.1 General

Depending on national or regional law or business models, prices can either have a static or dynamic nature. This may vary by operator or travel mode or specific products within a mode.

5.2.10.3.2 Static Prices

In classically systems, prices are fixed for a given period. The tariffs and their prices have a static nature and are publicised along with the underlying structure. This information has a fixed start and end date, during which tariffs and prices are constant. Depending on the use case, either the discrete prices of underlying features may be exchanged, along with the pricing parameters, or a complete set of pre-computed resolved fares for every allowed combination of features (for which the pricing parameters merely provide justification).

5.2.10.3.3 Dynamic Prices

In situations where PT operator competition is significant, or where networks are congested and it is desirable to smooth the load, tariffs and prices can be varied dynamically, provided the necessary advanced systems are in place. Such tariffs and prices can depend on market or yield based business rules. Prices are obtained by querying a pricing engine for a given set of criteria (e.g. origin, destination, type of user) and only an overall current price is disclosed. The calculation process may be opaque and

publication of the full list of current prices and the fare calculation algorithms used to derive them can be restricted.

In either case, in order for the user to select a product for pricing and understand its applicability to her needs, information still needs to be available about the available products in relation to the journeys they price including fare structure, access rights and their pre- and after-sales conditions. The information needs remain the same, except that the price is fetched at run time from a pricing service indicated on the price entity rather than being distributed along with the other components of the fare.

5.2.11 Consumption Control

5.2.11.1 General

To protect their revenues against free riders and ticket fraud, operators need to check the passenger's use of their systems, using control processes. To undertake accounting, operators need to validate passenger's actual travel. Although they often occur at the same time, control and validation may be considered as two distinct processes:

- **Control** is the checking of a passenger's entitlement to consume access rights. Typically, this is done at the start or during their trip and involves checking that the customer has an appropriate ticket and marking it as used ('cancellation'). Multiple controls may be made on a passenger during a trip.
- A control process is thus an elementary action of collecting data on the rights attached to the TRAVEL DOCUMENT controlled and on the actual inspection context (location, time, specific train, etc.) to which the rights are to be compared. A validator installed at a metro entry will identify a particular TRAVEL DOCUMENT (or more often only the TYPE OF TRAVEL DOCUMENT) and read the data stored on it. It will check for instance whether the stored FARE PRODUCT has a VALIDITY PERIOD including the current day, whether it allows to enter the metro at the STOP POINTs composing the station, or whether a time limit parameter is not already passed.
- **Validation** is the verification that an access right is valid, has been consumed and that this consumption was allowed. It uses the results of one or several consecutive controls and with Media centric and ABT ticketing systems, may trigger the charge to the customer for the trip.
- Validation is based on the comparison between the rights attached to a FARE PRODUCT stored on a TRAVEL DOCUMENT and the data collected through previous controls, characterising the actual situation. In the event that access rights are not valid, a penalty may be incurred by the traveller. In interoperable systems, validation is important for accounting between different networks.

Both control and validation may involve marking the travel document to indicate a control has been made or that the access rights have been consumed. In classical rail systems this is done by the ticket inspector. Some types of product require an explicit activation step by the user to indicate the commencement of use, for example time limited trips such as use of the metro for 60 minutes. In classical fare systems validator might be used to mark a ticket with a timestamp; the MCT equivalent would be to use an app to start a timer.

The product owner may delegate the checking that the passenger has the appropriate access rights for their travel to a separate organisation (authority, operator or another service provider); the TICKET CONTROLLING ORGANISATION.

5.2.11.2 Easements

Sometimes, during network disruption, the operator may offer the passenger an easement, that is additional or alternative access rights to travel on other routes or other modes; for example, during a strike metro ticket holders might be allowed to use a bus. Validation and control processes will typically be relaxed or suspended during an easement and the issue of access rights will be purely notional – modified travel documents with revised rights will not be issued.

5.2.12 Sales and Validation Entries

The customer's interactions with the system can be recorded as log entries, each recording relevant state about a specific event for accounting and summarisation purposes. Some of these are triggered by direct interaction by the customer with a device, such as when buying a ticket, checking in or out at a barrier, or validating a travel document; others may be inferred automatically by the fare control system on the basis of its inputs, such as detecting that a capping threshold has been reached by a customer within a given period, or that a customer failed to check out from the system on a given journey. It is also possible to add entries manually, as say to record penalties issued by a ticker inspector.

The specification includes a set of events and entries to support classical, media centric and account based ticketing. The architecture allows for further events and entries to be added to cover further evolution of fare systems or specific customisation in a particular implementation.

5.2.13 Revenue protection measures

The management of customer data and control of travel needs to include revenue protection measures to counter attempted fraud. Control and validation processes may detect different types of anomalous behaviour, such as repeatedly checking in at the same station within a short period of time (which might indicate a pass being handed back over the barrier), etc. To support enforcement, security lists can be compiled and exchanged that provide whitelists of explicitly authorised entities (customers, tickets, media etc.); and also blacklists of explicitly unauthorised instances for whom access to the system will be blocked. Blacklists may be used to refuse access permanently (as say for a stolen card), or to deny it temporarily (as say for a suspended account).

5.2.14 Roles

In classical fare systems, involving a single operator issuing paper tickets for a single network through ticket offices on the network, a single organisation undertook all the roles involved in devising, retailing and controlling a fare product. As systems have grown larger and more complex these various roles have been unbundled and may be undertaken by different parties or be combined in different ways among various organisations. With the advent of electronic payment systems, electronic media and devices and account based systems additional roles are involved in providing integrated systems and may also be undertaken by separate parties. Understanding the separate concerns of each role is helpful for characterising the data entities and is relevant for passenger information systems; in particular it is important to be able to identify the organisations responsible for providing each kind of service, especially when redress is needed for some error or failing of provision.

The Transmodel specification indicates a basic model for roles involved in fare management and travel consumption, based primarily on that of the Integrated Fare Management EN ISO 24014-1:2015. This assists with relating the model with other standards covering downstream functions such as reservations, fare management, clearing, etc.

Roles may be undertaken by an actor, that is a person, organisation or other system that interacts with a system; some roles are restricted only to organisations or only to individuals (e.g. PASSENGER ROLE,

DRIVER ROLE). An actor may perform more than one role. Each role implies an association between an entity and an actor that should be separately modelled, even if the same actor undertakes multiple roles. For example, a Fare product may be owned and distributed by the same organisation, represented as two different associations between fare product and organisation, each with a different role entity associated with them.

5.3 Use Cases for the Fare Model

5.3.1 General

This section outlines key function for the application of the Transmodel fares model, mainly by summarising the use cases described in CEN/TS 16614-3:2016. The use cases should help give a more precise understanding of the scope of the standardization work for fares.

5.3.2 Business context

5.3.2.1 Fare Planning

5.3.2.1.1 Workflow for creation and maintenance of Fare Structures

The workflow for creation and maintenance of fare structure requires the choice of a fare model that suits the characteristics of the mode and network (e.g. urban mass transit, long distance rail, rural bus, etc.); the available channels for ticket retailing and the viable methods of ticket validation, and the required business yields for the expected traffic - and estimated fraud levels. Fare models between different regions, operators and modes will be significantly different.

The definition of a fare structure is based in effect on generic quantitative rules that influence the access rights regulating the consumption, together with the price a passenger has to pay for a specific consumption factor: limitation of the duration or the length of a trip, price based on the number of zones crossed, etc.

These rules describe the use of the transport system in terms of space, time and service quality. Therefore, space-based, temporal and quality factors may need to be specified.

A particular version of all aspects of the fare structure, i.e. of the rules and associated parameter values [sometimes known as a “fare set”] will be called ‘tariff’ in this standard.

A fare structure typically contains base prices optionally enhanced with price differentiations for modality, user profiles, peak / off-peak hours, seat class, etc.

Fares can be flat, i.e. not depending on consumption factors, or graduated, that is increasing in proportion to consumption.

Fare structures differ greatly in their complexity, ranging from a single flat fare to multi-dimensional matrices of distinct pricing factors connected by a complex object model. The fare model may contain objects such as tariff zones and fare stages that need to be collated with network data such as stop points, as well as availability restrictions that need to be collated with demand on specific routes. An effective date and (geographical) validity scope will be assigned to the fare structure overall.

The output of all the processes will be fare tables in structured form.

5.3.2.1.2 Fare Structures and Fare Products

The fare planning use cases are broken down into distinct functional areas;

— Provision of **Fare Structure** information:

This considers the creation of information regarding the Fare Structure, i.e. the rules and their parameters, used to determine the qualitative, quantitative and pricing conditions for accessing public transport.

A distinction is made between distance, geographic unit and time-based fares. Together they can be regarded as the addition of the notion of fares to the PT network, and may involve some network related elements, for example the choice of Tariff Zones or border points. In addition, specific use cases are presented that consider the creation and setting of general concessionary fares.

— Provision of **Fare Product** information:

This considers the creation of Fare Product information to inform customers of the cost of travel.

A Fare Product is a generic description of a set of marketable access rights, for example, a single ticket from A to B, or free travel in 3 adjacent zones for a specified period. The generic description can be defined in the form of product templates that are used to market access rights.

Fare Products are entities that can be marketed and sold to and used by PT travellers to obtain access rights and by PT operators to validate access to PT services. Fare Product determined fares are based on the Fare Structure. Possession of a Fare Product gives a specific right to access a PT service. A Fare Product defines when a traveller is charged, either when buying the product, when enacting the access right or a combination of both. I.e. the possession of a Fare Product enables the traveller to use PT services and to be charged for this use.

Separating the concerns of Fare Structure and Fare Product has significant advantages both for business processes and for technical implementation:

- It enables PT authorities and operators to define and utilise marketable travel products that are based on a reusable Fare Structure, but distinct. It decouples the maintenance of fare products from the maintenance of the fare structure. E.g. annual changes in Fare Structure do not cause a need for drastic changes in products. Special event related products that provide a reduction with respect to the Fare Structure can be defined, sold and used without a need to change the Fare Structure itself at all.
- It enables the definition of simple fare structures and simple fare products that in combination are able to support a wide variety of business requirements.

5.3.2.1.3 Overall Fare Planning Process

A fare planning process will consider the effects of different possible procurements and prices for tickets. Consequently, the process requires modelling of expected traffic levels against the putative fare structure to decide where to place fare boundaries, what products to offer and what prices need to be set to obtain satisfactory returns on investment. This may be an iterative process that must also consider other factors such as network congestion and existing retail infrastructure and ticket validation methods. Sometimes social policy drives the offering of certain products – for example the provision of free passes for veterans or the elderly must also be modelled and costed, as must subsidised fares for the general populace – since they must all be accounted and paid for, even if “free” to the user. Although for purposes of exposition the following use cases break the fare policy processes down into discrete steps and separate the development of fare structures from that of fare products, in reality the two are closely interdependent and development involves the iterative consideration of the overall picture.

The choice of use cases also depends on the degree of transparency of the pricing process being offered. Where only the final resolved prices for every possible combination are exposed (say as a fully populated fare table) it is not necessary to expose all the underlying pricing factors, dependencies and discounts used to compute them. Only a final set of computed fares need be disclosed. In other cases, it is desirable to exchange a set of base fares with the necessary fare structure elements and pricing parameters to derive prices for all the dependant elements. Transmodel can represent both cases (i.e. “Fare Table Exchange” and “Fare Pricing Exchange”).

The fare planning process can be represented by a sequence of workflows (high level use cases):

- a) Choose validation & control technology and any application media platforms.
- b) Describe overall fare structure type (rules, parameters determining the access rights).
- c) Determine spatial/temporal/quality parameters of the fare structure, such as: (i) whole network, whole line (i.e. flat fares); (ii) point to point; (iii) zonal; (iv) fare stage; (v) sequence of stages; (vi) composite variants; (vii) time intervals; etc.
- d) Determine sequences of fare structure elements grouped together to be validated in one go (validable “elements”: e.g. bus ride, train ride, metro trip, metro ride etc.).
- e) Choose limitation parameters for access rights e.g. round trip allowed, specific user profiles, group tickets, etc.
- f) Determine fare products, i.e. “marketable elements” classified according to the “charging moment”, e.g. pre-paid monthly pass, post-paid monthly pass, etc.
- g) Add pricing rules and price parameters.
- h) Test these against predicted yields and iterate steps (a) to (f).
- i) Choose travel documents, distribution channels and fulfilment methods.
- j) Add deriving prices.
- k) Choose Sales Offer Packages to be marketed to customers that assemble fare products with travel documents and distribution factors.
- l) Derive final prices.

However, in reality, it is unusual to design a whole fare structure from scratch as a new workflow, or even to do this in order to create a new electronic representation. Rather most aspects of the system will be dictated by the existing network and its fare products, fare collection and fare management systems, which typically represent a major investment in equipment, staff training, back office processes, customer information, customer education, etc.

Processes are required to make updates to the existing representations of the system (stops, routes, services, products, conditions, etc.) and to manage and update the prices for the available fares.

The process described above may be used as well to represent the main steps to describe an existing fare set (fare structure, fare products, prices and all the linked concepts).

5.3.2.2 Calculating a Customer's Fare

5.3.2.2.1 General

In general, the pricing and purchase of a fare product breaks down into several successive steps. This is of particular importance for electronic ticketing systems providing automated fare calculation, but a similar flow for conventional ticketing system processes is observed in the following sections.

5.3.2.2.2 Selection of a Fare product

Whether the selection of a fare product is done prior to a trip, directly after finishing a trip or even later is fundamental to the fare charging process.

In a conventional ticketing system with printed paper tickets or magnetic strip tickets, the fare product, (e.g. a single ride ticket or a season ticket) is selected by the traveller before starting a trip.

The same process may be followed in an electronic ticketing system where the ticket is provided in electronic form by means of a data set stored on a smartcard or in a back-office system. The traveller may deliberately select a fare product in advance, e.g. a flat rate for a limited region and / or limited validity period, which entitles him to unlimited travel within the chosen scope (in conventional ticketing systems this is a period pass season ticket).

However, in an electronic ticketing system with automated fare collection and product selection (AFC system), the traveller actually only needs an access right to enter the vehicle and start a trip. No fare product selection need necessarily be done at the start of a journey. The selection of the product used for a specific trip (and its accounting) can be done by the AFC system after completion of the trip. For example, the AFC system will automatically distinguish whether the dedicated trip is done within the coverage of a season ticket product held by the user (such as a single trip within the limiting scope of a zonal pass already owned by the user), or whether another product is needed (e.g. a single trip in a different zone), or even a mixture of existing and additional access rights (e.g. a reduced price trip for use of local rail).

Moreover, if the tariff includes price capping that limits the total fare cost within a given period to a specified limit, the choice of products used to account for the fares may be modified by subsequent travel. For example, after the third ride with a single ride ticket at the same day the previously selected products (three single ride tickets) may be converted to a day ticket.

5.3.2.2.3 Price calculation and payment

5.3.2.2.3.1 General

Thus, the calculation of a ticket price may be done either:

- Prior to the beginning of a trip (classical, ticketing system – also found in ABT and AFC systems); **prepaid ticketing**.
- At the end of a trip (or part of a trip) (automated fare product selection and price calculation system); **AFC post-paid ticketing**.
- At the end of a trip or sometime later in back office to incorporate rebates like a fare cap or volume discounts, or route-based fare (**ABT post-paid ticketing**).

5.3.2.2.3.2 Prepaid Ticketing

In a conventional ticketing system with preselected products (paper based or electronic), the price will be charged directly after the price calculation by various means, e.g. a self-service ticket machine or at a sales counter.

Smartcard based electronic ticketing systems often require the user to pay an amount of money as a deposit in advance to riding. This is the case for stored value cards, where the deposit is registered on the smart card, but can also be achieved by linking the smartcard to an online system in the cloud that holds the deposit. In some cases, a certain amount of credit may be given.

In conventional electronic ticketing systems, deposits are used to pay the preselected tickets, so the process is very similar as paying with cash but without the necessity of cash-handling for every transaction. The smartcard may also be enabled as a payment device so that it links directly to a credit or debit card to make a payment for the prepaid travel at the time of purchase (as is the case of a travel payment application actually in a smart credit card).

A refinement (applicable to both prepaid and post-paid ticketing) is to enable a stored value card for automated top-up so that it will be recharged by a credit from a bank or credit card account at regular intervals or at a predefined credit trigger threshold.

5.3.2.2.3.3 Post-paid Ticketing

Post-paid ticketing systems are characterised by a sales transaction made by the public transport operator on completion of the journey – this may be either a debit for the full amount, or an adjustment against a prepaid deposit charged at the start of the journey. In both cases accounting is only completed after riding.

For stored value cards, the debit may be made against the store. For travel cards that allow credit (including for example the use of NFC credit cards to pay fares) the amount will later be charged to the user by deducting a bank or credit card account.

Stored value cards may be anonymous (i.e. the operator does not know who the owner is other than a passenger can show the card as proof of a ticket) or personal – i.e. registered with the operator, and traceable to an individual. Often such cards are non-transferable and are supported by a photo or other verification mechanism.

Post-paid systems may apply complex post travel rules to determine the amount actually charged. For example, the TfL Oyster system may charge a lower rate if the user travels via certain intermediate points, and charges a higher rate if it determines that the user failed to check out within a specified period.

5.3.3 Actors and use case types

The following table gives an overview of some information technology systems that serve as actors in the Transmodel Fare model. The “Producer” and “Consumer” columns indicate whether the systems will provide or receive the information content. In the last column examples for organisations are given that might operate such systems. The list in this table is not complete and may be extended (for example the additional roles of MEDIA PROVIDER and Identity Provider relevant for EMV and electronic media are not described).

Table 1 — Transmodel Fare Model system actors

Systems	Producer	Consumer	Organisations
Service tendering and timetable registration systems: with fare structure information (i.e. tariffs, tariff zones).	x	x	Public transport authorities.
Fare Management and Planning Systems: determining the pre- and post- sale conditions (i.e. generic parameter assignment for attaching conditions for the fare product retail process).	x	x	Public transport authorities, public transport operators.
Journey planning systems: for which the fare product information and fares apply.	x	x	Public transport authorities, public transport operators.
Ticket selling systems: including the price entities (i.e. Sales Offer Packages, fare products, validable element, usage parameters, access rights, etc.) and customer entities (i.e. passenger contract, customer, user profile) that accompany route information.	x	x	Public transport authorities, public transport operators.
Automated fare collection (AFC) systems (automatic ticket barriers (gate, turnstile) with fare collection (mechanical, infrared, magnetic)): travel documents, fare product data, access rights in product, access right parameter assignments, border points, blacklists.	x	x	Public transport operators.
Passenger information systems (i.e. on-board fare displays): with fare price for devices (fare prices charged at usage).	x	x	Public transport operators.
Demand responsive transport (DRT) or Dial-a-Ride Transit (DART) systems with graduated time-based fare structures (i.e. time interval price, time structure factor) and graduated geographically-based fare structure entities (i.e. geographical unit, geographical interval, border point) for (public, commercial mass transport).	x	x	Demand responsive transport operators.
Mapping systems: fare prices for public transport journey routes.		x	Commercial and non-commercial services providers like Google Maps, Yellow Pages, etc.
Strategic planning systems: price entities for planning and decision making in the development of public transport: controllable element price, fare structure element price, geographical interval price, distance matrix price, time interval price, validable element price, usage parameter price, fare product price, Sales Offer Package price.		x	All levels of public transport authorities.
General third-party systems.		x	Various.

5.3.4 Use Cases

5.3.4.1 General

The use cases listed here are given at only a summary level (i.e. as a one-line description). They are mostly based on the corresponding use cases described in more detail in CEN/TS 16614-3:2016. The use cases are subdivided into three main groups:

- Use-cases that implement a fare policy, including the definition of the features of a fare structure and the definition of fare products that use the fare structure to determine the sale prices.
- Use cases that provide fare data for passenger information on fares, and to feed sales channels and other operational processes such as validation. These processes may be executed all or in part by IT devices. Specific information to configure these devices, such as security sensitive data, are outside the scope of Transmodel.
- Use cases that use fare data for control and validation purposes.
- Use cases concerning the distribution of data between operators.

5.3.4.2 Fare Policy Use Cases

5.3.4.2.1 General

The fare policy use cases define the structural elements (fare structures) of a fare (network scope, basic geographical and temporal factor, fare price) and fare products (access rights, entitlements).

5.3.4.2.2 Definition of fare network scope (fare structure)

Use cases to formulate the fare structure:

- NETWORK-001: Determine network scope for fare structure; modes and geography, line, group of lines, mode, tariff zones, etc., based on the network characteristics.
- NETWORK-002: Demarcate fare zones as cells, rings, honeycombs, etc., and/or fare stages.
- NETWORK-003: Define route to be offered and permitted transfer points.
- NETWORK-004: Develop projections of fare spatial elements on maps.
- NETWORK-005: Determine fare structure factors: space (zone, point to point) route, time and quality.

5.3.4.2.3 Definition of fare pricing (fare structure)

Use cases to formulate the fare pricing and tariffs:

- PRICING-001: Determine price units and amounts.
- PRICING-002: Determine price calculation factors: rounding, tax, etc.
- PRICING-003: Determine market segmentation and user eligibility criteria; user profiles, concessions etc.

- TARIFF-001: Determine flat fares for flat fare products.
- TARIFF-002: Determine basic fare structure tariff for graduated fares (populate non-discounted base fares).
- TARIFF-003: Determine basis or derived tariffs for distance graduated fares (zone, point to point, etc.).
- TARIFF-004: Determine concessionary tariffs for flat and graduated fares.
- TARIFF-005: Determine concessionary tariffs for time graduated fares.

5.3.4.2.4 Definition of fare products

Use cases to formulate the fare products:

- PRODUCT-001: Determine product access rights.
- PRODUCT-002: Determine product interoperability between operators, modes, etc.
- PRODUCT-003: Determine product pre- and post- sale commercial conditions.
- PRODUCT-004: Determine distribution conditions.
- PRODUCT-005: Determine materialized Sales Offer Packages.
- PRODUCT-006: Determine additional fees and charges for fare product.
- PRODUCT-007: Determination of product deposits and credit limits.
- PRODUCT-008: Determine the product prices.
- PRODUCT-009: Periodically revise the product prices.

5.3.4.3 Fare Use Cases

5.3.4.3.1 Provide data for distribution of information about fare products

Use cases to provide passenger information about fare products:

- INFORMATION-001: Provide information on available fare product sales channels and fulfilment methods.
- INFORMATION-002: Provide information on available fare products.
- INFORMATION-003: Provide fare information for on-line trip queries.
- INFORMATION-004: Provide fare information for price optimisation for on-line trip queries.
- INFORMATION-005: Provide information about loyalty programs.
- INFORMATION-006: Provide information for maps on the spatial extent of zones, etc.
- INFORMATION-007: Provide an overview of fare products / tariffs.

- INFORMATION-008: Provide information on available media and payment options.

5.3.4.3.2 Support Sales processes

Use cases to provide information for sales processes:

- SALES-001: Provide up to date fare parameters for price calculation to downstream systems.
- SALES-002: Record product selection and purchase.
- SALES-003: Provide Product specifications to support for dynamic pricing.
- SALES-004: Provide data for recurring trips / travel products.

5.3.4.4 Control & Validation Use Cases

Use cases to support control and validation:

- CONTROL-001: Provide data to support processes to automatically validate passengers' use of the system on entry or exit to the system. Include support for travel across multiple systems.
- CONTROL-002: Record data about validation of passengers' use of the system, including check in, check out, validation.
- CONTROL-003: Provide data to support back office processes to perform account based ticketing, such as fare capping, failure to check out, station re-entry, etc.
- CONTROL-004: Record data about control of passengers' use of the system, including offences.
- CONTROL-005: Block or enable use of Customers, Contracts, Travel Documents and devices by placing them on Black or White Security lists.
- CONTROL-006: Provide data to detect change of eligibility status of a use for a fare product.

5.3.4.5 Provide fare data for support of PT operations

Use cases to provide information for operational processes:

- OPERATIONS-001: Exchange fare information between long distance (i.e. heavy rail) and local public transport.
- OPERATIONS-002: Plan flows of fare information for service providers.
- OPERATIONS-003: Provide fare information that applies to a PT Contract.
- OPERATIONS-004: Provide information about interoperable products between operators.
- OPERATIONS-005: Collect and forward tap and log entry data between interested parties.

5.4 Organisation of the Conceptual Model

The fare model is broken down into a number of sub-models, modularized into groups as described in the subsequent sections; each group of models is described in turn using UML Class diagrams to show the entities and their relationships.