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SINTEF REPORT

TITLE

MultiRIT

Multimodal Travel Information Services

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ABSTRACT

This report documents the results from the MultiRIT research project and the contents are

- The MultiRIT multimodal framework architecture for travel information services.
- The multimodal travel planner pilots developed in the project. They demonstrate different strategies and possibilities with respect to the realisation of multimodal travel information services
- A description of algorithmic solutions and limitations with respect to multimodal travel planning
- A feasibility study on the provision of accurate price information in travel information services

The MultiRIT framework is based on ARKTRANS, the Norwegian framework architecture for multimodal freight and passenger transport, and the results will be fed back into ARKTRANS. Through a holistic approach, open services for request and provision of travel information and travel information services are specified. The approach includes the identification and specification of the generic roles of the stakeholders involved; the required functionality, the processes; and the interactions between the roles.

The report concludes that the open services enable a flexible organisation of multimodal travel information services, and such services also arrange for new and improved functionality like the provision of dynamic information (e.g. delays and other deviations), accessibility information and context dependent information.

KEYWORDS	ENGLISH	NORWEGIAN
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SELECTED BY	System Architecture	Systemarkitektur
	Multimodal	Multimodal
	Travel Information Services	Reiseinformasjonstjenester

Preface

This report documents the results from the MultiRIT research project. The main part addresses the multimodal framework architecture for travel information services. This framework is based on ARKTRANS, the Norwegian framework architecture for multimodal freight and passenger transport, and the results described in this report will be fed back to ARKTRANS.

MultiRIT is a research project co-funded by the Research Council of Norway and the participants. The project started in May 2005 and ended in December 2008. The project participants have been ITS Norway; the Public Road Administration; Avinor; the Norwegian National Rail Administration; the Norwegian State Railways; Geomatikk AS; Norsk Reiseinformasjon; Trafikanten Møre og Romsdal; Logit Systems AS; and the Delta Centre in the Directorate for Social and Health Affairs. They have contributed through work group participation, input provision, and implementations of pilots that demonstrate the MultiRIT solutions. The work would have been impossible without their support and knowledge. SINTEF has been responsible for the coordination and management of the project and the establishment of the architecture.

In addition to the project participants mentioned above, other stakeholders and projects have also contributed to the work. Their contributions have been crucial. We especially will like to acknowledge the UNI HPI project and organisations representing disabled people (Funksjonshemmedes Fellesorganisasjon, Norges Handicapforbund) for input on accessibility information; the Møre og Romsdal county for support in the use of their county as pilot areas; TRIONA for hard work on the implementation of pilots and a lot of input to the work on the Web-services; DataGrafikk for implementation of Web-services; and the Ministry of Transport and Communication for support and interest.

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Abbreviations

Abbreviation	Description
ATP	Actual Transport Preferences
CEN	The European Committee for Standardization
CIM	Computation Independent Model
D2D	Door-to-Door
EDS	Electronic Data Systems
EU	European Union
GTP	General Transport Preferences
IATA	International Air Transport Association
ICF	International Classification of Functioning
ID	Identity/Identifier
ISO	International Standards Organization
ITS	Intelligent Transport Systems and services
MDA	Model Driven Approach
NCSU	North Carolina State University
NSB	Norges Statsbaner (the Norwegian state railways)
PIM	Platform Independent Model
PSM	Platform Specific Model
PT	Public Transport
RFID	Radio Frequency Identification
SMS	Short Message Service
SOAP	Simple Object Access Protocol
SSIM	Standard Schedules Information Manual
SVV	Statens Vegvesen (the Norwegian Public Road Administration)
TC	Technical Committee
TRIDENT	Transport Intermodal Data sharing and Exchange NeTworks
UD	Universal Design
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
UML	Unified Modelling Language
UN	United Nations
WS	Web-services
WSDL	Web-services Definition Language
XML	Extensible Markup Language

1 Introduction

According to policy statements in Norway and Europe, the use of public transport is to be increased. It has been documented that travel information services encourage people to change their habits towards more extensive use of public transport. The main objective of the MultiRIT project has been to arrange for new and improved travel information services to meet the needs of both the society and the transport users.

A transport user is in this context a person that plans to travel or a person that is travelling, either as a passenger or as a road user (driver, pedestrian or cyclist). There are different types of transport users, for example people going to work; tourists; disabled people; professional drivers; etc. They all have specific preferences that should be supported by new and improved travel information services.

1.1 Problem Specification and Motivation

Travel planning and travel information services today are offered by the transport companies themselves and by third party service providers. The services can to some extent belong to one or more following categories:

- Mode specific travel information services - addressing transport services within a single transport mode, e.g. air traffic.
- Multimodal travel information services – providing services for all transport modes (sea, road, rail and air)
- Travel information services for scheduled transport (mainly public transport)
- Travel information services for non-scheduled transport (e.g. car driving)

1.1.1 Challenges related to the provision of travel information services

The transport users of today demand more or less real time information about travel services. Good quality travel information services therefore require up to date information about time schedules, routes, deviations, etc. The information acquisition is however a bottleneck, especially for service providers that depend on input from many transport companies and multiple transport modes:

- The regulations that are meant to ensure information availability are not enforced, and the travel information service providers do not always get access to the required information. Even the national travel information provider has not had access to routes and time tables for all parts of the country.
- The information acquisition process requires a lot of manual work and quality assurance due to the lack of standards for exchange of travel information and due to the bad quality of the information received. In addition, the information is quite often not provided in time. Several travel information formats or variations of these formats are used, and they are not prepared for new functionality, for example provision of dynamic information and accessibility information.

1.1.2 Challenges related to user needs

The use of private cars and freight transport are crucial to the Norwegian society, and the travel information services should support such transport. However, the end user functionality provided by travel information services must also encourage use of public transport. The extensive use of private cars may partly be caused by shortcomings in the current travel information services:

- The journey is unpredictable due to lack of dynamic information about delays and expected arrival times.

- Delays in one leg of the journey may affect the next leg and the whole journey, and it is difficult to re-plan the journey when it has started.
- It may be considered as OK to go by train, but the traveller does not know how to get to the train station.
- The traveller is not familiar with public transport (how to buy tickets, types of tickets, time tables, etc.).
- Travellers may have special needs, and they do not know whether it is possible for them to go by public transport.
- The travel plans suggested by the travel information services may not include all relevant transport alternatives.

1.2 The MultiRIT objective and idea

The main objective of MultiRIT is

> To *arrange for* new and improved travel information service.

The new and improved end user functionality in the travel information services should address the shortcomings described above. In MultiRIT such functionality is specified and selected parts are demonstrated. It is however impossible to foresee the functionality provided by the travel information services of the future. New functionality will emerge depending on the current and foreseen needs of the travellers, new ideas, new technology, the willingness to pay for services, responses in the public, etc. Hence, the intention in MultiRIT has not been to "compete" with the natural evolution of functionality in travel information services. MultiRIT has focused *how to arrange for new and improved services*, i.e.:

- How to support the "invention" of new and useful services?
- How to simplify composition and provision of services?
- How to arrange for flexible organisation of travel information services?
- The needs for regulations, frameworks and business relations.

A framework architecture for travel information services is the answer to these challenges. Such a framework can support and simplify the establishment and provision of new and improved travel information services, and the establishment of such a framework has been one of the main activities in MultiRIT. The travel information service providers should be able to build new and improved services based on information received from a wide spectre of transportation network operators (e.g. road administrations), public transport operators and operators of public transport stops and passenger terminals. Interoperability and information exchange according to well defined interfaces are crucial, trough which planned time schedules as well as dynamic information about deviations and travel times can be provided.

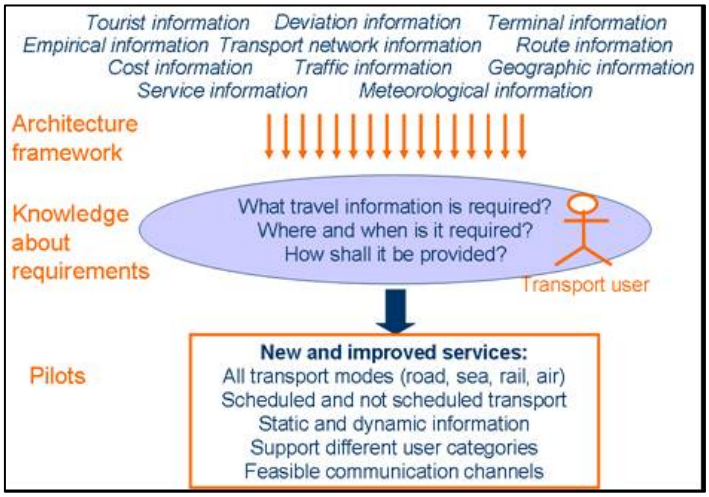


Figure 1 The MultiRIT idea

Figure 1 illustrates the MultiRIT idea. Different types of information may be of interest to the transport user. The relevant travel information can be exchanged between stakeholders according to a framework architecture. Based on knowledge about the requirements and needs of the transport user, new and improved travel information services can be provided. Some of these services are demonstrated in the MultiRIT pilots.

1.3 The content of this report

- Chapter 2 provides an overview of the approach used. This includes the use of ARKTRANS and a description of the strategy with respect to the challenges listed in 1.2.
- Several chapters address the framework architecture for multimodal travel information services:
    - Chapter 3 describes the relations to the ARKTRANS Reference Model
    - Chapter 4 defines the roles related to the provision of travel information services.
    - Chapter 4.5 defines the objects related to the provision of travel information services.
    - Chapter 6 specifies the functional view, i.e. the functionality required by the roles.
    - Chapter 7 specifies the process view, i.e. how the different roles interact.
    - Chapter 8 specifies the information view consisting of conceptual information models defining the relations and dependencies between information elements; and open service that realise the information flows identified in the process view.
    - Chapter 9 specifies the technical solutions
- Chapter 10 provides descriptions of the MultiRIT pilots
- Chapter 11 provides an overview of travel planning theory and issues
- Chapter 12 provides discussions related to provision of price information in travel information services
- Chapter 13 provides an overview of the most important conclusions from the work

2 The MultiRIT approach

As described in section 1.2, a framework architecture for travel information services can support the establishment and provision of new and improved travel information services. In MultiRIT, such a framework is specified, and the use and benefits of such a framework are tested and demonstrated in pilots.

2.1 The MultiRIT framework architecture

The MultiRIT framework architecture is multimodal. This means that it is common to all transport modes, and a multimodal terminology is used. The framework is based on ARKTRANS [1], the national framework for multimodal ITS , and the MultiRIT results will be used to refine ARKTRANS.

The main purpose of the MultiRIT framework is to support the establishment of new and improved travel information chains. This is done through the definition of standardised, multimodal interfaces for exchange of travel information. These interfaces arrange for efficient value change and flexible organisation of the travel information services throughout the country.

2.1.1 The content of the MultiRIT framework architecture

The content of the MultiRIT framework has, as illustrated in Figure 2, the same layered structure and viewpoints as ARKTRANS, and the same approach is used to establish the content.

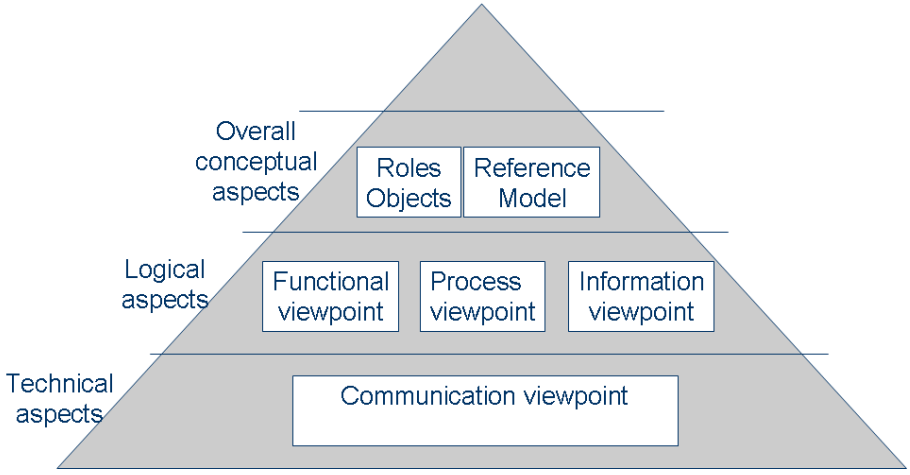


Figure 2 The MultiRIT framework architecture content

The layers address different abstraction levels and aspects:

- The overall concepts define the scope of MultiRIT and the responsibilities of the stakeholders:
  - The ARKTRANS Reference Model is used to define the scope of MultiRIT. The model divides the transport sector into sub-domains, each with specific responsibilities and focuses. The responsibility domains also define the structuring of the framework architecture description documented in this report.
  - The roles define different the generic types of stakeholders relevant to MultiRIT.
  - The objects define generic entities (resources, equipment, etc.) relevant to MultiRIT.
- The logical aspect defines the MultiRIT solutions from a logical point of view:
  - The Functional viewpoint describes functional requirements of the different sub-domains of the Reference Model by means of use cases.
  - The Process viewpoint describes how the different parts of the Reference Model will interact to fulfil their responsibilities. For example how the transport User will interact with the travel information provider.

- The Information viewpoint defines the content and structure of information elements that are exchange between the sub-domains of the Reference Model.
- The Technical aspects specifies the implementation the relevant parts of the logical aspects.

The MultiRIT results are used to refine ARKTRANS, as described in [2]. In a cyclic process the current working draft of ARKTRANS (a refined version of [1]) is used as the starting point for the MultiRIT framework. In the ARKTRANS refinement project the MultiRIT framework is evaluated and harmonized with input from other projects using ARKTRANS, and the generic parts are included in an updated version of ARKTRANS. In that way the generic solutions for multimodal travel information services will be part of the next version of ARKTRANS.

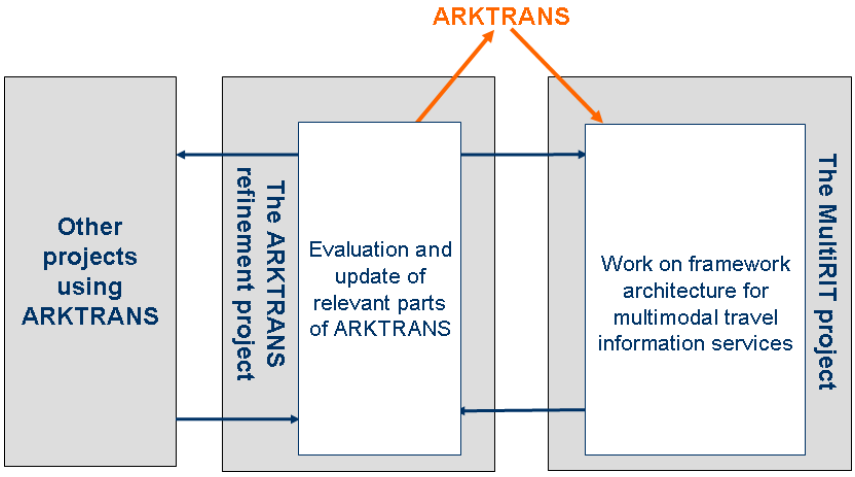


Figure 3 The cyclic process for improvement of ARKTRANS

2.1.2 Efficient and flexible value chains for travel information services

Many types of information may be of relevance to the traveller. Based on knowledge about the needs of the transport user, the transport information service provider will collect and combine information form many sources to establish the services. Different services may be based upon the same information. Hence, the information exchange should be according to a well defined interface.

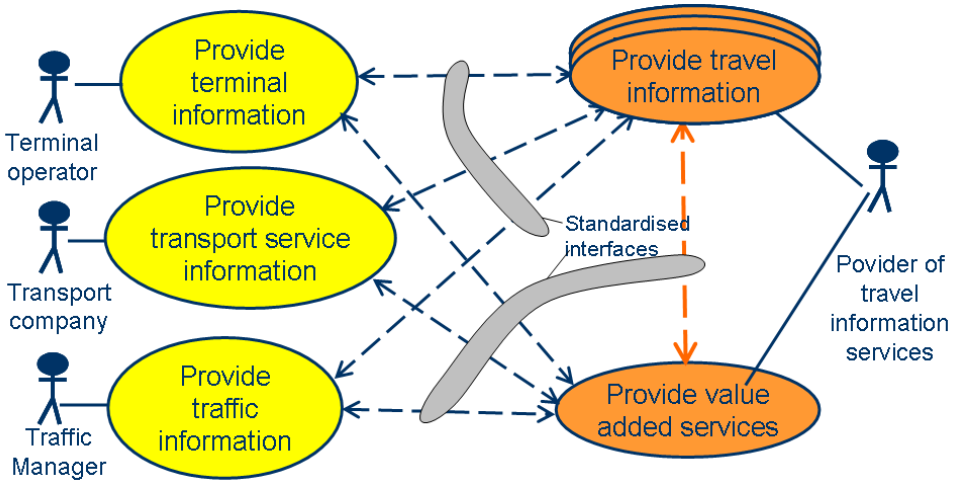


Figure 4 Standardised interfaces supports value chains and flexible organisation

MultiRIT aims to define standardised multimodal interfaces that support the collection and provision of travel information and travel information services. In that way the information collection for the composition of travel information services can be more efficient and support the

third-party travel information service providers in the establishment and provision of new and improved travel information services (see Figure 4). Transport companies representing all transport modes should for example provide route information and dynamic information about delays in the same way.

As illustrated in the figure, there are also standardised interfaces towards the providers of travel information services to support the establishment of value added services.

Existing route information formats are not suited as standardised and multimodal interfaces. They quite often include information that is of no importance to the transport user, e.g. information used in fleet management and traffic control. Issues that are specific to one specific transport mode are often reflected, and an adaptation to other modes usually requires compromises. In MultiRIT the focus is on the information needed by the transport user, such as time schedules and route patterns and information about services and facilities provided on-board, at stops, and at the terminals. In addition dynamic information about status and deviations is required. Information elements needed in new or improved services as well as in more traditional services (e.g. printed time tables) must be available. The information must count for all transport modes (road, sea, rail and air).

2.1.3 Model driven approach

The standardised interfaces mentioned above are in the MultiRIT framework architecture specified in the information viewpoint and in the technical specifications (see Figure 2) by means of a model driven approach (MDA), as described in [3]. MDA is a software development process which defines guidelines to separate business and application logic from the underlying platform technology.

Working with models is nowadays common in software engineering. It provides an abstraction of often very complex issues enabling an immediate focus on the relevant aspects and excluding the irrelevant ones. It also enables a larger group of collaborators due to the fact that humans not accustomed to working at code level also may participate in the collaboration.

2.2 New and improved travel information services

MultiRIT aims at complete and generic multimodal travel information services that combine all transport modes and scheduled and non-scheduled transport to find the best possible travel plans for the individual transport user. In general the travellers should get access to new and improved functionality that:

- Provides information about all transport alternatives.
- Support all phases of the travelling process (planning and preparations, just before start and during the travel).
- Provides information that makes the journey predictable, e.g. information about on-board facilities, accessibility, delays, status, estimated arrival time, etc.
- Supports different situations and preferences like information in case of delays, tourist information, etc.
- Supports adaptation to traffic situation (e.g. in case of congestion).

There are quite good navigation support systems for cars. However road users like pedestrians and cyclists do not get much support. Walking paths and bikeways must be included in navigation tools and travel planners for road use. The travel planners also lack dynamic information. Dynamic information, e.g. the effect of road works, weather conditions, ferry timetables, etc. should be considered when travel times are estimated.

Except for the walking part of door-to-door travel information services for public transport, the combination of public transport and road use (driving, walking, and cycling) is not well supported. The traveller does for example not get information on how to get to the station by car;

the park and ride facilities; the train leg of the journey; and how to walk to the final address. Multimodal travel information services should provide transport alternatives across all transport modes, also scheduled and non-scheduled transport.

Dynamic information about status and deviations with respect to time schedules, next departure, estimated arrival, etc. is required by the users of public transport. Such information is to some extent provided by information boards at for example railway stations, airports and bus terminals, or via Web-pages and radio channels. However, dynamic information should be provided in a more individual and flexible way with respect to information content, when it is provided, and how it is provided (e.g. via cell phones). Access to dynamic information may for example allow people to adjust to the deviations, for example by finding other transport alternatives.

The travel process should be predictable. Information about the different transport alternatives and their qualities with respect to travelling times; waiting times; delays; services and facilities on-board and at stops (toilet, nursery, etc.); accessibility; etc. should be provided. Travellers should be able to compare the alternatives to select the one that is best for them. Accessibility information may be crucial (see Annex A for more information). The access to services and facilities at terminals may for example very well be a key for deciding whether a journey by public transport is possible.

Context and situation dependent information like information about the next station and foreseen time of arrival should be provided during the travel via the preferred information channels, e.g. mobile phones.

2.3 Pilots

The MultiRIT framework and the new and improved travel information services are tested and demonstrated or studied by means of pilot studies. Four different issues are addressed:

- Door-to-door multimodal travel planner
- Travel planner for non-scheduled transport
- Travel planner for scheduled transport
- Context dependent travel information

All the pilots more or less depend on the same information. Hence the standardised interfaces specified by the MultiRIT framework are crucial for efficient information exchange.

The most relevant aspects of the pilots are further described in Chapter 10.

2.4 Related work

Existing route and travel information formats have been consulted during the work to get input about the concerns of existing solutions. Route information exchange formats used today are mainly related to one transport mode, and applications to more transport modes required adjustments. Route information for trains may for example be specified by means of an air transport format, but the train departures have to be registered as flights. The available formats also have shortcomings with respect to provision of information about the availability of services and facilities, as well as dynamic information. Formats that are consulted are:

- REGTOPP formats [4] that are mainly used for buses, but may also be used for trams, metro and ferries. The format is widely used by Trafikanten.
- The Swedish format for route information used by Samtrafiken [5]
- The internal format used by Norsk Reiseinformasjon.
- SSIM [6] that is commonly used for air transport.
- UIC formats [7] that are used by the railway sector.
- EDS International File Format [8] that also is used in the railway sector.

The TRIDENT (Transport Intermodal Data sharing and Exchange NeTworks) [9] project (EU project IST-1999-10076) has specified comprehensive information model packages that are relevant to MultiRIT. A location package specifies information models for locations and topology. A public transport (PT) package includes information models for timetables and the status of transport means. Finally, a trip package has information models for trip times for public transport rides, road journeys, and various connecting lines between transport modes and from the origin of journeys to the destination. An itinerary information model is also provided.

The TRIDENT information models are to some extent overlapping with MultiRIT. In addition to the information models, XML schemas specify information exchange formats. TRIDENT is multimodal to some extent, but the content is just partly harmonised across the transport mode. We think that a more complete harmonisation will benefit intermodal transport planning, and we also see that the TRIDENT information models lack information about many services and facilities that can be provided on-board the transport means and at the terminals.

TRANSMODEL [10] specifies a data model that supports public transport operation and management as well as passenger information. Multimodality is supported to some extent (bus, trolley bus, light rail), but does not fulfil the MultiRIT view upon multimodality.

As far as we can see, TRANSMODEL is mainly related to fleet management (tactical as well as operational). Passenger information is limited to information about departures and arrivals. A terminology for public transport is defined, but so far MultiRIT has chosen to use the terms preferred by the participants in the multimodal work group.

3 Relations to the ARKTRANS Reference Model

The ARKTRANS Reference Model [1] defines the overall concepts for multimodal transport, and by its simplicity, the Reference Model is an overall conceptual model of the transport sector and transport issues. The transport sector is divided into domains and sub-domains, each with specific responsibilities.

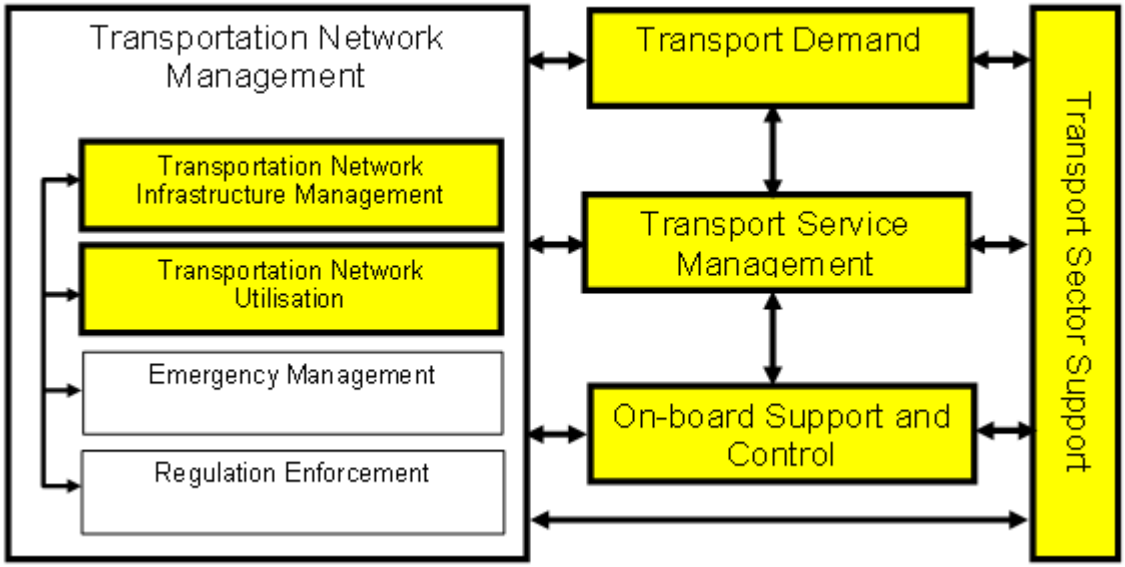


Figure 5 The ARKTRANS Reference Model

Travel information issues are more or less related to the yellow parts of the figure. These parts are addressed by the MultiRIT framework architecture.

3.1 Transportation Network Management

The term transportation network denotes the network that arranges for transport in general. The flow and movement of transport means in the infrastructure and the regulations are considered. (The term transport, and *not* transportation, is used about the specific transport done by transport companies and other).

The Transportation Network Management sub-domain is comprehensive and provides functionality to a wide spectre of stakeholders. Thus, it is further decomposed into sub-domains. Just the Transportation Network Utilisation and the Transportation Network Infrastructure Management sub-domains are of relevance to MultiRIT. The main focuses are:

- Safety and efficiency related to traffic (the flow of transport means).
- To arrange for transport that is to the best of the society, efficient, environmental friendly, etc.).

3.1.1 Transportation Network Utilisation

The Transportation Network Utilisation sub-domain addresses traffic management and the transportation planning. The efficiency of traffic flows is of course of huge importance to those who are travelling, as well as the availability of public transport. Thus, the following objectives of the sub-domain are of relevance to MultiRIT:

- To arrange for efficient traffic flows
- To arrange for the availability of information and supportive services that contributes to the planning and accomplishment of safe, efficient and environmentally friendly transport.

- To arrange for the establishment of transport services that provide the required capacities, routes, schedules and qualities (these services will however be established and operated as a part of the Transport Service Management sub-domain).

3.1.2 Transportation Network Infrastructure Management

The Transportation Network Infrastructure Management sub-domain provides functionality required by those who are managing the physical transportation infrastructure, the public transport stops and terminals included. The objectives of the sub-domain that are of relevance to MultiRIT are:

- To provide information services and other services that support transport planning as well as efficient and safe accomplishment of transport.

3.2 Transport Demand

The Transport Demand domain supports transport preparation and planning, transport booking, and follow-up. Functionality needed by transport users who want to travel, as well as functionality needed by those who are organising the transport on behalf of the transport user (travel agencies) is provided. Transport chains of variable complexity that may include several transport modes are defined and managed.

The use of travel information services is important to the transport user during all phases of the travelling process, and the following objectives of the sub-domain are relevant to MultiRIT:

- To provide administrative services for preparation, planning and establishment of a transport chain (ordering, information management, etc.)
- To support the establishment of a transport plan by enabling the use of predefined preferences and templates
- To support the definition of the preferred transport chain
- To support the execution of the transport chain (information exchange towards the transport companies, authorities and service providers as well as coordination)
- To support the follow up of the transport chain and to support corrective actions in case of deviations
- To support the termination of a transport chain in such a way that experience gained can be reused

3.3 Transport Service Management

The Transport Service Management domain addresses transport services and their management and provision of transport services. The responsibilities towards other parts of the transport domain that are relevant to MultiRIT are:

- To provide information about the transport services that are provided
- To provide information about terminal services are be provided
- To provide the required services
- To provide services according to orders and regulations
- To provide required feedback about the status of transport operations as well as alerts and other information that may support the Transport User’s management of the transport chain

3.4 On-board Support and Control

The On-board Support and Control domain addresses functionality on-board the transport means that supports security, safety and efficiency. In MultiRIT this is support to Road Users such as drivers, cyclists and pedestrians. The Road Users should by means of information services get information that supports the route selection. Information about traffic conditions and traffic situation is also of interest. In MultiRIT the relevant objectives are:

- To promote safety and efficiency by providing information and support to the Road User
- To inform the Road User about dangerous or irregular situations

3.5 Transport Sector Support

The Transport Sector Support domain addresses the services that support the other domains of the Reference Model. Several types of services may be offered the transport users and the Road User s. In MultiRIT the focus is on the travel information services, e.g. provision of traffic flow information, travel planning, transportation network information, transportation network condition information, route information, terminal information, etc. The objectives that are of relevance to MultiRIT are:

- To collect and manage information related for the provision of the services
- To publish information about transport related issues
- To receive and handle service requests
- To provide administrative services related to transport (e.g. fee collection)

4 Roles

The roles are general names for stakeholders related to the transport sector. One role relates to one part of the Reference Model. Just the roles relevant to MultiRIT are described in this report.

4.1 Roles related to Transport Sector Support

The roles related to the Transport Sector Support domain in the Reference Model that are of relevance to travel information services are described in the table below. The Service Provider is the main role. In the MultiRIT framework architecture, we use the Service Provider sub-roles. We will however not use the Information Provider role instead of the sub-roles.

Table 1 Roles related to the Transport Sector Support domain

Superior roles	Detailed roles	Descriptions
Service Provider	*Information Provider*	See below
	Travel Information Provider	Responsible for the provision of travel information services to the Transport User. This may be the provision of travel plans or additional information related to the travel plan.
	Door-to-door Travel Plan Provider	Responsible for the provision of door to door travel planning services. A combination of scheduled and non-scheduled transport is supported.
	Scheduled Travel Plan Provider	Responsible for the provision travel planning services for scheduled transport services, e.g. public transport.
	Non-scheduled Travel Plan Provider	Responsible for the provision travel planning services for non-scheduled transport services, e.g. driving car, walking and using bike.
Information Provider	Traffic Condition Information Provider	Responsible for provision of information about the traffic flow. This may be dynamic/real time or empirical information about traffic density, travel times, speed and delay. Also responsible for provision of dynamic information about abnormal and unplanned conditions in the transportation network (slippery road, high waves, obstructions, restricted view, air pollution, oil spill, etc.) due to situations that cannot be controlled (weather, incidents, accidents, etc.).
	Transportation Network Information Provider	Responsible for provision of static and dynamic information about the transportation network. Also responsible for provision of dynamic information about the transportation network infrastructure. This is regulations due to transportation network conditions and events, e.g. closed roads, platooning, speed limitations, quality, restrictions, constraints, general route and navigation guidelines about normal routes, alternative routes and route diversions (in case of obstructions).
	Meteorological Information Provider	Responsible for provision of information about meteorological conditions (observations, prognosis).
	Terminal Information Provider	Responsible for the provision of information about public transport stops. This may be small bus stops as well as large passenger terminals. Information about facilities, services, deviations, etc. has to be available.
	Tourist Information Provider	Responsible for the provision of tourist information.
	Cost Information Provider	Responsible for provision of cost information related to transport costs (however not the price of transport products), e.g. costs due to environmental issues, travel time, etc. (Has to be further specified).

4.2 Roles related to Transport Demand

The roles related to the Transport Demand domain in the Reference Model that are of relevance to travel information services are described in the table below. In the MultiRIT framework architecture we will use the main role, the Transport User.

Table 2 Roles related to the Transport Demand domain

Superior roles	Detailed roles	Descriptions
Transport User	Responsible for finding the best transport services and for preparing and follow up of the transport.	
	Traveller	Responsible for the planning, preparation and accomplishment of the travel. May use a set of different transport modes, scheduled and non-scheduled transport services included.
	Transport Consumer	Responsible the commercial relations towards the Transport Service Provider (e.g. booking, booking amendments, etc.)
	Transport Organiser	Responsible for organising the transport on behalf of another Transport User. May be a travel agency or a tour operator that orders transport services on behalf of the Transport User. (However, from the Transport User's point of view, a forwarding agent and a tour operator are Transport Services Providers.)

4.3 Roles related to Transport Service Management

The role related to the Transport Service Management domain in the Reference Model of relevance to travel information services is described in the table below.

Table 3 Roles related to the Transport Service Management domain

Superior roles	Descriptions
Transport Service Provider	Responsible for the provision of transport services, i.e. the transport from one location to another as well as terminal services like assistance and baggage handling. Also responsible for the provision of information about such services.

4.4 Roles related to On-board Support and Control

The roles related to the On-board Support and Control domain in the Reference Model that are of relevance to travel information services are described in the table below. The Road User is the main role and will be used in the MultiRIT framework architecture.

Table 4 Roles related to the On-board Support and Control domain

Superior roles	Detailed roles	Descriptions
Road User	Driver	Responsible for navigation and adaptation to the traffic situation in a way that ensures safety and efficiency.
	Cyclist	
	Pedestrian	

4.5 Roles related to Transportation Network Management

The roles related to the Transportation Network Management domain in the Reference Model that are of relevance to travel information services are described in the table below.

Table 5 Roles related to the Transportation Network Management domain

Sub-domain	Superior roles	Descriptions
Transportation Network Infrastructure Management	Transportation Network Manager	Responsible for the management of the transportation network infrastructure information. This includes road, fairways and railroads as well as public transport stops and terminal areas. Also responsible for the provision of transportation network infrastructure, information about the overall services and facilities at the terminal and public transport stops included.
Transportation Network Utilisation	Traffic Manager	Responsible for the traffic management, e.g. by controlling the infrastructure and by guidance or orders given to the driver. Responsible for the provision of traffic condition information.

5 Objects

The objects are general names for entities related to the transport sector. One object relates to one part of the Reference Model. Just the objects relevant to MultiRIT are described. They may not all be used in the MultiRIT framework architecture, but they are included in this report to provide a terminology for further use related to travel information services.

5.1 Objects related to Transportation Network Management

The objects related to the Transportation Network Management domain of relevance to travel information services are listed in the table below.

Table 6 Objects related to the Transportation Network Management domain

Superior object names	Detailed object names	Descriptions	Examples
Transportation Network	Physical infrastructure that makes movement of vehicle, goods and people possible.		o Road network and related equipment, terminals, loading and unloading areas, etc.
	Transport Link	A part of the infrastructure that enables transport between locations such as addresses, Terminals and Transportation Network Resources.	o The road network.
	Terminal	The part of the Transportation Network where passengers can enter, leave and change between transport means.	o Public transport stops, terminals, railway stations, etc.
	Transport Network Resource	See below	
	Transportation Network Equipment	See below	
Transport Network Resource	An identified resource with managed availability. The access is managed according to some strategy, for example first come first served or booking of timeslots		
	Stop Point	Location at a terminal at which a transport means stops.	o Gates at airports o Tracks at railway stations
	Terminal Area	An area of the terminal assigned specific tasks.	o service area o transit area
	Parking Area	Area in which vehicles may park.	o Parking areas in a city.
Transportation Network Equipment	An integrated part of the Transportation Network (located along, over, under, or at specific points in the Transportation Network). Can be used to support, monitor and/or control behaviour or situations. The equipment may exchange information with systems or other equipment, and there may be several strategies for signalling, communication and information dissemination. The same physical equipment may serve as several object types.		
	Equipment for Traffic Control	Provides mechanisms for control of traffic or vehicles (e.g. to detect illegal behaviour).	o Equipment for ATC (Automated Traffic Control), closed-circuit television (CCTV), etc.
	Traffic Data Collection Equipment	Collects data about traffic flow (amount of traffic, speed) and the behaviour of individual vehicles.	o Sensors (traffic counters, detectors) o Closed-circuit television (CCTV) o Equipment for automatic number plate recognition (ANPR), etc. o Traffic signal control systems may also provide this functionality (e.g. SCOOP).

Superior object names	Detailed object names	Descriptions	Examples
	Electronic Fee Equipment		
	Traffic Regulation Equipment	Provides mechanisms for traffic regulation (to affect the traffic flow and behaviour in the traffic)	o Traffic signals, fixed signals, variable message signs, etc.
	Transportation Network Condition Monitoring Equipment	Monitors Transportation Network conditions, weather conditions that may affect the Transportation Network conditions and environmental condition (pollution).	o Misc. sensors detecting meteorological issues, the Transportation Network condition (wet road, slippery road, etc.) and the quality of the air (amount of pollution)..
	Equipment for Information	Equipment for dissemination of information to those using the Transportation Network, e.g. drivers.	o Fixed signs, variable message signs (VMS), information boards, communication equipment, etc.

5.2 Objects related to Transport Sector Support

The objects related to the Transportation Sector Support domain of relevance to travel information services are described in the table below.

Table 7 Objects related to the Transport Sector Support domain

Superior object names	Detailed object names	Descriptions
Ticket Equipment Equipment that issues and handles tickets	Ticket Machine	Provides payment facilities and issues tickets.
	Validation Machine	Registers payment information
Payment Equipment		Provides payment facilities and registers payment information

5.3 Objects related to Transport Demand

The objects related to the Transport Demand domain of relevance to travel information services are described in the table below.

Table 8 Objects related to the Transport Demand domain

Superior object names	Detailed object names	Descriptions
Transport Item	Person	Person served by a Transport Service Provider.
	Luggage	The luggage of the Person See below
Luggage	Animals	
	Unhandy luggage	Luggage needing special handling/treatment.

5.4 Objects related to On-board Support and Control

The objects related to the On-board Support and Control domain of relevance to travel information services are described in the table below.

Table 9 Objects related to the On-board Support and Control domain

Superior object names	Detailed object names	Descriptions
Transport means	Transport Means	Transport Means that transports people, in the air, on roads, on rails or water bound.
On-board Equipment	Equipment on-board the transport means.	
	Communication Equipment	Provides mechanisms that enable communication with systems or equipment located outside the transport means, e.g. along the transportation network, in other transport means, or elsewhere.
	Equipment for Identification	Identifies the transport means in a unique way.
	Equipment for Positioning	Provides position information.
	Equipment for Driver Support	Laptops, PDAs or other equipment that provides access to information systems or other solutions useful to the driver. May support the driver with respect to the accomplishment of the driving operation and in emergency situations.
	Equipment for Navigation Support	Equipment that helps the driver to find the required route.

6 Functional views

In this chapter the functionality supporting travel information services is described. The functionality will be a part of the domains and sub-domains of the Reference Model, and the top level use cases in Figure 6 are related to the Reference Model.

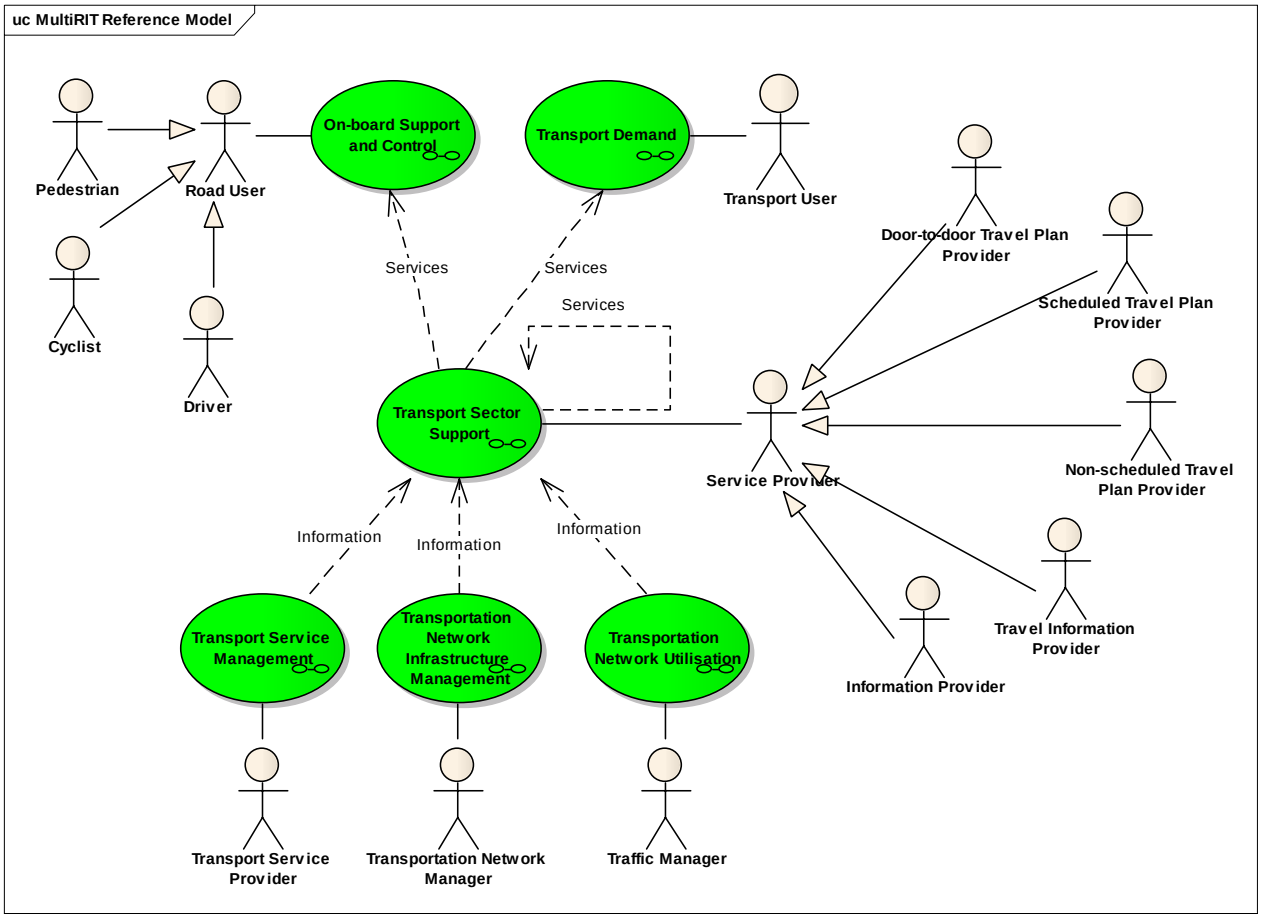


Figure 6 Top level use cases – related to the Reference Model

In the sections below the top level use cases are further decomposed and described. Just those parts that are relevant to MultiRIT are included.

Remark: In ARKTRANS the same use cases may also include additional functionality since ARKTRANS has a broader scope than MultiRIT. To show the relations to ARKTRANS and the refinement of ARKTRANS, we have however tried to use the same de-composition structure as in ARKTRANS. Thus, some use cases may seem to have more decomposition levels than required in MultiRIT.

6.1 Functional view - Transportation Network Utilisation

The part of Transportation Network Utilisation that is relevant to MultiRIT is shown in Figure 7. The parts addressed in the process view are green.

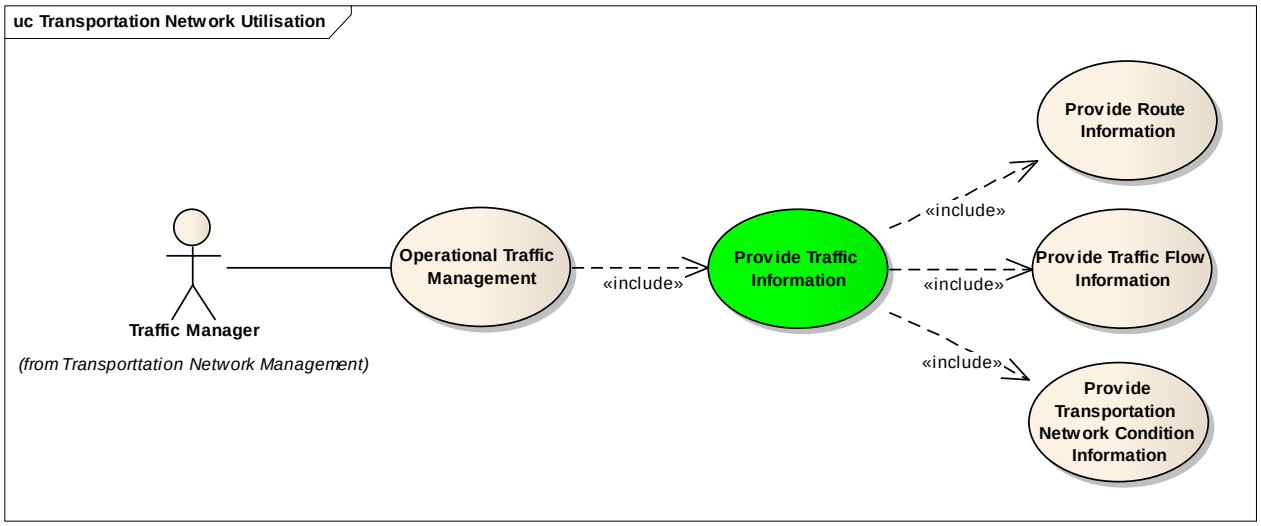


Figure 7 Functional decomposition of Transportation Network Management – Transportation Network Utilisation

6.1.1 Operational Traffic Management

The traffic is continuously managed based on information about the traffic flow and conditions. Several traffic management measures may be taken to influence on the traffic flow, and relevant information is provided to the Road Users.

6.1.1.1 Provide Traffic Information

Traffic information is established and disseminated to Road User to influence on safety and traffic flow (traffic information may also be provided by the Information Provider as an information service – see 6.6.2).

Traffic information may be prognoses for the future as well as information based on real time observations or measurements. Thus, the traffic information must contain meta information that reflects how the information is established (observation, measurement, calculated forecast, etc.).

6.1.1.1.1 Provide Route Information

The Road User may need information or guidance to find or follow the optimal route with respect to traffic flow and safety. General route and navigation guidelines about normal routes, alternative routes and route diversions (in case of obstructions) are communicated to the Road User.

6.1.1.1.2 Provide Traffic Flow Information

Traffic flow information is provided. This is dynamic traffic information and statistical traffic information about traffic flow, such as traffic density, speed, delays and travel times.

6.1.1.1.3 Provide Transportation Network Condition Information

Transportation Network Condition Information is provided. This is dynamic information about abnormal and unplanned conditions in the transportation network (slippery road, turbulence, high waves, obstructions, restricted view, air pollution, oil spill, etc.) due to situations that cannot be controlled (weather, incidents, accidents, etc.)

6.2 Functional view - Transportation Network Infrastructure Management

The part of Transportation Network Infrastructure Management that is relevant to MultiRIT is shown in Figure 8.

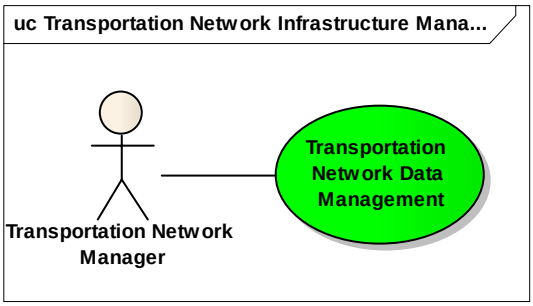


Figure 8 Functional decomposition of Transportation Network Management – Transportation Network Infrastructure Management

6.2.1 Provide Transportation Network Data

Information about the transportation network infrastructure is established, managed and provided to those needing such information. This includes information about:

- Physical Transportation Network Information: Static information about the transportation network.
- Dynamic Transportation Network Information: Dynamic information about situations in the transportation network infrastructure due to transportation network conditions and events as well as regulations valid in the transportation network, e.g. closed roads, platooning, speed limitations, quality, restrictions, constraints, general route and navigation guidelines about normal routes, alternative routes and route diversions (in case of obstructions).

6.3 Functional View - Transport Demand

The Transport Demand domain is decomposed as shown in the figure below. Just the parts of relevance to MultiRIT are included. The most relevant use cases, which also are addressed in the process, view are green.

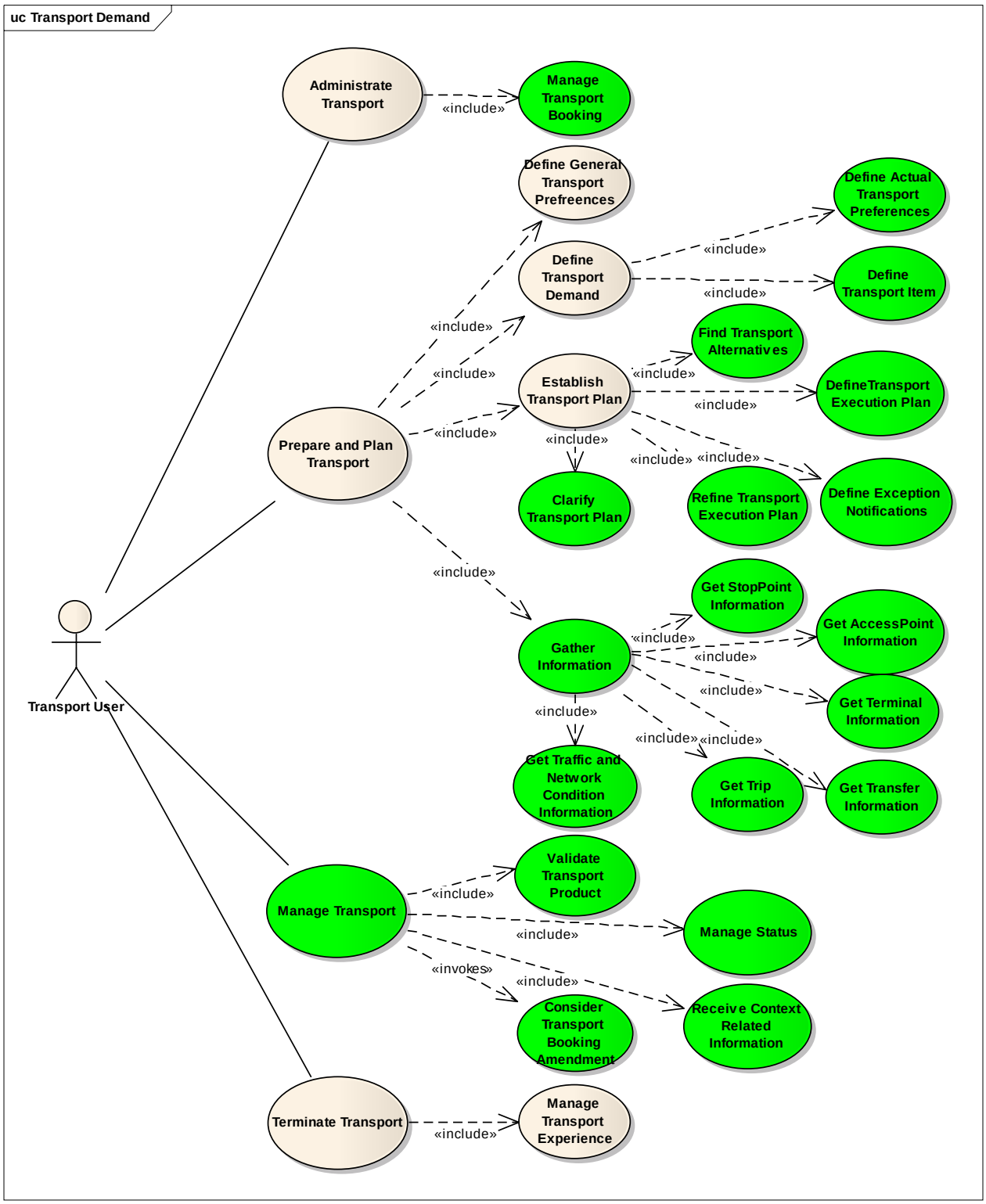


Figure 9 Functional decomposition of Transport Demand

6.3.1 Administrate Transport

A transport chain and its Transport Services Providers are defined in a transport execution plan. Whenever the services defined in the plan have to be booked or the bookings have to be amended, the formalities must be handled.

6.3.1.1 Mange Transport Booking

Some transport services addressed in the transport execution plan may have to be booked. The bookings have to be managed both before and during the transport, and the relation towards the Transport Service Provider is more formal than if no booking is required.

The booking management initially handles the submission bookings to all relevant Transport Service Providers (the Transport Service Management domain) and the follow up of these bookings. Such bookings may also be required for other services than the transport itself, e.g. terminal services like assistance. Preliminary bookings may be used if services are depending on each other. The Transport User will receive positive or negative confirmations from the Transport Service Providers. In case of negative confirmations, alternative transport services must be chosen. Firm bookings are usually not made until all preliminary bookings are confirmed.

Deviations may occur after the initial booking, and the Transport Service Providers may provide a revised transport execution plan for his part of the journey. The Transport User has to consider whether the revised plan should be accepted.

If the contract towards the Transport Service provider allows it (all transport services cannot be amended – the Transport User may be obliged to pay), the Transport User may also take the initiative to change the transport execution plan and to amend the bookings accordingly.

6.3.2 Prepare and Plan Transport

The Transport User has a transport demand. In the planning and preparation phase, the Transport User is supported with respect to

- The definition of the transport demand by means of *general transport preferences* (GTP) and *actual transport preferences* (ATP).
- The identification of relevant transport alternatives.
- The definition of a *transport execution plan* that defines the transport services that will fulfil the transport demand.

6.3.2.1 Define General Transport Preferences (GTP)

The *general transport preferences* (GTP) for the Transport User are defined. One Transport User may have several GTPs, each indicating preferences for different types of transport demands (e.g. business travel, pleasure travel, etc.).

The GTPs may be used as a basis for the actual transport preferences related to a travel. A GTP may for example include the preferred Transport Service Providers and the associated customer numbers, preferred transport modes, criteria for selection of transport modes (e.g. costs, time schedules, environmental issues), requirements (e.g. environmental profile, restrictions with respect to additional cargo on the transport means, no tunnels, no smoker, seat by the aisle, vegetarian food, special requirements for disabled people, preferred payment, etc.).

6.3.2.2 Define Transport Demand

The transport demand is defined by means of preferences and specifications of what is to be transported.

6.3.2.2.1 Define Actual Transport Preferences (ATP)

The actual transport preferences (ATP) for a specific transport operation are defined. Relevant information from the GTP (general transport preferences) associated with the transport is included.

The ATP encompasses requirements such as start and end locations for the transport (door-to-door should be possible), departure times, arrival times, number of transits, criteria for optimising (costs, time, comfort, quality, contract references, etc.), requirements concerning the ability to change the plans (deadline for cancellation or changes, costs related to changes, etc.), the ability to give alerts in case of deviations, etc.

6.3.2.2.2 Define Transport Item

Relevant information about the Transport Items to be transported (Passenger and/or Luggage) is established.

Transport Item instructions, i.e. requirements with respect to handling, etc., may be registered.

6.3.2.3 Establish Transport Execution Plan

The *transport execution plan* is the Transport User's itinerary. The plan may be established in several ways:

- From the best (from a subjective point of view) of several transport alternatives.
- Based on a transport execution plan used earlier.
- Based on a proposed plan, e.g. received from others.

The plan specifies the journey segments, the services and service providers involved, the time schedules, the alert conditions (if specified), etc.

A transport execution plan may contain the following information:

- Relevant parts of ATP.
- Information about the Transport Items to be transported (passenger(s) and cargo).
- Departure and arrival locations.
- Departure and arrival times.
- Notification conditions.

6.3.2.3.1 Find Transport Alternatives

Based on the ATP and the definition of the Transport Items, relevant transport alternatives are found. The alternatives may be transport chains involving one ore more transport means and transport modes.

If relevant, transport alternatives that are in conflict with the GTP or the ATP should be marked.

It may be necessary to change the transport plans during the transport operation due to derivations. If so, it may be necessary to find new transport alternatives. They can be found by means of updates in the transport demand (i.e. updates in the actual transport preferences).

6.3.2.3.2 Define Transport Execution Plan

The *transport execution plan* defines the preferred transport chain. The first version of the plan may be established from the best of a set of transport alternatives derived from the transport demand (see 6.3.2.3.1), or an existing transport execution plan can be used as a template.

A Transport execution plan may be refined due to deviations in the transport services or new transport demands.

6.3.2.3.3 Define Exception Notification

The transport should be carried out according to the transport execution plan. However, deviations may occur (e.g. delays, cancellations, reduction in service level, etc.).

The Transport User should be able to request exception notifications related to the booked transport services. The preferred way to receive the exception notifications should also be define (automatic response to information system, SMS, etc.). Such requests for exception notifications should be entered into the transport execution plan.

The handling of deviations may be the responsibility of the Transport User or the Transport Service Provider. The Transport Service Provider will be responsible for the handling of delays that affects the next leg of the journey if he is responsible for several consecutive journey segments.

6.3.2.3.4 Refine Transport Execution Plan

It may be relevant to update the transport execution plan with information from the Transport Service provider, e.g. information about seats.

6.3.2.3.5 Clarify Transport Plan

In case of specific requirements the Transport User may want to clarify the ability to accomplish the transport. An existing transport execution plan may for example be checked with respect to accessibility. If the requirements are not fulfilled, the transport execution plan may for example be modified to include assistance.

6.3.2.4 Gather Information

The Transport User may gather information to be able to take better decision with respect to how and when to travel. Thus, additional information about transport alternatives can be requested. The user should be able to expand the transport alternatives with the retrieved information.

The Transport User may also want gather additional information about the entries in the transport execution plan.

6.3.2.4.1 Get Access Point Information

Information about the access points to terminals may be gathered.

6.3.2.4.2 Get Stop Point Information

Information about the relevant stop points at terminals may be gathered.

6.3.2.4.3 Get Terminal Information

Information about the relevant terminals may be gathered.

6.3.2.4.4 Get Transfer Information

Information about the relevant transfers at terminals may be gathered.

6.3.2.4.5 Get Trip Information

Information about actual trips may be gathered.

6.3.2.4.6 Get Traffic and Network Condition Information

Information about the traffic situation is gathered. This may be:

- Transportation network information

- Transportation network condition
- Traffic flow and traffic density

6.3.3 Manage Transport

The transport is accomplished according to the transport execution plan, and the progress is followed up.

6.3.3.1 Validate Transport Product

The transport product that is to be used (documented by means of a paper ticket or an eTicket) is validated. After the validation the Transport User is entitled to use the transport service.

6.3.3.2 Manage Status

If the transport service is booked and exception notifications are requested, exception notifications about deviations (delays, cancellations, etc.) are received from the Transport Service Provider. Some Transport user may also send exception notifications in any case.

If the transport service is not booked or exception notifications are not requested, the Transport User may request status information on demand.

An exception notification may be followed by an adjusted transport execution plan. The Transport Service provider may for example have booked the Transport User on the next plane due to a late arrival. Such amendments must be considered by the Transport User (see 6.3.1.1).

6.3.3.3 Consider Transport Booking Amendment

The Transport User may consider changing the transport execution plan due to deviations (deviations at one leg of the journey may lead to problems for the following journey legs) or due to new transport demands. However, the ability to amend booking must be considered. Due to the contract the Transport User may not be able to amend bookings for free.

6.3.3.4 Receive Context Related Information

During the transport, the Transport User may get information that depends on the context, e.g. the location, the status of the trip (e.g. delayed), etc.

6.3.4 Terminate Transport

6.3.4.1 Manage Transport Experience

On termination of a transport task experiences should be stored. This may be statistics as well as calculated information and comments (typed inn by a user).

6.4 Functional View - Transport Service Management

The Transport Service Management domain is decomposed as shown in the figure below. Just the parts of relevance to MultiRIT are included. The most relevant use cases, which also are addressed in the process, view are green.

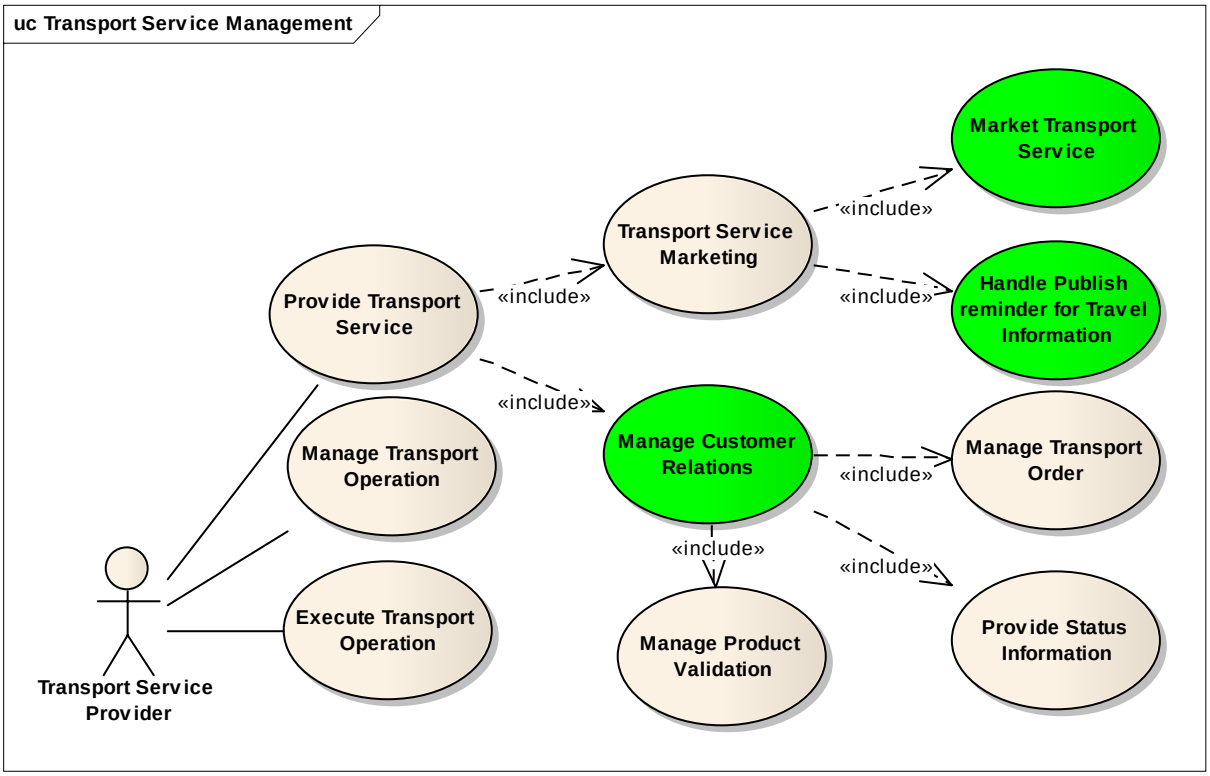


Figure 10 Functional decomposition of Transport Service Management

6.4.1 Provide Transport Service

The Transport Service Provider will provide transport services to the Transport User. A transport service may be all types of services related to transport, e.g. assistance services, handling services, etc.

6.4.1.1 Transport Service Marketing

Information about the transport services that are/can be provided shall be published.

6.4.1.1.1 Market Transport Service

Information about the available transport services is published according to conventions for how the publishing is to be done. This may be information about trips, routes, services on board, services at terminals, deviations, accessibility, rates, etc.

6.4.1.1.2 Handle Publish Reminder for Travel Information

A Transport Service Provider that fails to publish service information may receive a reminder.

6.4.1.2 Manage Customer Relations

All contact with the Transport User is managed, bookings and reporting in case of exceptions included.

6.4.1.2.1 Manage Transport Order

The order management is outside the scope of MultiRIT. However, the interaction with this functionality is a part of the total picture.

Booking requests for transport services are managed. The orders are processed, information about the orders and amendments are managed.

6.4.1.2.2 Provide Status Reports

Exceptions are reported based on status information received from the Manage Transport Operation function. Exception notifications are sent to the Transport User according to the notification requests in the bookings.

The Transport User may also request status information on demand. Such requests are responded upon.

6.4.1.2.3 Manage Product Validations

The use of transport products is registered and managed.

6.4.2 Manage Transport Operation

The transport operation is planned and managed. This part is not relevant to MultiRIT. However, transport operation management will collect the information about the status.

6.4.3 Execute Transport Operation

The actual transport operation is executed. This part is not relevant to MultiRIT. However, this is the origin of the status information respect to time schedules and service provision.

6.5 Functional View - On-board Support and Control

The On-board Support and Control domain is decomposed as shown in the figure below. Just the parts of relevance to MultiRIT are included.

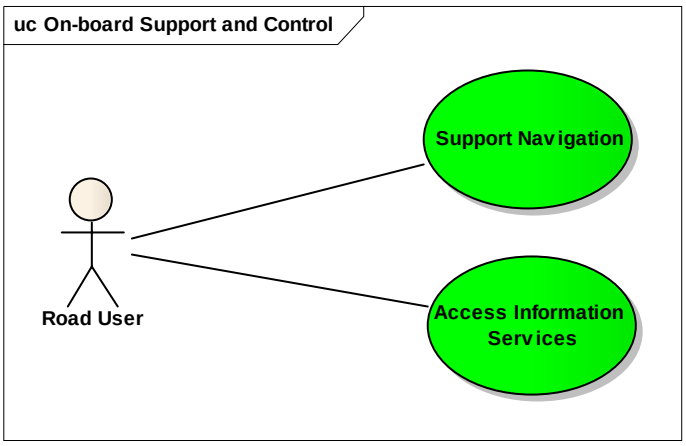


Figure 11 Functional decomposition of On-board Support and Control

The driving and navigation operations are supported. Information about irregularities detected with respect to traffic and transportation network condition may be provided by the Transportation Network Management domain.

Remark: The person who is driving the car, walking or cycling is a Road User when he/she adapts to the traffic situations and aims to move around in a safe and efficient way. To achieve this he related to the Transportation Network Management sub-domain. The same person may also, more or less simultaneously, have the Transport User role. The Transport User is however using the travel information services provided by the Travel Information Provider.

6.5.1 Support Navigation

The navigation support may be provided by separate equipment or by separate systems, or the support may be done by integration of several tools. By means of the latter, several types of information (e.g. maps with information about traffic conditions) may be combined. The information used may be acquired by means of different information services (see 6.5.2). Such integration may simplify navigation and support decisions. The actual tools and systems for navigation support are outside the scope of MultiRIT. The information flows are however identified.

Functionality that may be provided is:

- Electronic maps may show the real-time position of other Transport Means as well as the position and movement to the Driver's Transport Means.
- Route planning and route definition may be supported. The planning may for example be done with basis in the Operational Route Plan received from the Transport Service Management. Several propositions for routes may be suggested. The route chosen can be defined and if required it may be communicated to the Transport Service Management.
- A planned route can be simulated. In that way the navigation can be tested in advance.
- The Driver may be guided through the planned route.
- Information about current position, deviations from the planned route, and status may be passed on to the Driver (and if needed also to the Transport Service Management).
- Information about the expected time of arrival can be provided.
- Information is collected (e.g. by means of the information services – see 6.5.2) and presented in an integrated way, e.g. on the map used for the navigation. This may for example be:

- The current traffic situation (the density, incidents, accidents etc)
- The current condition in the Transportation Network (the state of the Transportation Network, cordons, one-way driving, etc)
- The current weather conditions
- The current regulations
- Notices to the Driver
- Information from the control functions and the monitoring functions

6.5.2 Access Information Services

The Driver or the systems on-board may request several types of information, e.g.:

- Maps or map updates
- Meteorological conditions
- The current regulations
- Traffic Flow Information
  Dynamic traffic information and statistical traffic information about traffic flow, such as traffic density, speed and delay.
- Transportation Network Condition Information
  Dynamic information about abnormal and unplanned conditions in the transportation network (slippery road, turbulence, high waves, obstructions, restricted view, air pollution, oil spill, etc.) due to situations that cannot be controlled (weather, incidents, accidents, etc.).
- Dynamic Transportation Network Information
  Dynamic information about situations in the transportation network infrastructure due to transportation network conditions and events as well as regulations valid in the transportation network, e.g. closed roads, platooning, speed limitations, quality, restrictions, constraints, general route and navigation guidelines about normal routes, alternative routes and route diversions (in case of obstructions).
- Physical Transportation Network Information
  Static information about the transportation network
- Traffic Condition Information
  A total assessment of the situation in the transportation network that may affect safety and efficiency or just elements of such information. Information elements that may be provided are Traffic Flow Information, Transportation Network Information and Transportation Network Condition.

6.6 Functional view - Transport Sector Support

The Transport Sector Support domain provides different types of services. Just those of relevance to MultiRIT are included in the figure below.

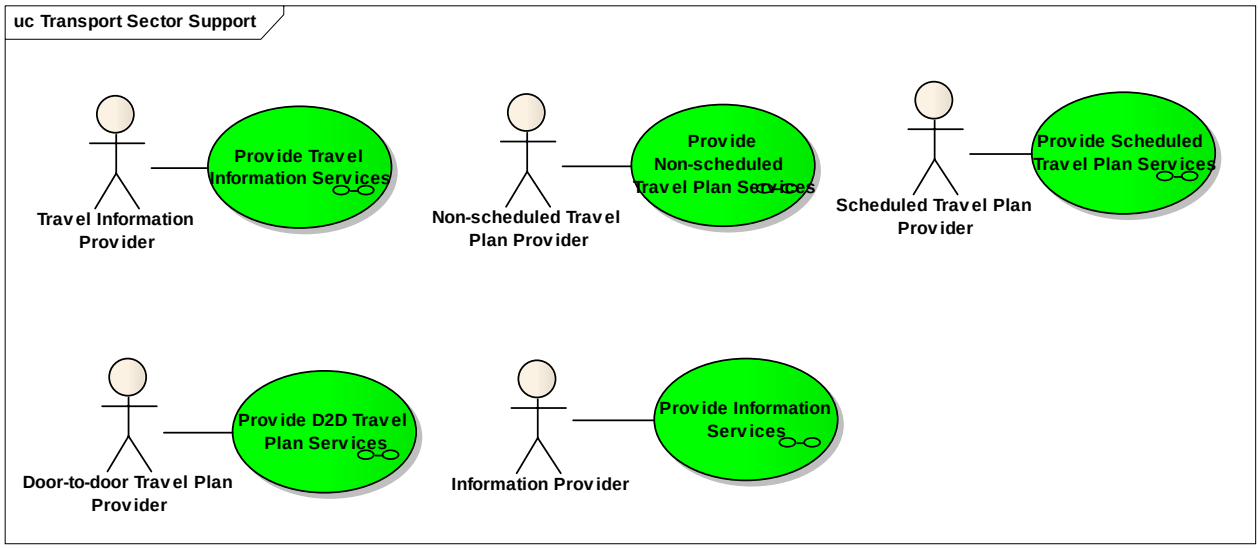


Figure 12 Services of relevance to MultiRIT in Transport Sector Support domain

The use cases are further decomposed and described below. The most relevant use cases, which also are addressed in the process, view are green.

6.6.1 Provide Travel Information Services

The use cases described in this section support the provision of travel information services to the Transport User. The services are provided via some sort of user interface. Other services may be used to establish parts of the services or to collect the required information. This is described in the Process view in Chapter 7.

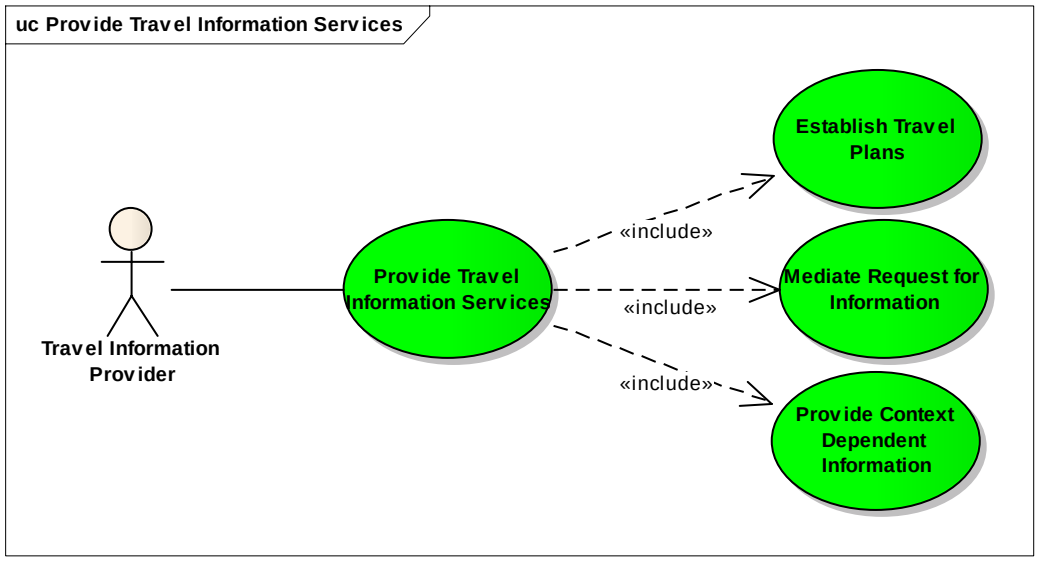


Figure 13 Functional decomposition of Provide Travel Information Service

6.6.1.1 Establish Travel Plans

Travel plans that satisfy the transport demand are established by means of access to the suitable travel planners. Additional information, e.g. about individual trips, can be collected and entered into the travel plans.

6.6.1.2 Mediate Request for Information

The Travel Information Provider receives requests for several types of information from the Transport User. The requests are processed, and the required information requests are forwarded to different Information Providers. When the required information is collected, the response is composed and provided to the Transport User.

The Transport User with specific preferences may have a transport execution plan that he wants to check towards these preferences. Information is collected to verify that the transport execution plan fulfils the requirements of the Transport User.

6.6.1.3 Provide Context Dependent Information

The Transport User may request context dependent information. Several strategies may be used to provide such information, for example:

- Context information is received from the Transport User (e.g. the location of the Transport User, transport service used, preferences, etc.), and information is provided according to this information.
- The systems providing the information may register the relevant context information themselves and provide relevant information to the Transport Users. On-board systems may for example register the location (by means of GPS) and they systems may also be informed about delays. Based on this context, relevant information is broadcasted to Transport Users on-board. In the same way, terminal information systems may be informed about delays and arrival times, and the information may be provided to Transport Users waiting for the bus.

6.6.2 Provide D2D Travel Plan Services

The Door-to-door Travel Planner calculates travel plans according to the request from the Travel Information provider. This may be done by means of centralised or de-centralised solutions.

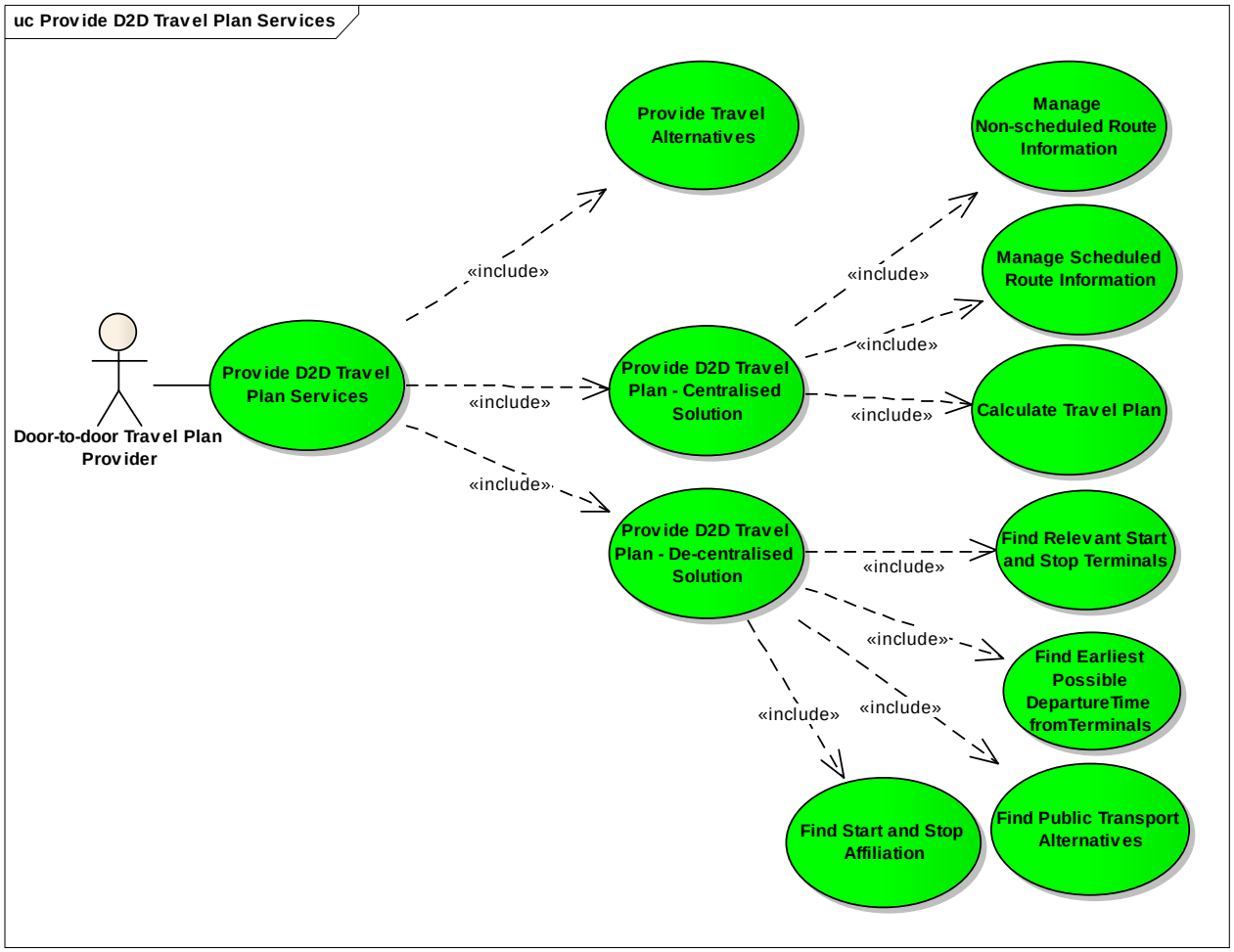


Figure 14 Functional decomposition of Provide D2D Travel Plan Service

6.6.2.1 Provide Travel Alternatives

The calculated travel plans are provided to the Travel Information Provider.

6.6.2.2 Provide D2D Travel Plan – Centralised Solution

In a centralised solution all information that is required for the calculation of the travel plans are locally available.

6.6.2.2.1 Manage Non-scheduled Route Information

Non-scheduled route information is managed. This is information about the transportation network infrastructure, travel times and other properties that is of relevance to the travel planning.

6.6.2.2.2 Manage Scheduled Route Information

Route information is managed. This must be the routes of all relevant scheduled transport services.

6.6.2.2.3 Calculate Travel Plan

Based on the route information (scheduled and non-scheduled) the relevant route alternatives are calculated.

6.6.2.3 Provide D2D Travel Plan – De-centralised Solution

In a de-centralised solution the travel plans have to be calculated based on input from different travel planners.

6.6.2.3.1 Find Relevant Start and Stop Terminals

Assuming that public transport is to be used for a part of the route, the relevant terminals at each end of the journey have to be identified.

If there are specific requirements to the terminal (e.g. with respect to accessibility), requests for additional information may be required.

6.6.2.3.2 Find Earliest Possible Departure Time from Terminals

It will take time to get to the start terminals. Depending on the earliest start of the journey and the travel time to the relevant terminals, the earliest departure time for the public transport at the relevant start terminals are calculated.

6.6.2.3.3 Find Public Transport Alternative

The public transport alternatives from the start terminals to the possible stop terminals are calculated.

6.6.2.3.4 Find Start and Stop Affiliation

The routes to the start terminals and from the stop terminals to the destination are calculated.

6.6.3 Provide Scheduled Travel Plan Services

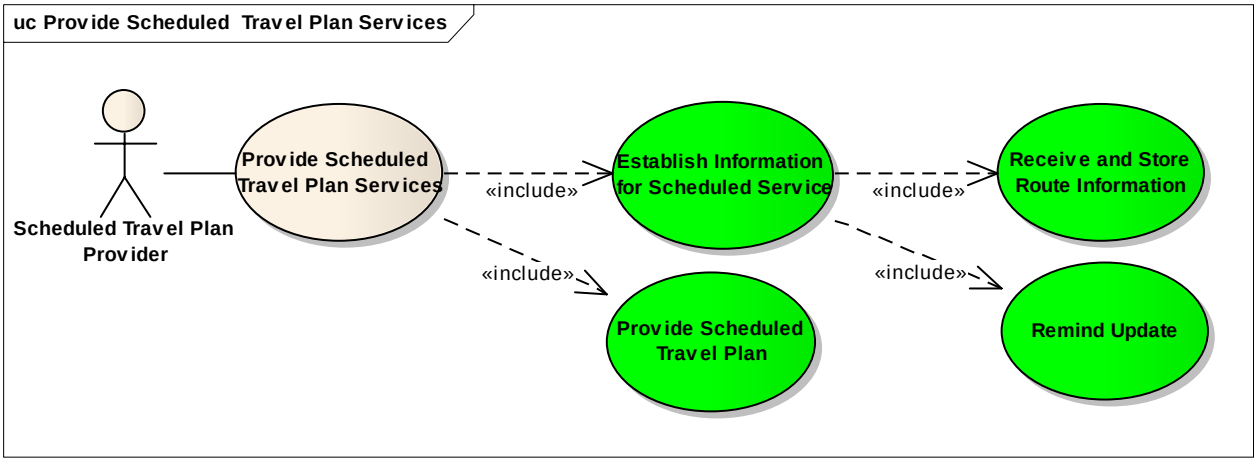


Figure 15 Functional decomposition of Provide Scheduled Travel Plan Service

6.6.3.1 Establish Information for Scheduled Services

The data required for the travel planning is established.

6.6.3.1.1 Receive and Store Route Information

Information about all relevant routes are collected from the Transport Service Providers and managed.

6.6.3.1.2 Remind Update

If a Transport Service Provider does not provide route information according to agreements and regulations, the Transport Service provider is notified.

6.6.3.2 Provide Scheduled Travel Plan

The travel plan is calculated and provided.

6.6.4 Provide Non-scheduled Travel Plan Services

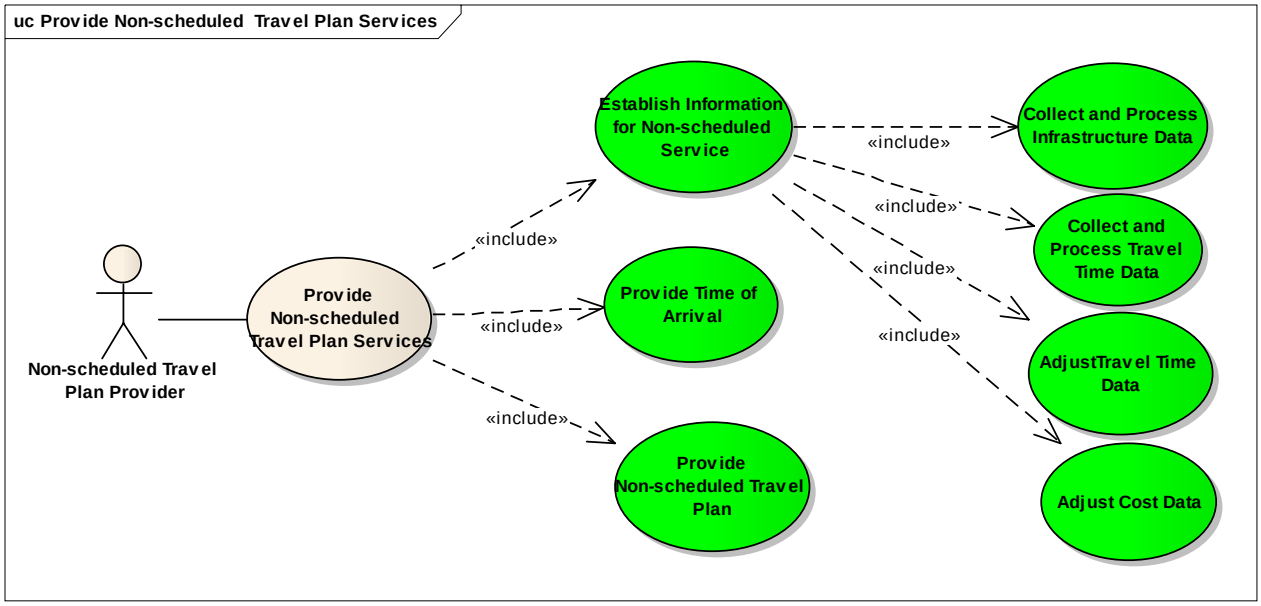


Figure 16 Functional decomposition of Provide Non-scheduled Travel Plan Service

6.6.4.1 Establish Information for Non-scheduled Service

The data required for the travel planning is established.

6.6.4.1.1 Collect and Process Infrastructure Data

Information about the Transport Network Infrastructure is collected and managed. This also includes information about public transport Terminals (so that the link towards public transport can be handled).

6.6.4.1.2 Collect and Process Travel Time Data

Travel time date is collected and managed. Depending on the request, real time data or prognosis (e.g. statistics) should be used.

6.6.4.1.3 Adjust Travel Time Data

The travel time date is modified based on information about dynamic issues, e.g. meteorological issues, incidents and events and the transportation network condition.

6.6.4.1.4 Adjust Cost Data

Cost information is updated. Different types of costs may be relevant to patch the preferences of the Transport User.

6.6.4.2 Provide Time of Arrival

The travel time for a journey between two locations are calculated.

6.6.4.3 Provide Non-scheduled Travel Plan

Travel plans for a journey between two locations are calculated. Preferences are considered.

6.6.5 Provide Information Services

Many types of information may be of relevance to those providing travel information services or travel plans. In addition to travel planning, the information may be used to compose value added services or as a basis for simple travel information services. This information is provided by the Information Provider role. Several stakeholders may have this role, and they may also have other roles at the same time (e.g. Traffic Manager and Transport Network Manager).

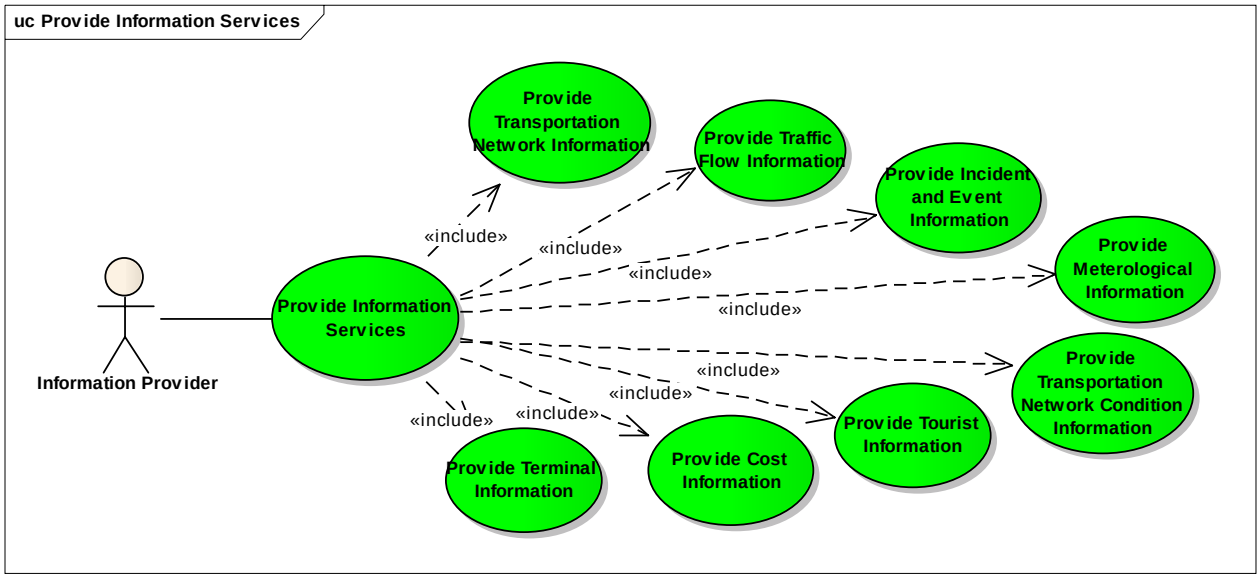


Figure 17 Functional decomposition of Provide Information Service

6.6.5.1 Provide Transportation Network Information

Information about the transportation network infrastructure provided to those needing such information. This includes information about:

- Physical Transportation Network Information: Static information about the transportation network.
- Dynamic Transportation Network Information: Dynamic information about situations in the transportation network infrastructure due to transportation network conditions and events as well as regulations valid in the transportation network, e.g. closed roads, platooning, speed limitations, quality, restrictions, constraints, general route and navigation guidelines about normal routes, alternative routes and route diversions (in case of obstructions).

6.6.5.2 Provide Traffic Condition Information

Traffic flow information is provided. This is dynamic traffic information and statistical traffic (e.g. statistics) information about traffic flow, such as traffic density, speed, delays and travel times.

6.6.5.3 Provide Incident and Event Information

Information about incidents, accidents and events that may affect the traffic flow is provided.

6.6.5.4 Provide Meteorological Information

Meteorological information is provided.

6.6.5.5 Provide Tourist Information

Different types of tourist information are provided.

6.6.5.6 Provide Transportation Network Condition Information

Transportation Network Condition Information is provided. This is dynamic information about abnormal and unplanned conditions in the transportation network (slippery road, turbulence, high waves, obstructions, restricted view, air pollution, oil spill, etc.) due to situations that cannot be controlled (weather, incidents, accidents, etc.)

6.6.5.7 Provide Cost Information

Information about the costs related to transport is provided.

7 Process view

The domains and sub-domains of the Reference Model will interact during the establishment and provision of travel information services and during the different phases of the travelling process. Processes are described to identify the need for interactions and open services. They address the interactions between the stakeholders playing the different roles, i.e.

- Between the Transport User and the Travel Information Provider who provides end-user travel information services.
- Between those who provide transport services (bus companies, air lines, train operators, etc.) and those who provide travel information services.
- Between providers of different types of travel information services. They may use the existing services to establish value added services.

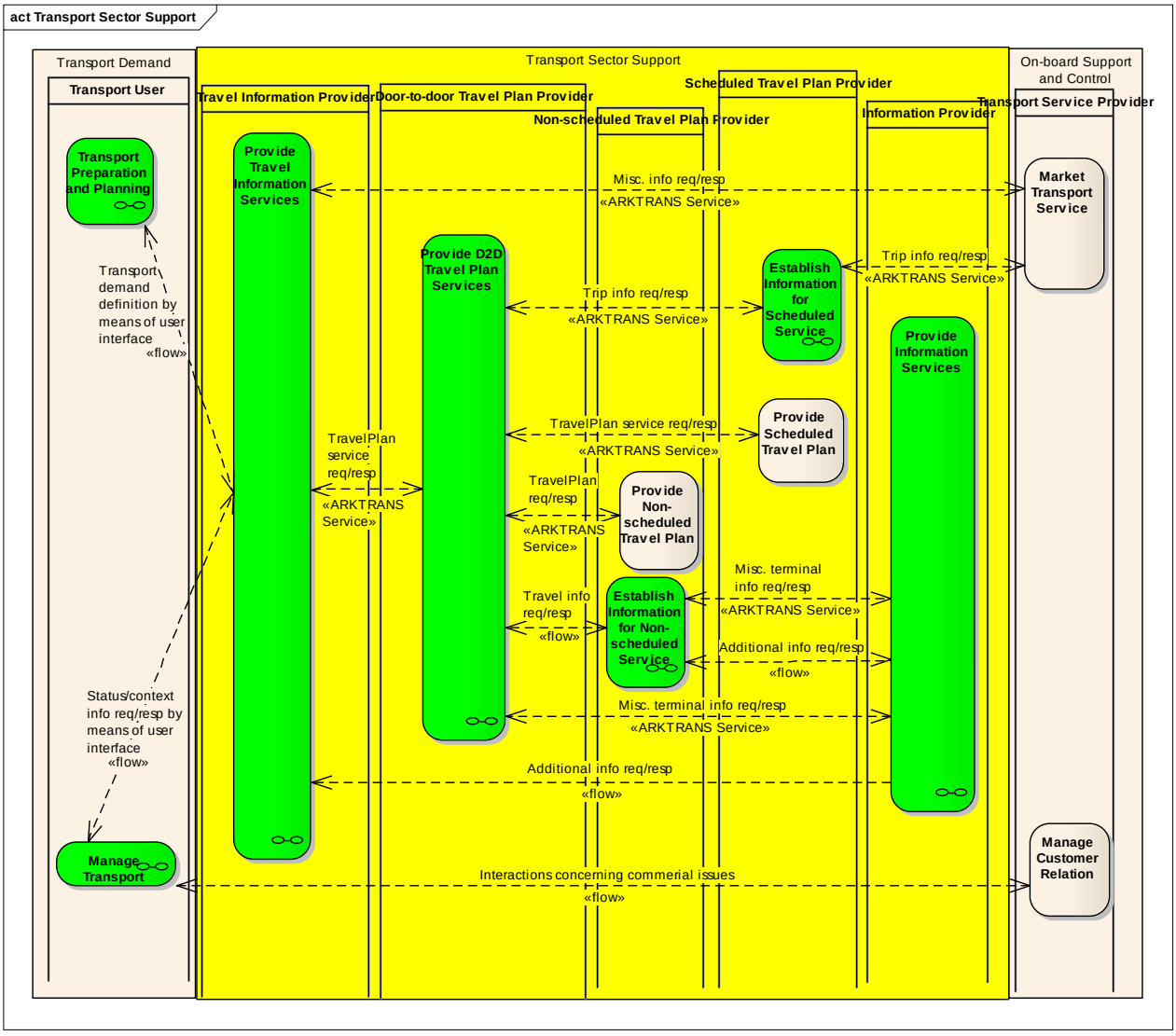


Figure 18 The overall process with references to roles in the different parts of the transport sector

Figure 18 shows an overall process that involves some of these roles identified as the target group in Figure 6. Interactions caused by the needs of the Road User are depicted in Figure 31. It is important to bear in mind that the roles may be played by different stakeholders, and the same stakeholder may also have more than one role. A transport company may for example have both the Travel Information Provider and the Transport Service Provider roles.

The overall process and the more detailed processes are described by UML activity diagrams in swim lanes.

- There is one “swim lane” for each role involved. The use cases described in Chapter 6 are related to activities with similar names.
- The required interactions between the roles (i.e. between the swim lanes) are represented by information flows (dotted arrows).
- The solid-drawn arrows within the swim lanes are control flows (*not* information flows).
- The information flows between activities within the same swim lanes are *not* addressed as they are internal matters to the systems involved.
- The information flows that are realised by means of the open services specified by MultiRIT are stereotyped with “ARKTRANS service” to indicate that they will be a part of the ARKTRANS framework. These services are further defined in the Information view in 7.8.

It is important to notice that the processes are examples. The activities may be combined in other ways as well. The required interactions between the roles (i.e. between the swim lanes) are however to a large extent general.

7.1 Transport Demand – the Transport User’s processes

7.1.1 The Travel process

The travel process is from the Transport User’s point of view quite different for different types of journeys. For long distance journeys, the required transport services may have to be pre-booked. In cities, however, no booking is usually required. Figure 20 and Figure 19 illustrate the examples. There may of course also be combinations, but the figures illustrate the main principles and identify the required interactions.

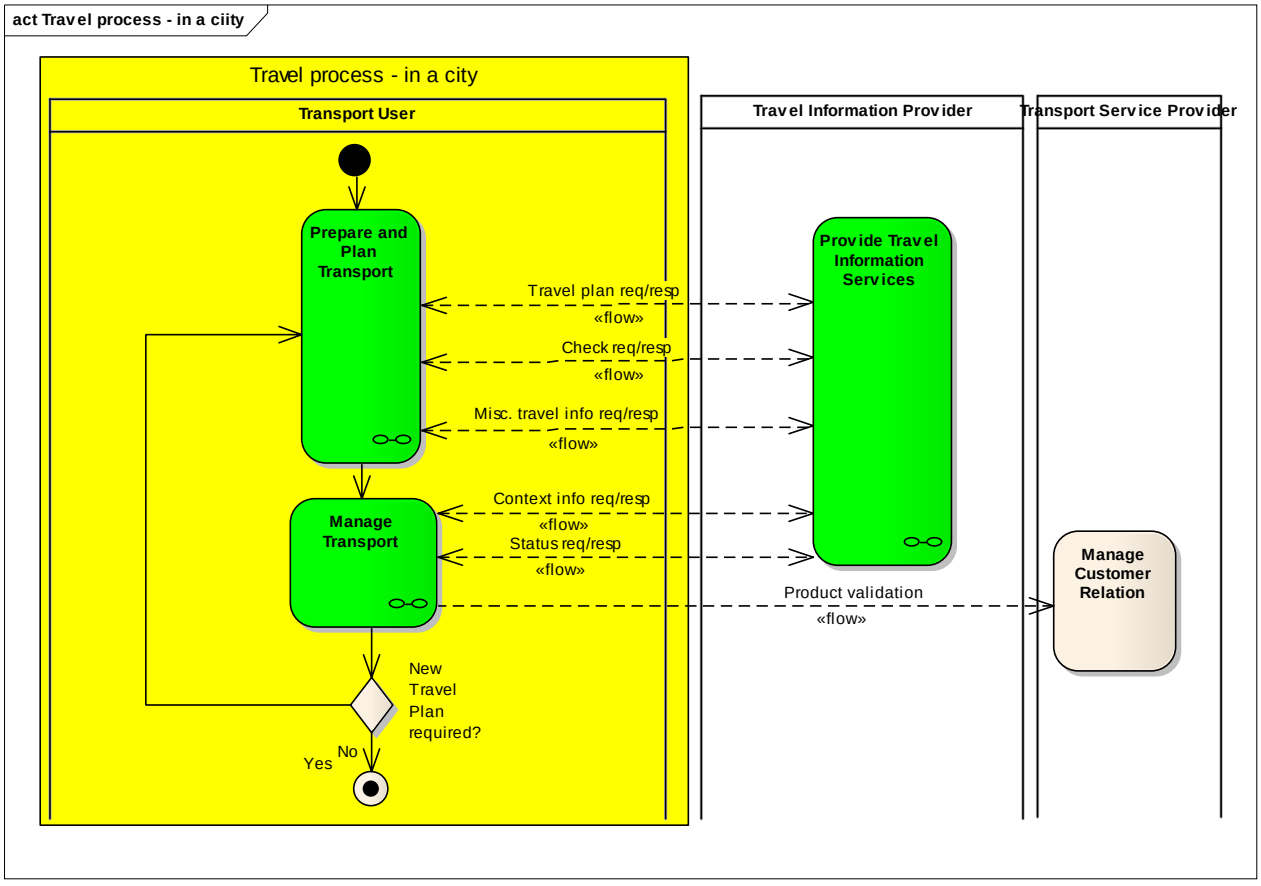


Figure 19 The travel process in a city from the Transport User's point of view

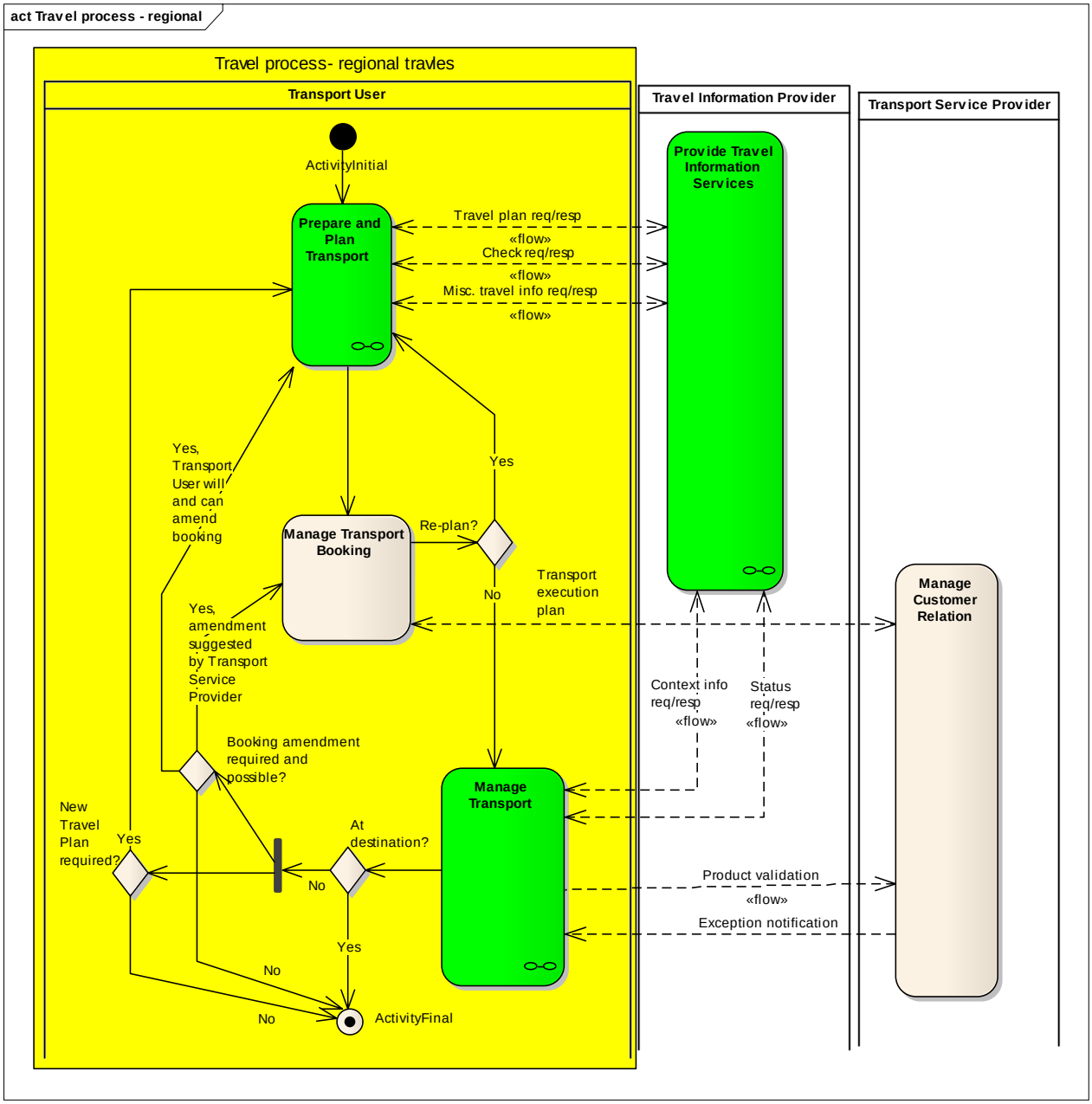


Figure 20 The travel process for long distance travels from the Transport User's point of view

7.1.2 The Prepare and Plan Transport process

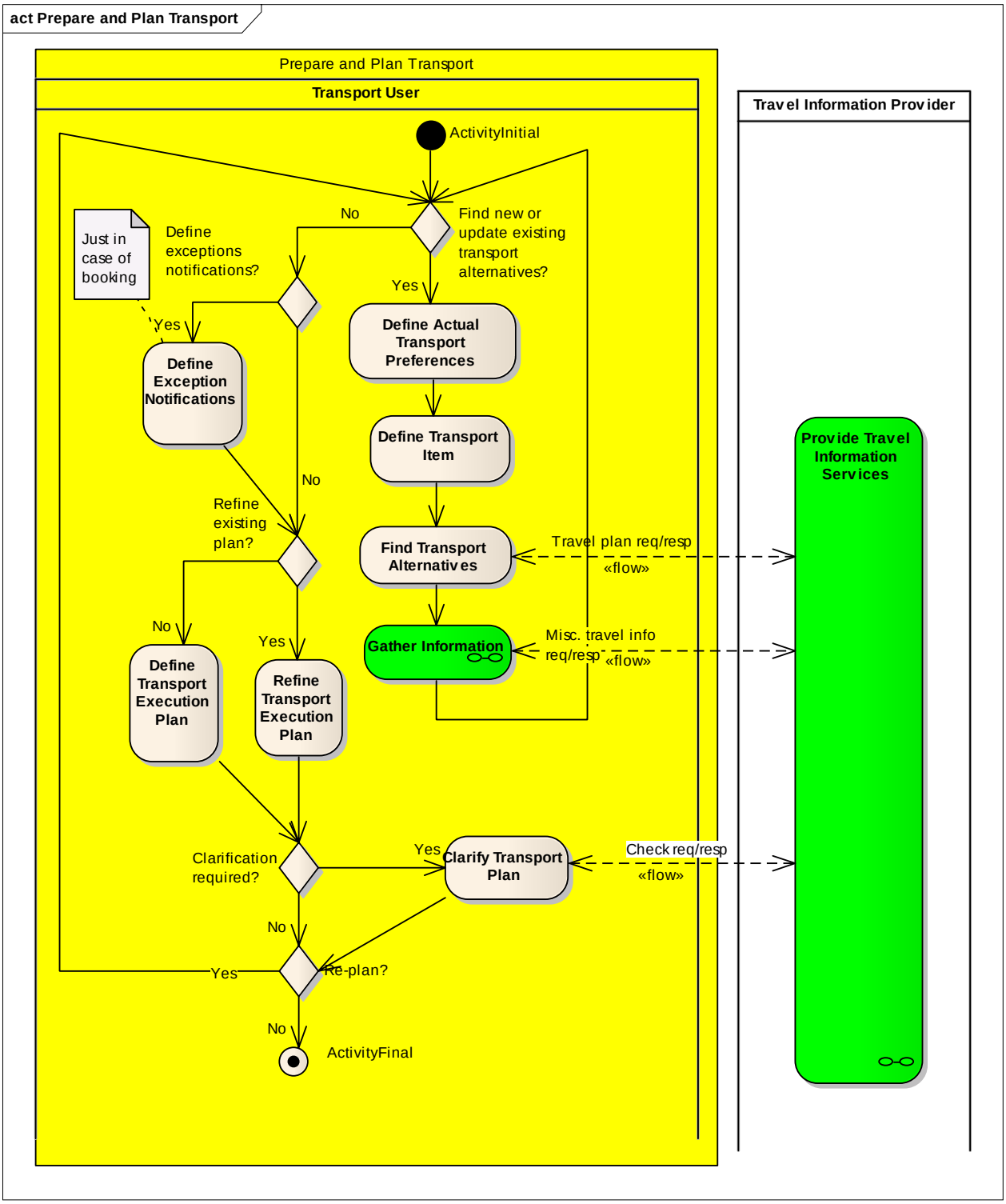


Figure 21 The Prepare and Plan Transport proces from the Transport User's point of view

7.1.3 The Gather Information process

The Transport User may collect additional information about transport alternatives.

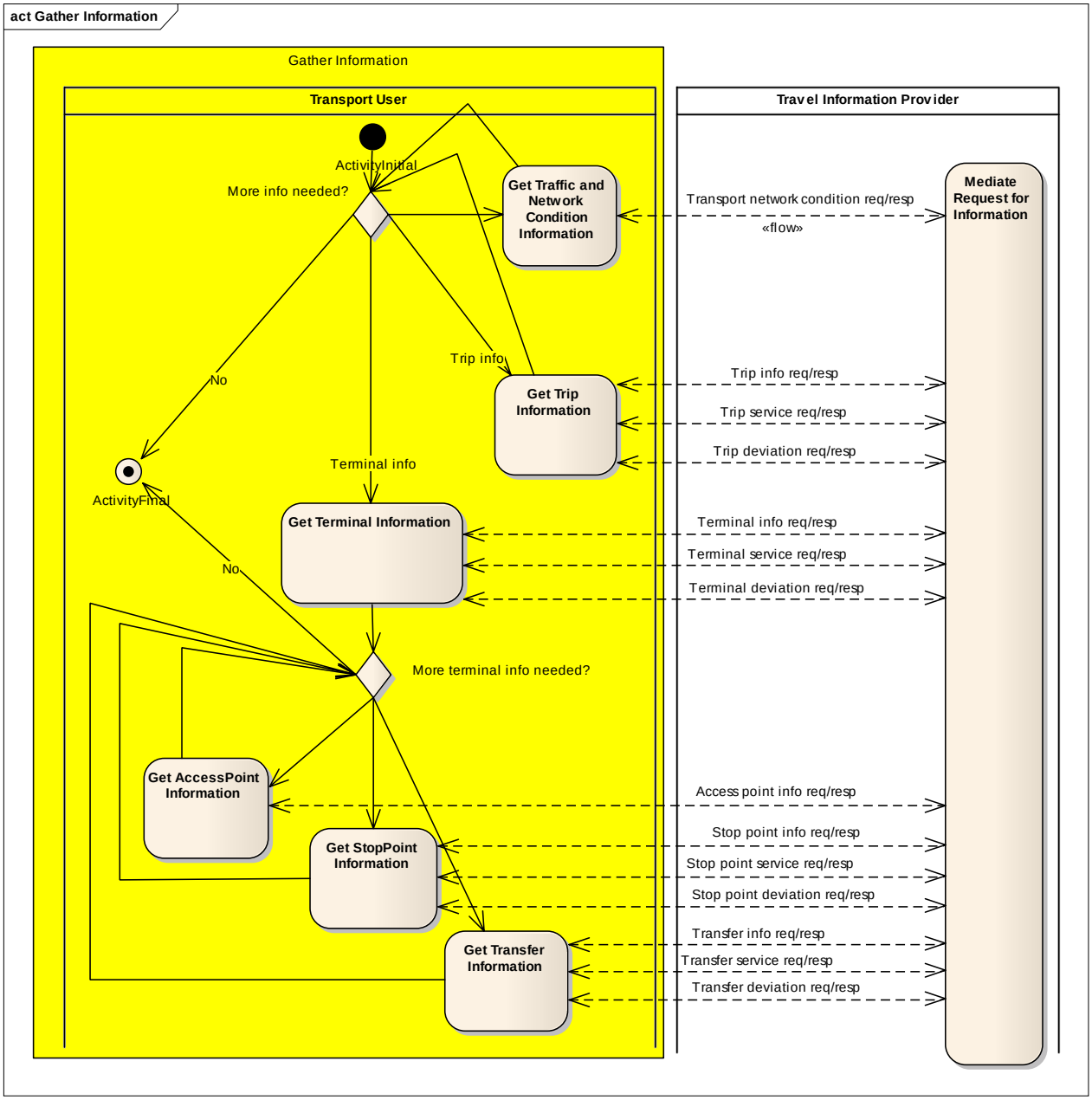


Figure 22 The Gather Information process

7.1.4 The Manage Transport process

The on-going transport is managed.

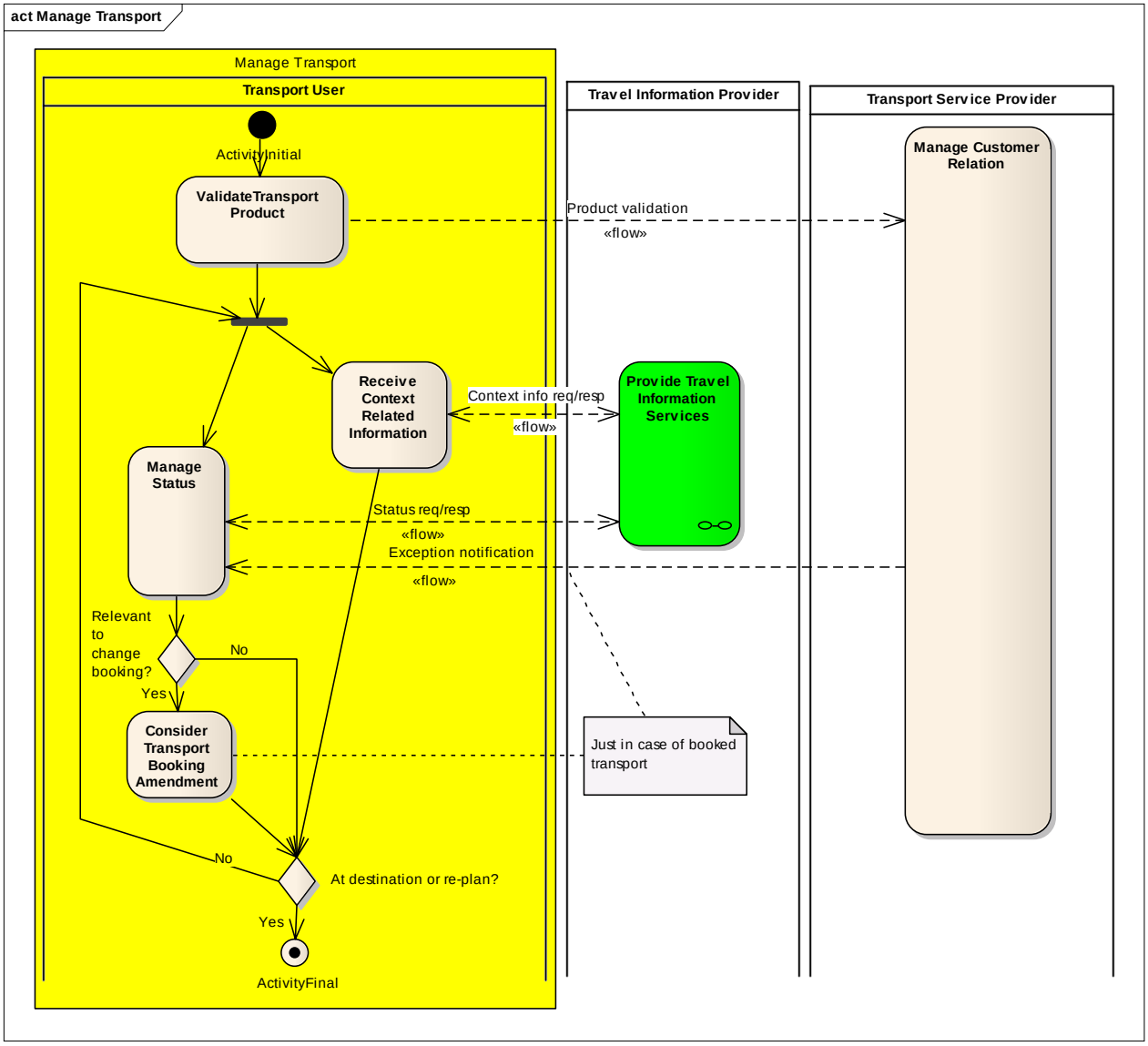


Figure 23 The Manage Transport process

7.2 Transport Sector Support - the Travel Information Provider's processes

7.2.1 The Provide Travel Information Services process

The Travel Information Provider will provide travel information services and interact with the Transport User via a user interface. However, to establish the travel information services, the Travel Information Provider has to interact with other service and information providers. A part of the interaction will be done by means of open services specified by MultiRIT (stereotyped with "ARKTRANS Service").

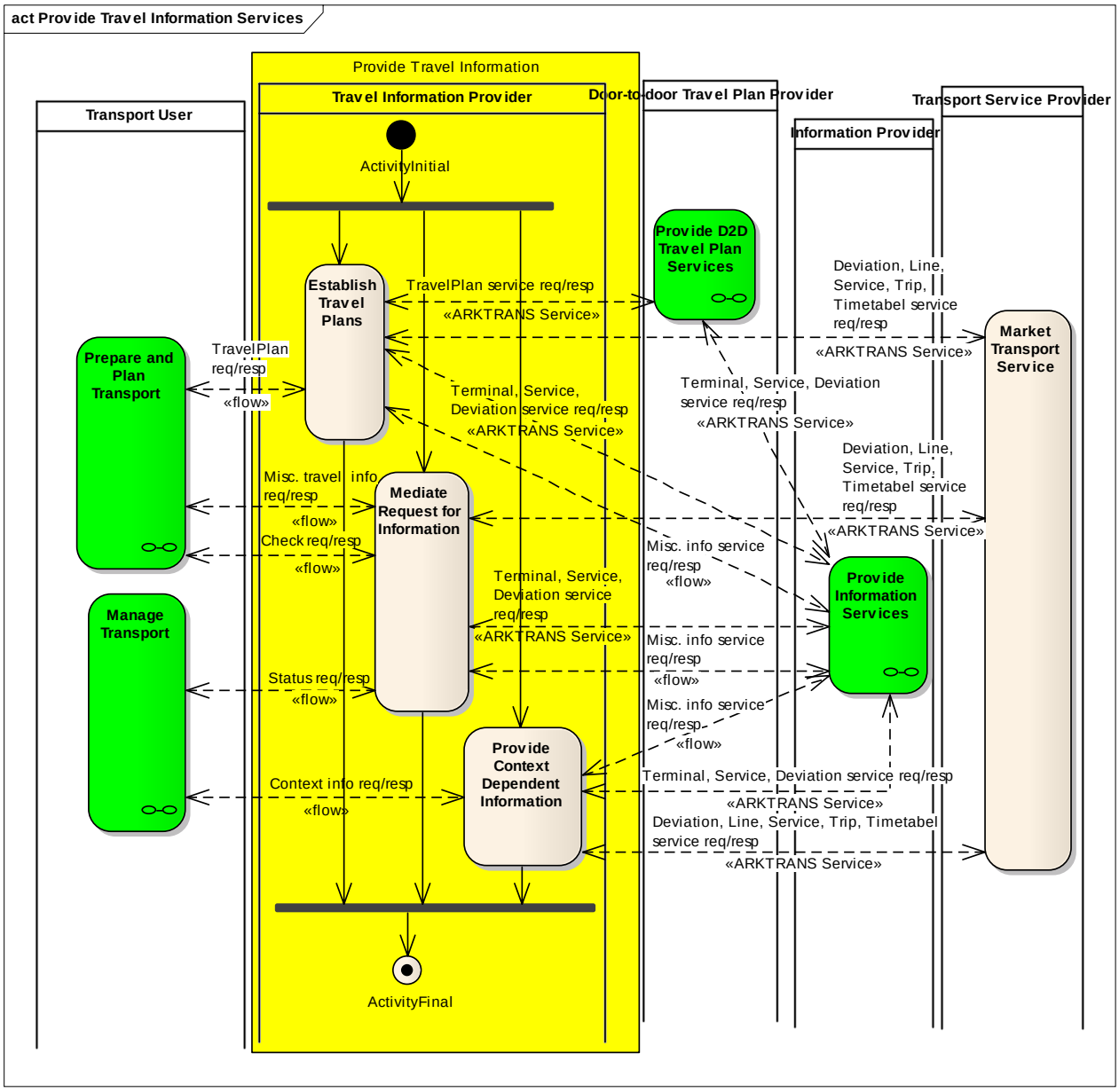


Figure 24 The Provide Travel Information Services process

7.3 Transport Sector Support - the Door-to-door Travel Plan Provider's processes

7.3.1 The Provide D2D Travel Plan Services process

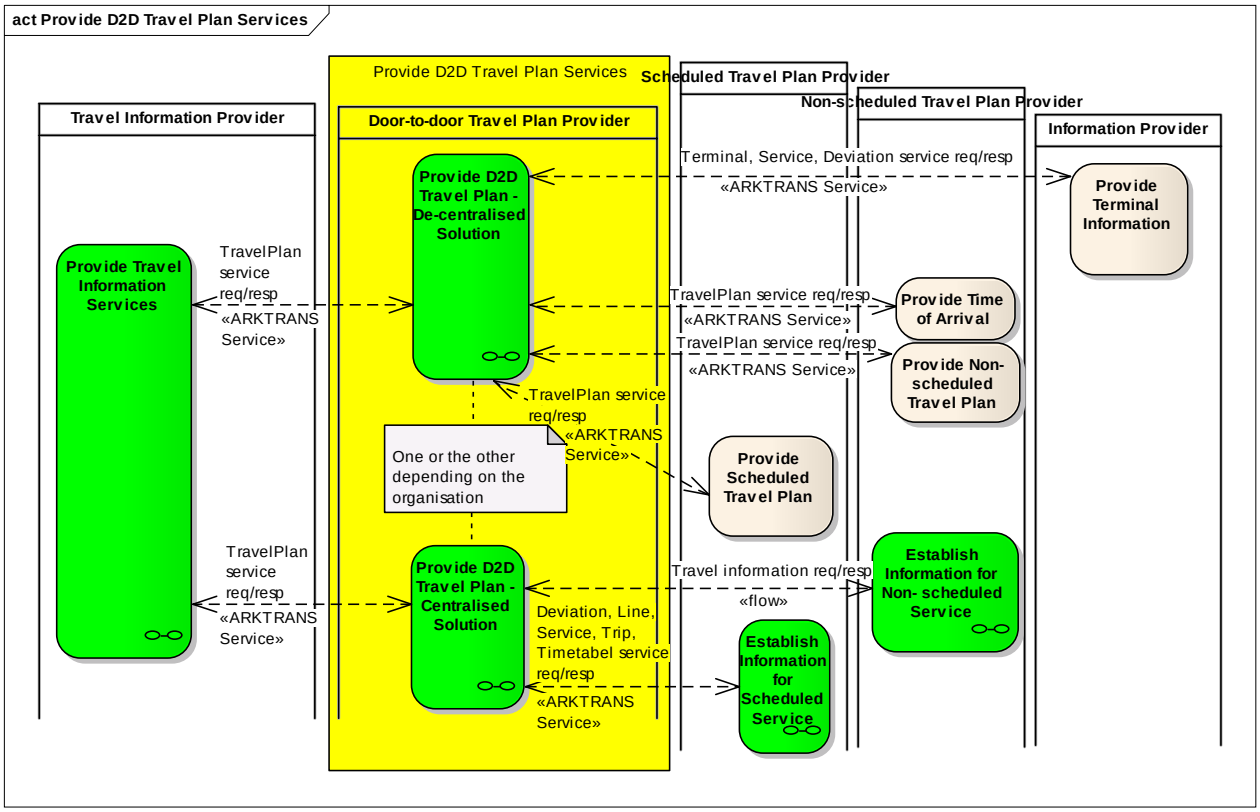


Figure 25 The Provide D2D Travel Plan Services process

7.3.2 The Provide D2D Travel Plan – Centralised solution process

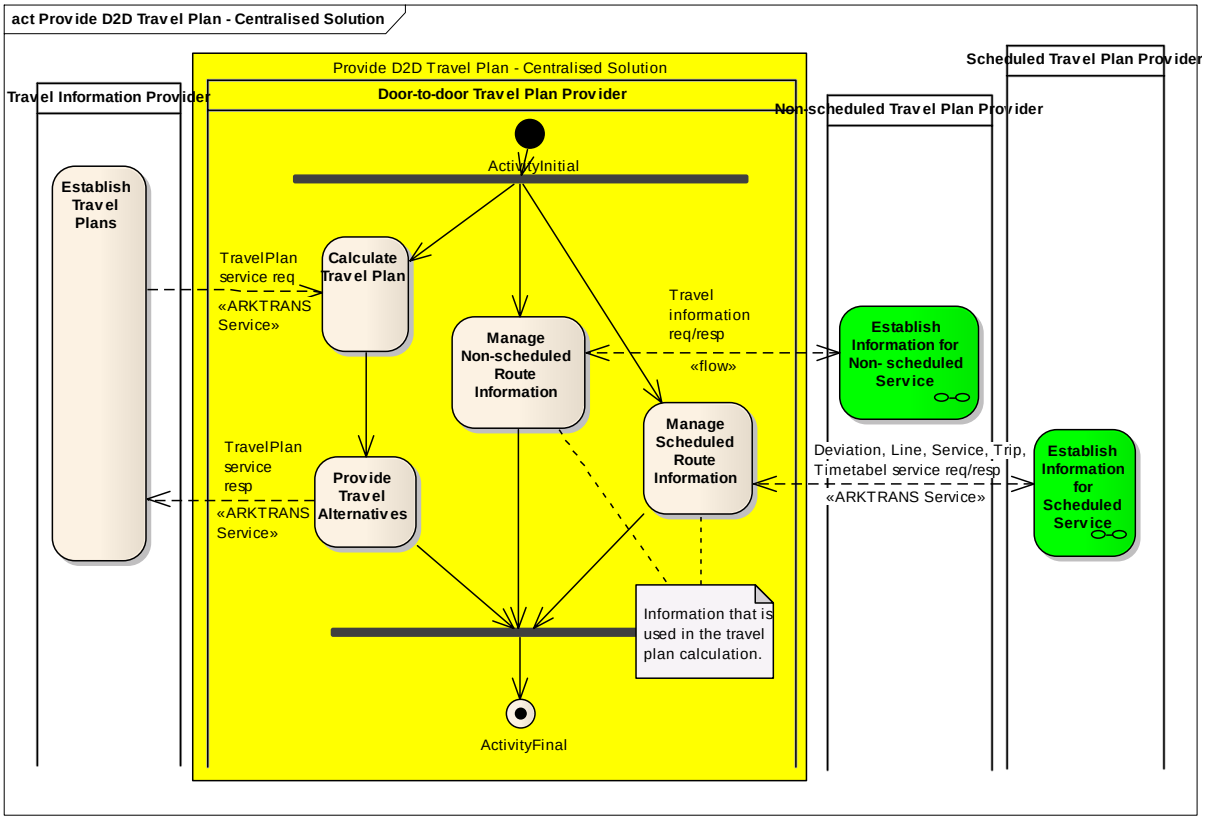


Figure 26 The Provide D2D Travel Plan – Centralised solution process

7.3.3 The Provide D2D Travel Plan – De-centralised solution process

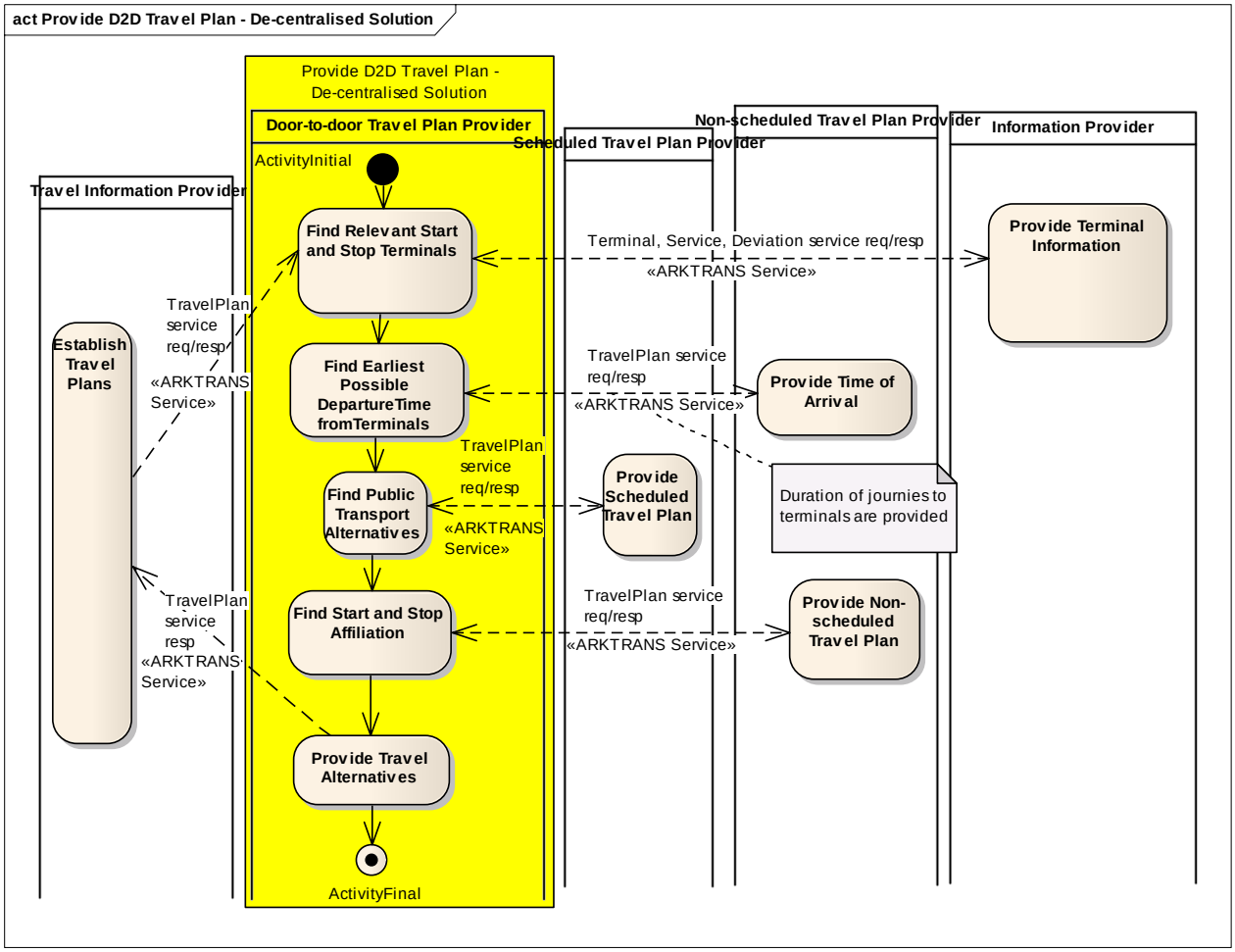


Figure 27 The Provide D2D Travel Plan – De-centralised solution process

7.4 Transport Sector Support - the Information Provider processes

7.4.1 The Provide Information Services process

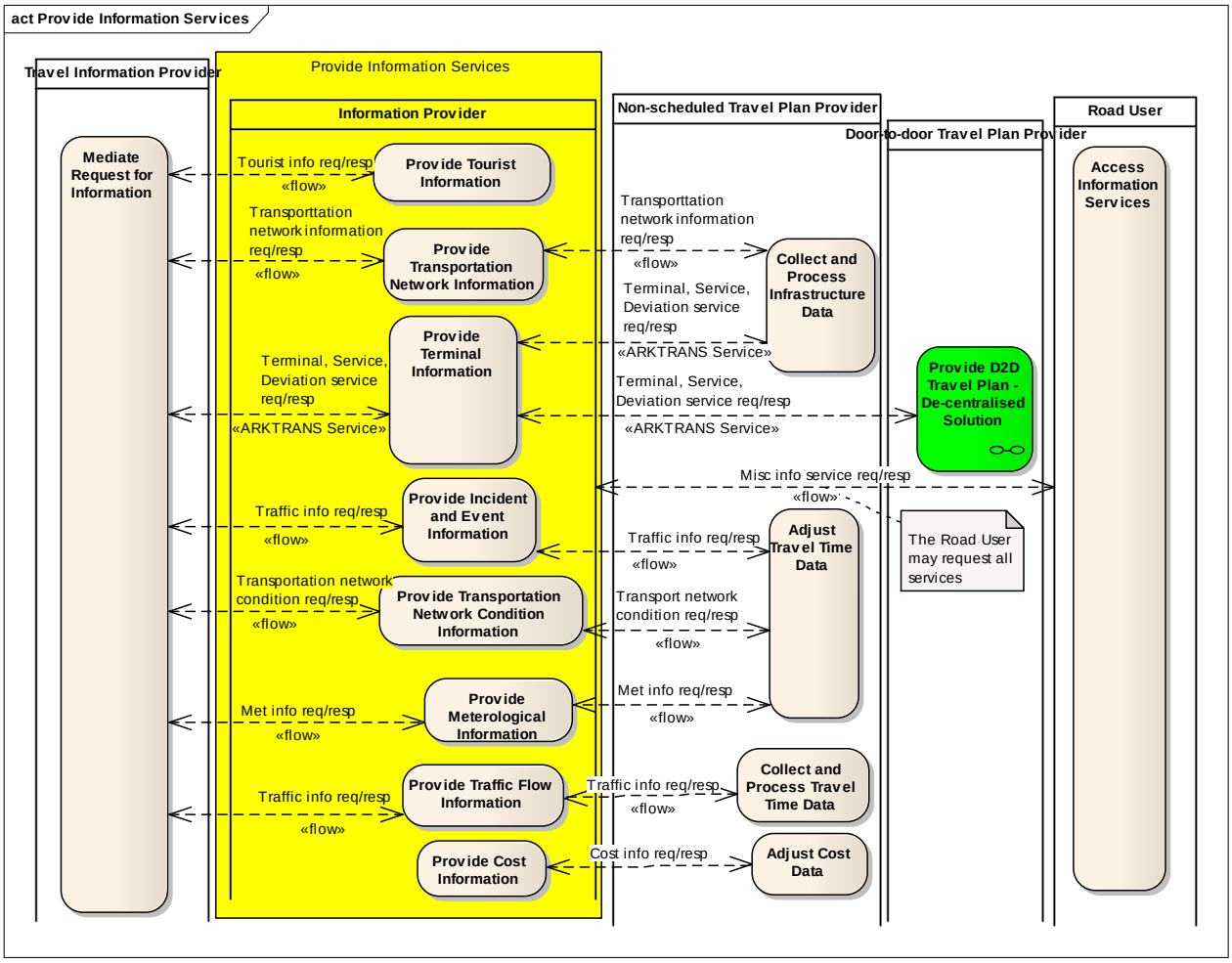


Figure 28 The Provide Information Services process

7.5 Transport Sector Support - the Non-scheduled Travel Plan Provider's processes

7.5.1 The Establish Information for Non-scheduled Service process

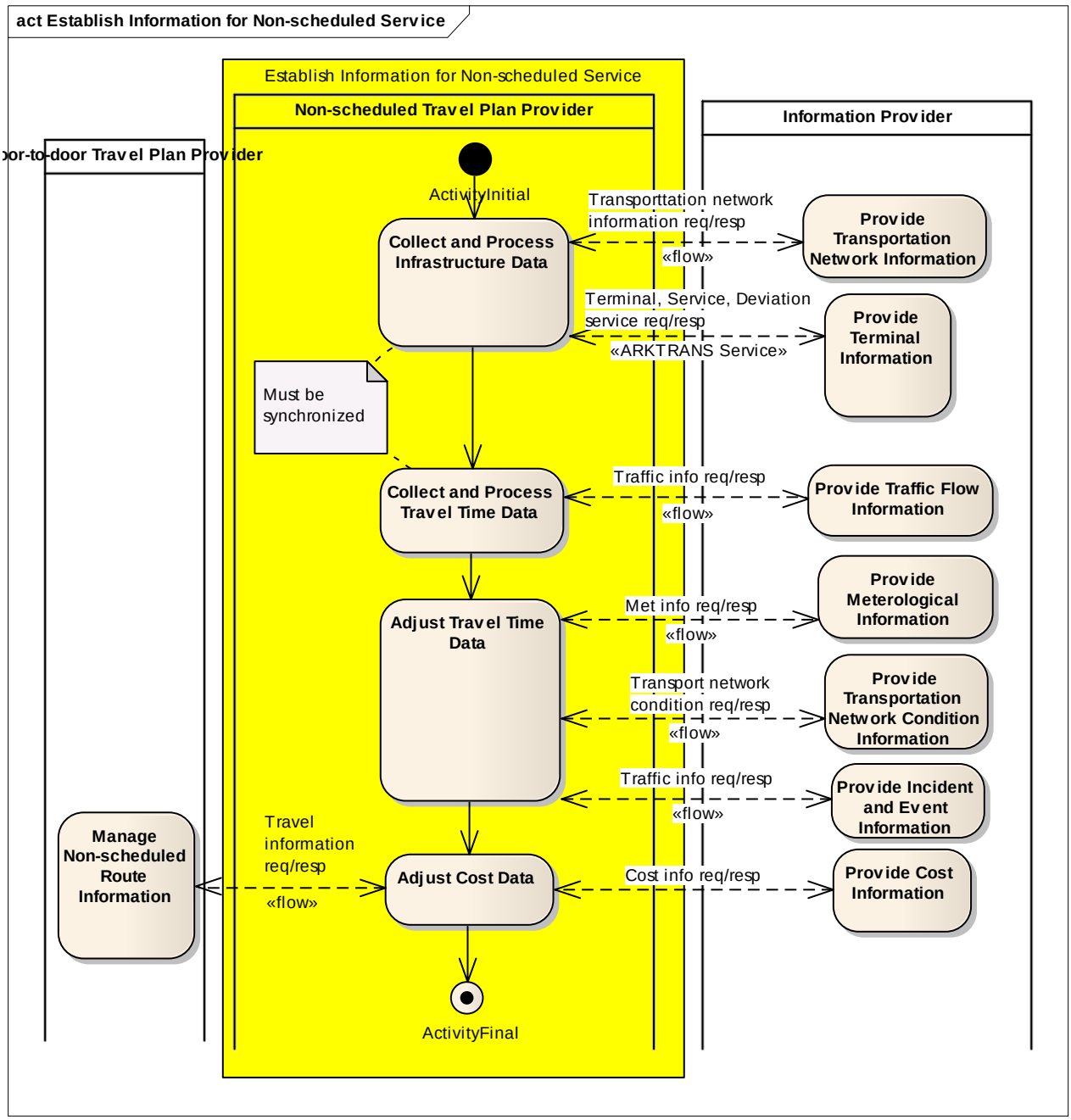


Figure 29 The Establish Information for Non-scheduled Service process

7.6 Transport Sector Support - the Scheduled Travel Plan Provider's processes

7.6.1 The Establish Information for Scheduled Service process

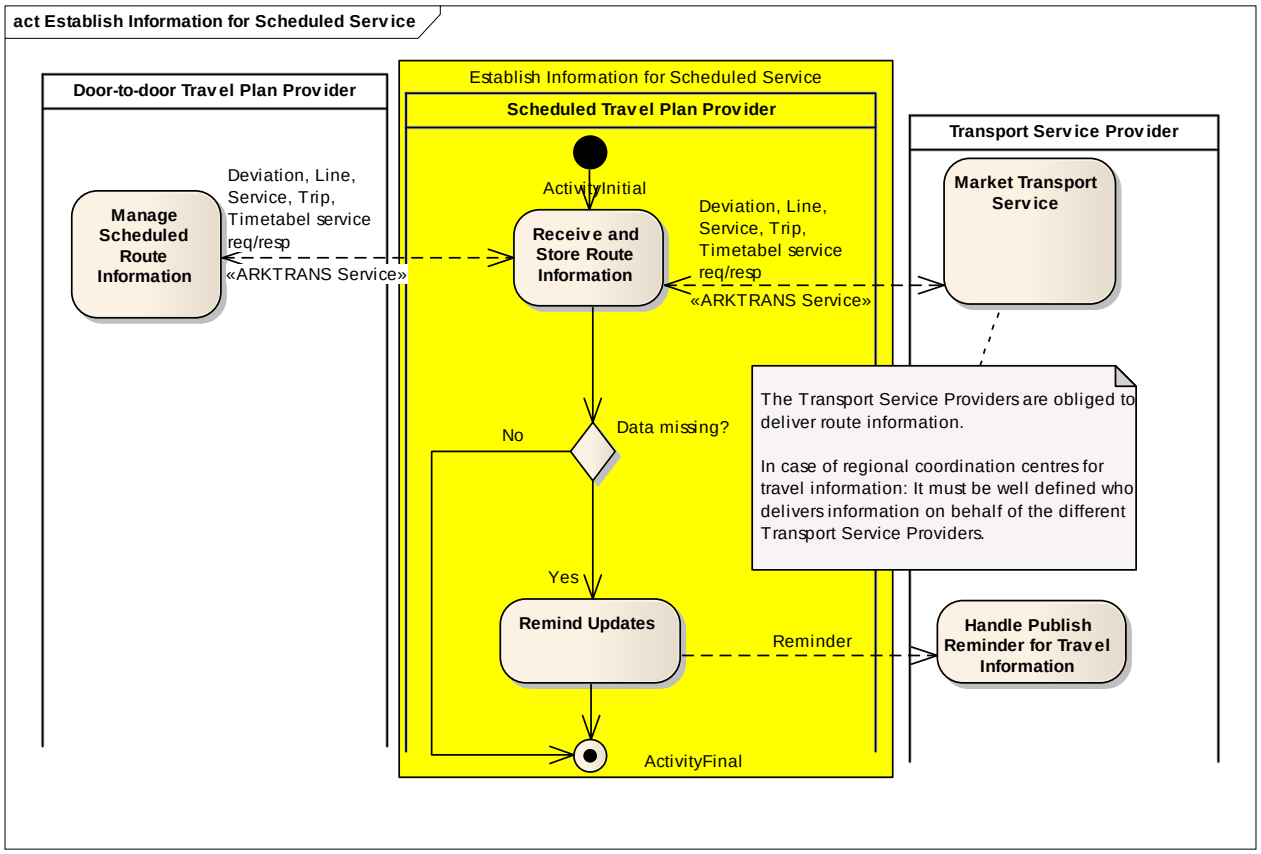


Figure 30 The Establish Information for Scheduled Service process

7.7 On-board Support and Control – the Road User's processes

7.7.1 The Navigation Support process

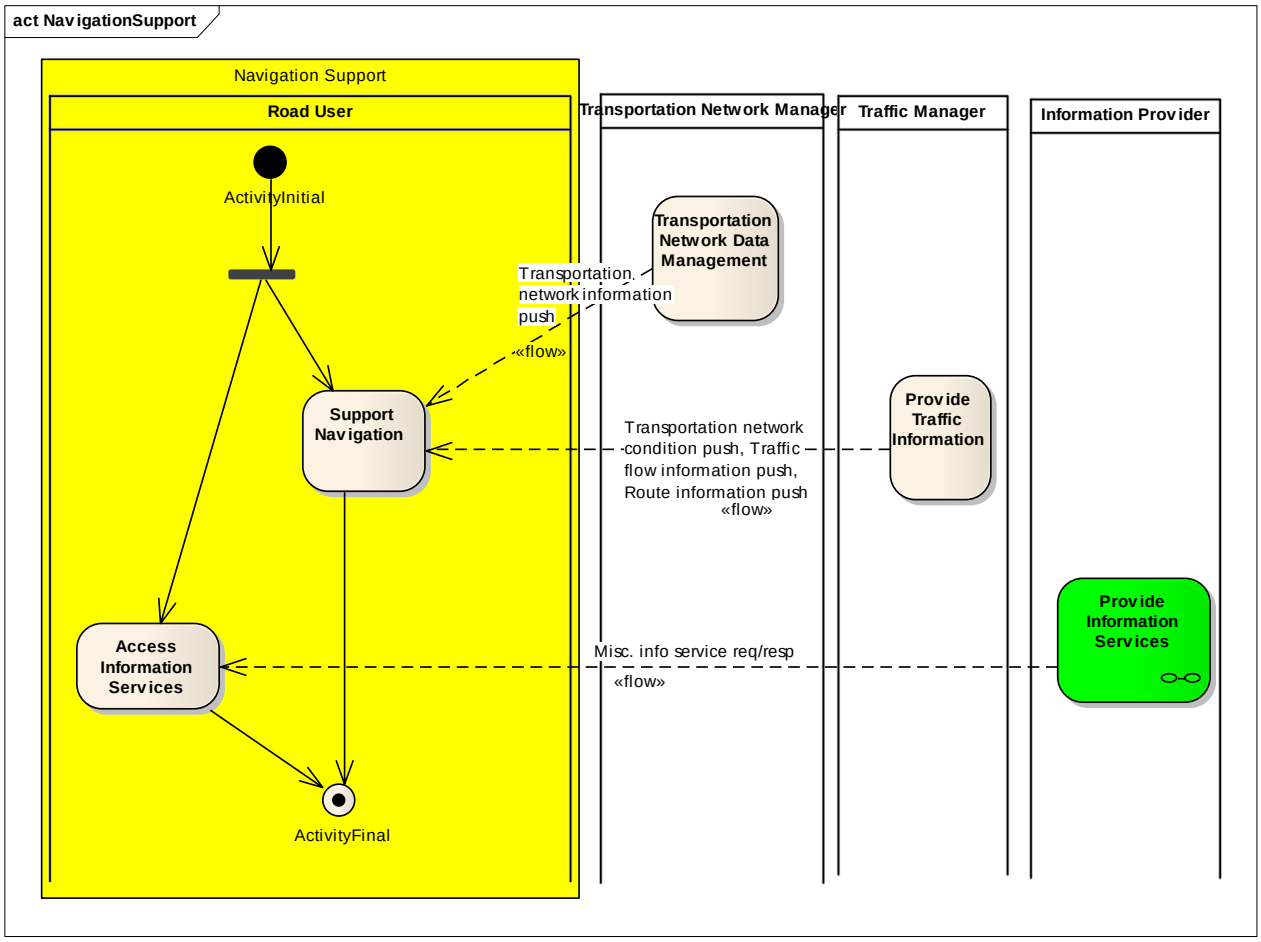


Figure 31 The Navigation Support process

7.8 Information flows in the process diagrams

The information flows in the process diagrams are summarised in the tables below. The information flows that are ARKTRANS services are further described in 8.2.

Table 10 Transport User – Travel Information Provider

Interaction	Description
Travel plan req/resp	Request travel plan that is according to specified preferences
Status req/resp	Requests status information for trip, terminal, etc.
Check req/resp	Check travel plan towards preferences
Context info req/resp	Request context information
Misc. travel info req/resp – represents: • Access point info req/resp • Stop point deviation req/resp • Stop point info req/resp • Stop point service req/resp • Terminal deviation req/resp • Terminal info req/resp • Terminal service req/resp • Transfer deviation req/resp • Transfer info req/resp • Transfer service req/resp • Trip deviation req/resp	Information or services are requested and provided via a user interface. The MultiRIT framework architecture does not interfere with how this user interface is designed.

• Trip info req/resp • Trip service req/resp • Transport network condition req/resp	

Table 11 Road User – Transportation Network Manager / Traffic Manager

Interaction	Description
Transport network information push	The road User requests information about network conditions ad traffic.
Transport network condition push	
Traffic flow information push	
Route information push	

Table 12 Transport User – Transport Service Provider

Interaction	Description
Transport execution plan	Interactions related to payment and, if booking is required, the business relation (booking, follow up) towards the Transport Service provider.
Exception notification	
Product validation	

Table 13 Travel Information Provider / Scheduled Travel Plan Provider - Transport Service Provider

Interaction	Description
Deviation req/resp *(ARKTRANS Service)*	See service specifications in 8.2.
Line service req/resp *(ARKTRANS Service)*	
Service req/resp *(ARKTRANS Service)*	
Timetable service req/resp *(ARKTRANS Service)*	
Trip service req/resp *(ARKTRANS Service)*	

Table 14 Travel Information Provider - Door-to-door Travel Plan Provider

TravelPlan info req/resp (ARKTRANS Service)	See service specifications in 8.2.

Table 15 Travel Information Provider / Non-scheduled Travel Plan Provider / Door-to-door Travel Plan Provider / Road User - Information Provider

Interaction	Description
Terminal service req/resp *(ARKTRANS Services)*	See service specifications in 8.2.
Service req/resp *(ARKTRANS Service)*	
Deviation req/resp *(ARKTRANS Service)*	
Tourist info req/resp	Request information types
Transport network information req/resp	
Traffic info req/resp	
Transport network condition req/resp	
Met info req/resp	
Cost info req/resp	

Table 16 Door-to-door Travel Plan Provider - Scheduled Travel Plan Provider -

Interaction	Description
TravelPlan info req/resp *(ARKTRANS Service)*	See service specifications in 8.2.
Trip service req/resp *(ARKTRANS Service)*	
Deviation req/resp *(ARKTRANS Service)*	
Line req/resp *(ARKTRANS Service)*	
Service req/resp *(ARKTRANS Service)*	
Timetable req/resp *(ARKTRANS Service)*	

Table 17 Door-to-door Travel Plan Provider - Non-scheduled Travel Plan Provider

Interaction	Description
TravelPlan info req/resp *(ARKTRANS Service)*	See service specifications in 8.2.
Travel information req/resp	Requests the information needed for non-scheduled travel planning.

8 Information view on multimodal route and travel information

The information view addresses the information that is exchanged between the stakeholders involved in the transport information value chain in a technology independent way. The results are harmonised across all transport modes. The aim is to define open services for exchange of travel information and travel plans. The services are specified by means of a model driven approach (MDA) [11].

The UML models in the information view are technology independent. CIMs (Computation Independent Models) provide conceptual specifications of the information to be shared (conceptual information models) and the services to be exchanged (conceptual service models). The latter is composed of elements from the first. The conceptual service models are the bases for the PIMs (Platform Independent Models), which specifies the open services. The resulting software models, transformed from the PIM, are called PSM (Platform Specific Model). A PSM is directed towards an implementation by means of specific technology (platform).

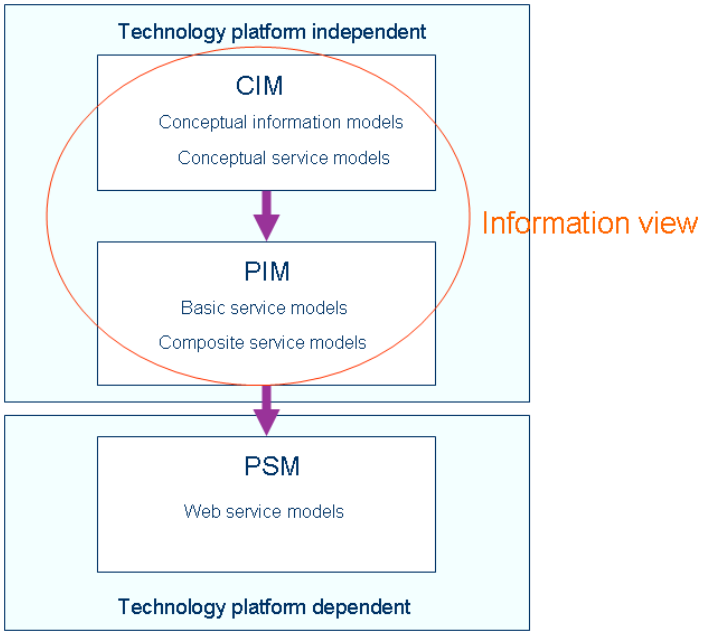


Figure 32 Model Driven Approach (MDA)

8.1 CIM - Conceptual information models

The computation independent conceptual information models specify travel information that may be useful for the Transport User. The information is defined by means of UML class diagrams. For details about attributes, etc. see Annex B.

The conceptual information models differ from physical data models as the intention is not to define physical databases. The conceptual models define the generic and multimodal travel information elements, which may be useful to the traveller; and the relations and dependencies between them. The models are a common reference, and the information elements will be used as building blocks in the conceptual service models (see section 8.2), which define the interfaces that are used for information exchange between the actors in the travel information value chain.

8.1.1 Terminal model

The terminal model is shown inside the square in the Figure. It specifies information required about terminals, stop points, terminal access points and transfers.

- Terminal represents all types of public transport stops: railway stations, simple bus stops along the road, bus terminals, airports, ferry berths, etc.

- Stop Point is the exact location where the transport means stops. This is the gate at an airport, the gate/track at a railway station, the location of the bus stop sign at a bus stop, etc.
- Terminal Access Point is the entrance to a terminal.
- Transfer is a transfer at a terminal or between terminals

The logical relations and dependencies are expressed in the diagram:

- Many terminals may be co-located. Thus, a Terminal may be a part of a superior Terminal that contains many Terminals.
- The Terminal has one or more Stop points
- A Terminal has one or more Terminal Access Points that may be the entrance of the terminal or another well recognised point at the terminal used as a waypoint during transfers. One Terminal Access Point may belong to more terminals, e.g. several co-located terminals.
- A Transfer may start at a Terminal, a Stop Point or a Terminal Access Point and end at another Terminal, Stop Point or Terminal Access Point.
  A sequence of transfers may also be required to come to the right location. The first may for example start at the first Stop Point and end at a Terminal Access Point. Then there may be successive transfers between different Terminal Access Points, and the last transfer may end at the final Stop Point.

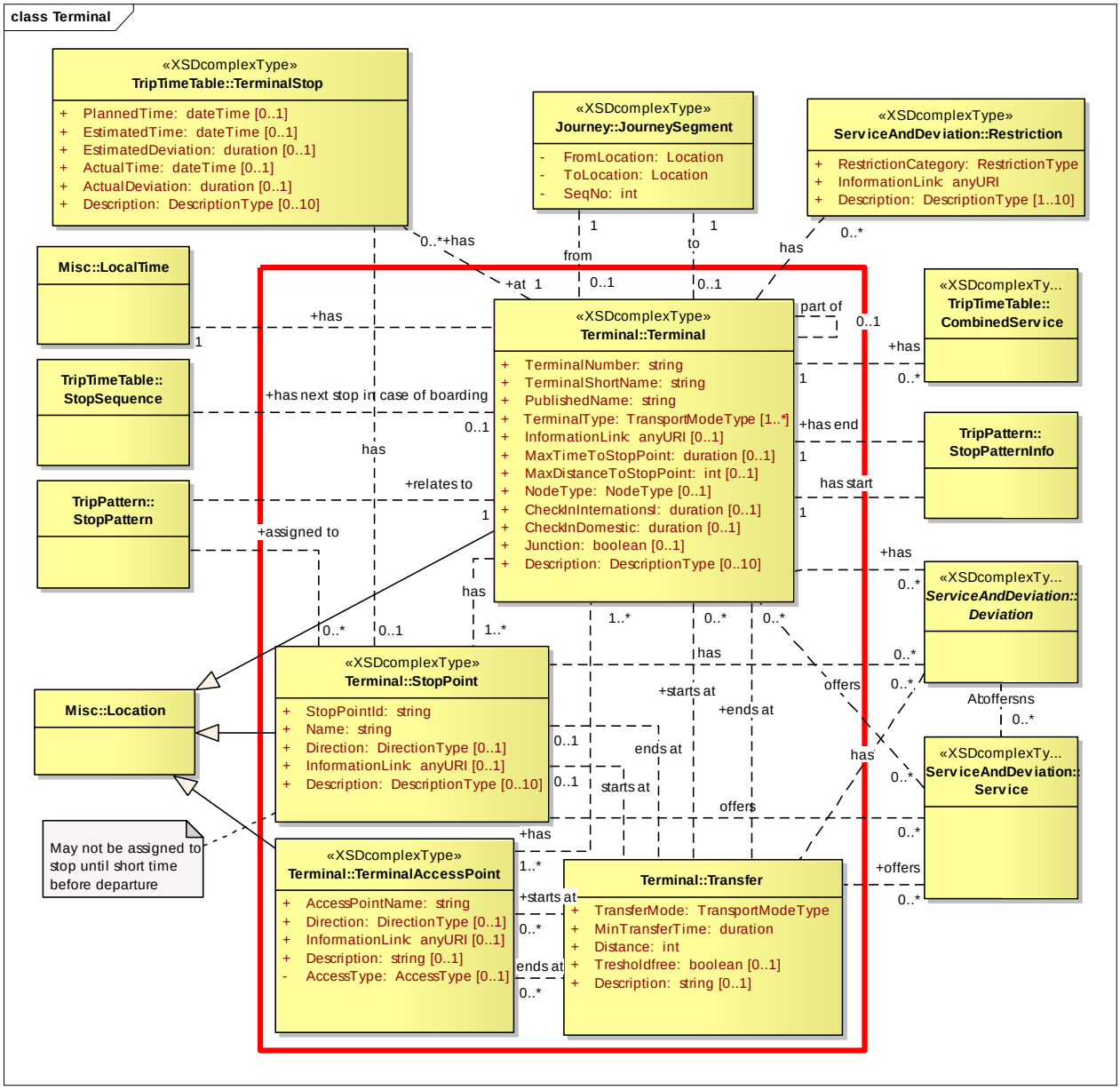


Figure 33 Terminal model

Inheritance:

- A Terminal is a Location
- A Stop Point is a Location
- A Terminal access point is a Location

External relations are as follows:

- A Terminal has a Local time
- A Terminal Stop is related to one Terminal, and a Terminal Stop may also be assigned a Stop Point, but this may not happen until just before the stop.
- A Journey Segment may be between two Terminals
- There may be Combined Services related to a Terminal
- A Terminal, a Stop Point or a Transfer may have Deviations
- A Terminal, a Stop Point or a Transfer may offer Services
- There may be Restrictions associated to a Terminal

- A Trip Pattern (represented by the StopPatternInfo class) has one start and one end Terminal
- A Stop Pattern (representing one of the stops in a Trip Pattern) is related to one Terminal, and may also be assigned to a Stop Point.
- One stop (represented by the Stop Sequence class) may have restrictions concerning the where alighting is allowed. If so, the next Terminal where alighting is allowed is identified.

8.1.2 Trip Pattern model

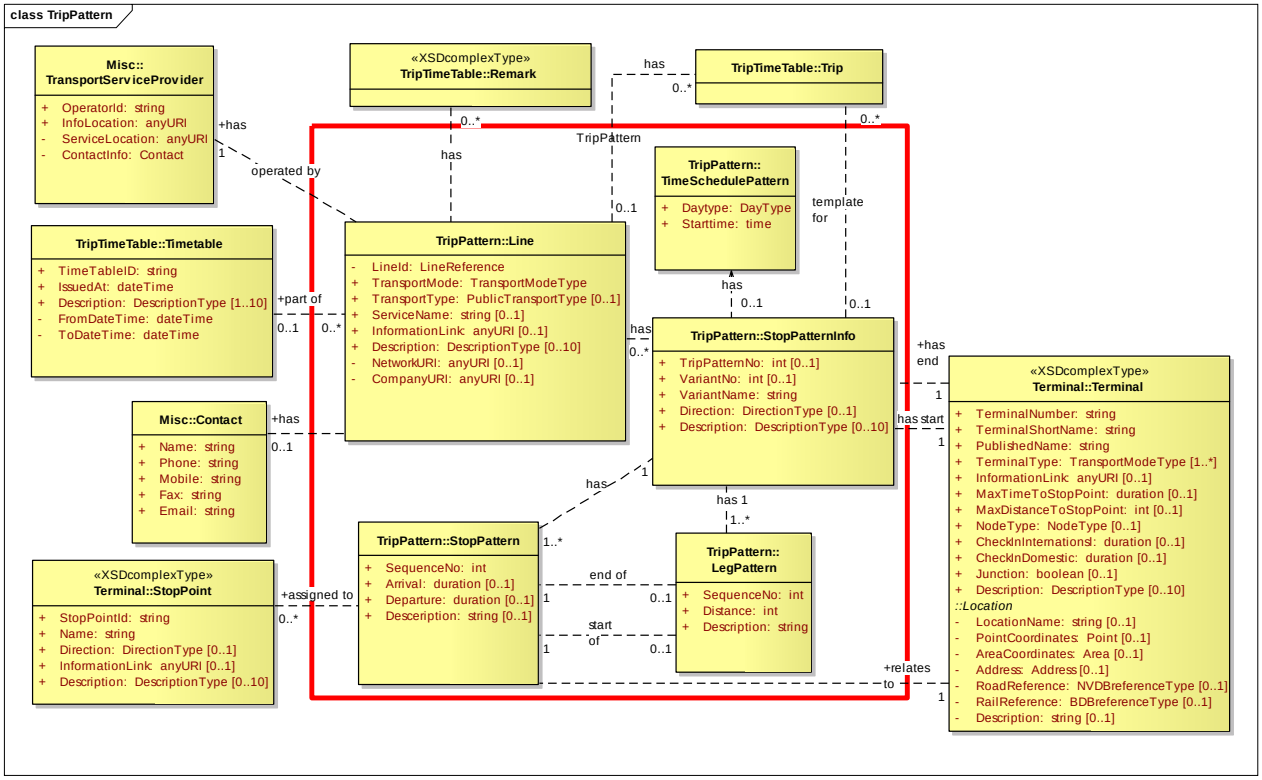


Figure 34 Trip pattern model

The trip pattern model is shown inside the square in the Figure and represents information about the pre-defined trip patterns of a line:

- A Line is a transport service that can be identified by means of a LineID of type LineReference consisting of:
  - A Network Id – the PTA (Public Transport Authority).responsible for the line- As defined in the eTicketing framework (ISO).
  - A Line Identifies - depends on the transport mode. May be:
    - The number used by the transport users (e.g. bus number, flight number, train number
    - An internal number that is not known to the transport user.
    - No value (for coastal liner)
  - Line Name – the published name. May for example indicate the start and the stop locations for the line, or another descriptive reference that refers to the route that the Line is serving
  - An Operator ID – the code of the Transport Service Provider as used in eTicketing
- A Line often has several route variants. One such route variant is represented by the StopPatternInfo class. The variants may for example represent different paths between the same stop or end points; different directions of a for example a bus line; or variants

representing different segments of a line, e.g. two segments of a line that runs through a city – from starting point to the city centre, and from the city centre to the final destination.

- A route variant may have several Time Schedule Patterns, which indicates the days and the start times for departures for trips serving the route variant.
- A route variant consists of a sequence of one or more Stop Patterns, representing the stops at terminals along the route. The arrival and the departure are provided relatively to the start time in the Time schedule pattern of the Trip pattern.
- A route variant consists of a sequence of one or more legs, represented by the Leg Patterns.
- One Leg Pattern stops and ends at specific terminals, represented by Stop Patterns..

External relations:

- A Timetable may include the route information for several Lines.
- A Contact may be responsible for a Line
- A Line will be operated by a Transport Service Provider (however, the actual trips that constitute the Line may be operated by other Transport Service Provider – see the Trip timetable model).
- A route variant (the StopPatternInfo class) may be the template for one or more Trips.
- A Line may be served by many Trips.
- A route variant (the StopPatternInfo class) starts and ends at Terminals.
- In the same way, Terminals and Stop points that are used by visited by the Trips may be related to and assigned to Stop Patterns.
- There may be Remarks associated to a Line.

Table 18 Examples of trip pattern attributes applied on transport modes

Transport mode	Line name (part if LineId) examples	StopPatternInfo attribute examples			Comments
		Trip pattern no	Variant no	Variant name	
Road	Examples: • Risvollan - Dronningens gt. • Dronningens gt. – Stavset • Stavset – Dronningens gt. • Dronningens gt. - Risvollan	Number	1 if just one pattern or first variant or higher sequence number	Name to be published in addition to Line name (if there is a need for a more detailed name). Examples: • Via St.Olavs hospital. • Stops at Stavet • Limited route • A • B	One or more Trips, identified by means of trip numbers will be related to each trip pattern.
Sea	Line name Examples: • Kystekspressen Trondheim – Kristiansund • Kystekspressen Kristiansund - Trondheim	Number	1 if just one pattern or first variant or higher sequence number	Name to be published in addition to Line name (if there is a need for a more detailed name). Example: • No call at Brekstad	One or more Trips, identified by means of trip numbers will be related to each trip pattern.
Rail	Line name	Number	1	Name to be published in addition to Line name (if there is a need for a more detailed name). Example: • Via Bodø	One or more Trips, identified by means of train number + date will be related to each trip pattern.
Air	Flight name	Flight number	1	Name to be published in addition to Line name (if there is a need for a more	One or more Trips, identified by means of flight number +

Transport mode	Line name (part if LineId) examples	StopPatternInfo attribute examples			Comments
		Trip pattern no	Variant no	Variant name	
				detailed name)	date will be related to each trip pattern.

8.1.3 Trip timetable model

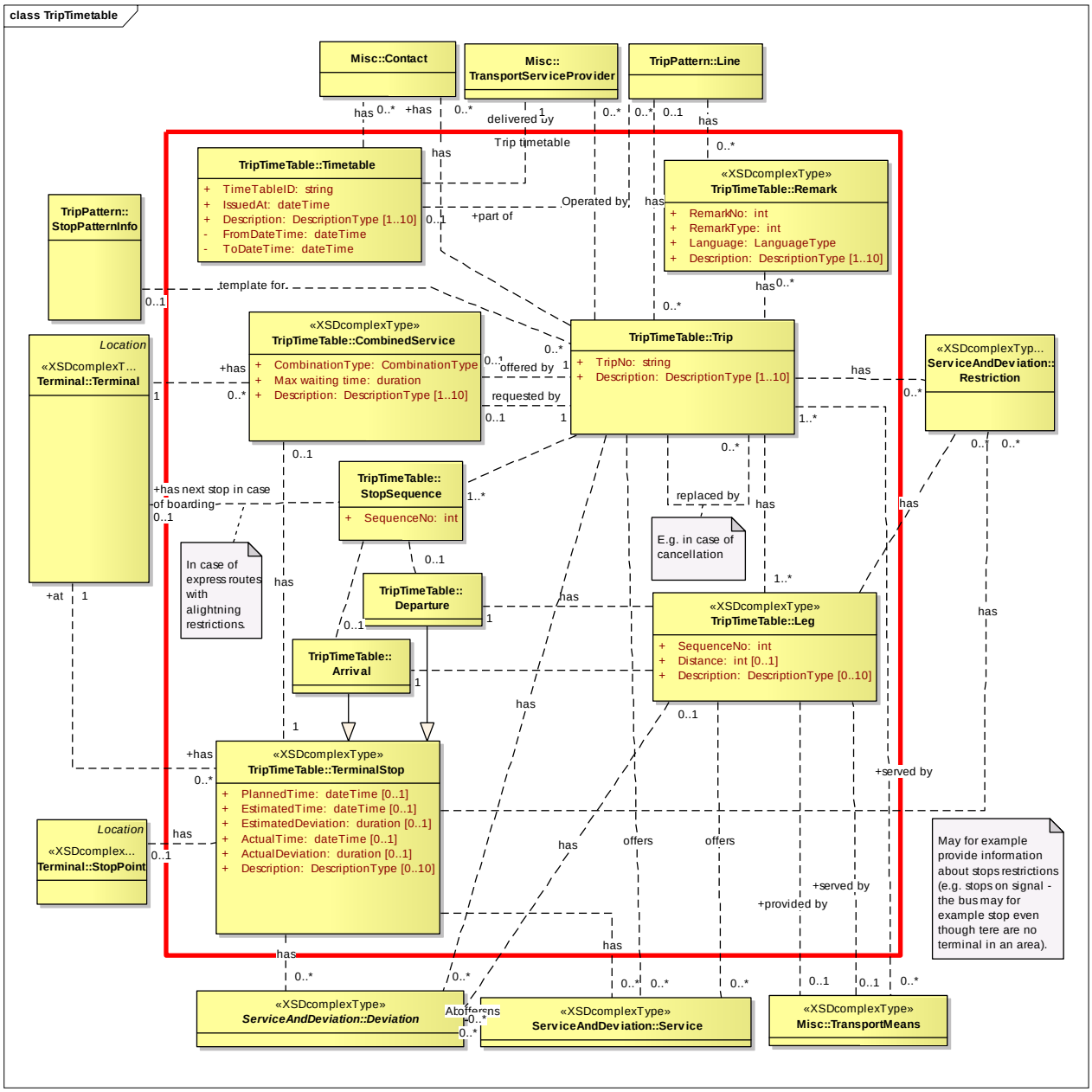


Figure 35 Timetable model

The trip timetable model is shown inside the square in the Figure. It specifies information about actual trips, e.g. their time schedule, terminal stops, services provided and deviations.

Inheritance:

- An Arrival is a Terminal Stop
- A Departure is a Terminal Stop

The logical relations and dependencies are expressed in the diagram:

- A Trip may be replaced by another Trip, for example if the Trip is cancelled due to engine problems or for other reasons. The new trip may stop at the same terminals, but the route may also be different from the original route. E.g. the ferry may have to go from another berth due to the weather.
- Arrivals and Departures to a terminal are considered as Terminal Stops with a planned time, an estimated time, an actual time, etc. However, some stops may not be dictated by a time schedules as they may not be check points in the route plan. Thus, the time attributes may have no values.
- The Departures/Arrivals of a Trip are carried out in a specific sequence, indicated by the Stop Sequence. For each visit to a terminal there may be just a Departure (the first stop in the sequence), just an Arrival (the last stop in the sequence), or both an Arrival and a Departure (the stops in between – if any).
- A Trip will consist of e sequence of Legs, each with a Departure and an Arrival.
- A Combined Service is offered by one Trip to another Trip.
- Through the inheritance of the Terminal Stop properties, an Arrival or a Departure may be related a Combined Services. This means that they may be related to an Arrival or a Departure of another Trip. This may for example be used to express that a connection can be provided despite of a short transfer time, or that the departure of a bus may depend on the arrival of another bus (the first bus may wait). A Combined Service may also be used to indicate a trough service (the same Transport Means will be used on both Trips, and the passenger will not have to change Transport Means).
- There may be Remarks related to a Trip.
- A Timetable will be for a certain time period.

External relations:

- A Timetable may include the route information for several Lines.
- A Timetable will be delivered by a Transport Service Provider (the Transport Service Provider operating the lines described in the timetable), and there may be a defined Contact related to the Timetable.
- A Trip may serve a Line according to a certain route variant (StopPatternInfo). Such Trips are named according to the line name, the trip pattern name and, if present, the variant name of the trip pattern. Some Trips may have no relations to a Line or a route variant. Such Trips are for example on demand trips.
- A Trip is operated by a Transport Service Provider, and there may be a Contacts for a Trip
- Terminal Stops are related to a Terminal, and a Terminal usually has several Terminal Stops. However, terminals that are not in operation will have no stops.
- A Terminal Stop is assigned a Stop point. This may be done when the route plan is established, or it may be done just before the stop at the Terminal. In the last case no Stop Point will be assigned to the Terminal Stop until just before the stop.
- The whole Trip may be served by a Transport Means
- The individual Legs may also served by specific Transport Means (if different Transport Means at different Legs of the Trip).
- In some cases a Leg may have accompanied transport where the actual transport is provided by another Transport Means, e.g. the leg may be served by a bus, but the complete bus may enter a ferry that provides the transport.
- A Combined Service is provided at a Terminal.
- There may be restrictions on alighting at some of the stops in the Stop Sequence. An express route may for example stop for passengers at local terminals. Depending on the entry point, a passenger may not be allowed to alight at specific locations (to avoid competition with local routes). The next stop in case of boarding will be the first Terminal where alighting is allowed, but not necessarily the next in the Stop Sequence.
- A Trip, a Leg and a Terminal Stop (i.e. an Arrival and a Departure) may offer Services.

- A Trip, a Leg and a Terminal Stop (i.e. an Arrival and a Departure) may have Deviations.
- A Trip, a Leg and a Terminal Stop (i.e. an Arrival and a Departure) may have Restrictions.

8.1.4 Service and Deviation model

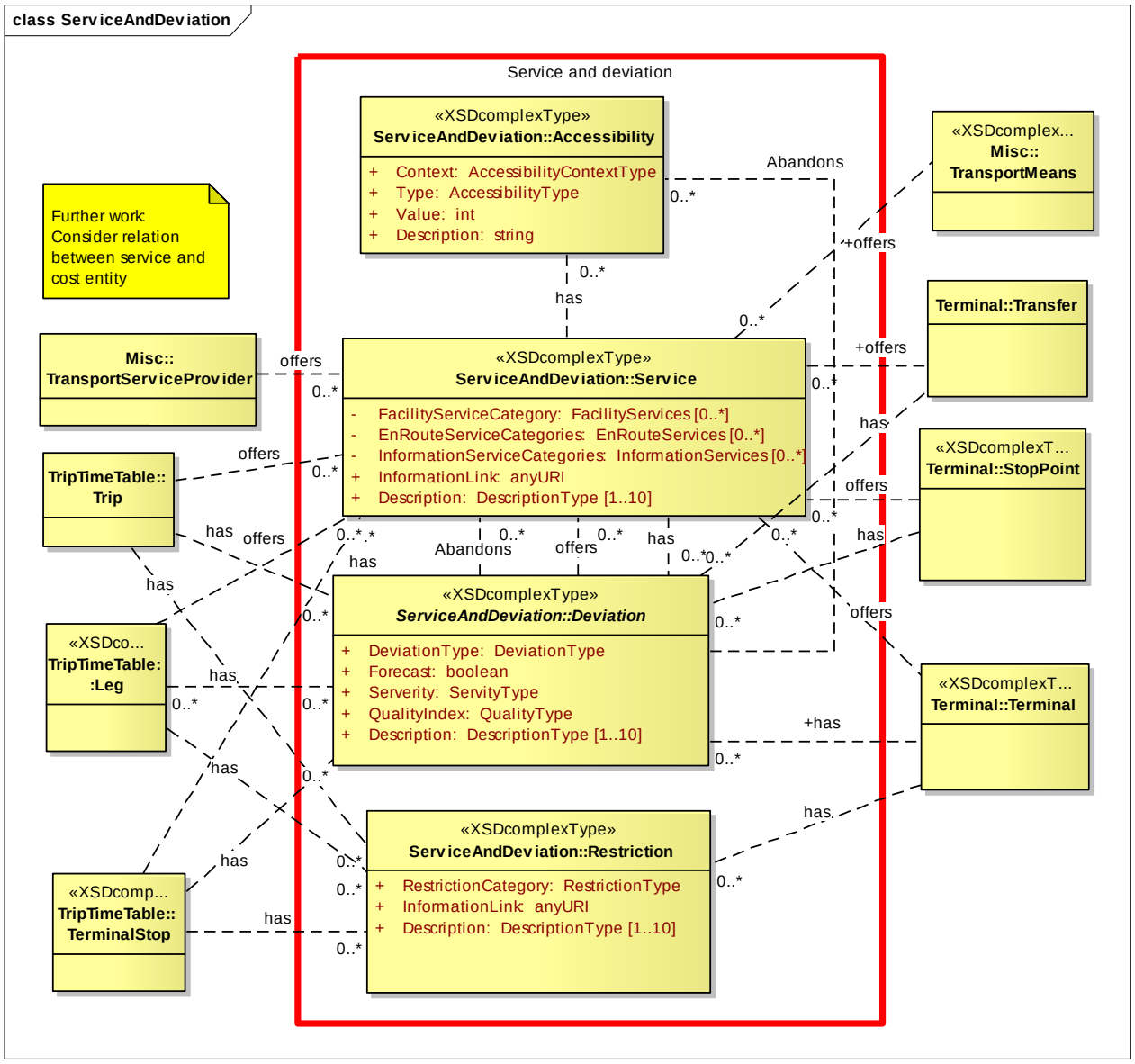


Figure 36 Service and deviation model

The service and deviation model is shown inside the square in the Figure. It specifies information required about services and deviations:

- A Service may be a service offered by persons or systems, or it may be the availability of a physical facility. The type of service is indicated by the ServiceCategoryType.
- A Service may have (i.e. be affected by) a Deviation. This means that a Service may be abandoned due to a Deviation, or a Service may be offered due to a Deviation.
- A Service may have associated Accessibilities.
- An Accessibility may be affected by deviation. An Accessibility may be abandoned due to a Deviation.
- A Restriction is of a certain type, defined by the RestrictionCathegory.

External relations are as follows:

- A Service is offered by a Transport Service Provider
- During the transport, a Service may also be offered by a Trip in general, by specific Legs on a Trip, at Terminal Stops (i.e. at Arrivals and Departures), at Transfer, at Stop Points or at Terminals.
- The ability to provide a Service often depends on whether the Service can be offered by the Transport means used.
- A Deviation concerning a delay or an early arrival or departure affects a Terminal stop.
- A Deviation with respect to the availability of services and facilities may influence on a Leg, a complete Trip, a Terminal, a Stop Point and a Transfer.
- There may be Restrictions related to Trips, Legs, Terminal Stops (i.e. at Arrivals and Departures) and Terminals.

8.1.4.1 Services

A generic description of the services that are provided supports multimodal travel planning across several transport modes. By means of a standardised terminology representing the available service types, transport alternatives can be compared, and the door-to-door transport can be planned across all transport modes. The transport chain that satisfies the demands of the transport user can be chosen. By Service we mean

- Overall transport services
- En route services provided at terminals and on board transport means
- Information services at terminals and on board transport means
- Facilities at terminals and on board transport means

All services can be decomposed into a set of service categories that contain standardised service types. As stated by the attributes in Figure, a service has a service category and a service type attribute. For some of the services it may also be relevant to inform about the section in which the service is available, for example which part of a terminal or which part of a transport means (e.g. whereabouts facility on deck 3 of the ferry).

Services can be related to the actual transport, to arrivals and departures, to the terminals, and to transits. Some services just make sense related to parts of the transport chain (e.g. at terminals). Other services may be provided on both transport means and terminals. Services may be specified for the whole trip or for specific legs.

Overall transport services

The overall transport services describe the main types of transport services that are offered.

Table 19 Service categories and types for overall transport services

Service Category	Service Type
Route offers (Rutetilbud)	Predefined route (Rutegående transport) On demand (Behovsdefinert) On demand route (Behovsdefinert rute) Pre-booked space (Forhåndsbestilt plass) Space warranty (Plassgaranti)
Passenger transport (Passasjertransport)	
Luggage transport (Transport av reisegods)	Luggage check in (Bagasjeinnsjekking) Hand luggage only (Kun håndbagasje) Special luggage (Spesialbagasje)

Service Category	Service Type
	Luggage self service (Selvbetjening på bagasje)
Car transport (Biltransport)	
Freight transport (Godstransport)	Thermo transport (Termovarer) Controlled environment transport (Kontrollert transportmiljø) Bulk cargo transport (Bulktransport) Container transport (Containertransport) Ro-ro transport (Ro-ro transport) Dangerous cargo (Transport av farlig gods) Animal transport (Dyretransport)

En route services

The en route services describe the services that are offered to the transport user at terminals, on-board the transport means, at stops, and at transfers during the transport.

Table 20 Service categories and types for en route services

Service Category	Service Type	Relevance
Handling services (Håndteringstjenester)	Check in (Innsjekking) Customs (toll) Luggage check in (Bagasjeinnsjeking) Luggage security control (Sikkerhetskontroll av bagasje) Passenger security control (Sikkerhetskontroll av passasjerer)	At terminal During transport
Entertainment services (Underholdningstjenester)	Children's entertainment (Underholdning for barn) Live music (Levende musikk) Movie (Film) Music channel (Musikkanal) News (Nyheter)	At terminal During transport
Payment services (Betalings-tjenester)	By phone (Via telefon) Cash (Kontanter) Credit card (Kredittkort) E-ticket (Elektronisk bilett)	At terminal During transport
Assistance provided (Assistanse tilbys)	Free transport of aids (Gratis hjelpemiddeltransport) Assistance to unaccompanied minors (Assistanse til barn som reiser alene) Assistance to sick people (Assistanse til syke) Luggage assistance (bagasjeassistanse) Assistance to disabled (Assistanse til funksjonshemmede) Assistance in security control (Assistanse i sikkerhetskontroll)	At terminal During transport At stops
Free offers (Gratistilbud)	Alcoholic beverages (Alkoholholdig drikke) Breakfast (Frokost) Cold meal (Kald mat) Dinner (Miiddag) Lunch (Lunsj) Newspapers (Aviser) Non-alcoholic beverages (Alkoholfri drikke)	At terminal During transport
Attendance (Betjening)	Cabin crew (Kabinpersonale) Conductor (Konduktør) Guard (Vakt)	At terminal During transport At stops

Facilities

The facilities describe physical installations that are offered to the transport users at terminals, and departures, on-board the transport means and at arrivals during the transport.

Table 21 Service categories and types for facilities

Service Category	Service Type	Relevance
Whereabouts facilities (Fasiliteter på oppholdssteder)	Lounge with refreshments (Lounge med forfriskninger) Smoking area (Røykeområde) Seating accommodation (Sitteplasser) Silence (Stille sone) Physical unit (Enhet) – e.g. terminal, transport means Waiting-room (Venterom) Shelter (Lehus) Security control area (Område for sikkerhetskontroll)	At terminal During transport
Local facilities (Fasiliteter i omgivelsene)	Parking garage (Parkeringshus) Short time parking area (Korttidsparkering) Car rental (Bilutleie) Long time parking area (Langtidsparkering) Cycle parking (Sykkelparkering) Car service (Biltjenester) Park and ride Taxi stop Kiss and ride	At terminal
Entry and exit facilities	Terminal access (Terminalinngang) Transport means access (Av- og på-stigning)	At terminal Terminal stops
Commercial facilities (Kommersielle fasiliteter)	Misc. (Diverse) Kiosk (Kiosk) Cloths (Klær) Bank (Bank) Pharmacy (Apotek) Food (Mat) Tax Free (Tax free) Books (Bøker) Gifts (Gaver)	At terminal During transport
Ticket sale facilities (Bilettsalg-fasiliteter)	Attended ticket office (Bemannet bilettkontor) E-ticket reader (Leser av e-bilett) Ticket machine (Bilettautomat)	At terminal During transport
Refreshment sale facilities (Fasiliteter for salg av forfriskninger)	Bar (Bar) Coffee or Tea (Kaffe og te) Fast food (Hurtigmat) Restaurant (Restaurant) Trolley (Trallsalg)	At terminal During transport
Facilities for children (Fasiliteter for barn)	Nursery (Stellerom) Playroom (Lekerom) Infant room (Spebarnsrom)	At terminal During transport
Misc. facilities (Diverse fasiliteter)	Cash dispenser (Minibank) Chapel (Kapell) Cloakroom (Bagasjeoppbevaring) Computer (Datamaskin) Desk (Arbeidsbord) Emergency telephone (nødtelefon) Fax (Fax) Internet access (Internettaksess) Library (Bibliotek) Lost property (Hittegods) Luggage space (Bagasjeplass) Luggage trolley (Bagasjetralle) Meeting point (Møteplass) Phone (Telefon)	At terminal During transport

Service Category	Service Type	Relevance
	Physical training (Treningsfasiliteter) Power supply (Stikkontakt) Pram space (Barnevognsplass) Seats (Sittemuligheter) Swimming pool (Svømmebaseng) Table (Bord) Toilet (Toalett)	
Accommodation (Innkvartering)	Allergy room (Allergirom) Single (Enmannsrom) Room adapted to disabled (Rom tilpasset funksjonshemmede) Shared (Rom dom deles med andre) Shared bath room (Felles baderom) Suite (Suite) With bath room (Med eget bad)	At terminal During transport

Information services

The information services are offered to the transport users at terminals and during the transport.

Table 22 Service categories and types for information services

Service Category	Service Type	Relevance
Travel information services	Arrival and departure information (Ankomst- og avgangstider) Dynamic arrival and departure information (Dynamiske ankomst- og avgangstider) Traffic information (Trafikkinformasjon) Contact information (Kontaktinformasjon) Route pattern (Rutenett) Time tables (Ruteplaner) Terminal information (Terminalinformasjon) Terminal map (Oversiktskart over Terminal) Transport means map (Oversiktskart over transportmiddel) Trip information (Turinformasjon)	At terminal During transport
Tourist information services (Turistinformasjons-tjenester)	Activity information (Aktivitetsinformasjon) Location information (Lokasjonsinformasjon) Accommodation information (Innkvarteringsinformasjon) Historic information (Historisk informasjon)	At terminal During transport

8.1.4.2 Restrictions

The restrictions are related to terminals, departures and arrivals, and to the transport.

Table 23 Restriction categories and types

Restriction Category	Restriction Type	Relevance
Stop restrictions (Begrensninger på stopp)	No alighting (Ingen avstigning) No boarding (Ingen påstigning) Stops on signal (Stopper på signal) Must be pre-booked (Må forhåndsbestilles)	Terminal stops
Transport restrictions (Begrensninger på transport)	Age restriction (Aldersbegrensning) Bikes prohibited (Forbud mot sykler) Check-in required (Innsjekking kreves) Must be pre-booked (Må har forhåndsbestilling) Must have space reservation (Obligatorisk plassreservering) Must have ticket (Må ha gyldig bilett ved påstigning) Pets prohibited (Forbud mot kjæledyr) Smoking prohibited (Røyking forbudt) Wheelchair restrictions (Restriksjoner på rullestol)	During transport
Access restrictions (Aksessrestriksjoner)	Must be entitled to admission (Må ha rett til adgang) Must have entrance card (Må ha adgangskort) Must have ticket (Må ha gyldig billett)	At terminal

8.1.4.3 Accessibilities

Accessibility defines the way a service is provided or the quality level of a service. Information about such accessibility is very important for some user groups. A lift may for example be available, but the physical conditions in the lift may be influence on the usability.

The accessibilities are organised into contexts and types. There will be several types for each context. For each type there will be a value set defining the different levels of accessibility support.

In the table below the contexts and the types associated to each context is defined. The service categories related to each accessibility context is also defined. However, the results are so far preliminary, and further studies are needed.

Table 24 Accessibility categories and types and relations to service categories

Accessibility context	Accessibility Type	Relevant to service categories
Accessibility for allergic people (Tilgjengelighet for allergikere)	Cleaning (Rengjøring) Mould (Mugg) Pets (Dyr) Pollen (Pollen) Smoking (Røyking)	Accommodation (Innkvartering) Commercial facilities (Bank, apotek og butikker) Local facilities (Fasiliteter i omgivelsene) Misc. facilities (Diverse fasiliteter) Whereabouts facilities (Fasiliteter på oppholdssteder)
Accessibility supported by lighting and contrast (Tilgjengelighet støttet ved lys og kontrast)	Contrasts (Kontraster) Lightening (Belysning)	Accommodation (Innkvartering) Commercial facilities (Bank, apotek og butikker) Facilities for children (Fasiliteter for barn) Local facilities (Fasiliteter i omgivelsene) Misc. facilities (Diverse fasiliteter) Refreshment sale facilities (Fasiliteter for salg av forfriskninger) Ticket sale facilities (Bilettsalgfasiliteter) Whereabouts facilities (Fasiliteter på oppholdssteder)
Information accessibility (Informasjons-	Audio information (Lydinformasjon)) Marking (Merking) Tactile information (Taktil informasjon)	Accommodation (Innkvartering) Commercial facilities (Bank, apotek og butikker) Entry and exit facilities (Fasiliteter ved inngang) Facilities for children (Fasiliteter for barn)

Accessibility context	Accessibility Type	Relevant to service categories
tilgjengelighet)	Visual information (Visuel informasjon)	Local facilities (Fasiliteter i omgivelsene) Refreshment sale facilities (Fasiliteter for salg av forfriskninger) Ticket sale facilities (Bilettsalgfasiliteter) Travel information services Tourist information services (Turistinformasjons-tjenester)
Information means providing accessibility (Informasjonsmåter)	Equipment for interactive information (Utstyr for interaktiv informasjon) Information desk (Informasjonsskranke) Information displays (informasjonsskjermer) Information handouts (Trykt informasjon) Information placards (Oppslag med informasjon) Internet access Maps Mobile services Route map (Rutekart) Signs and icons (Skilting og ikoner) Voice information (Informasjon over høyttaler)	Accommodation (Innkvartering) Commercial facilities (Bank, apotek og butikker) Entry and exit facilities (Fasiliteter ved inngang) Facilities for children (Fasiliteter for barn) Local facilities (Fasiliteter i omgivelsene) Refreshment sale facilities (Fasiliteter for salg av forfriskninger) Ticket sale facilities (Bilettsalgfasiliteter) Travel information services Tourist information services (Turistinformasjons-tjenester)
Machine accessibility (Automattilgjengelighet)	Easy to find (Tilgjengelige) Usability (Brukbarhet)	Local facilities (Fasiliteter i omgivelsene) Misc. facilities (Diverse fasiliteter) Ticket sale facilities (Bilettsalgfasiliteter)
Misc. accessibility (Diverse tilgjengelighet)	Handicap toilet (Handikaptoalett) Seats adoption (Tilpassing av sittemuligheter)	Misc. facilities (Diverse fasiliteter)
Physical accessibility (Fysisk tilgjengelighet)	Broad wise gradient (Fallforhold) Doors (dører) Gradient (Stigning) Lane line (Ledelinje) Lift (Heis) Space requirement (Plassbehov) Surface (Overflate) Tactile marking (Taktil markering) Threshold (Nivåsprang) Waiting area / passages (Venterom/gang) Well arranged interior (Overskuelig innredning) Wheelchair area (Rullestolområde)	Accommodation (Innkvartering) Commercial facilities (Bank, apotek og butikker) Facilities for children (Fasiliteter for barn) Misc. facilities (Diverse fasiliteter) Local facilities (Fasiliteter i omgivelsene) Refreshment sale facilities (Fasiliteter for salg av forfriskninger) Ticket sale facilities (Bilettsalgfasiliteter) Whereabouts facilities (Fasiliteter på oppholdssteder)
Terminal entrance accessibility (Tilgjengelig adkomst til holdeplass)	Gradient (Stigning) Handicap parking (Handikapparkering) Lane line (Ledelinje) Tactile marking (Taktil markering) Threshold (Nivåsprang)	Entry and exit facilities (Fasiliteter ved inngang)
Transport means accessibility (Tilgjengelighet til transportmiddel)	Angle (Vinkel) Distance (Avstand) Grip (Håndtak ved rampene) Height level difference (Nivåforskjell) Lift (Heis) Wheelchair platform (Rullestolrampe)	Entry and exit facilities (Fasiliteter ved inngang)

8.1.4.4 Deviations

Deviations may occur related to the accomplishment of the transport represented by the trips and the legs, to the terminal, to specific terminal stops or to transfer. A deviation is temporary, and is

defined as a deviation to the planned or normal situation. The table below also includes deviations that may not be reported to transport users, e.g. unlawful interferences, damages and security deviations.

Table 25 Deviation categories and types

Deviation Category	Deviation Type	Relevance
Time schedule deviation (Tidsavvik)	Delayed arrival (Forsinket ankomst) Delayed departure (Forsinket departure) Early arrival (For tidlig ankomst) Early departure (For tidlig avgang)	Route/travel information: Terminal stop
Transport execution deviation (Endring i transportgjennom-føringen)	Cancelled (Kansellert) Disrupted (Avbrutt) Transport mode altered (Endret transportmodus) Transport means replaced (Nytt transportmiddel) Reduced capacity (Redusert kapasitet) Re-routed (Ny rute)	Route/travel information: Trip/Leg
Stop deviation (Endring av stopp)	New stop (Nytt stopp) Stop omitted (Stopp fjernet)	Route/travel information: Terminal stop
Service deviation (Tjenesteavvik)	Reduced service (Redusert service) Increased service (Tilleggstjeneste) Reduced accessibility (Redusert tilgjengelighet)	Route/travel information: Terminal Trip/Leg Terminal stop Transfer
Unlawful interference (Lovbrudd)	Terrorism (terrorisme) Theft (Tyveri)	Transport management: Traffic control Fleet management Etc.
Damage (Skade)	Illness (Sykdom) Cargo damage (Skade på gods)	Transport management: Traffic control Fleet management Terminal operation Etc.
Security deviation (Sikkerhetsavvik)	Missing passenger Wrong or missing document (Manglende eller feil dokumentasjon) Wrong packing Dangerous cargo Unruly passenger	Transport management: Traffic control Fleet management Terminal operation Etc.

8.1.5 Preference model

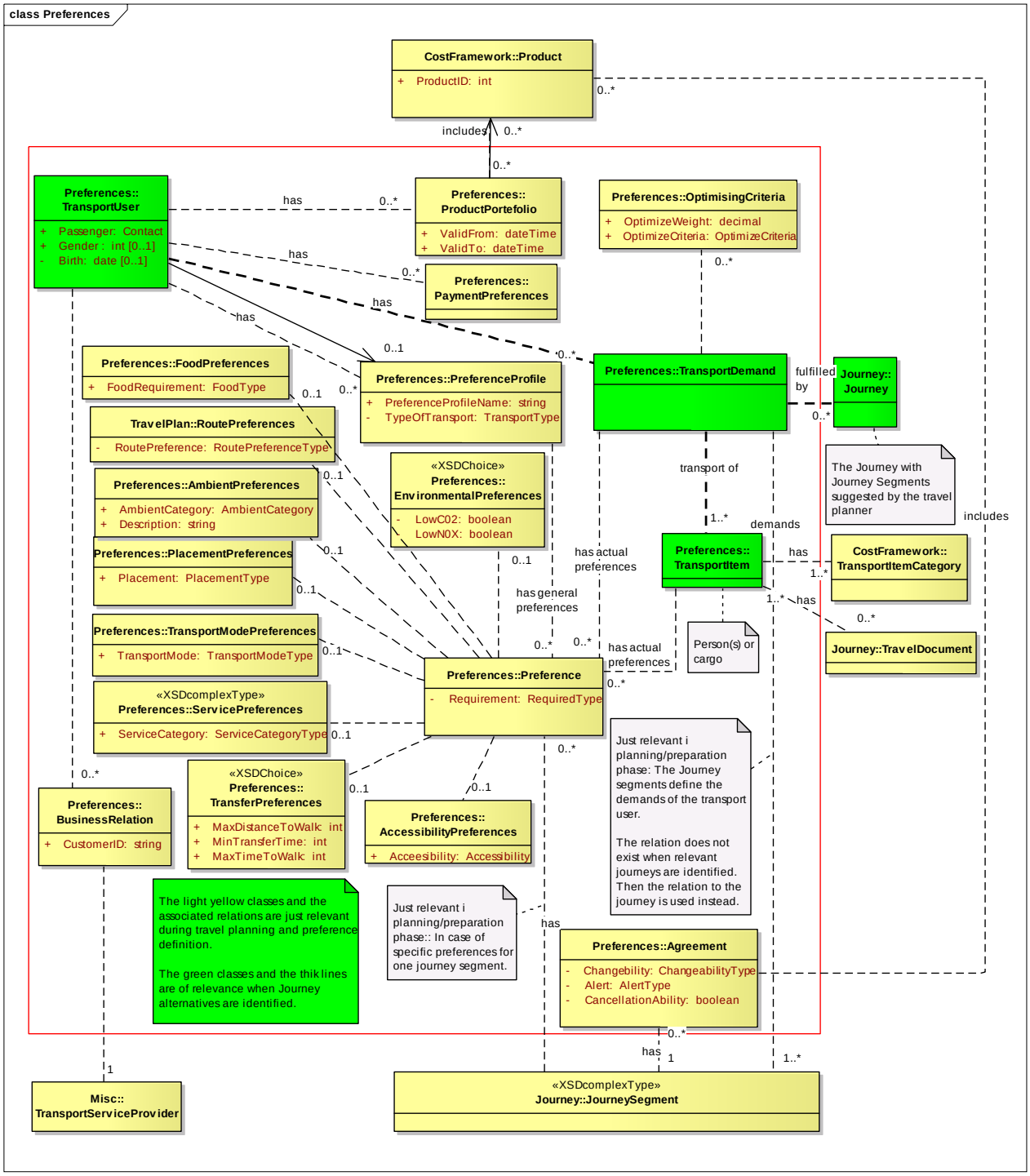


Figure 37 Preferences

The Preferences model is shown inside the square in the Figure and represents information about transport demands as seen from the Transport User. Several classes represent the general preferences and properties of the Transport User:

- A Transport User may have several Business Relations, and each Business Relation is related to a Transport Service Provider.
- A Transport User may also have Payment Preferences.
- A Transport User may have a Product Portfolio, i.e. transport Products (e.g. monthly tickets) that influences on the way he wants to travel.

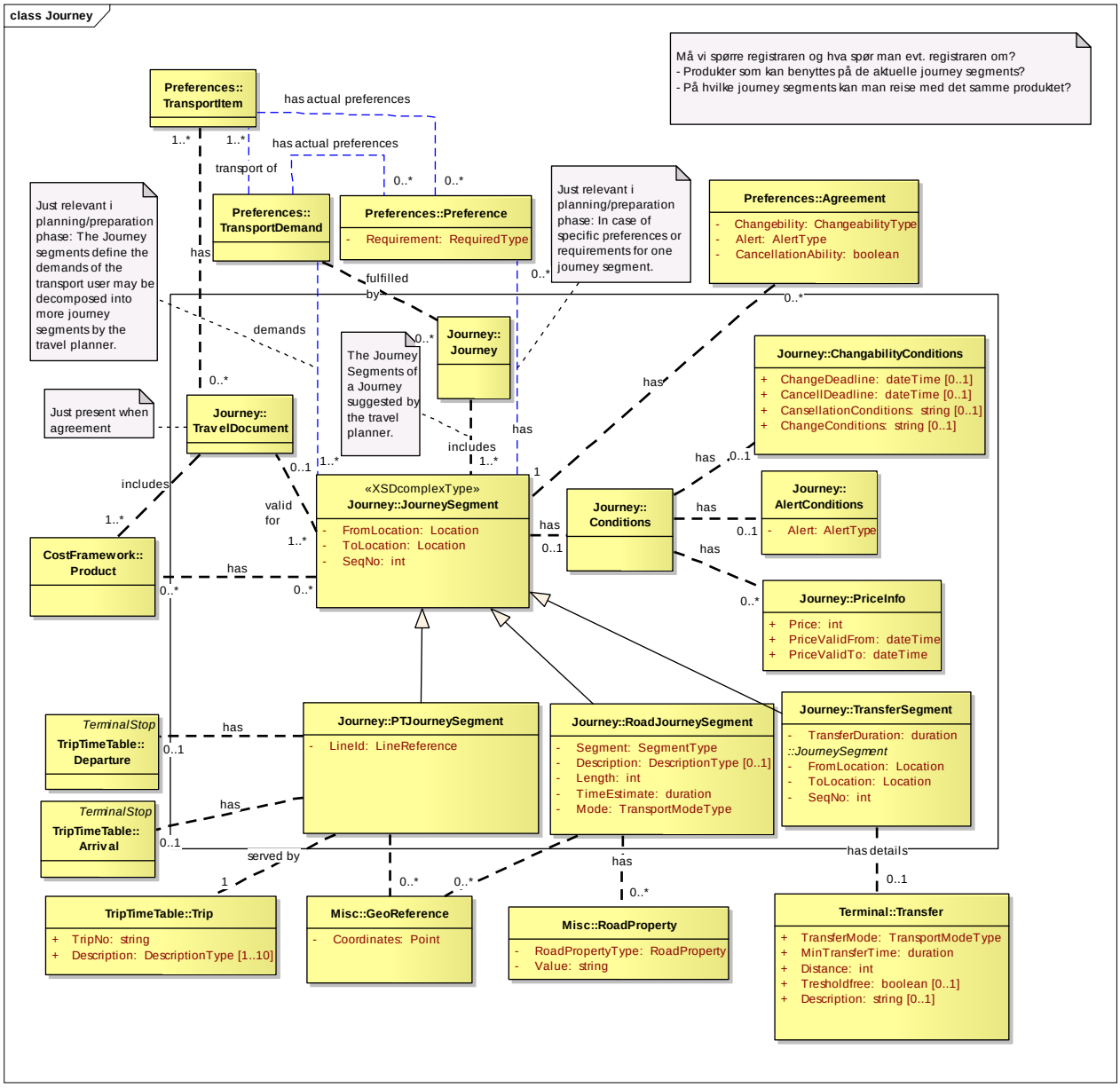
- A Transport User may have several User Preference Profiles that specify the preferences with respect to different types of travel.
- A User Preference Profiles may contain Preference of several types (environmental issues, food during the travel, ambient condition, placement, transport modes, access to service, transfer and accessibility), and they all inherit the Requirement attribute which state the type – “must have”, “do not care”, “will not have”:
    - Environmental Preferences
    - Food Preferences
    - Transport Mode Preferences
    - Ambient Preferences (about the surroundings)
    - Service Preferences
    - Transfer Preferences
    - Accessibility Preferences

The Transport User has a Transport Demand:

- The Transport Demand is about transport of one or more Transport Items.
- There may be a set of actual Preferences related to the Transport in general. These actual Preferences may for example be established by means of the generic preferences from a User Preference Profile, or the actual Preferences may be established from scratch (the model does not consider how they are established)
- Each Transport Item may have also have actual Preferences that will overrule the actual Preferences stated for the complete Transport Demand.
- There may be Optimising Criteria related to the Transport Demand, i.e. criteria for optimising with respect to costs, time, preferences, quality, contract references, environmental issues, etc. (so far the criteria ere not specified).
- A Transport Demand will consist of one or more Journey Segments, which define the desired from and to locations (more than one Journey Segment in case of desired via locations).
- There may be specific Preferences related to the individual Journey Segments.
- There may be Agreements (or requirements with respect to the agreement) between the Transport User and the Transport Service Provider. These requirements concerns contractual issues regarding flexibility in the transport service (with respect to cancellations, changes, etc.) and requirements with respect to status reporting to the Transport User.

The Transport Demand is submitted, and the response will contain information about Journeys that fulfil the demand.

8.1.6 Journey model



The Journey model is shown inside the square in the Figure. A request for relevant journeys will contain:

- A Transport Demand concerning one or more Transport Items.
- The Transport Demand in general as well as each Transport Item many have a set of Preferences.
- The Transport Demand may define one or more Journey Segments, and there may also be Preferences related to these Journey Segments.
- There may also be Agreement requirements related to the Journey Segments.

When relevant Journeys that fulfil a Transport Demand are found:

- The Transport Demand will be fulfilled by zero or more possible Journeys
- A Journey may be composed of one or more Journey Segments. The Journey Segments are specialisations: PT Journey Segments, Road Journey Segments and Transit Segments.
- There may be possible Agreements related to the Journey Segments
- A PT Journey Segment will have a Departure and an Arrival, and there will be a related Trip. The actual route may also be specified by means of Geo References.

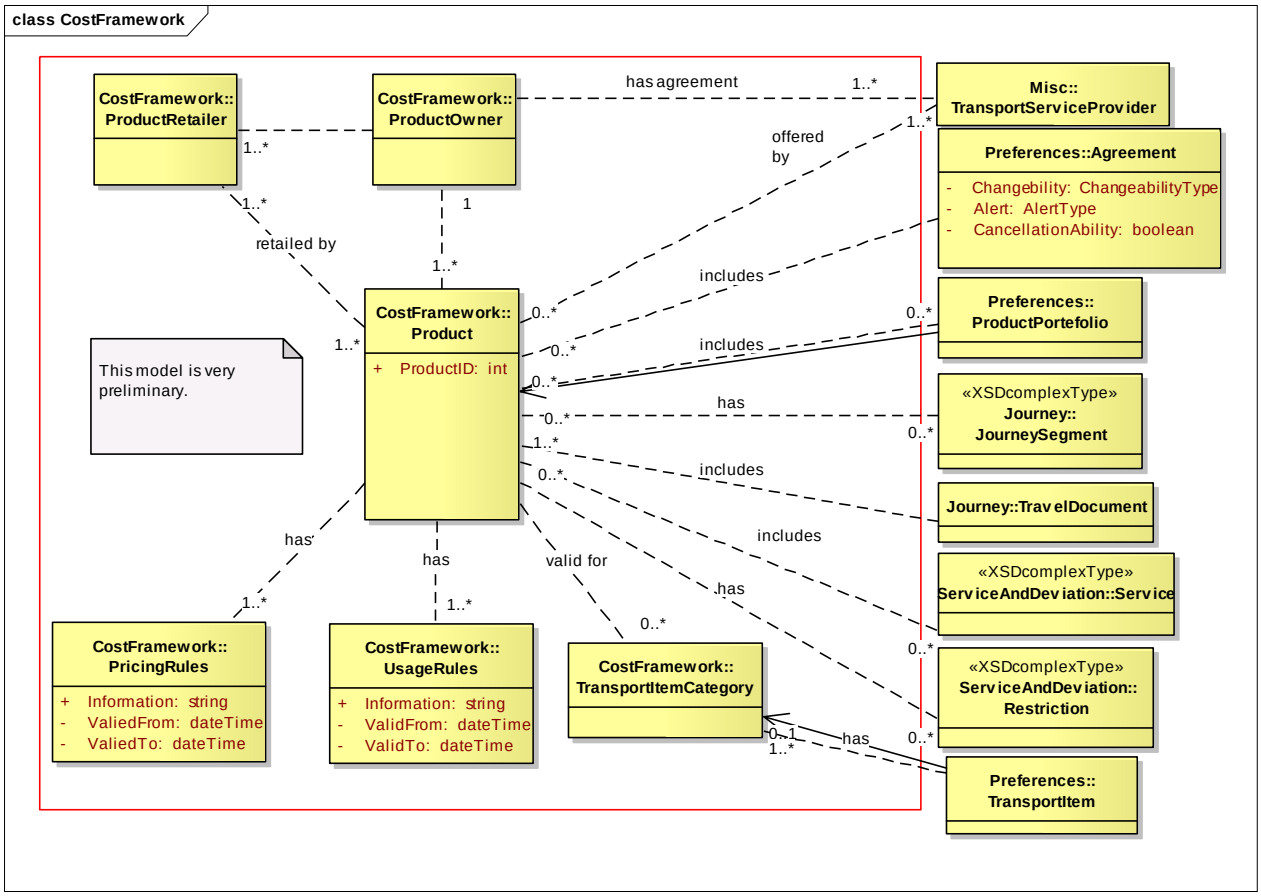
- A Road Journey Segment will have a route that may be specified by means of Geo References, and the Road Properties are specified.
- A Transfer Segment may be further described by means of information about the actual Transfer.
- There may be Conditions related to each Journey Segment concerning the changeability of the bookings, conditions when the Transport User should be notified and the Price.
- The Journey Segment may be associated to a Product.

When the journey is booked or decided upon

- There may be one Agreement for each Journey Segment
- There will be a Travel Document associated with the Journey Segment.
- There will be Products associated with the Journey Segment.
- There will be Products associated with the Travel Document.

8.1.7 Cost model

The current conceptual model on for costs is based on the product concept from eTicketing [12].



The Cost model is shown inside the square in the Figure:

- A Product has a Product Owner
- A Product may have several Product Retailer
- A Product has a set of Pricing Rules
- A Product has a set of Usage Rules
- A product is for a set of Transport Item Categories (i.e. traveller categories).
- A Product may be offered by one or more Transport Service Providers.
- An Agreement (with a Transport User) may refer to Agreements.
- A Product Portfolio (of a Transport User) may include several Products.

- Several Products may be available on a Journey Segment.
- A Transport Document may include several Products
- A Product may include several Services
- There may be Restrictions associated with a Product
- A Transport Item may have one or more Transport Item Categories. They should be harmonised with the eTicketing handbook.

8.1.8 Other information model elements

Elements that do not belong to any of the other models are in the Misc model shown in the Figure below.

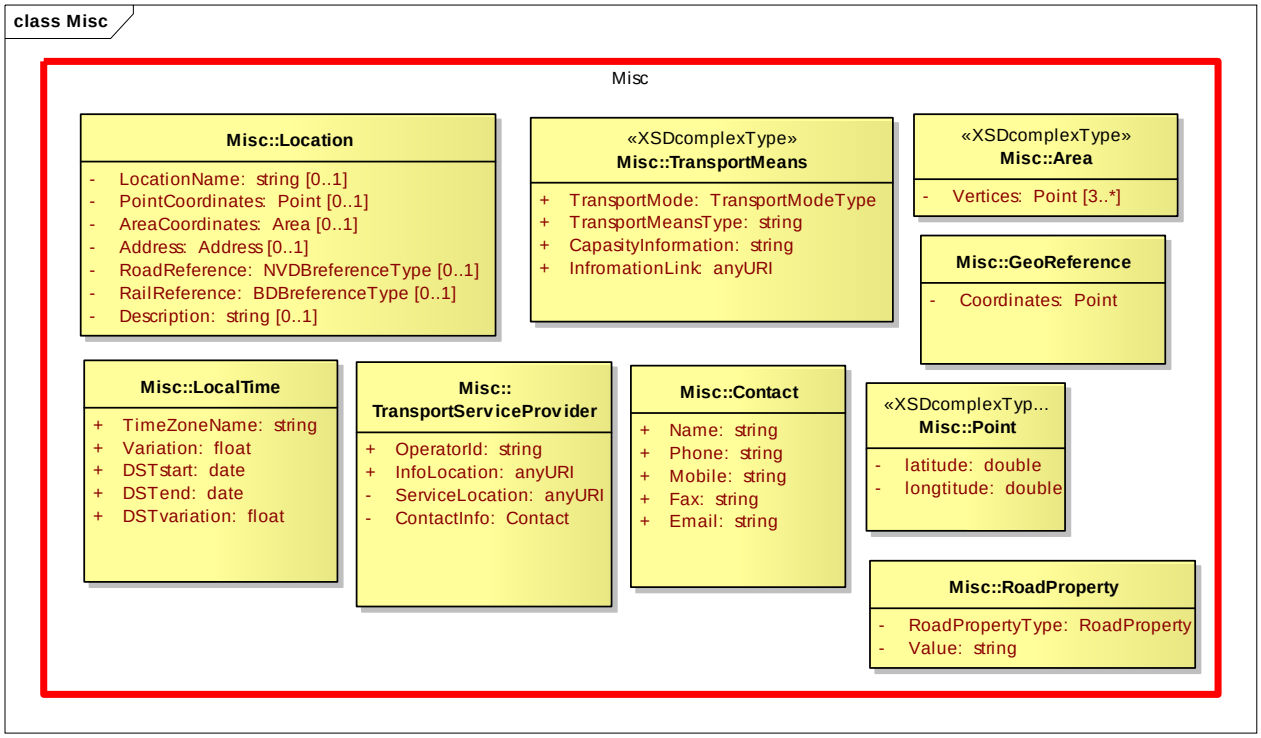


Figure 38 Other information model elements

8.2 CIM - Conceptual service models

The MultiRIT project has aimed to specify a set of open services that will arrange for new and improved travel information services. These services will realise the information flows that in the process diagrams in the process view are “ARKTRANS service” stereotypes.

The services are modelled by means of UML class diagrams in the computation independent service models (see Figure 32), and the classes in the conceptual information models (see 8.1) are used as building blocks.

There are several operations related to each service. As far as possible, there is no or little overlap between the operations. Thus, it may be necessary to use several operations to get the required information. So far just operations of type request–response have been specified. However, many of the same information structures may also be used in one-way request operations (input to travel information providers) and push operations (output from travel information providers)

Table 26 Services and operations

Service	Operation	Request parameters	Response parameters	Comments
Deviation	getTerminalDeviation	Terminal reference	Terminal deviations	Provides i deviation information (service and accessibility deviations included) for Terminals, Transfers, Stop Points and Trips
	getTransferDeviation	From terminal reference, To terminal reference	Transfer deviations	
	getStopPointDeviation	Stop point id, Terminal reference	Stop point deviations	
	getTripDeviation	Trip reference	Trip deviation	
	getArrivalDeviation	Terminal reference, Trip reference	Arrival deviation	
	getDepartureDeviation	Terminal reference, Trip reference	Departure deviation	
Line	getLineInfo	Line reference	Line	Provides details about line, stop pattern, name, etc.
Service	getTerminalService	Terminal reference	Terminal service info	Provides services information. F facilities are also considered as services. Information about accessibility is included.
	getTransferService	From terminal reference, To terminal reference	Transfer service info	
	getStopPointService	Stop point id, Terminal reference	Stop point service info	
	getTripService	Trip reference	Trip service info	
Terminal	getTerminalInfo	Terminal reference	Terminal information	Name, location etc. and access points
	getTerminalArrivals	From date time, To date time, Terminal reference	List of trips	List of arrivals at terminal
	getTerminalDepartures	From date time, To date time, Terminal reference	List of trips	List of departures at terminal
	getAccessPointInfo	Terminal reference	List of access point info	Access point info (location, etc.)
	getTerminals	Location, Radius	List of terminal info	Terminal info for terminals in area
	getTransferInfo	From location, To location	Transfer info	Transfers from a terminal (or a stop point or access point at the terminal) to access points or stop points at this terminal or to other terminals.
TimeTable	getLineTimetable	Line reference, From date time, To date time	Timetable	Timetable for one Line
	getNetworkTimetabel	Network id, From date time, To date time	Timetable	Timetable for all Lines administrated by a Public Transport Authority
TravelPlan	getTravelPlan	Preference info	List of journey info	Trips and routes that fulfil preferences

	getNextDeparture	Previous trip reference, From terminal; To terminal	PT Journey segment	Finds next departure
	getPreferences	User id, Preference profile name	Preference profile	Retrieves generic preference profile registered for that user
	updatePreferences	Preference info, User id, Preference profile name	Boolean (OK if true)	Register new or updates existing preferences
	getTravelTime	Preference info	Duration	Calculates and returns travel time.
Trip	getTripInfo	Trip reference	List of trip info	Overall Info for one Trip: Planned/actual route + Restrictions + combined services
	getTrips	Line reference, From date time, To date time	List of trip info	Overall Info on all Trips provided by one Public Transport Authority: Planned/actual route + Restrictions + combined services
	getLineTrips	Line reference, From date time, To date time	List of trip info	Overall Info on all Trips of a Line: Planned/actual route + Restrictions + combined services

The service models are depicted below. For information about the attributes, etc., see the conceptual information models in 8.1 and Annex B.

8.2.1 Deviation service model

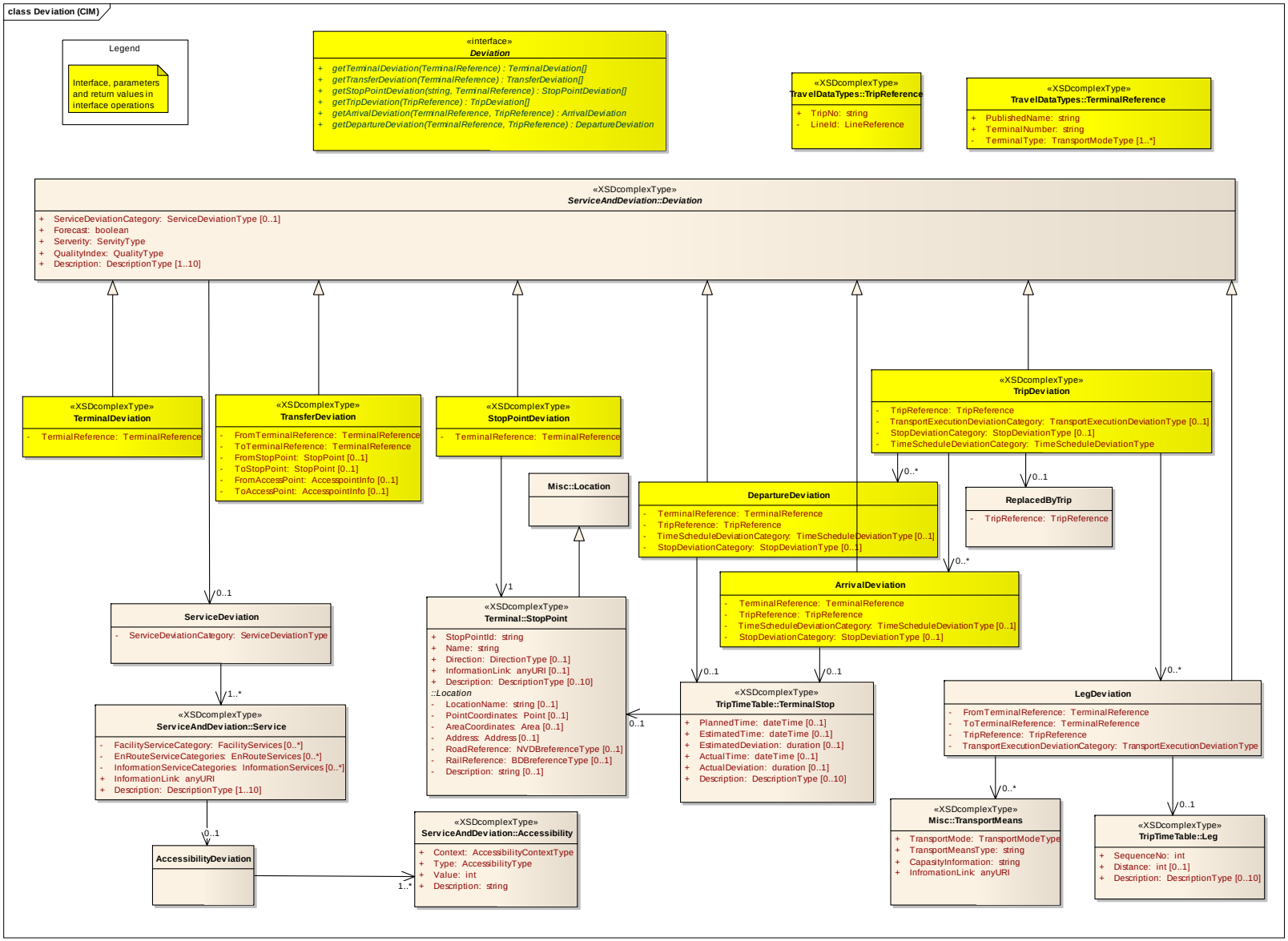
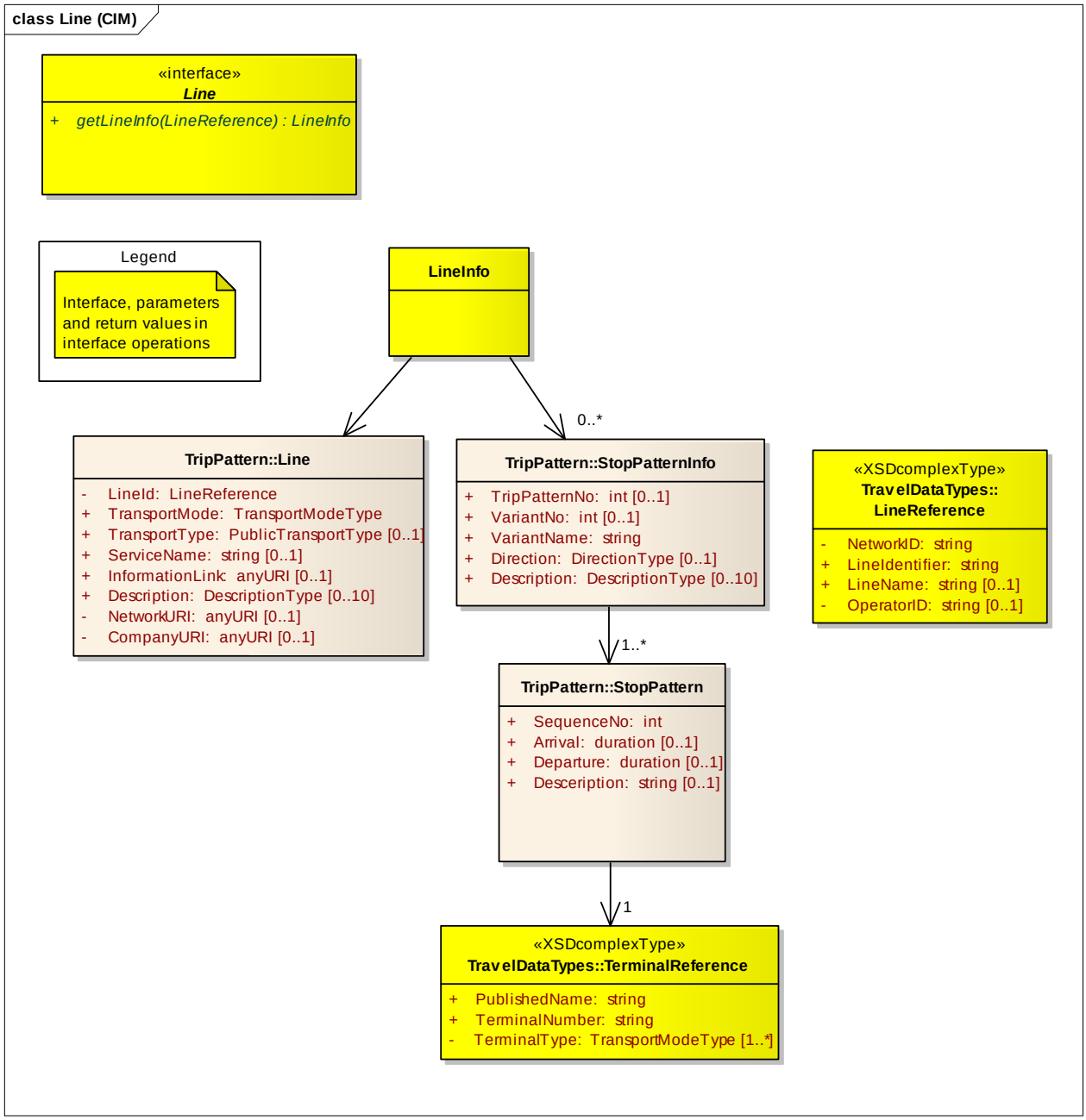


Figure 39 Deviation service model

8.2.2 Line service model



8.2.3 Service service model

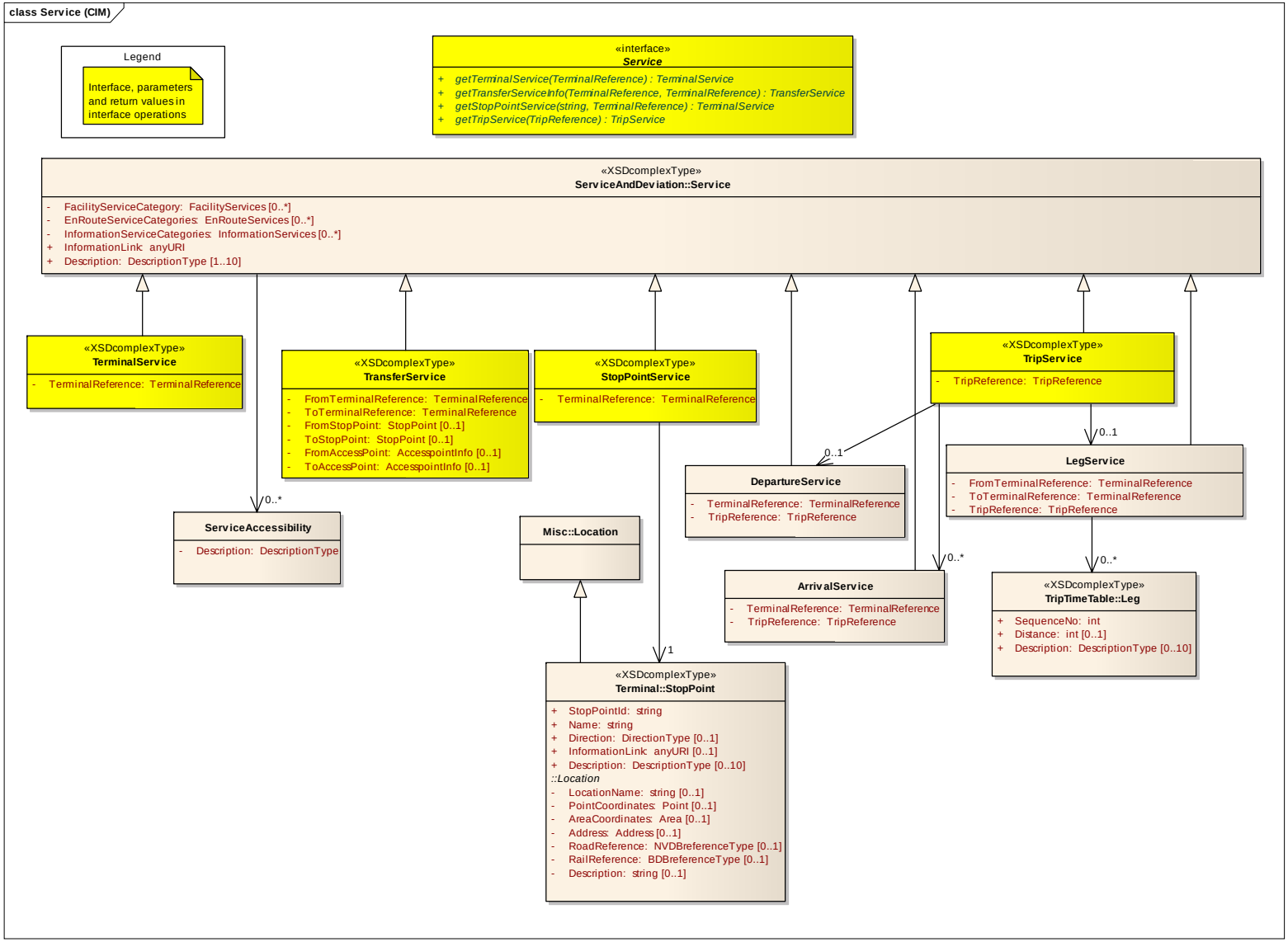


Figure 40 Service service model

8.2.4 Terminal service model

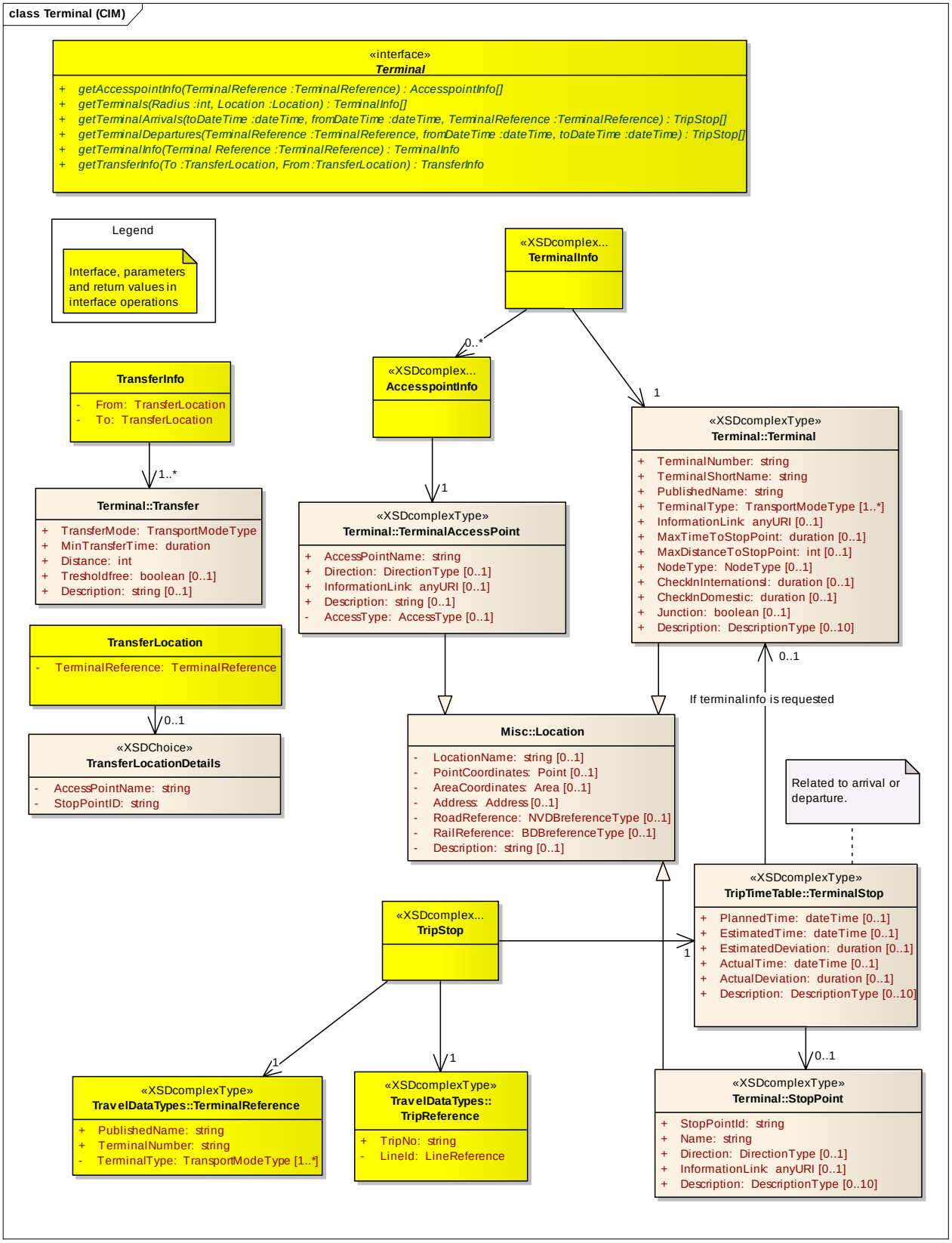


Figure 41 Terminal service model

8.2.5 Timetable service model

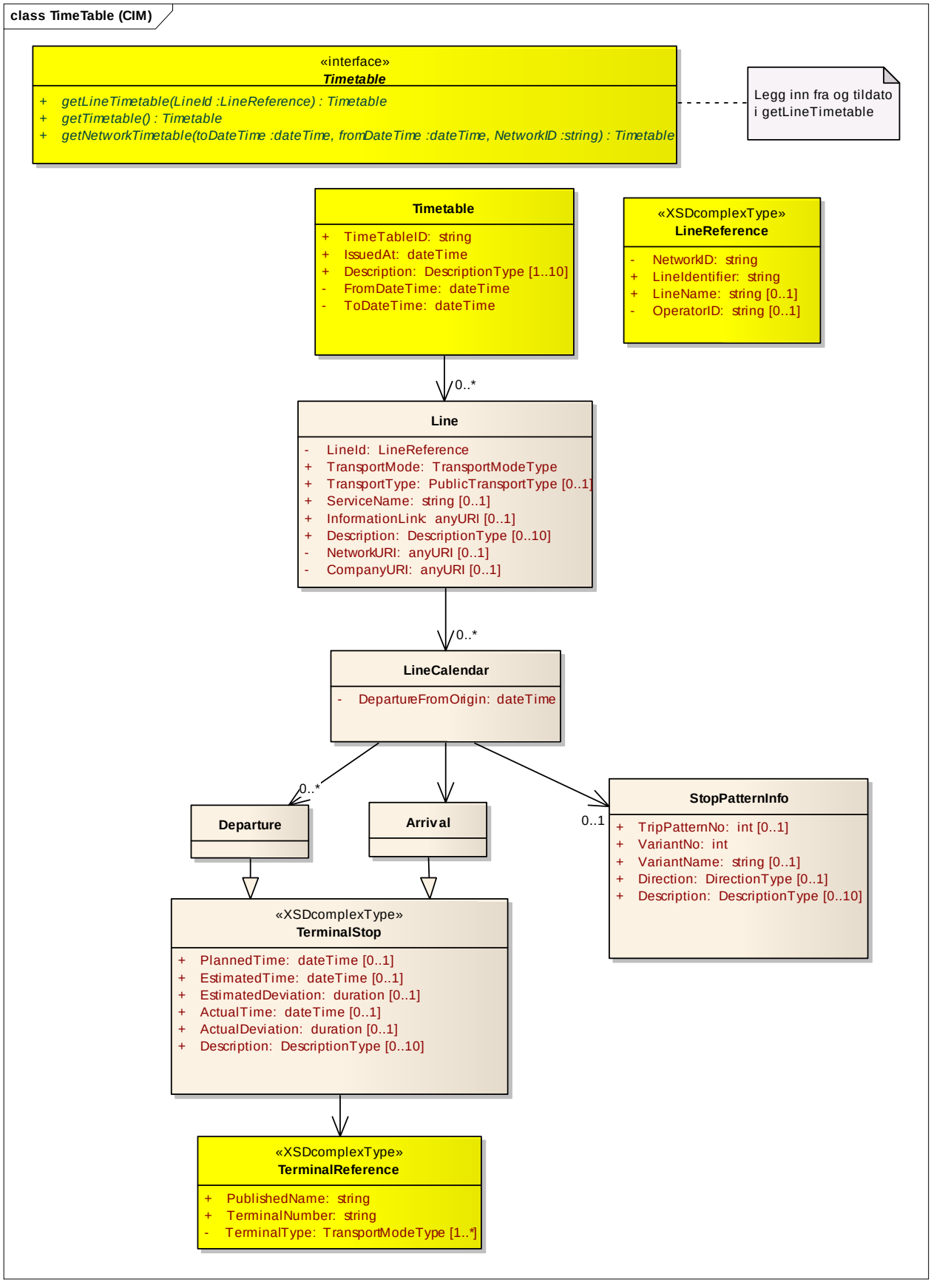


Figure 42 Timetable service model

8.2.6 TravelPlan service model

The travel plan service model is defined by the service models in Figure 43 and Figure 44.

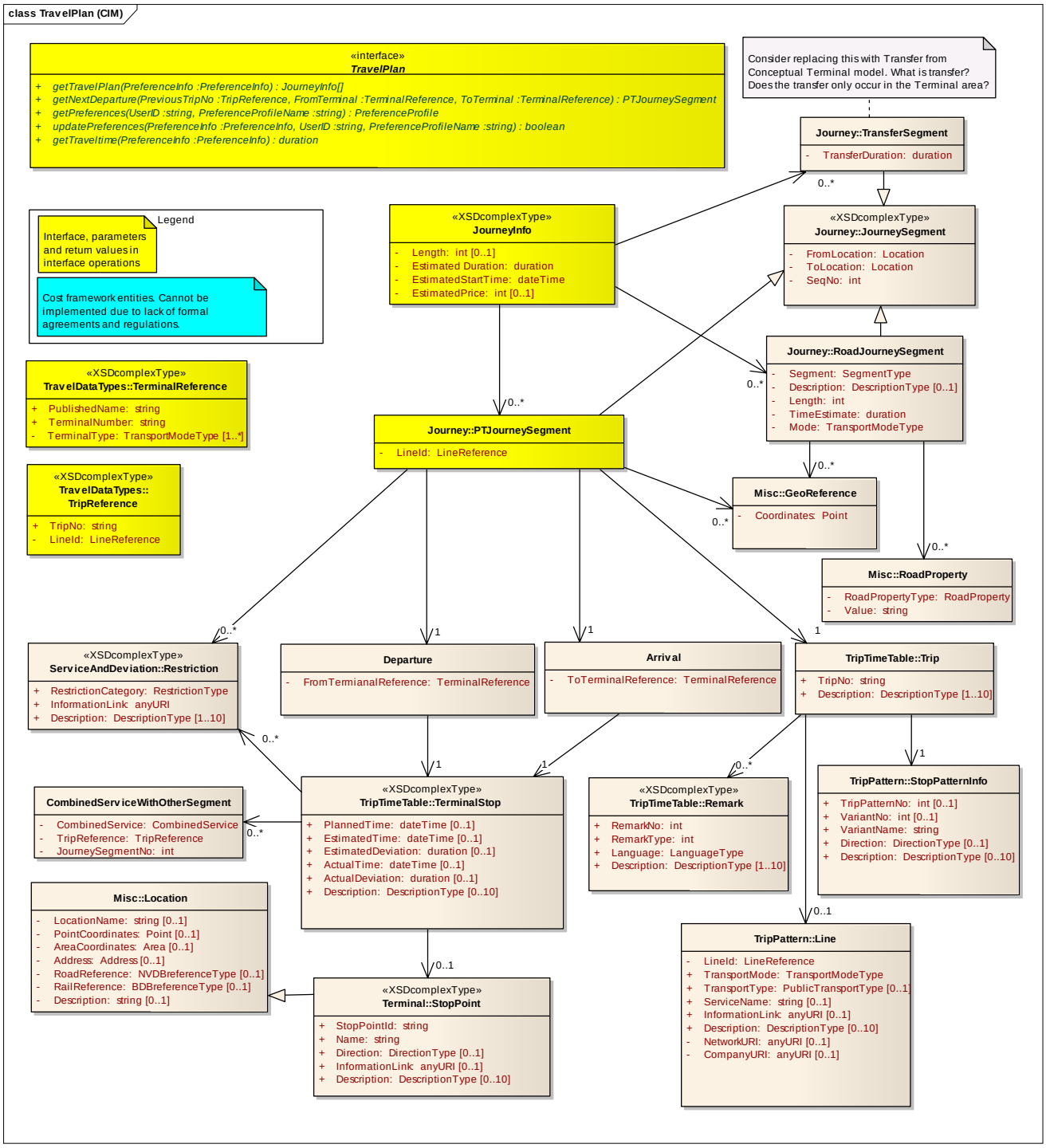


Figure 43 TravelPlan service model – part 1

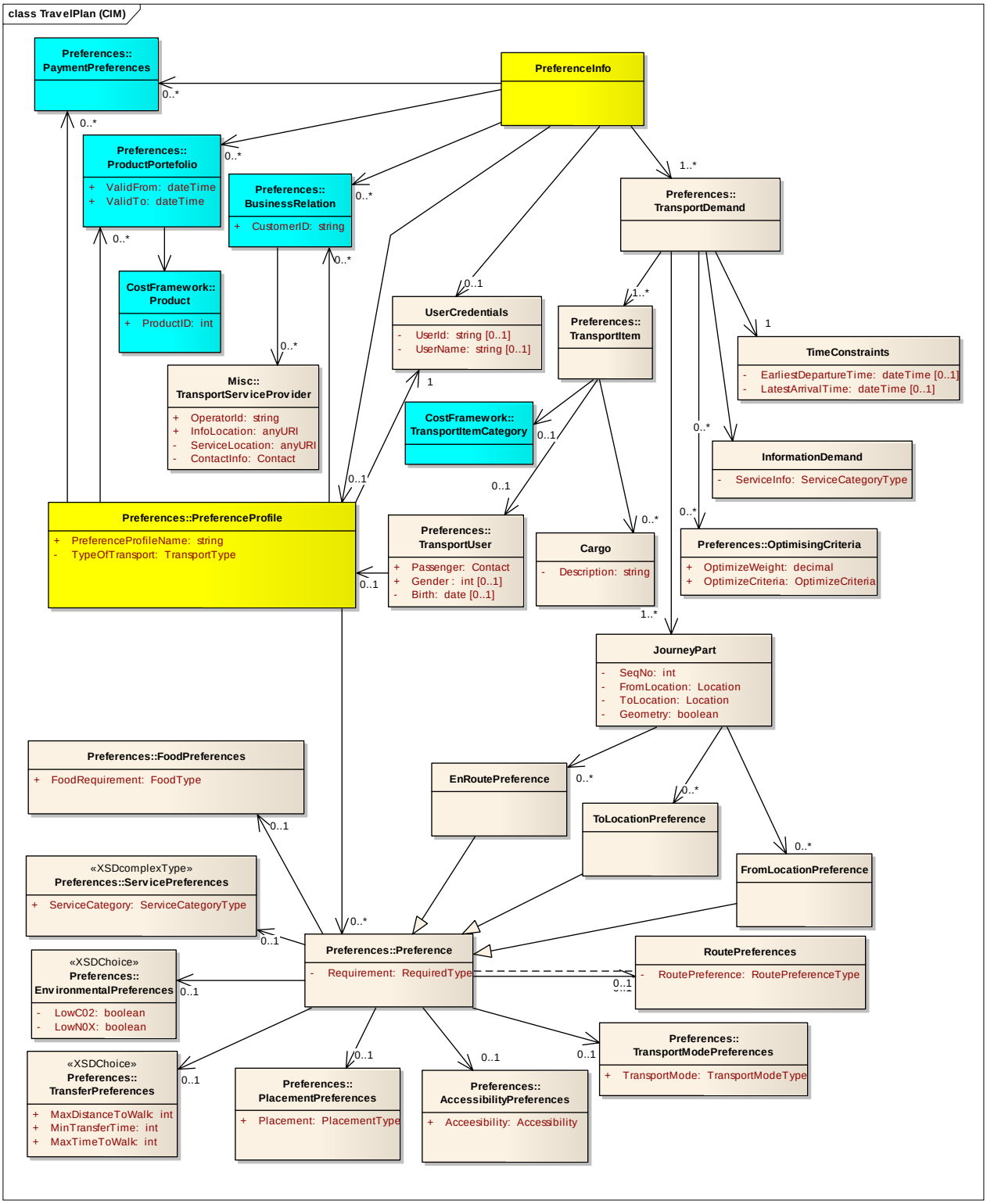


Figure 44 TravelPlan service model – part 2

8.2.7 Trip service model

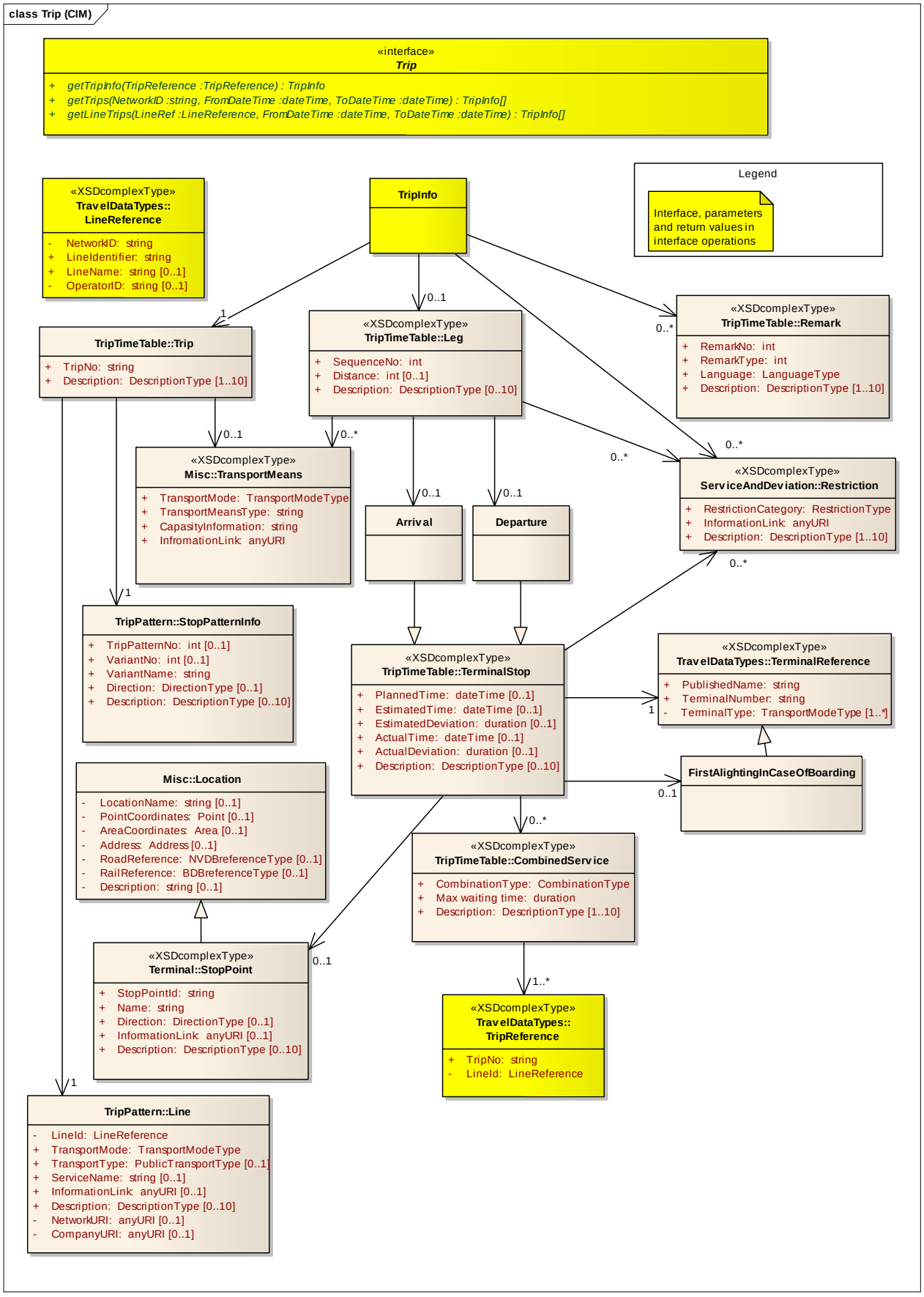


Figure 45 Trip service model

8.2.8 Sequence diagram example

The open services defined above can be used to collect information that can be combined into travel information services that are provided to the Transport User, as illustrated in the figure below.

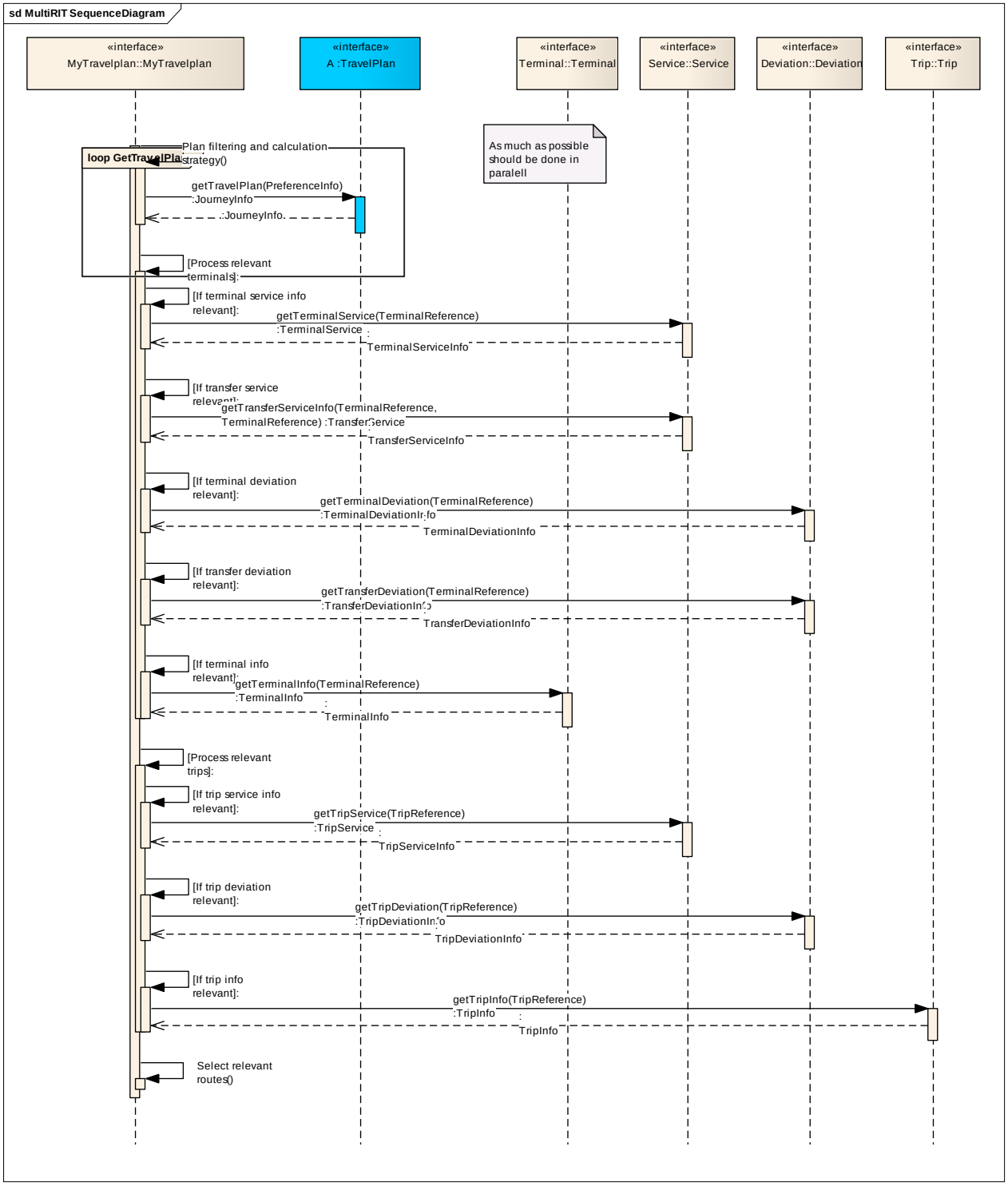


Figure 46 Sequence digram example

8.3 Basic service models

The basic service models appear exactly as the conceptual service models. The difference is that the classes in the conceptual service models contain all relations to other classes that are present in any of the conceptual service models. To be able to successfully transform the basic service

models into web service models (PSMs), all hidden and unneeded relations must be removed from each of the service models.

Since the conceptual service models and the basic service models actuallydepict the same information content we have not included diagrams showing the basic service models in this report.

9 Technical aspects

9.1 Web service models

Based on the basic service models, a new set of models are created. These are referred to as web service models and in MDA terminology these models relate to what is called Platform Specific Models (PSM). In addition to the information described in the previous models (CIMs and PIMs) they prescribe how the travel information is formatted (XML), how it is being communicated (SOAP over HTTP) as well as technical details related to this.

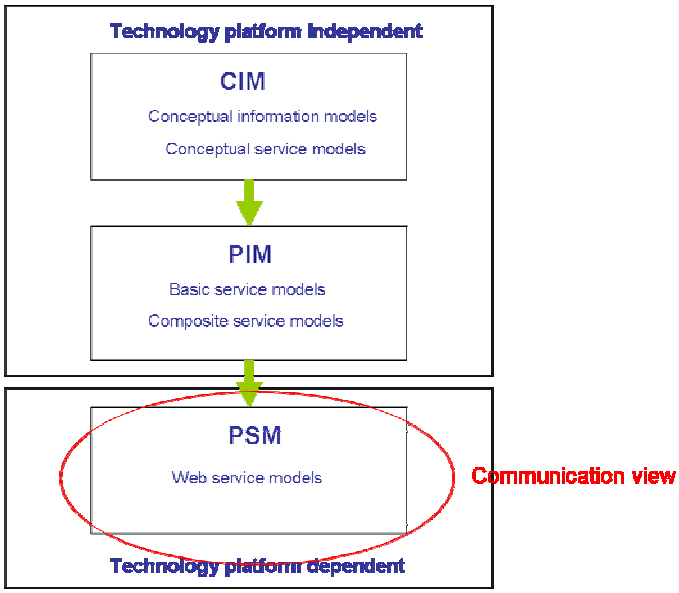


Figure 47 MDA - Communication view

The web service models are one step closer to the practical implementation of the travel information services. From these models WSDL (Web Service Definition Language) files can be generated. In addition to defining the web service interface according to the web service models, these files support automatic generation of generate skeleton code needed to communicate with the web services as well as code that may be used in the development of the web services themselves.

The technical aspects described in the web service models includes information about the actual services, what protocols to be used to transfer the information (bindings), information about the operations that are included in the web service (port types), information about the messages that are being distributed (messages) and the data types that are used in the messages (types). An excerpt from a web service models demonstrating the abovementioned components is depicted in Figure 48.

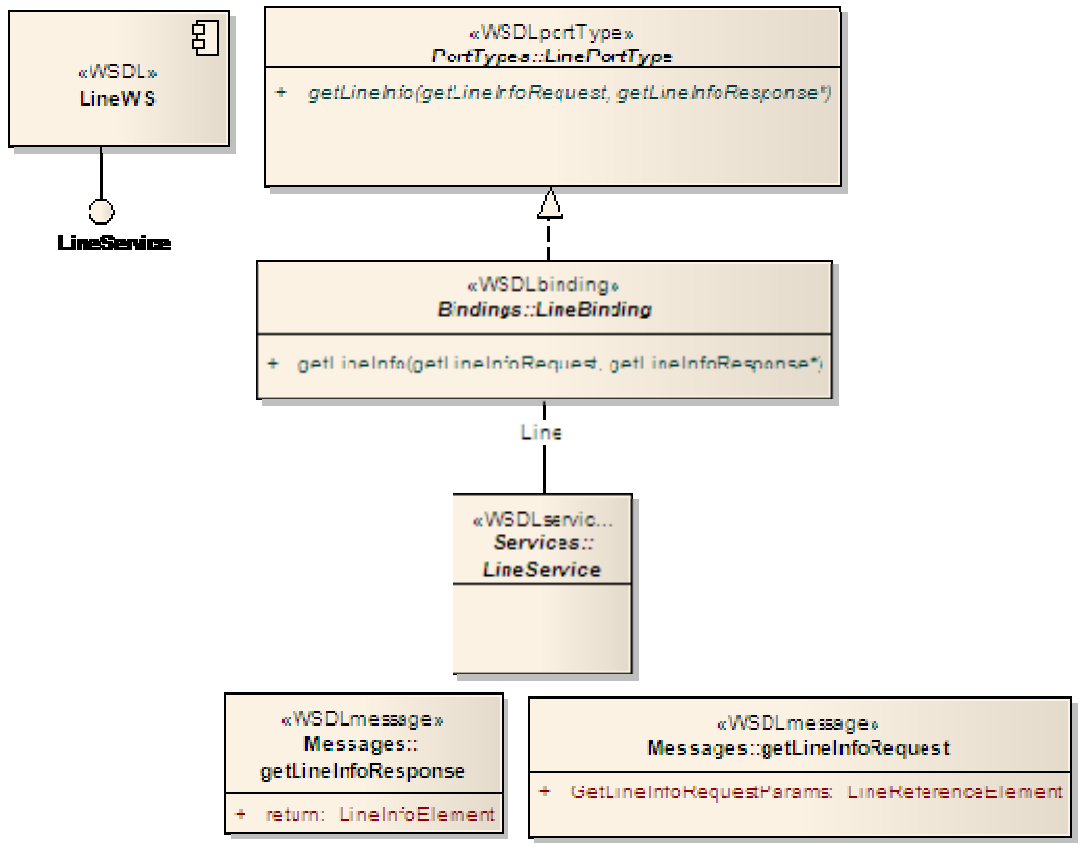


Figure 48 Web Service Model

A further description on how MDA is used to develop these Web Service models may be found in Annex C – the MDA Methodology for MultiRIT.

9.2 XML Schema

An XML schema is a structured document that contains the vocabulary used to communicate XML messages. We developed an XML schema based on the conceptual information models which includes a mixture of enumerations and classes. The classes are transformed into complex XML elements whereas the enumerations are transformed into simple XML elements as depicted in Figure 49. The following XSD schemas were developed in the project:

- CostFramework
- Incident
- Journey
- Misc
- Preferences
- ServiceAndDeviation
- TripPattern
- TripTimeTable
- Terminal
- TravelDataTypes
- RestrictionTypes
- ServiceTypes
- DeviationTypes
- AccessiblityTypes

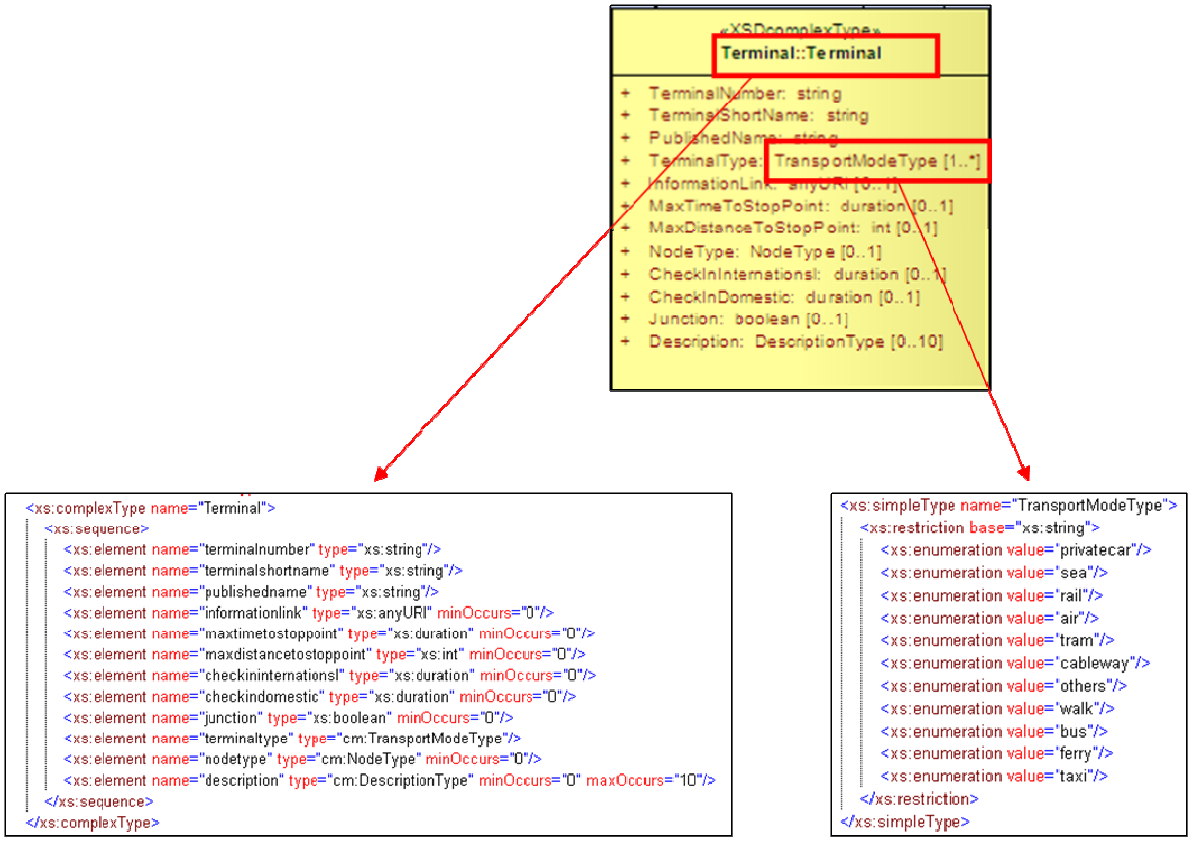


Figure 49 Transformation from model to XSD schema

10 Pilots

Two of the operations in the web service models were implemented as web services. These were getTravelplan from the Travelplan model (see conceptual model in 8.2.6) and getTripInfo from the Trip model (see conceptual model in 8.2.7).

Several alternative getTravelplans were tested. This implementation made it possible to verify that the model driven procedure worked according to plan. When errors were detected during the implementation, we could make changes accordingly in the models.

The web services were tested on both Java and Delphi environments. getTravelplan worked well in both environments. However, getTripInfo did not work well when the Web Service was hosted in a Java environment and accessed from a Delphi client.

The setup of the pilot demonstration is illustrated in Figure 50. One of the getTravelplan web services provided travel plans based on railroad travel information (1-3) while another getTravelplan service provided travel plans by car travel (2-3). The third instance of getTravelplan web service provided multimodal travel planning utilising both centrally stored and distributed travel information (3) while the fourth instance of getTravelplan provided travel information by bus (4). The getTripInfo web service published trip information based on railroad routes (1-4).

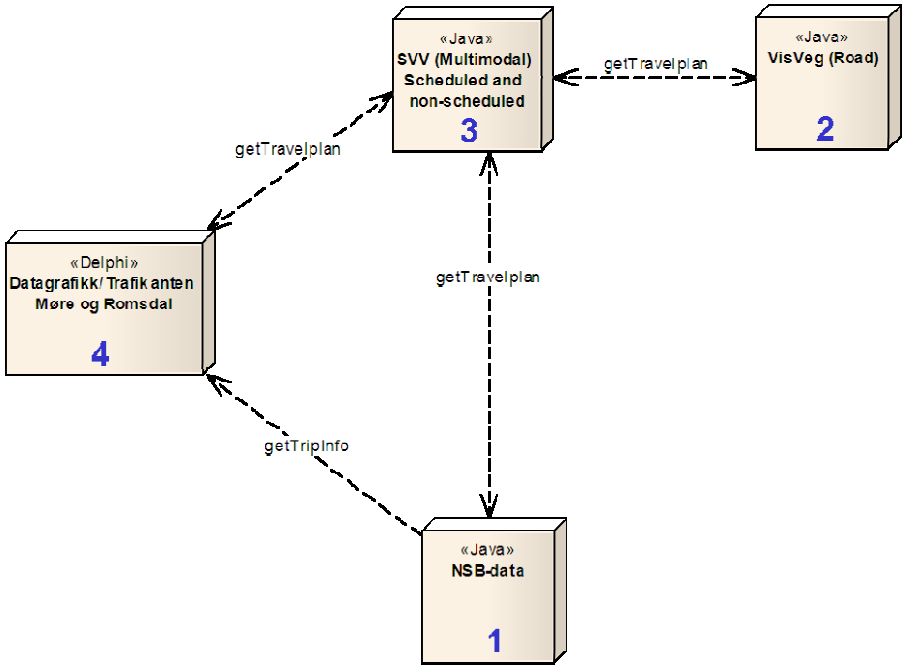


Figure 50 Testing and validation

In the following a more detailed description of the pilots is given.

10.1 Multimodal pilot

The multimodal pilot is developed and demonstrated in MultiRIT as described above. The pilot combines scheduled and non-scheduled transport to provide multimodal travel plans and it also combines centrally calculated travel information with distributed travel planning. This pilot demonstrated six different travel planning alternatives at the MultiRIT seminar held October 31st 2008:

1. Scheduled transport - centrally calculated.
2. Non-scheduled transport (car) including the use of ferry time tables - centrally calculated. Dynamic traffic information (e.g. closed roads) influenses on the routing.

3. Combination of non-scheduled (car) and scheduled transport - centrally calculated
4. Non-scheduled transport (car) – de-centrally calculated in the new version of VisVeg and provided by the getTravelplan service into the multimodal pilot (no ferry timetables were used.
5. Scheduled transport (bus journey in Møre og Romsdal) – de-centrally calculated by Datagrafikk's travel planner and provided to the the multimodal pilot through the getTravelplan service.
6. Scheduled transport providing travel information for trains from NSB (using getTravelplan) combined with a car transport. - centrally calculated.

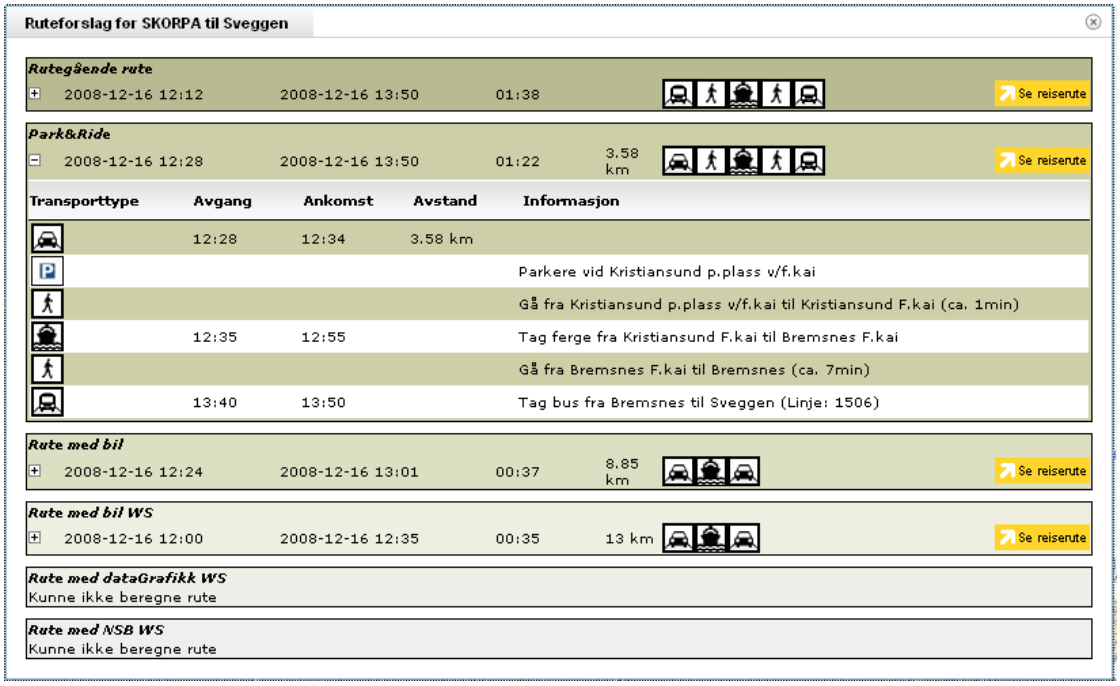
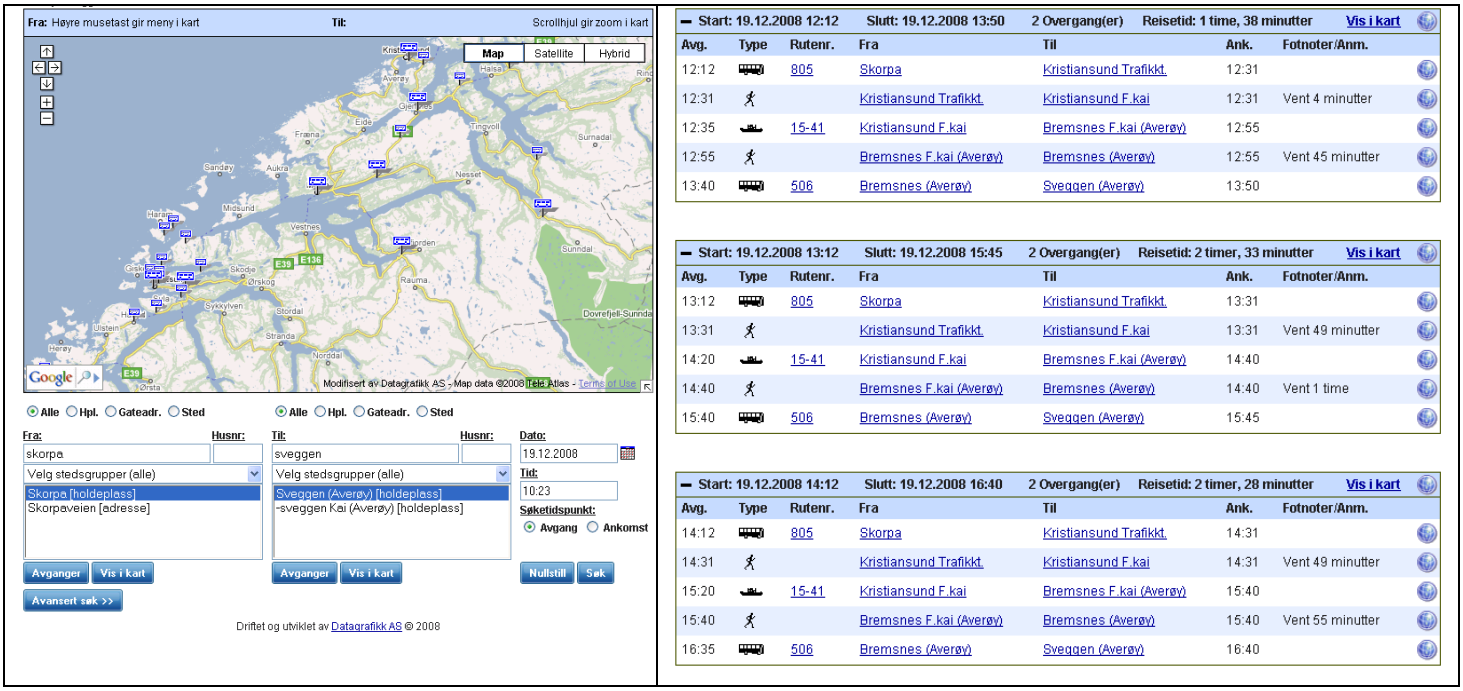


Figure 51 User interface of the multimodal VisVeg pilot

More details about the pilot can be found in and in the TRIONA report about the pilot [13].

10.2 Scheduled pilot

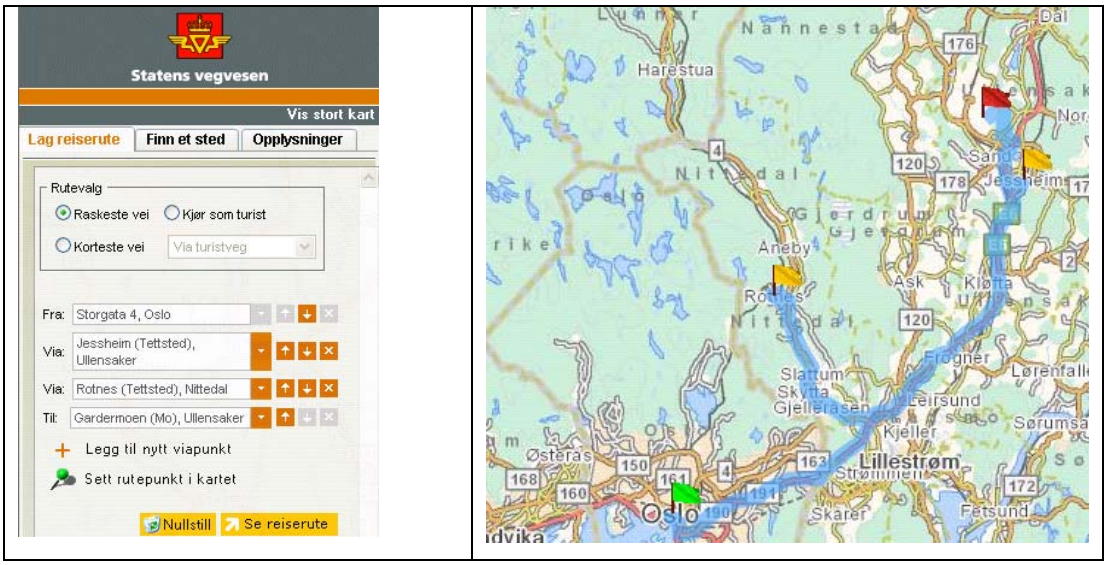
Datagrafikk developed a pilot providing travel plans by scheduled transport (bus information in Møre og Romsdal) through getTravelplan in the MultiRIT project. The figure below depicts the pilot's user interface, using Google Maps to gather user input and present routes.



Figur 52 Datagrafikk's pilot

10.3 Non-scheduled pilot

VisVeg is a travel planner for travelling by car. VisVeg is administered by the Norwegian Road Administration and contains all public and private roads extending 50 meters and that can be driven on by a private car. To calculate the best possible route, VisVeg among other criteria speed limits and road types. A new version of VisVeg is released ultimo 2008. A preview of this new version is shown in Figur 53.



Figur 53 VisVeg's non-scheduled travel planner

10.4 Context dependent information services during travel

NSB (the Norwegian State Railways) is currently testing a set of new on-board travel information services. The travellers can during the transport get access to internet, entertainment services and travel information (deviation information, services and facilities provided on-board, map showing current location, tourist information, etc.). The intention is among others to improve the services

offered to the travellers and with that to achieve better customer satisfaction, more income and improved market position.

Before the start of the pilot, a market survey was carried to find the demand for different types of services:

- Free access to services (63%)
- Map showing the current location (63%)
- Information about arrivals and delays (59%)
- Tourist information about places along the route (53%)
- News (44%)
- Information about services available on-board (43%)
- Information about along the route cities and activities, events, etc. (33%)
- Information about NSB (10%)
- Chat channel (towards others on-board) (9%)
- Do not want any services (13%)

The travellers have been asked whether they will use the services the next time they are travelling, and about 40% confirm that they will use the services every time.

11 Travel planning - algorithmic solutions and limitations

The basic functionality in all travel information services, including multimodal services, is to find the best path between two locations. The problem can be described precisely using mathematics and solved with specialized algorithms that exploit specific mathematical structures. An understanding of these structures and algorithms is important to be able to do a proper evaluation of different travel information systems and designs.

This chapter does not consider difficulties of technical and political nature, but discusses possibilities and limitations of the underlying algorithms. The level of the text is attempted kept at an understandable level without excess use of mathematics, but some is needed to give the necessary precision.

The content is based on work done in the MultiRIT project and additional experience from previous work at SINTEF. In addition we draw upon experiences and literature from other projects.

11.1 Multimodal transport networks

11.1.1 Graphs

The structure normally used to solve shortest path problems is a *graph*. A (directed) graph consists of a set of nodes *V* and a set of edges *E*. The notation $G = (V, E)$ is used for the whole graph. Each edge $e = (u, v)$ starts at a node *u* and ends at a node *v*. Figure 54shows an example of a small graph. If there are attributes attached to the edges of the graph, one often uses the term *network*.

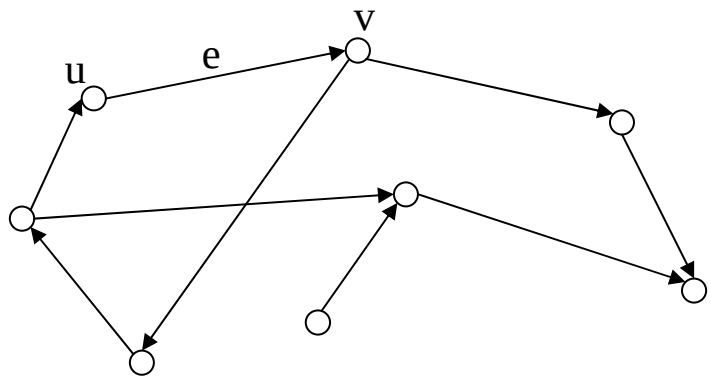


Figure 54 Small graph example

11.1.2 Multimodality

Multimodal problems combine multiple transport modes in the same network. This can be illustrated and modelled in several ways. The common approach is to have a network with multiple levels, where each level represents one or more transport modes. One possibility is to have three levels – car, walking and public transport. The car network contains all roads available for cars together with information about parking areas. The public transport network contains all available lines together with time table information. These two networks are connected using a walking network where both stop points and parking are included as nodes. Figure 55 shows this graphically. To improve readability the edges are undirected. In the walking network there will typically be an arc in both directions.

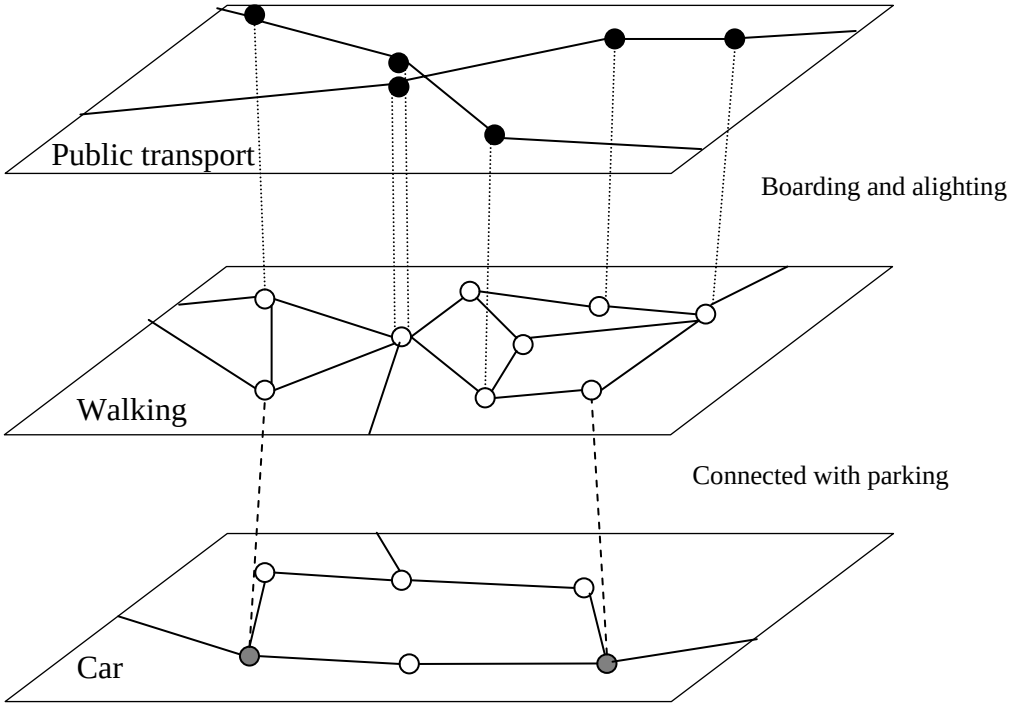


Figure 55 Three level multimodal network

Note that this network can be represented in a single graph. By giving each edge a label, it is possible to identify the level and the properties of the edge. For example the edges could be labelled ‘p’, ‘w’ and ‘c’ for public transport, walking and car respectively.

11.2 Shortest path algorithms

11.2.1 The shortest path problem

The classic shortest path problem is to find the shortest path between two nodes in a graph where you have a length associated with each edge in the graph. This length is assumed to be constant over time. There are many algorithms to solve this problem, the most well known being Dijkstra’s algorithm which is described in the next section.

If the lengths of the edges are time dependent, the problem is referred to as a dynamic shortest path problem. In this setting the shortest path will depend upon when travel begins. This will be the normal situation with regard to travel information services. Both scheduled transport based on time table information and unscheduled transport in traffic with rush time variations will have time dependent travelling times. These problems are also tackled by various methods, most of them based on variants of Dijkstra’s algorithm.

Note that a shortest path can mean different things depending upon what the length of the edge models. By setting this to a suitable value one can answer various requests for best path, including:

- Fastest path (travel time)
- Shortest path (distance)
- Cheapest path (cost)
- Path with the lowest number of transfers
- Path with the least amount of transfer time/distance
- Path with highest sightseeing value

It is also possible to combine one or more of these criteria. This situation is discussed in the section on multicriteria optimization.

11.2.2 Dijkstra's algorithm

Dijkstra's algorithm is a classic and efficient algorithm to find shortest path in a graph where all edge weights are positive. The algorithm calculates the shortest path from one node to all other nodes in the graph. Starting with the start node, the algorithm spreads outward to the other nodes in such a manner that the distance label to processed nodes is equal to the shortest distance. For each node one stores the predecessor, i.e., the previous node in the shortest path. This can be used to generate the shortest path from A to B by following the predecessor nodes backwards from B to A.

Dijkstra's algorithm is a general algorithm and is used as a basis for almost all shortest path algorithms, both for time dependent problems and multi criteria problems.

11.2.3 Space-time graphs

In travel time services the shortest path is time dependent and a request normally gives either preferred arrival or departure time. The most used approach for this problem is by means of a space-time graph. Each node in the graph represents a location in both space and time. The edges represent a movement in both space and time. This can be edges representing lines for scheduled transport or for transfers between lines. Figure 56 shows an example of a space-time graph.

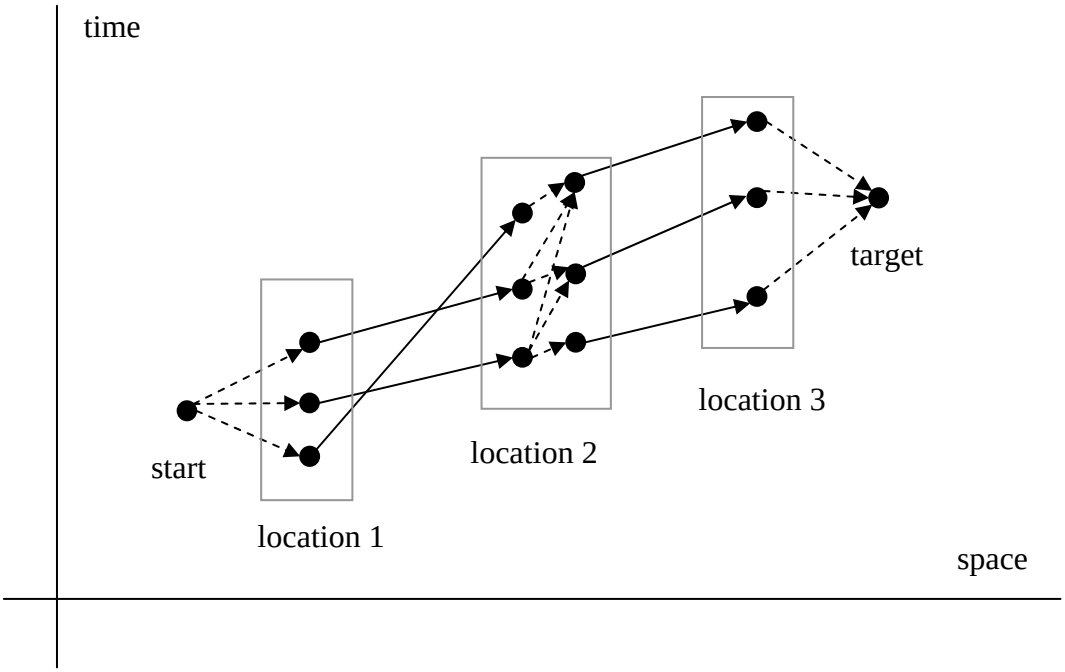


Figure 56 Space-time graph

Routes from start to target are represented by directed paths from start node to target node in the graph. The graph is acyclic by construction and it is easy to find shortest paths efficiently.

Such a representation is well suited for problems based on time tables where there are relatively low numbers of nodes and the time dependency is discrete by nature. The representation is less suitable in time dependent road networks where the number of nodes at the start is very large and the time dependency introduces a great number of new nodes. For more information about space-time graphs and corresponding algorithms, see [14] and [15].

11.2.4 Time dependent graphs

Another way to represent the problem with time dependencies is to use a graph where the time dependency is given for each edge in the graph. This can be done in a number of ways. One possibility is to introduce a cost *C* for each edge that is a function of both arrival and departure

time. If we consider the edge $e = (u, v)$, this can be written as $C(t_u, t_v)$. By setting this cost to infinity if $t_v - t_u$ is less than the required travel time, we can generate shortest paths with regard to travel time. For further details about this approach in connection with road networks, see [16].

This approach is also general enough to accommodate travel times based on time tables.

11.2.5 Multicriteria shortest paths

Sometimes one wants to combine two or more criteria to find the best travel path. One example is to have a shortest possible travel time while at the same time have as few transfers as possible. In this situation one criterion may conflict with the other criterion. The solution is to find paths that are Pareto-optimal, i.e., paths that can not be improved with regard to one criterion without worsening the other criterion. The alternative Pareto-optimal paths can be presented to the user and the user can select amongst them. It is possible to solve such problems by an extension of Dijkstra's algorithm, see [15]. The increased flexibility does not come for free, but leads to an increase in calculation time.

11.3 Distributed solutions

Travel information is often spread amongst several providers and companies. Independent systems may cover different geographical regions and different transport modes (plane, train, bus, and car) and there is a need to coordinate this information. If the assumption is to keep these independent systems, there is a need to construct a shortest path solver on a higher level. This solver, called a *master*, will answer travel requests that are not covered by individual systems by extracting route information from the individual systems as needed.

The presentation in this section is based on [17] and [15].

11.3.1 Algorithms

The simplest distributed solution is to split the transport network in two. The nodes connecting the two partitions are called a separator. If these nodes are removed, the graph is divided into two parts that are disconnected. If the number of nodes in the separator is small compared to the total number of node in the graph, the graph is said to be *weakly connected*. This is illustrated in Figure 57.

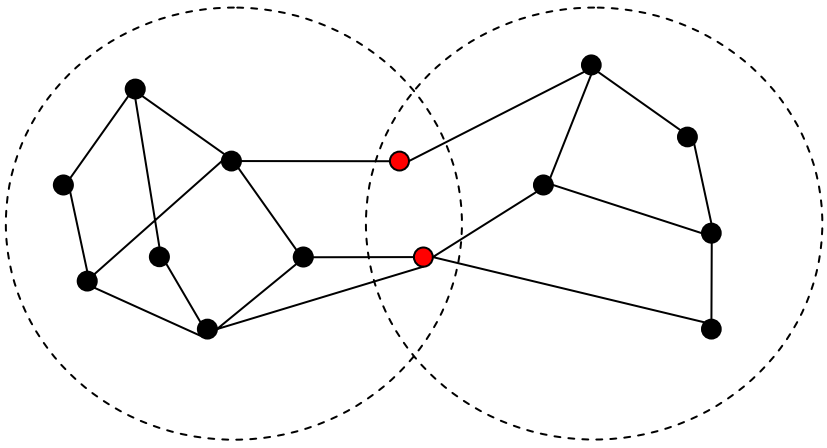


Figure 57 Weakly connected graph. Nodes in the separator are red.

More relevant for a travel information service is the case with three weakly connected networks. Two of the networks represent regional travel information, while the third models transport between regions.

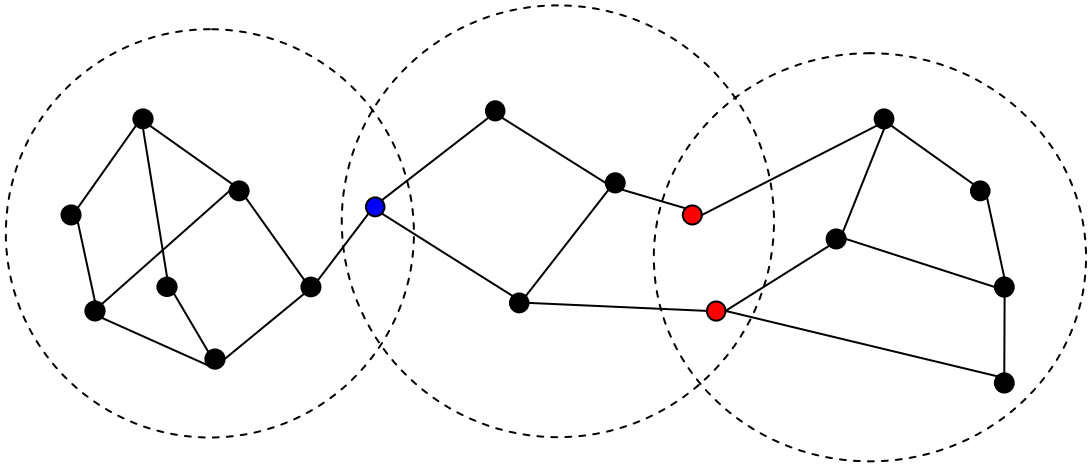


Figure 58 Travel network with three weakly connected networks.

A request for a route between the two local regions will be handled by the master. In the beginning only start and end locations are known to the master. First, it has to identify the regions in which the locations belong. This kind of information is referred to as meta information, and will typically be available as part of a central database. We further assume that the network connecting the regions is available. The next information needed is the separator nodes between the different networks. This is also a form of meta information that needs to be available.

The master now knows start node, end node, corresponding regions and the connecting network together with the separators. The master then has to solve a shortest path problem on the graph illustrated in Figure 59.

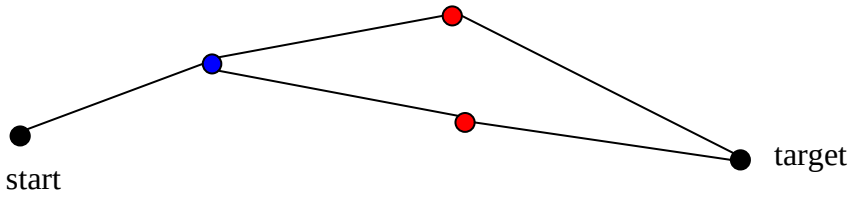


Figure 59 Reduced network for distributed shortest path.

The properties of the edges from the start node to the connecting nodes are found by querying the local system. In the same way edges into the end node is generated by querying the other local system.

11.3.2 Regional splitting

As described above, the natural splitting that gives rise to weakly connected graphs, is to partition the transport network based on geographical regions. Each region should contain the shortest path between all locations within the region. Travels between regions should be performed using a central network (typically plane, train or express coaches). The exception is neighbouring regions, where one may travel directly between the regions without the use of a central network. In both cases each region needs to define all connection points, that is, locations where you can start travel with the central network or a neighbouring region.

11.3.3 Modal splitting

Another option to split by modality, i.e., let each type of transport have its own network. The problem is that this often leads to a strongly connected graph. A typical example is an urban region with several forms of scheduled transport – bus, tram, subway and train. It is in general difficult to do a distributed search in these settings as the central system needs to duplicate almost

all local information, increasing the number of queries to local systems and leading to a dramatic loss in efficiency.

If there is a clear hierarchy or a sequence in how different transport means are used, there is a possibility of using a distributed search. An example is the sequence car – scheduled transport – walking where separate planners can be used for each leg of the journey.

11.3.4 Examples

Transport Direct

TransportDirect [18] is a travel information service developed on behalf of the British ministry of transportation. The service is the most complete solution in operation with regard to multimodal transport, including the possibility of comparing car use with scheduled transportation. Journeys are calculated in a distributed manner with a set of geographic separate regional services that are combined with a centralized network. The communication between the journal planning systems are handled by the JourneyWeb protocol.

DELFI

DELFI (Durchgängige ELektronische FahrplanInformation) [19] is a large project that has been running in Germany since 1994. The project was set up to combine travel information from all German federal states. It calculates shortest paths by querying the local system for each state and combining the results with data from the national railway system.

EU-Spirit

EU-Spirit is an extension of DELFI aimed at the whole of Europe. Currently the system is working with input from Sweden, Denmark and parts of Germany. The technology is similar to that used in DELFI. Itineraries within one country are calculated locally, while travels from one region to another are calculated by a central system that sends queries to the local systems involved.

12 Price information in travel information services – a feasibility study

The Transport User will like to have price information for different transport alternatives. For road use the price can easily be calculated from the distance of the journey by means of a standard cost factor. However, it is not easy to calculate the price of a journey that consists of several public transport legs, provided by several Transport Service Providers. The total price may depend on a substantial amount of variables, for example:

- The division into legs, and the Transport Service Providers serving them
- The responsibilities of the Transport Service Providers (with respect to the connected legs)
- Pricing agreements between the Transport Service Providers involved.
- When the travel is to be performed (weekdays, weekend, high/low season etc.)
- When the travel is booked (long before the departure, close to the departure, onboard etc.)
- Who is travelling (child, adult, retired, Gold Card member, etc.)
- The freedom of re-booking
- The availability of seats on the requested travel (yield management)
- The availability of additional services (meals, lounge facilities etc.) on the journey. These services may either be pre-paid or their availability itself may be included in the travel price.

12.1 Requirements

There is a need for a facility supporting price calculation of multimodal, composite travels involving a number of different Transport Service Providers. The following overall requirements must apply:

- **Traveller profiles.** To ease the process of issuing a price calculation request, a concept of registered traveller profiles must be supported.
- **Service pricing.** Price calculation shall support a variety of options with respect to services included in the travel/available to the traveller.
- **Transport Service Provider agreements.** All agreements between Transport Service Providers shall be known and taken into consideration when calculating the price of the travel.
- **Dynamic pricing.** The calculated price shall at any time reflect the actual price (i.e. dynamic pricing through yield management shall be accounted for).
- **Time limited price guarantee.** A calculated (and offered) price of a specific travel shall always be guaranteed within a specified time frame.
- **Flexible payment methods.** Different Transport Service Providers will in general support different methods of payment, and they may have their own proprietary bonus/credit card arrangements. Such agreements must be considered during price calculations.
- **Web-interface for price information.** Price calculation of a composite travel shall have a common, non-operator specific interface.

12.1.1 Traveller profiles

“Elektronisk billettering. Håndbok 206-1” (The Norwegian handbook for electronically ticketing) [12] contains a definition of traveller classifications. However, few Transport Service Providers are completely compliant with this. They have their own traveller classification schemes, e.g. age limits for child, youth etc. One option is that the travellers provide information about year of birth, etc. However, a common and standardised traveller classification scheme, which is used by all Transport Service Providers, will simplify the solution.

A traveller profiles should be provided when prices are requested. The profiles do not have to identify the traveller by name (unless the booking stage is reach and identity information is required by the transport mode or due to payment information). A profile with information about

traveller classification and preferences with respect to services can be used when price information is requested. The traveller profile should contain:

- Traveller classification (or optionally information about. age, student or retired status)
- Memberships, bonus programs, etc.
- Preferences with respect to transport mode, travel services, seating, meals, special service needs (e.g. disablement facilities) etc.
- Preferences with respect to means of payment
- Traveller's currently valid travel products (e.g. monthly tickets).

12.1.2 Service pricing

Like traveller classification, service classification is today in general specific from each Transport Service Provider: Not all Transport Service Providers support the same set of services (facilities on board, etc.), and the same services may be differently named. A common service classification scheme wills simplify the provision of price information. Specific well-defined services can be requested, and price information can be offered. Different pricing strategies may be used;

- Pay for services, even if not used (a train with a restaurant coach can be priced higher than a train without).
- Pay for additional services (the meal in the restaurant coach must be paid).
- Luxury products: Services are included (a 3-course dinner in the restaurant coach is included in the fare).

12.1.3 Transport Service Provider agreements

Transport Service Providers may have mutual (bilateral) agreements, or be part of a larger regional agreement with respect to travel pricing. Such agreements must be taken into account when calculating the price of the total, composite travel.

The product concept in eTicketing can be used as a mechanism. The different agreements between Transport Service Providers will be separate products.

A national registry of existing products (those involving agreements included) will simplify the price calculation. When requesting the price of a travel leg provided by a Transport Service Provider, the products involving other Transport Service Providers can be found. The price request to the next Transport Service Provider must, if relevant, refer to these products.

If there is no product registry, the entire travel plan must be included in the price information request to every Transport Service Provider. The individual Transport Service Providers have to identify any agreements having impact on the price calculation.

12.1.4 Dynamic pricing

In addition to the transport service being purchased, the actual *time of purchase* (or actually price request) and also the *identity of the traveller* may be taken into consideration when a Transport Service Provider calculates the price of a travel product.

12.1.4.1 Time of price request

Yield management is the mechanism where the Transport Service Provider analyses the actual situation to maximise his revenue by correctly balancing the risk for the transport leaving with unsold seat vs. selling the seats to a reduced price. Different principles of yield management are discussed in [20] (public transport in cities) and [21] (multi-modal transport in general with focus on rail).

The dynamic aspects of pricing discussed in this chapter may either be:

- Calculated by each Transport Service Provider individually without looking to other Transport Service Providers and possible combinations with their products.
- Calculated by taking all travel products together covering the entire travel route into consideration. Needless to say, performing yield management over a number of in principle independent Transport Service Providers will represent a major challenge.

A very good example of yield management is the pricing of airline seats: In general, airline seats are cheapest if purchased a long time in advance combined with a no-refund restriction. The seats will then be more and more expensive as time of travel approaches, for eventually be dramatically cheaper when the flight is so close in time that the operator sees that there is a substantial risk of the plane taking off with empty seats.

Although for mostly being used in conjunction with airline tickets, the principle in itself is universal and may thus be utilized by all modes of transport being part of a multi-modal travel. As more and more people get access to the Internet and learn to take advantage of services available on the Internet, the dynamic aspect of travel pricing will be increasingly important.

12.1.4.2 Business agreements with the traveller

Pricing policy according to business agreements with the traveller may also have a dynamic aspect: The traveller may have some form of bonus card or membership. Such bonus cards will often be organized into a number of levels (e.g. Basic, Silver and Gold to use the SAS Eurobonus as an example) that may imply different service levels.

12.1.5 Time limited price guarantee

A consumer will always like to have the possibility of comparing an offered price with other alternatives before deciding which alternative to go for. To facilitate this, an offered price should be accompanied by a *time-limited guarantee*.

Today, prices offered by e.g. airline booking systems have no such guarantee, they are only valid during the current interaction with the booking system: If the traveller logs out of the booking system and then in again, the actual seat(s) may have been taken and a new price request may either be denied (plane full) or result in a higher price.

The solution to this would be to allow the traveller to specify that the price request he is about to make also should be a *time-limited pre-booking*. As far as the value of the actual limit-time is concerned, the Transport Service Provider will always prefer the shortest possible time while the traveller will prefer the longest possible time. A suitable compromise may here be in the order of 15 minutes.

To accommodate this, Transport Service Providers must redefine their yield management policy to allow a price request to imply a time-limited pre booking

12.1.6 Flexible payment methods

According to "*Elektronisk billettering. Håndbok 206-1*" [12] chapter 2.3, a number of payment means may be used for the payment of travels:

- Cash
- Electronic purse (electronic values stored on a smart card, mobile phone, loaded by debiting a traditional bank account)
- Electronic values stored on the same card as the electronic ticket (product) and where the issuer of the card in both cases is the same legal entity.
- Electronic values stored on the same card as the electronic ticket (product) and where the issuer of the card in both cases is not the same legal entity
- Central account stored by a financial institution (e.g. a credit card company)

- Central account stored by someone which is not a financial institution (e.g. a Transport Service Provider or a cooperation of Transport Service Providers)

Except from cash, all other payment means are electronic. Pricing of a travel may be dependent on the actual payment method.

12.1.7 Web-interface for price information

Price information should be provided through *one* open interface, common to all Transport Service Providers. The interface should make use of:

- Traveller profile. The profile should at least contain the traveller classification according to the standard classification in "*Elektronisk billettering. Håndbok 206-1"*[12].
- Service classifications. A common service classification scheme wills simplify the solution. This classification should cover the transport services themselves as well as services for additional services requested (e.g. food, lounge access, disablement facilities etc.).
- Travel context information. To be able to take agreements with other Transport Service Providers into account when calculating the price of a travel, the price calculation request must include information of other Transport Service Providers/travel products to be involved in the travel.

12.2 Related work

12.2.1 IFM model

The IFM model, Interoperable Fare Management, contained in the ISO/DIS 24014-1 standard [22] describes a generic model for distribution and use of fare products in an interoperable Public Transport environment. The different entities (stakeholders, roles) the operational and management environments of the IFM model in an IFMS (Interoperable Fare Management System) are shown in Figure 60.

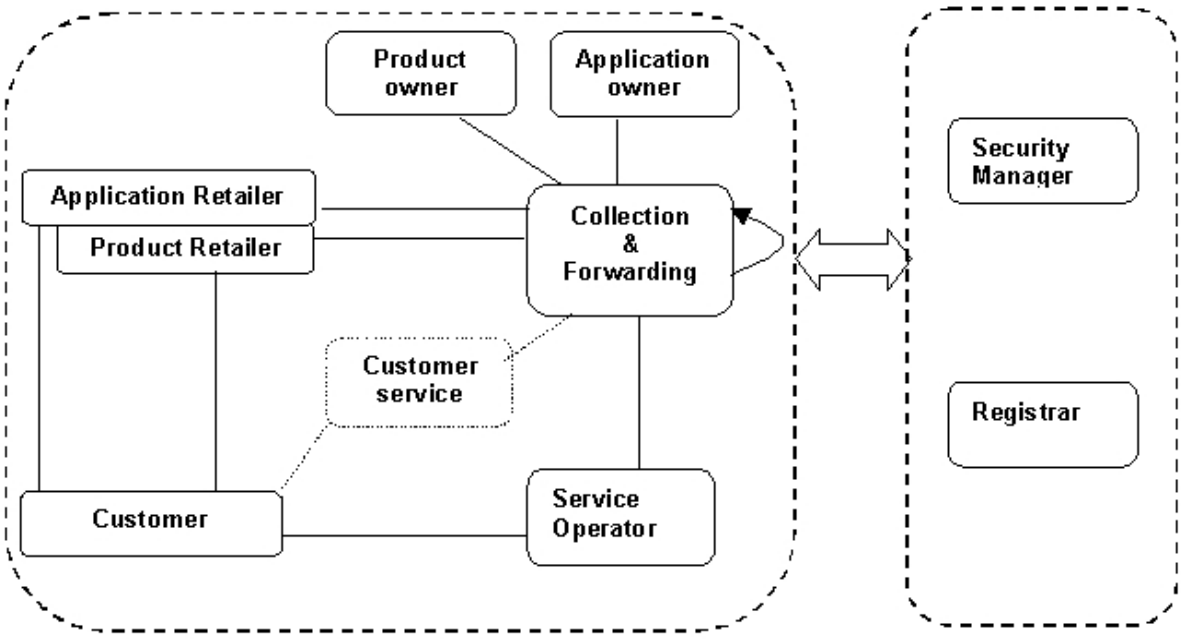


Figure 60 The IFM operational and management domains [22]

12.2.2 ARKTRANS vs. IFM

The MultiRIT framework architecture is based on ARKTRANS. While ISO/DIS 24014-1 describes a standardised architecture of interoperable fare management (IFM) systems, ARKTRANS [1] looks at interoperable fare management as a part of the larger transport sector. This implies some extensions and differences compared to ISO/DIS 24014-1:

- In ARKTRANS, interoperable fare management is made generic with respect to the ticket medium. Electronic and paper tickets are covered by the same architecture descriptions.
- In ARKTRANS, interoperable fare management is put into a wider context. The policy making roles are defined, and it is reflected that the policy may be decided upon by authorities or by one or more commercial Transport Service Providers. Different roles may be responsible for the *fare policy* depending on the involvement of public government: The *Fare Authority* role (the Regulation Enforcement sub-domain) is responsible for the fare policy for transport services subsidies by authorities. For such transport services the Fare Authority will, for the area they cover, provide fare scheme guidelines. Fares are also decided upon. There is no corresponding entity in ISO/DIS 24014-1
- The purchase of fare products is just one of many actions taken by the traveller. ARKTRANS includes the whole picture including transport demands, purchase of fare products, transport execution, etc.
- In a similar way, ARKTRANS focuses on a wide spectre of activities accomplished by transport companies, and the provision of transport services against the use of a fare product is a part of the totality.
- Generic issues, that are not specific to fare management, are in ARKTRANS described outside the scope of fare management. This count for roles and functionality related to the security and registrar functions.
- One or more stakeholders possessing the *Transport Service Provider* role (the Transport service Management sub-domain) may be responsible for the fare policy for transport services that are *not* subsidies by authorities. There is no corresponding entity in ISO/DIS 24014-1.

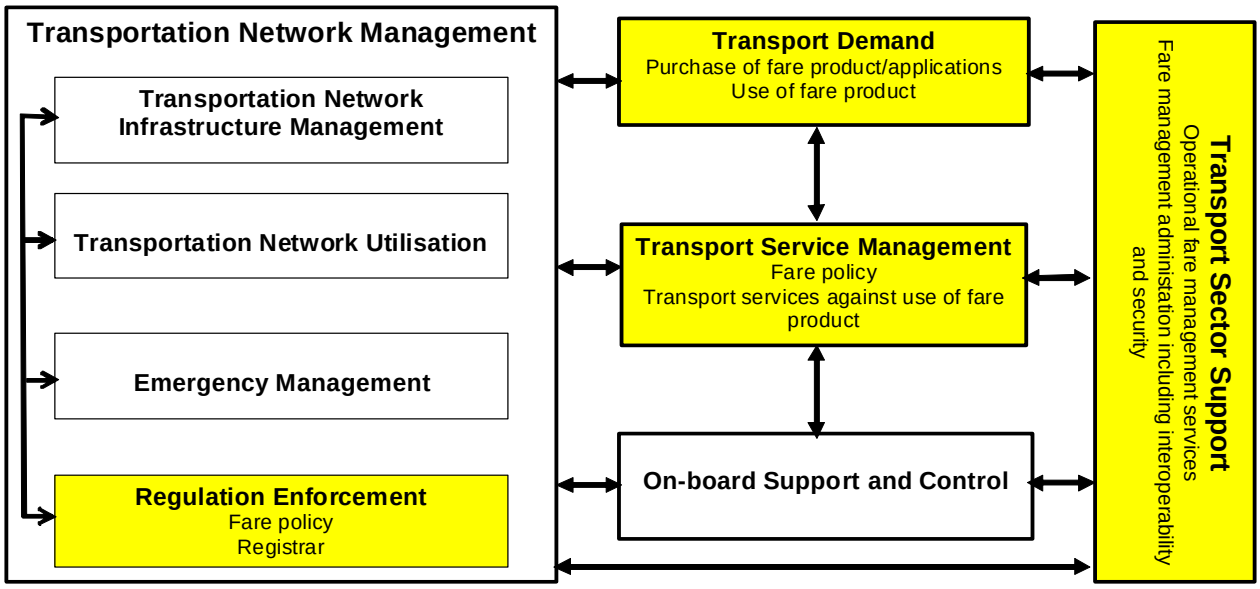


Figure 61 Sub-domains of relevance to fare management [1]

The sub-domains marked yellow in Figure 61 are of relevance to fare management, and ARKTRANS defines the associated roles. For some of these roles, relations can be drawn towards the entities of ISO/DIS 24014-1. Many of the roles related to fare management are in ARKTRANS considered as *Service Provider* roles (the Transport Sector Support sub-domain) as

they provide services to different types of stakeholders (travellers, authorities, transport companies, etc.):

- The *Fare Management Service Provider* is the overall role responsible for the provision of fare management operational services. The role can be used instead of the detailed roles listed below when operational details are not required. The Fare Management Service Provider role is decomposed into the *Application Owner* role, the *Application Retailer* role, the *Product Owner* role, the *Product Retailer* role and the *Collection and Forwarding* role.
- The Fare Management Interoperability Provider is responsible for the fare interoperability between two or more Fare Management Service Providers. A stakeholder possessing this role operates according to the instructions provided by the policy making roles mentioned above. The role corresponds to the IFM management in ISO/DIS 24014-1 shown in [22].
- The Security Service Provider role is in ARKTRANS [1] made generic as security management is of relevance to more areas than fare management. The role corresponds to the Security Manager entity in ISO/DIS 24014-1, being part of IFM management.

Within the transport sector, many different types of customers may buy different types of services. ARKTRANS focuses on many types of customers, and for fare products the customer is the *Traveller* role (the Transport Demand sub-domain). The Traveller role in ARKTRANS corresponds to the Customer entity in ISO/DIS 24014-1.

The transport is executed by a transport company providing transport services, the *Transport Service* Provider role (the Transport Service Management sub-domain) in ARKTRANS. The Transport Service Provider role in ARKTRANS corresponds to the Service Operator entity in ISO/DIS 24014-1.

The *Registrar Authority* role (Regulation Enforcement sub-domain) in ARKTRANS is generic as the assignment of unique identifications to entities is of relevance to more areas than fare management. The role corresponds to the Registrar entity in ISO/DIS 24014-1, being part of IFM management.

Altogether, IFM entities vs. ARKTRANS roles may be summarized into the table below.

Table 27 IFM vs. ARKTRANS roles

IFM	**ARKTRANS**		**Comment**
	Superior role	**Detailed role**	
Application Owner	Fare Management Service Provider	Application Owner	
Application Retailer		Application Retailer	
Collection and Forwarding		Collection and Forwarding Provider	
Product Owner		Product Owner	
Product Retailer		Product Retailer	
IFM	Fare Management Interoperability Provider	Interoperable Fare Management Provider	
	Security Service Provider		
Customer	Traveller	-	
Service Operator	Transport Service Provider	Passenger Carrier	
Registrar//IFM Management	Authority	Registrar Authority	
Security Manager/IFM Management	Security Service Provider		
Customer service	Fare Management Service Provider	Customer service	Currently not contained in ARKTRANS (ARKTRANS roles are suggestions only)

12.2.3 Price calculation

In Norway, the Norwegian Public Road Administration has developed a handbook for an electronic ticket system ([12] and [23]), mainly focused on public transport. The handbook also contains a formula for how to calculate the price the traveller has to pay for a travel.

The Norwegian Public Road Administration recommends in the preface of handbook [12] that the principles contained in the handbooks shall be included as requirements in conjunction with the development of public transport electronic ticketing systems.

The calculation is based on a so-called basic price: The price for an adult person travelling the shortest possible distance. To calculate the price of an actual travel the basic price is to be multiplied by correction factors.

Table 28 Correction factors for price calculations

Correction factors	Description
K_{RUTE}	The actual length of travel compared to the "shortest possible distance" being basis for the basic price. The correction may be linear or decreasing (price pr. Kilometre should be lower for a long travel than for a short travel).
$K_{KUNDEKATEGORI}$	To be used in case the traveller is not an adult. Each traveller category has its own correction factor.
$K_{TYPE\ REISEBEVIS}$	Reflecting the type of ticket being used (single travel, multiple travel, etc.)
K_{TID}	Reflecting the time of day on which the travel is performed
$K_{SERVICE\ OG\ KVALITET}$	Reflecting that a travel may have a service level and quality different from what is contained in the basic price. Note. The different levels of service and quality may be implemented as a number of "classes" (business, economy etc.) with the possibility of buying extra services in addition. The handbook formula may be extended to price these extra services by including a new correction factor "$K_{TILLEGGSTJENESTER}$"
$K_{RETNING}$	Used to allow discounts for round-trip tickets

Using these correction factors, the actual price of a travel can be calculated as follows:

$$\text{Price} = \text{Basic price} * K_{RUTE} * K_{KUNDEKATEGORI} * K_{TYPE\ REISEBEVIS} * K_{TID} * K_{SERVICE\ OG\ KVALITET} * K_{RETNING} + \text{Administrative correction}$$

A constraint in using this formula, explicitly expressed in [12], is that the calculation shall be insensitive to whether the travel travels across several public transport administration areas and fare schemes and also to the direction of travel (A to B, or B to A).

12.3 Implementation issues

12.3.1 Support of Transport Service Provider agreements

For travels involving services provided by more than one Transport Service Provider, the price for each service may depend on the context, i.e. which services from which Transport Service Providers are to be combined. Consequently, the Transport Service Providers must know the context to be able to calculate the price of its own journey segment correctly. This may be done in two ways:

- Sequentially. Each Transport Service Provider is requested in turn.
- In parallel. Each Transport Service Provider is requested in parallel.

In both cases the request must contain enough context information for the Transport Service Provider to calculate its own price. The amount of context information required is determined by the actual pricing agreements between the Transport Service Providers.

12.3.1.1 Required context information

With respect to the services that are to be included in the price request there are basically two alternatives:

- Pricing may only be affected by connecting journey segments. Context information must contain information of journey segment preceding and following Transport Service Providers own segment.
- Pricing may be affected by all services in the journey. Context information must contain information about all the journey segments.

However, there is another dimension to this: Are the Transport Service Provider agreements generic in the sense that they cover all services from a specific Transport Service Provider, or are they individual for each service? The implication of the latter alternative is that pricing calculation will be individual for each combination of Transport Service Provider services, in the worst case requiring full details about all journey segments to be sent to all Transport Service Providers covering one or more journey segments.

12.3.1.2 Where can information be found?

Basically, two types of information are required to plan and calculate a complete price from A to B:

1. Travel plan alternatives are provided by a Travel Information Provider. Different combinations of journey segments from different Transport Service Providers are assemble a complete travel from A to B.

2. Price/availability information. Based upon the travel plan alternatives from step 1, the Transport Service Providers involved must be requested for price/availability information. These requests must contain all context information required from the nature of the agreements of the Transport Service Providers involved in each route alternative.

13 Conclusions

The MultiRIT framework architecture provides a generic and holistic specification of aspects related to travel information and travel information services. All stages of the travel process are addressed, and the roles of the stakeholders, the use cases, the processes and the open services for information exchange and service provision are specified. The framework arranges for:

- ARKTRANS refinements
- Flexible organisation of travel information services
- New and improved functionality in travel information services

13.1 ARKTRANS refinements

The MultiRIT framework architecture is based on ARKTRANS and has demonstrated the usefulness of ARKTRANS. MultiRIT has also provided valuable input to the ARKTRANS refinement project, as described in [2], where the MultiRIT results are harmonized with results from other projects using ARKTRANS. This has among others opened for synergies between MultiRIT and the European 6FP European Freightwise project, which is dealing with co-modal freight transport.

13.2 Flexible organisation of travel information services

There are several challenges related to the establishment and organisation of travel information services, among others:

- The access to the travel information needed in travel information services
- The organisation of travel information services

13.2.1 The access to travel information

The access of updated information about terminals and public transport services, e.g. route information and deviation information, is crucial to providers of travel information services. There is a close relation between the quality and scope of the available information and the quality and content of the services that can be provided. Today, the information acquisition requires a lot of manual work and quality control, and the information available to third party service providers is usually restricted to the planned timetables.

MultiRIT defines open services for exchange of travel information and provision of travel information services (summarised in Table 26). The open services are defined to fulfil the requirements to new and improved functionality in travel information services (e.g. dynamic information).

However, technical definitions of open services (Web-service definitions) are not enough. The interfaces must also be implemented, and there are two main alternatives:

- Regulations must state that all providers of public transport services and all owners of terminals (public transport stops) must publish the required information according to the open service specifications. The regulations must also be enforced.
- A repository for travel information (route information and travel information) must be established (in more or less the same way as today), and the information must be published and available to everyone by means of the open services.

13.2.2 The organisation of travel information services

The open services defined in MultiRIT will, as illustrated in Figure 4, arrange for standardised interfaces for exchange of information and service provision. Different types of stakeholders may deliver travel information to providers of travel information services and the providers of travel information services may deliver services to each other. Information and services may be combined into value added services.

The multimodal pilot is MultiRIT (see Chapter 10) demonstrates how services provided by different travel planners can be combined. Travel plans for road use are combined with travel plans for regional public transport, etc. The same open service is used towards all transport modes and for both road use and public transport. The multimodal travel planner may also use open services to collect additional information about trips, terminals (public transport stops), etc. The information can be collected from a service provider or directly from the source, e.g. the terminal operator.

The open services arrange for flexibility in the organisation of travel information services. A de-centralised solution may for example utilise existing travel planners. However the organisation should, as described in Chapter 11, support weakly connected graphs. The transport network can be partition into geographical regions. Travels between regions should be performed using a central network (typically plane, train or express coaches). The exception is neighbouring regions, where one may travel directly between the regions without the use of a central network. In both cases each region needs to define all connection points, that is, locations where you can start travel with the central network or a neighbouring region.

13.3 New and improved functionality in travel information services

The MultiRIT framework can contribute to new and improved functionality in travel information services. The open services arrange for access to information and services that can be used to build new and enhanced travel information services.

13.3.1 Multimodality in travel information services

MultiRIT support the establishment of multimodal travel information services. The whole framework has common specifications for all transport modes, and the open services support information acquisition from all transport modes in the same way. Hence, it should be easier to establish travel information services that support door-to-door travels using all available transport modes.

13.3.2 Accessibility information in travel information services

A study done in collaboration with MultiRIT showed that the need for accessibility information in travel information services (see [24] and Annex A). Initially, some preliminary services and facilities for disabled people were defined, but the 'for disabled people' classification was disliked. Accessibility is about anyone's access to services and physical facilities, as at least ten percent of the total population have problems using the public transport system [25]. Hence, information about accessibility should a natural part of the travel information.

In the MultiRIT framework architecture the services provided on-board transport means and at terminals are described by means of a set of standardised service definitions (see 8.1.4), and the accessibility information should be attached. As for the services, a well defined terminology must be defined to support the provision of information about accessibility. MultiRIT has started on this work (see 8.1.4.3), but further work is required. The accessibility information to be registered has to be decided upon. The information must be sufficient to support the traveller, but the work effort related to registration and maintenance must also be considered.

13.3.3 Price information in travel information services

MultiRIT has carried out a feasibility study related to the provision of accurate price information in travel information services. The work has been just theoretical as the provision of price information is a complex issue due to discount schemes, different fare schemes, fare agreements between Transport Service Providers, fares depending on the capacity that is available on-board, etc. Today it will be almost impossible to provide price information (other than information based upon ordinary fare for each leg of the travel) even though it is of great importance to the Transport user.

As described in Chapter 12, the challenge is mainly due to possible bi-lateral or regional agreements between Transport Service Providers. Hence, the price of a journey segment may depend on the context, e.g. the transport services provided on other segments of the journey. Due to this context dependency, a price request must contain information about the context.

The provision of context information in a price request is a challenge. The whole travel plan can be submitted. This is however not a good solution with respect to privacy and protection of commercial interests. The product concept from eTicketing can be used as a common reference. A product registry, which provides an overview of products and associated agreements between Transport Service Providers, may be a useful tool.

There must be an open interface for exchange of price information related to transport services. Chapter 12 suggests several measures that may simplify the establishment of such interfaces:

- A standard set of traveller categories used by all Transport Service Providers
- A standard set of service categories used by all Transport Service Providers

- Standard fare schemes
- An adoption of the products concept from the eTicketing standard. Transport services should be considered as products.
- A registry of products (where one product may be related to specific agreements between Transport Service Providers – either bi-lateral or regional)
- To support the Transport User, an offered price should be accompanied by a time-limited guarantee.

13.4 Further work

The Ministry of Transport and Communications plans to establish a national travel planner. MultiRIT has provided a good starting point for this work:

- The MultiRIT framework should be used when the organisation and the information exchange value chain is planned. The open services specified by MultiRIT will enable a flexible organisation where existing services can be utilised and enhanced.
- The MultiRIT project has tested some of the open services, but further testing is required to detect deficiencies.
- The access to travel information is crucial to those who provide travel information services. To ensure availability, the current regulations concerning the provision of route information should be more specific. The stakeholders should be obliged to publish electronic information according to a standard, and a fully tested version of the open services (Web-services) specified by MultiRIT are a relevant standard.
- The regulations concerning information publishing must be enforced. Neglections should have consequences.
- Accessibility information should be a part of travel information services. A standardised categorisation of such information should be defined, and profiles for information registration at different types of terminal should be made.
- Further work and harmonisation of fare schemes are required to arrange for more accurate price information in travel information services.

14 Terminology

The table below provides descriptions of some of the terms are used in the MultiRIT framework architecture.

Term	Description
Accessibility	Accessibility defines the way a service is provided or the quality level of a service. Information about such accessibility is very important for some user groups. A lift may for example be available, but the physical conditions in the lift may be influence on the usability.
Deviation	A deviation is a deviation from a plan. This may be deviations with respect to the time schedule or the accomplishment of the transport, or deviations with respect to the services or facilities that are provided.
Leg	The part of a trip that is between the stop points of two consecutive terminals.
Line	Commonly used about routes or trips that are known to the public by similar names or numbers
Restriction	Limitations related to a transport service, e.g. stop restrictions like "no boarding".
Route	The route concept related to public transport is unclear. A route may have many variations, it may be a repetition of strictly the same pattern every time, it may be composed of sub-routes, it may be circular, it may be a common reference to a public transport service in both directions between end points, or just in one direction, etc. Thus, we are not using the route as an object in the MultiRIT information models. Focus is on the Trip as it is moving from a strait point to an end point along a specific route pattern.
Service	Refer to services that are offered by transport service providers (meals served, help provided, etc.) as well as facilities (more physical installations like toilets, shops, etc.). Such services and facilities are available during the transport, at arrivals to and at departures from a terminal, and at terminals.
Stop point	A location at a terminal where transport means stops for boarding/alighting or loading/unloading. This may for example be a gate, a track, or a qui. A terminal may contain one or more stop points, and each stop point must have a unique identification.
Terminal	A location or and area where transport means may stop to allow passengers to enter or leave the transport means, or to allow the loading and unloading of cargo. Terminals may be small stations or bus stops, or large and complex terminals that arrange for the handling of many transport means at the same time, e.g. airports with many gates or railway stations with many tracks. Two or more terminals may be co-located, this co-location of terminals may be considered as a terminal as well, e.g. the Oslo Airport Gardermoen terminal that includes several airport terminals (domestic, international, arrival, departure, freight terminals, etc.), a railway station, and a bus terminal. A terminal must have a unique identification. (Term used in TRANSMODEL: STOP AREA)
Transportation Network	Transportation network denotes the network that arrange for transport in general. The flow and movement of transport means in the infrastructure and the regulations are considered.

	Remark: The term transport (and not transportation) is however used about the specific transport done by transport companies and other.
Trip	A tour accomplished by a transport means according to a planned route or on a more ad hoc basis. A trip may consist of one or more legs, and may include stops at two or more terminals. (Term used in TRANSMODEL: JOURNEY PATTERN)

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Annex A. Accessibility information in travel information services

It is difficult to find an agreed upon definition of the term ‘disability’. The United Nations High Commissioner for Human Rights has an ongoing ad-hoc committee [26] that is still discussing the term disability, with different suggestions from countries [27, 28]. Several governmental and non-governmental organisations have developed their own definitions, and The Disability Discrimination Act 1995, DDA (c.50) in the United Kingdom defines a disabled person as one having “a physical or mental impairment which has a substantial and long-term adverse effect on his ability to carry out normal day-to-day activities” [29]. The carrying out of such ’normal day-to-day activities’ is thus strongly related to the environment of the person. If he/she is in an environment where he/she is able to perform activities in a normal way, the person would in this particular situation not be considered disabled. “International Classification of Functioning” (ICF) is WHO’s framework for health and disabilities. In ICF, disability and functioning are viewed as outcomes of interactions between health conditions (diseases, disorders and injuries) and contextual factors [30]. The focus has shifted from separating disabled from the rest (“cause”), and instead focussing on measuring ability to function in the society (“impact”) regardless of the reasons for one’s impairment. In ARKTRANS we focus on the transport domain and peoples’ use of this (either as travellers or workers), thus regarding a particular context. We have in this article chosen to define our use of the term disabled as DDA did, keeping the WHO definition of the disability being related to this context, in mind. The DDA definition in no way states that contextual factors are not important, contextual factors contribute to the abilities to carry out “normal day-to-day activities” such as using public transport. The focus is held on accessibility as in the ability to partake in a normal environment.

The population in many countries is getting increasingly older. Japan expects 33% of its citizens to be senior citizens by 2050, Europe and North America isn’t trailing far behind with figures around 25% [31]. Older people in general tend to obtain a lot of disabilities, for instance problems with seeing, hearing and moving around. While medical and technical research provides us with tools and surgery that eases or even removes a person’s disability (for instance eye surgery and hearing aids), there is still a set of problems relating to disabled or elderly people which still cannot be helped in such ways. An example could be a person with a strong need to sit down and relax every hundred metres. In order for her to be able to navigate the environment by herself, the environment must support this. Creating an environment that will let most people be self-manageable heightens their comfort level; people want to be self-reliant.

A.1 Universal design

Public services have gradually changed from humans assisting you in different tasks to letting users themselves perform the task, be it withdrawing money from an ATM or using self-service machines at the airport to check in and mark your luggage with a baggage tag. It might very well be an efficient way of dealing with such services, but they also require the users to understand and be able to properly use such systems. Many people have tried to coin a definite term for what constitutes “universal design”. While “Design for all” is more often used in Europe, we will in this article use the term universal design (UD). Trost interprets UD as being “comprehensive philosophy” while design for all relates more to “practical applications” [32]. Beecher and Paquet describe universal design as “a process intended to promote the development of products or environments that can be used effectively by all without adaptation or stigmatization” [33]. This means that a person otherwise defined as disabled would be able to use a product or environment without having to resort to special support as manual assistance.

NCSU defines seven principles of universal design: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance of errors, low physical effort and size and space

for approach and use [34]. There are efforts going on to produce equipment and tools with such principles in mind. In Japan companies are improving the accessibility of ATMs, [35] and the Copenhagen Metro in Denmark is being designed with the concept “Stations for all” [36]. The goal is to let people navigate systems and environments regardless of their otherwise hindering disabilities or impairments.

There’s a lot of research on advanced systems that will help disabled people in their daily activities. A prototype of an “American Sign Language recognition apparatus” [37, 38] which will translate sign language into spoken language. A guidance system for handicapped people suggests adding RFID tags in the environment, connected to information about the environment taking your special disability into consideration, is a way to helps travellers move around [39]. While identifying the different needs depending on impairment or disability, Matsubara et al. also emphasize the semantic similarity of this information.

According to investigations, at least ten percent of the population have problems using the public transport system [25]. The group with more severe disabilities related to transport is a small subset of these. Among the ten percent is a large group of people, often elderly, that do not use the transport because of small problems. This gives an indication that many people that would normally not use public transport today would be able to do so if it was accessible to them. Their otherwise hindering disabilities would, given a more accessible context, be rendered unimportant.

When linking universal design and availability to the transport sector, there are two main points to focus on: Design of the environment and information about the environment. In order to create a travel planner these two will be tightly linked. An environment with a small degree of accessibility would possibly be easier to navigate in if the traveller already knows about the limitations, and can plan for this. In such a case, experienced accessibility would be enhanced via the use of good information in advance.

One important aspect of creating an environment with focus on universal design is the impact it has, not only for disabled persons. People not normally physically or mentally impaired might in some situations have great use of a more accessible environment. Examples are using prams, carrying heavy bags after a shopping spree, or having to use crutches after performing knee surgery.

A.2 Disabled and design of the environment

There’s currently a growing emphasis on creating environments that are available to all persons, regardless of any disabilities. In Norway there’s a discussion proposition about altering the Norwegian laws in order to forbid discriminating persons with disabilities in a broad scale: “The Committee shall draft a new bill and/or proposals to amend existing legislation in order to strengthen the protection accorded by the law against the discrimination of persons with disabilities. The object is to promote full participation in society and equality between persons with disabilities and other citizens” [40]. Focus in Norway and abroad has shifted from supporting for disabled as a welfare approach to a human rights approach, that “everyone is able to take part in society on an equal footing” (ibid.).

When designing an environment where all kinds of people can partake, one needs information on how to best design these. Support organisations in Norway have for a long time created guidelines for what constitutes a proper environment for their users [25] [41]. Deltasenteret (The Delta Centre) is the Norwegian competence centre for “participation and accessibility for all”. It is financed through the Directorate for Health and Social Affairs. Many of the organisations and the Delta Centre have cooperated in defining a proper public transport environment. Among them is the template for accessibility for public transport [42]. This pamphlet covers the areas of infrastructure (accessibility on the terminal), means of transportation (the buses etc.), information needs and management / routines.

A.3 Disabled and information about the environment

So far, we have only covered regulations and hopes for increasing the accessibility of the environment. But the environment isn't always designed like that. Users can have a wide range of disabilities, permanent or temporary. It doesn't help a blind user if the transport terminal has been developed only with wheelchair users in mind. In a travelling mode, it can be valuable to know the qualities of the terminals before deciding how to travel. Such information enables the travellers to find the most accessible terminals and transport means. The question is what kind of information one needs to know before deciding if and how to travel. Is there any subset of information that is more important to know before-hand, or does all kinds of information have to be treated in the same manner? Registering all kinds of information would risk ending up with a hard-to-maintain system, while registering too little information would give little value to the specific users. They key point is finding the appropriate level of information registration.

Annex B. Informaton elements

This annex describes the informaton elements in the conceptual information model, enumerated datatypes included.

The elements will be further refined in the ARKTRANS refinement project.

B.1 CostFramework

B.1.1 PricingRules

PK	Name	Type	Notes
	Information	string	
	ValiedFrom	dateTime	
	ValiedTo	dateTime	

B.1.2 Product

PK	Name	Type	Notes
	ProductID	int	

B.1.3 ProductOwner

B.1.4 ProductRetailer

B.1.5 TransportItemCategory

Notes: E.g. traveller categories like child, student, etc.

B.1.6 UsageRules

PK	Name	Type	Notes
	Information	string	
	ValidFrom	dateTime	
	ValidTo	dateTime	

B.2 Journey

B.2.1 AlertConditions

PK	Name	Type	Notes
	Alert	AlertType	

B.2.2 ChangabilityConditions

Notes: Conditions concerning the ability to change the plans (deadline for cancellation or changes, costs related to changes, etc.),

PK	Name	Type	Notes
	ChangeDeadline	dateTime	Not required if change always is possible
	CancellDeadline	dateTime	Not prsent if cancellation always is possible
	CansellationConditions	string	
	ChangeConditions	string	

B.2.3 Conditions

B.2.4 Journey

B.2.5 JourneySegment

Notes: A journey segment is a part of a Trip (one or more legs). A Journey segment may be executed by means of a public transport or by use of the road (driving, walking using a bike).

PK	Name	Type	Notes
	FromLocation	Location	
	ToLocation	Location	
	SeqNo	int	What sequence this segment is in the total journey. If the service returns three segments; one PTJourneySegment, one TransferSegment and one RoadJourneySegment these segments might be delivered in sequences 1, 2 and 3 as the user will need to start his trip with PT (1), then a transfer (2) and finally by car (3).

B.2.6 PTJourneySegment

Notes: Using public transport,

PK	Name	Type	Notes
	LineId	LineReference	The LineReference consists of NetworkID, LineIdentifier, LineName and OperatorID.

B.2.7 PriceInfo

PK	Name	Type	Notes
	Price	int	
	PriceValidFrom	dateTime	
	PriceValidTo	dateTime	

B.2.8 RoadJourneySegment

Notes: Driving, walking or using a car.

PK	Name	Type	Notes
	Segment	SegmentType	Indicates the type of journey segment - to assist the user: LeftTurn: Used when next journey segment is preceeded by a leftturn RightTurn: Used on journey segment that is a rightturn U-Turn: Used on journey segment that is u-turn

			Link: Used on journey segment that is u-turn
	Description	DescriptionType	Road description to be understood by road user, e.g. road number/name
	Length	int	In meters
	TimeEstimate	duration	In minutes
	Mode	TransportModeType	Car, bike, walk

B.2.9 TransferSegment

PK	Name	Type	Notes
	TransferDuration	duration	

B.2.10 TravelDocument

B.3 Misc

B.3.1 Area

PK	Name	Type	Notes
	Vertices	Point	

B.3.2 Contact

PK	Name	Type	Notes
	Name	string	
	Phone	string	
	Mobile	string	
	Fax	string	
	Email	string	

B.3.3 GeoLocation

B.3.4 GeoReference

PK	Name	Type	Notes
	Coordinates	Point	

B.3.5 LocalTime

PK	Name	Type	Notes
	TimeZoneName	string	
	Variation	float	Variation to UTC (Universal Time Coordinated). +0430 is 4.5 hours ahead of UTC. -1100 is 11 hours behind UTC.
	DSTstart	date	<DST is Daylight Saving Time. Expressed in UTC (Universal Time Coordinated)
	DSTend	date	DST is Daylight Saving Time. Expressed in UTC (Universal Time Coordinated)
	DSTvariation	float	DST (Daylight Saving Time) variation to UTC (Universal Time Coordinated). +0430 is 4.5 hours ahead of UTC. -1100 is 11 hours behind UTC

B.3.6 Location

PK	Name	Type	Notes
	LocationName	string	
	PointCoordinates	Point	
	AreaCoordinates	Area	
	Address	Address	
	RoadReference	NVDBreferenceType	Towards NVDB
	RailReference	BDBreferenceType	
	Description	string	

B.3.7 Point

Notes: Reference system: WGS84

PK	Name	Type	Notes
	latitude	double	
	longtitude	double	

B.3.8 RoadProperty

PK	Name	Type	Notes
	RoadPropertyType	RoadProperty	
	Value	string	

B.3.9 TransportMeans

PK	Name	Type	Notes
	TransportMode	TransportModeType	
	TransportMeansType	string	
	CapasityInformation	string	
	InfromationLink	anyURI	

B.3.10 TransportServiceProvider

PK	Name	Type	Notes
	OperatorId	string	OperatorID = Org.nr
	InfoLocation	anyURI	Location for internet site
	ServiceLocation	anyURI	E.g. URI to WSDL
	ContactInfo	Contact	

B.4 Preferences

B.4.1 AccessibilityPreferences

PK	Name	Type	Notes
	Acceesibility	Accessibility	

B.4.2 Agreement

Notes: Requrements regarding the contract with the Transport Servive Procider.

PK	Name	Type	Notes
	Changebility	ChangeabilityType	
	Alert	AlertType	
	CancellationAbility	boolean	

B.4.3 AmbientPreferences

PK	Name	Type	Notes
	AmbientCategory	AmbientCategory	
	Description	string	

B.4.4 BusinessRelation

PK	Name	Type	Notes
	CustomerID	string	

B.4.5 EnvironmentalPreferences

PK	Name	Type	Notes
	LowC02	boolean	
	LowN0X	boolean	

B.4.6 FoodPreferences

Notes: E.g. restrictions to additional cargo on the transport means, no tunnels, no smoker, type of food to eat, etc.

PK	Name	Type	Notes
	FoodRequirement	FoodType	

B.4.7 OptimisingCriteria

Notes: Criteria for optimising (costs, time, preferences, quality, contract references, environmental issues, etc.),

PK	Name	Type	Notes
	OptimizeWeight	decimal	
	OptimizeCriteria	OptimizeCriteria	

B.4.8 PaymentPreferences

Notes: Chash, auto re-new, auto re-load, value purse, central account

B.4.9 PlacementPreferences

Notes: Seat by aile, where to store cargo, etc.

PK	Name	Type	Notes
	Placement	PlacementType	Seat by aile, where to store cargo, etc.

B.4.10 PreferenceProfile

PK	Name	Type	Notes
	PreferenceProfileName	string	
	TypeOfTransport	TransportType	Different types of cargo, business travel, pleasure

			travel, etc

B.4.11 ProductPortefolio

PK	Name	Type	Notes
	ValidFrom	dateTime	
	ValidTo	dateTime	

B.4.12 TransferPreferences

PK	Name	Type	Notes
	MaxDistanceToWalk	int	
	MinTransferTime	int	
	MaxTimeToWalk	int	

B.4.13 TransportDemand

Notes: Use more TransportDemands to spesify via locations

B.4.14 TransportItem

Notes: Passenger and/or cargo information

B.4.15 TransportModePreferences

PK	Name	Type	Notes
	TransportMode	TransportModeType	

B.4.16 TransportPreferencesRank

PK	Name	Type	Notes
	PreferenceWeight	decimal	

B.4.17 TransportUser

PK	Name	Type	Notes
	Passenger	Contact	
	Gender	int	
	Birth	date	

B.4.18 ServicePreferences

PK	Name	Type	Notes
	ServiceCategory	ServiceCategoryType	

B.5 ServiceAndDeviation

B.5.1 Accessibility

PK	Name	Type	Notes
	Context	AccessibilityContextType	
	Type	AccessibilityType	
	Value	int	
	Description	string	

B.5.1.1 AllergicsAccessibilityType

PK	Name	Type	Notes
	Cleaning		
	Mould		
	Pets		
	Pollen		
	Smoking		

B.5.1.2 InfoMeansProvidingAccessibilityType

PK	Name	Type	Notes
	EquipmenrForInteractiveInformation		
	InformationDesk		
	InformationDisplay		
	InformationHandout		
	InformationPlacard		
	InternetAccess		
	Map		
	MobileServices		
	RouteMap		
	SignAndIcon		
	VoiceInformation		

B.5.1.3 InformationAccessibilityType

PK	Name	Type	Notes
	AudioInformaton		Audio signals, wire loop, noise in the area, announcements, etc.
	Marking		Clarity with respect to naming and directions, font size, etc.
	TactileInformation		E.g. tactile maps and braille.
	VisualInformation		Placing, lightening, contrast end reflection, fonts used, visibility from waiting area, etc.

B.5.1.4 LightAndContrastSupportedAccessibilityType

PK	Name	Type	Notes
	Contrast		Contrast colours on furniture, doors and frames, making of glass doors and glass walls, etc
	Lightening		Troublesome reflection of light from floor, etc. Lightening that support orientation and access to information. Unngå blending

B.5.1.5 MachineAccessibilityType

PK	Name	Type	Notes
	Usability		Easy to use, can be reached from wheelchair, tactile buttons, etc.
	EasyToFind		E.g. close to lane lines.

B.5.1.6 MiscAccessibilityType

PK	Name	Type	Notes
	SeatAdaption		Reclining chairs, contrast colors, hight, space for wheelchair close to seat, arm rest, back rest, etc.
	HandicapToilet		

B.5.1.7 PhysicalAccessibilityType

PK	Name	Type	Notes
	BroadwiseGradient		More than 1:33
	Doors		Type of door (roundabout door, sliding door, etc.) and their characteristics
	Gradient		
	LaneLine		
	Lift		
	SpaceAvailable		So that the wheelchair can be turned, etc.
	Surface		Antiskid, smoth, carpet characteristics, etc.
	TactileMarking		
	Treshold		
	WaitingArea		
	WellArrangedInterior		No obstacles, easy to get an overview.
	WheelchairArea		

B.5.1.8 TerminalEntranceAccessibilityType

PK	Name	Type	Notes
	Gradient		E.g. 1:12 or 1:20
	HandicapParking		
	LaneLine		
	TactileMarking		E.g. betweeen pavement and stop area
	Treshold		More than 2,5 cam

B.5.1.9 TransportMeansAccessibilityType

PK	Name	Type	Notes
	Angle		
	Distance		Between transport means and stop area platform or between transport means and stop point mark.
	Grip		
	HightLevelDifference		Between platform and transport means
	Lift		
	WheelchairPlatform		

B.5.1.10 AllergicsAccessibility

PK	Name	Type	Notes
	Type	AllergicsAccessibilityType	

B.5.1.11 InfoMeansProvidingAccessibility

PK	Name	Type	Notes
	Type	InfoMeansProvidingAccessibilityType	

B.5.1.12 InformationAccessibility

PK	Name	Type	Notes
	Type	InformationAccessibilityType	

B.5.1.13 LightAndCintrastSupportedAccessibility

PK	Name	Type	Notes
	Type	LightAndContrastSupportedAccessibilityType	

B.5.1.14 MachineAccessibility

PK	Name	Type	Notes
	Type	MachineAccessibilityType	

B.5.1.15 MiscAccessibility

PK	Name	Type	Notes
	Type	MiscAccessibilityType	

B.5.1.16 PhysicalAccessibility

PK	Name	Type	Notes
	Type	PhysicalAccessibilityType	

B.5.1.17 TerminalEntranceAccessibility

PK	Name	Type	Notes
	Type	TerminalEntranceAccessibilityType	

B.5.1.18 TransportMeansAccessibility

PK	Name	Type	Notes
	Type	TransportMeansAccessibilityType	

B.5.2 Deviation

PK	Name	Type	Notes
	ServiceDeviationCategory	ServiceDeviationType	
	Forecast	boolean	Indicates whether the deviation is forecased or actual.
	Serverity	ServityType	Indicates the amount of disruption to traffic likely to be caused by the deviation (extremly severe, very severe, severe, low severity, lowest severity, not provided).
	QualityIndex	QualityType	Indicates the confidence of the deviation information (certain, very reliable, reliable, probably reliable, unconfirmed).
	Description	DescriptionType	

B.5.2.1 TerminalDeviation

Notes: *Changes will be considered – must be in line with service model*

B.5.2.2 TransportDeviation

Notes: *Not relevant to travel information services*

Changes will be considered – must be in line with service model

B.5.2.3 TerminalStopDeviation

Notes: *Changes will be considered – must be in line with service model*

B.5.2.4 SecurityDeviation

Notes: *Not relevant to travel information services*

Changes will be considered – must be in line with service model

PK	Name	Type	Notes
	DeviationType	SecurityDeviationType	

B.5.2.5 DamageDeviation

Notes: *Not relevant to travel information services*

Changes will be considered – must be in line with service model

PK	Name	Type	Notes
	DeviationType	DamageDeviationType	

B.5.2.6 LawViolationDeviation

Notes: *Not relevant to travel information services*

Changes will be considered – must be in line with service model

PK	Name	Type	Notes
	DeviationType	LawDeviationType	

B.5.2.7 ServiceDeviation

Notes: Changes will be considered – must be in line with service model

PK	Name	Type	Notes
	DeviationType	ServiceDeviationType	

B.5.2.8 StopDeviation

Notes: Changes will be considered – must be in line with service model

PK	Name	Type	Notes
	DeviationType	StopDeviationType	

B.5.2.9 TimeScheduleDeviation

Notes: Changes will be considered – must be in line with service model

PK	Name	Type	Notes
	DeviationType	TimeScheduleDeviationType	

B.5.2.10 TransportExecutionDeviation

Notes: Changes will be considered – must be in line with service model

PK	Name	Type	Notes
	DeviationType	TransportExecutionDeviationType	

B.5.3 Restriction

PK	Name	Type	Notes
	RestrictionCategory	RestrictionType	
	InformationLink	anyURI	
	Description	DescriptionType	

B.5.4 Service

PK	Name	Type	Notes
	FacilityServiceCategory	FacilityServices	
	EnRouteServiceCategories	EnRouteServices	
	InformationServiceCategories	InformationServices	
	InformationLink	anyURI	
	Description	DescriptionType	

B.5.4.1 EnRouteService

PK	Name	Type	Notes
	ServiceCategory	EnRouteServiceType	

B.5.4.2 FacilityService

PK	Name	Type	Notes
	ServiceCategory	FacilityServiceType	

B.5.4.3 InformationService

PK	Name	Type	Notes
	ServiceCategory	InformationServiceType	

B.5.4.4 TerminalService

B.5.4.5 TerminalEnRouteService

B.5.4.5.1 TerminalFacility

B.5.4.5.2 TerminalRestriction

B.5.4.6 OnBoardService

B.5.4.6.1 OnBoardEnRouteService

B.5.4.6.2 OnBoardFacility

B.5.4.6.3 OnBoardRestriction

B.5.4.7 TerminalStopService

B.5.4.7.1 TerminalStopEnRouteService

B.5.4.7.2 TerminalStopFacility

PK	Name	Type	Notes
	ServiceCategory	FacilityCategoryType	

B.5.4.7.3 TerminalStopRestriction

PK	Name	Type	Notes
	ServiceCategory	RestrictionCategoryType	

B.5.4.8 TransferService

B.5.4.8.1 TransferFacility

B.5.4.9 AccommondationFacility

PK	Name	Type	Notes
	ServiceType	AccommondationType	

B.5.4.10 ChildrenFacility

PK	Name	Type	Notes
	ServiceType	ChildrenFacilityType	

B.5.4.11 CommercialFacility

PK	Name	Type	Notes
	ServiceType	CommercialFacilityType	

B.5.4.12 EntryAndExitFacility

Columns

PK	Name	Type	Notes
	ServiceType	EntryAndExitFacilityType	

B.5.4.13 LocalFacility

PK	Name	Type	Notes
	ServiceType	LocalFacilityType	

B.5.4.14 MiscFacility

PK	Name	Type	Notes

	ServiceType	MiscFacilityType	

B.5.4.15 RefreshmentSaleFacility

PK	Name	Type	Notes
	ServiceType	RefreshmentSaleType	

B.5.4.16 TicketSaleFacility

PK	Name	Type	Notes
	ServiceType	TicketSaleType	

B.5.4.17 WhereaboutFacility

PK	Name	Type	Notes
	ServiceType	WhereaboutFacility	

B.5.4.18 AssistanceService

PK	Name	Type	Notes
	ServiceType	AttendanceServiseType	

B.5.4.19 AttendanceService

PK	Name	Type	Notes
	ServiceType	AttendanceServiseType	

B.5.4.20 EntertainmentService

PK	Name	Type	Notes
	ServiceType	EntertainmentServiceType	

B.5.4.21 FreeOfferService

PK	Name	Type	Notes
	ServiceType	FreeOfferServiceType	

B.5.4.22 HandlingService

PK	Name	Type	Notes
	ServiceType	HandlingServiceType	

B.5.4.23 PaymentService

PK	Name	Type	Notes
	ServiceType	PaymentServiceType	

B.5.4.24 TouristInformationService

PK	Name	Type	Notes
	ServiceType	TouristInformationType	

B.5.4.25 TravelInformationService

PK	Name	Type	Notes
	ServiceType	TravelInformationType	

B.5.4.26 AccessRestriction

PK	Name	Type	Notes
	ServiceType	AccessRestrictionType	

B.5.4.27 TransportRestriction

PK	Name	Type	Notes
	ServiceType	TransportRestrictionType	

B.5.4.28 StopRestriction

PK	Name	Type	Notes
	ServiceType	StopRestrictionType	

B.6 Terminal

B.6.1 StopPoint

PK	Name	Type	Notes
	StopPointId	string	
	Name	string	
	Direction	DirectionType	E.g. direction of trips served by this stop point. May be misc. compass directions, clockwise, counerclockwise, or a mixture.
	InformationLink	anyURI	
	Description	DescriptionType	

B.6.2 Terminal

PK	Name	Type	Notes
	TerminalNumber	string	
	TerminalShortName	string	
	PublishedName	string	
	TerminalType	TransportModeType	
	InformationLink	anyURI	
	MaxTimeToStopPoint	duration	
	MaxDistanceToStopPoint	int	
	NodeType	NodeType	Domestic, international, regional, ordinary, etc. ??? Designates whether this is a transfernode or not.
	CheckInInternationsl	duration	
	CheckInDomestic	duration	
	Junction	boolean	True if this terminal is used as a transfer points between lines. ?????
	Description	DescriptionType	

B.6.3 TerminalAccessPoint

PK	Name	Type	Notes
	AccessPointName	string	
	Direction	DirectionType	
	InformationLink	anyURI	
	Description	string	
	AccessType	AccessType	

B.6.4 Transfer

Notes: If transferinfo requested.

PK	Name	Type	Notes
	TransferMode	TransportModeType	
	MinTransferTime	duration	Avarage
	Distance	int	In meters
	Tresholdfree	boolean	
	Description	string	

B.7 TravelDataTypes

B.7.1 AccessType

PK	Name	Type	Notes
	Person		
	KissAndRide		
	ParkAndRide		

B.7.2 Address

PK	Name	Type	Notes
	Street	string	
	PostalNumber	string	

B.7.3 AlertType

PK	Name	Type	Notes
	Delayed		
	ReadyForBoarding		
	Cancelled		
	AccessibilityDeviation		Deviation related to planned/announced accessibility
	OtherDeviation		E.g. changes in level of service
	ServiceDeviation		Deviation related to planned/announced service (e.g. food on board)

B.7.4 AmbientCategory

PK	Name	Type	Notes
	Humidity		
	Temperature		
	Cleanness		
	Silence		

B.7.5 ChangeabilityType

PK	Name	Type	Notes
	NoFlexibility		
	FullFlexibility		

B.7.6 FoodType

PK	Name	Type	Notes
	VegetarianFood		
	StrictVegatarienFood		
	KosherFood		
	HinduFood		
	MuslimFood		
	GlutenFreeFood		
	LactoseFreeFood		
	DiabetsFood		
	NoSaltedFood		
	BabyFood		

B.7.7 LocationName

B.7.8 NVDBreferenceType

PK	Name	Type	Notes
	RouteID	string	
	Measure	float	
	Direction	int	

B.7.9 OptimizeCriteria

Notes: Criteria for optimising (costs, time, preferences, quality, contract references, environmental issues, etc.),

B.7.10 PlacementType

PK	Name	Type	Notes
	Aisle		
	Window		
	ExtraLegSpace		
	InTravel Direction		
	SeatedTogether		If more than one Travel Item related to one Transport User (e.g. several people travelling together.
	Silence		
	NoAnimals		
	NoSmoking		
	HighComfort		

B.7.11 PreferenceRestrictionType

Notes: Restrictions to the transport defined by the preferences of the Transport User.

PK	Name	Type	Notes
	NoTunnels		

B.7.12 RequiredType

PK	Name	Type	Notes
	Must have		
	Do not care		
	Will not have		

B.7.13 RoadPropertyType

PK	Name	Type	Notes
	RoadProp1		
	RoadProp2		
	etc		

B.7.14 RoutePreferenceType

PK	Name	Type	Notes
	Tunnels	int	
	Scenic	int	

B.7.15 SegmentType

PK	Name	Type	Notes
	LeftTurn		
	RightTurn		
	Link		
	UTurn		

B.7.16 TransferFrom

PK	Name	Type	Notes
	FromTerminalReference	TerminalReference	

B.7.17 TransferType

PK	Name	Type	Notes
	Wait		
	RoadToRail		
	RoadToBus		
	RoadToBoat		

	RoadToAir		
	etc		

B.7.18 TransportType

PK	Name	Type	Notes
	business		
	pleasure		
	cargo		

B.7.19 IATAlocations

Notes: In air transport there is no line numbers (just the flight numbers of individual trips). The IATA location codes are used instead. A line includes all flights of an airline between two destinations (no matter the number of via locations).

PK	Name	Type	Notes
	FromLocation	string	
	ToLocation	string	

B.7.20 AreaCodeType

Notes: Identifies a part of a country, a county or a city

B.7.21 CombinationType

Notes: Combination possible - e.g transfer to other transport means (even though the time available may be short). .

Wait- The other transport means may wait for some time before departure

Trough services - No need to change transport means. The same transport means will continue as another trip.

ns

PK	Name	Type	Notes
	Wait		
	ThroughService		

B.7.22 CountyCodeType

PK	Name	Type	Notes
	Ostfold		
	Akershus		
	Finmark		
	xxx		

B.7.23 DirectionType

PK	Name	Type	Notes
	South		
	West		
	East		
	North		
	Clockwise		
	CounterClockwise		
	AwayFromCentre		
	TowardsCentre		
	ThroughTransport		

B.7.24 LanguageType

PK	Name	Type	Notes
	Norwegian		
	English		

	French		
	German		

NodeType

PK	Name	Type	Notes
	Ordinary		
	Regional		
	National		
	International		

B.7.25 QualityType

PK	Name	Type	Notes
	Reliable		
	Probable		
	Unconfirmed		

B.7.26 SeverityType

PK	Name	Type	Notes
	VerySevere		
	Severe		
	NotSevere		
	NotProvided		

B.7.27 TerminalType

B.7.28 TransportModeType

PK	Name	Type	Notes
	PrivateCar		
	Sea		
	Rail		
	Air		
	Tram		
	Cableway		
	Others		
	Walk		
	Bus		
	Ferry		
	Taxi		

B.7.29 PublicTransportType

PK	Name	Type	Notes
	LocalTransport		Lines within a county or lines crossing county boarders that are not long distance or express lines (less than 100 km). May be lines between cities or between a city and the surrounding area.
	CityTransport		Lines within a city.
	LocalExpressTransport		Local transport (less than 100 km) with limited number of stops. Used when there is local express transport in addition to more time consuming local transport.
	SchoolTransport		Route pattern is decided by the school transport demands (school holidays, school starting and ending hours).
	NightTransport		Limited route pattern decided by demand for transport during night time. Mainly in cities.
	ShuttleService		To express transport, subway, etc.
	AirportTransport		Transport to airport. May differ from shuttle service in the way that airport transport is not subsidised.
	RoRoTypeTransport		Fery transport and other transport where cars etc. can drive on board.
	TouristTransport		Transport for tourists.
	AdaptedTransport		Scheduled transport with facilities adapted to special transport demands (these demands may be reported in advance). Fixed stop locations.
	OnDemandTranspotr		Not-scheduled transport. Stop locations and times depend on demands.
	ExpressTransport		Fast. Limited number of stops. More than 100 km.>

	LongDistanceTransport		Slower than express transport and more stops. More than 100 km.
	CoastalLiner		"Hurtigruten"
	InternationalTransport		Lines to other countries.
	RegionalTransport		Used for air transport.
	NationalTransport		Used for air transport.
	HelicopterTransport		

B.7.30 TerminalReference

PK	Name	Type	Notes
	PublishedName	string	
	TerminalNumber	string	
	TerminalType	TransportModeType	

B.7.31 LineReference

PK	Name	Type	Notes
	NetworkID	string	PTA (Public Transport Authority). As defined in the eTicketing framework (ISO).
	LineIdentifier	string	The format and content depends on the transport mode. May be: (1) The number used by the transport users (e.g. bus number, flight number, train number (?)) (2) An internal number that is not known to the transport user. (3) no value (For coastal liner)
	LineName	string	Published name
	OperatorID	string	Operator. Code as used for e-ticketing

B.7.32 TripReference

PK	Name	Type	Notes
	TripNo	string	
	LineId	LineReference	

B.7.33 DescriptionType

PK	Name	Type	Notes
	Text	string	
	Language	LanguageType	
	DamageDeviation	int	

B.7.34 AccessibilityTypes

B.7.34.1 AccessibilityContextType

B.7.34.2 AccessibilityType

B.7.35 DeviationTypes

B.7.35.1 DeviationType

PK	Name	Type	Notes
	DamageDeviation		
	LawDeviation		
	SecurityDeviation		
	ServiceDeviation		
	StopDeviation		
	TimeScheduleDeviation		
	TransportExecutionDeviation		

B.7.35.2 DamageDeviationType

PK	Name	Type	Notes
	Illness		
	CargoDamage		

B.7.35.3 LawDeviationType

PK	Name	Type	Notes
	Terrorism		
	Theft		

B.7.35.4 SecurityDeviationType

PK	Name	Type	Notes
	DocumentationDeviation		
	MissingPassenger		
	DangerousCargo		Deviation - the dangerous cargo is not reported
	WrongPacking		
	UnruelyPassenger		

B.7.35.5 ServiceDeviationType

PK	Name	Type	Notes
	ReducedAccessibility		
	ReducedService		
	IncreasedService		

B.7.35.6 StopDeviationType

PK	Name	Type	Notes
	NewStop		
	StopOmitted		

B.7.35.7 TimeScheduleDeviationType

PK	Name	Type	Notes
	DelayedArrival		
	DelayedDeparture		
	EarlyArrival		
	EarlyDeparture		

B.7.35.8 TransportExecutionDeviationType

PK	Name	Type	Notes
	Cancelled		
	Disrupted		
	TransportModeAltered		
	ReducedCapasity		
	TransportModeReplaced		
	ReRouted		

B.7.36 RestrictionTypes

B.7.36.1 RestrictionType

PK	Name	Type	Notes
	Accessestriction		
	FoodRestriction		
	StopRestriction		
	TransportRestriction		

B.7.36.2 AccessRestrictionType

PK	Name	Type	Notes
	MustBeEntitledToAdmission		
	MustHaveTicket		
	MustHaveEntranceCard		

B.7.36.3 StopRestrictionType

PK	Name	Type	Notes
	NoAlighting		

	NoBoarding		
	StopsOnSignal		
	MustBePreBooked		

B.7.36.4 TransportRestrictionType

PK	Name	Type	Notes
	AgeRestriction		
	BikesProhibited		
	CheckInRequired		
	PreBookingRequired		
	SpaceReservationRequired		
	TicketRequired		
	PetsProhibited		
	SmokingProhibited		
	WheelchairRestrictions		
	GroupRestrictions		

B.7.37 ServiceTypes

B.7.37.1 EnRouteServices

B.7.37.2 FacilityServices

B.7.37.3 InformationServices

B.7.37.4 ServiceCategoryType

PK	Name	Type	Notes
	FacilityService		
	EnRouteService		
	InformationService		

B.7.37.5 AccommodationFacilityType

PK	Name	Type	Notes
	AllergyRoom		
	Single		
	RoomAdaptedDisabled		
	Shared		
	SharedBathRoom		E.g. Part of terminal or transport means. Can be used to indicate assessibility.
	Suite		
	WithBathRoom		

B.7.37.6 FacilityServiceType

PK	Name	Type	Notes
	LocalFacility		
	WhereAboutFacility		
	TicketSaleFacility		
	CommercialFacility		
	RefrechmentSaleFacility		
	AccomondationFacility		
	ChildrenFacility		
	MiscFacility		
	EntryAndExitFacility		

B.7.37.7 EnRouteServiceType

PK	Name	Type	Notes
	AssistanceService		
	AttendanceService		

	EntertainmentService		
	FreeOfferService		
	HandlingService		
	PaymentService		

B.7.37.8 AssistanceServiceType

PK	Name	Type	Notes
	AssistanceToDisabled		
	AssistanceToSick		
	AssistanceToMinors		
	AssistanceInSecurityControl		
	FreeTransportOfAids		
	LuggageAssistance		

B.7.37.9 AttendanceServiceType

PK	Name	Type	Notes
	CabinCrew		
	Conductor		
	Guard		

B.7.37.10 EntertainmentServiceType

PK	Name	Type	Notes
	ChildrenEntertainment		
	LiveMusic		
	Movie		
	MusicChannel		
	News		

B.7.37.11 FreeOfferServiceType

PK	Name	Type	Notes
	AlcoholocBeverages		
	Breakfast		
	ColdMeal		
	Dinner		
	Lunch		
	Newspaper		
	NonAlcoholicBeverages		

B.7.37.12 HandlingServiceType

PK	Name	Type	Notes
	CheckIn		
	Customs		
	LuggageCheckIn		
	LuggageSecurityControl		
	PassengerSecurityControl		

B.7.37.13 PaymentServiceType

PK	Name	Type	Notes
	ByPhone		
	Cash		
	CreditCard		
	ETicket		

B.7.37.14 InformationServiceType

PK	Name	Type	Notes
	TouristInformationService		
	TravelInformationService		

B.7.37.15 ChildrenFacilityType

PK	Name	Type	Notes
	Nursery		
	PlayRoom		
	InfantRoom		Room to stay in during the travel

B.7.37.16 CommercialFacilityType

PK	Name	Type	Notes
	Bank		
	Books		
	Cloths		
	Food		
	Gifts		E.g. Part of terminal or transport means. Can be used to indicate assessibility.
	Kiosk		
	misc		
	TaxFree		
	Pharmacy		

B.7.37.17 EntryAndExitFacilityType

PK	Name	Type	Notes
	TerminalAccess		
	TransportMeansAccess		

B.7.37.18 LocalFacilityType

PK	Name	Type	Notes
	CarRental		
	CarService		
	CycleParking		
	KissAndRide		
	ParkAndRide		E.g. Part of terminal or transport means. Can be used to indicate assessibility.
	ShortTimeParkingArea		Less than 12 hours
	LongTimeParkingArea		More than 12 hours
	ParkingGarage		
	TaxiStop		

B.7.37.19 MiscFacilityType

PK	Name	Type	Notes
	CashDispenser		
	Chapel		
	Cloakroom		
	Computer		
	Desk		
	EmergencyPhone		
	Fax		
	InternetAccess		
	Library		
	LostProperty		
	LuggageSpace		
	LuggageTrolley		
	MeetingPoint		
	Phone		
	PhysicalTraining		
	PowerSupply		
	PramSpace		
	Seats		
	SwimingPool		
	Table		

	Toilet		

B.7.37.20 RefreshmentSaleFacilityType

PK	Name	Type	Notes
	Bar		
	CoffeeOrTea		
	FastFood		
	Restaurant		
	Trolley		

B.7.37.21 TicketSaleFacilityType

PK	Name	Type	Notes
	AttendedTicketOffice		
	Validator		
	TicketMachine		

B.7.37.22 WhereAboutFacilityType

PK	Name	Type	Notes
	LoungeWithRefreshments		
	SeatingAccommodation		
	SecurityControlArea		
	Shelter		
	PhysicalUnit		E.g. Part of terminal or transport means. Can be used to indicate assessibility.
	SmokingArea		
	WaitingRoom		

B.7.37.23 TouristInformationServiceType

PK	Name	Type	Notes
	AccomodationInformation		
	ActivityInformation		
	HistoricInformation		
	LocationInformation		

B.7.37.24 TravelInformationServiceType

PK	Name	Type	Notes
	ArrivalDepartureInformation		
	DynamicArrivalDepartureInformation		
	TrafficInformation		
	ContactInformation		
	RoutePattern		
	TerminalInformation		
	TimeTables		
	TerminalMap		
	TransportMeansMap		
	TripInformation		

B.8 TripPattern

B.8.1 LegPattern

PK	Name	Type	Notes
	SequenceNo	int	
	Distance	int	Meters
	Description	string	

B.8.2 Line

PK	Name	Type	Notes
	LineId	LineReference	
	TransportMode	TransportModeType	
	TransportType	PublicTransportType	
	ServiceName	string	Indicates that the line is a part of a transport service (a brand).
	InformationLink	anyURI	
	Description	DescriptionType	
	NetworkURI	anyURI	
	CompanyURI	anyURI	Web Service Access point

B.8.3 StopPattern

PK	Name	Type	Notes
	SequenceNo	int	Represents the number in the sequence.
	Arrival	duration	Time after start of the trip
	Departure	duration	Time after start of the trip
	Desceription	string	

B.8.4 StopPatternInfo

Notes: A trip has a certain trip pattern

PK	Name	Type	Notes
	TripPatternNo	int	Pattern id. (May be internal) Identifies an overall route pattern
	VariantNo	int	1 indicates the normal pattern. Identifies a specific deviation from the normal pattern (extra stop, stop omitted, etc.)
	VariantName	string	May be published in addition to Line name
	Direction	DirectionType	Indicates the nature of the trip with respect to direction (compass direction, clockwise, counter clockwise, towards centre, away from centre, through transport or other textual description).
	Description	DescriptionType	

B.8.5 TimeSchedulePattern

PK	Name	Type	Notes
	Daytype	DayType	
	Starttime	time	

B.9 TripTimeTable

B.9.1 Arrival

B.9.2 CombinedService

Notes: Combination possible - e.g transfer to other transport means (even though the time available may be short). .

PK	Name	Type	Notes
	CombinationType	CombinationType	
	Max waiting time	duration	
	Description	DescriptionType	

B.9.3 Date

PK	Name	Type	Notes
	DateTime	dateTime	

B.9.4 Departure

B.9.5 Leg

Notes: If other transport means than the one referred to by trip are used, e.g. a ferry, the leg should refer to all transport means involved.

PK	Name	Type	Notes
	SequenceNo	int	
	Distance	int	Meters
	Description	DescriptionType	

B.9.6 Remark

PK	Name	Type	Notes
	RemarkNo	int	
	RemarkType	int	
	Language	LanguageType	
	Description	DescriptionType	

B.9.7 TerminalStop

PK	Name	Type	Notes
	PlannedTime	dateTime	Should be present for all stops that have a time schedule
	EstimatedTime	dateTime	
	EstimatedDeviation	duration	
	ActualTime	dateTime	
	ActualDeviation	duration	
	Description	DescriptionType	

B.9.8 Timetable

PK	Name	Type	Notes
	TimeTableID	string	
	IssuedAt	dateTime	
	Description	DescriptionType	
	FromDateTime	dateTime	
	ToDateTime	dateTime	

B.9.9 StopSequence

PK	Name	Type	Notes
	SequenceNo	int	

B.10 Trip

PK	Name	Type	Notes
	TripNo	string	Unique number identifying a trip
	Description	DescriptionType	

Annex C. MDA Methodology for MultiRIT

C.1 MultiRIT Package structure

The package structure in MultiRIT is shown in Figure 1.

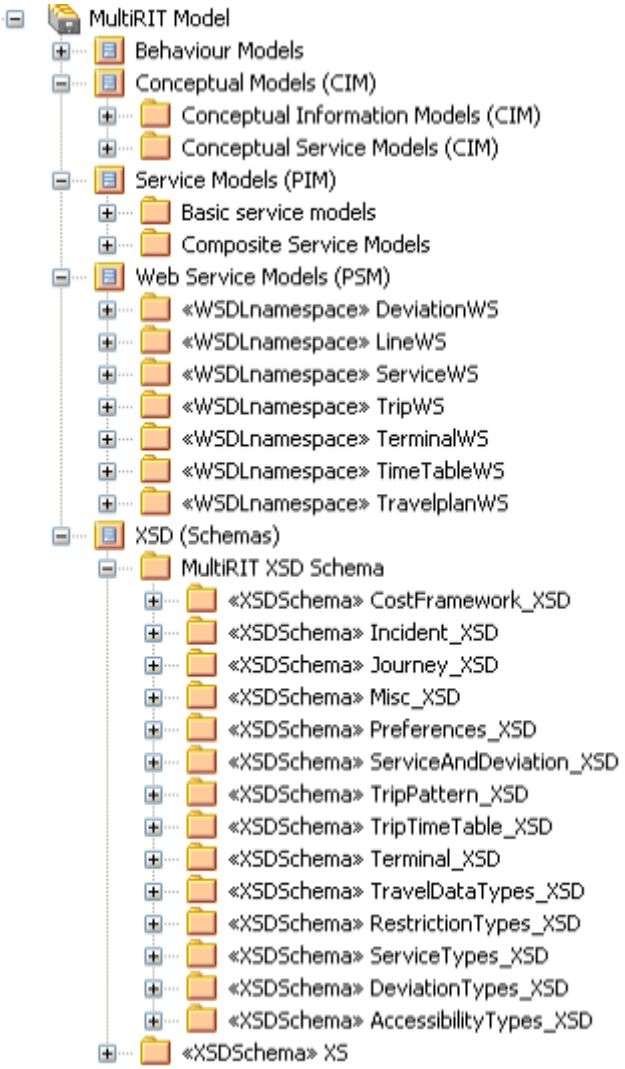

Figure 1 - MultiRIT Package structure

3 main packages are used for the web service creation. These are:

- Conceptual Models (CIM)
- Service Models (PIM)
- Web Service Models (PSM)

C.1.1 Conceptual Models (CIM)

This package contains two sub-packages: Conceptual Information Models and Conceptual Service Models.

C.1.1.1 Conceptual Information Models

These models compose the conceptual information models of MultiRIT and data types definitions used by the conceptual models. They demonstrate the logical dependencies between the information classes.

Actions taken to prepare for use in WSDL modelling:

- The relations in Conceptual Information Models are modelled as dependencies to distinguish these relations from the relation in the message models in the Conceptual Service Models (see below).

C.1.1.2 Conceptual Service Models

This package contains models of the messages exchanges in the services (inputs and outputs exchanged). There is one diagram for each service. Each diagram contains models of the relevant messages. The messages are mainly composed by means of classes from the conceptual information models (included in the diagrams as logical links). Relations (associations) are used to show the structure of the messages.

Actions taken to prepare for use in WSDL modelling:

- Associations from other diagrams are hidden. Only the relations relevant to the actual messages are visible. (The other associations are however still associated with the classes, hence the WSDL cannot be generated from these models).
- The relevant data types are included by means of logical links.

C.1.2 Service Models (PIM)

This package is equal to the Conceptual Service Models package, but the message models are converted to local copies. This means that all the relations (associations) that are not relevant to the specific messages are removed from the classes used.

Actions taken to prepare for use in WSDL modelling:

- Associations not relevant to the actual messages are deleted. Only the relations relevant to the actual messages will be used in the WSDL generation.

C.1.3 Web Service Models (PSM)

These models are platform specific models (PSM). This means that they are tied to particular technology platforms. In our case this is XML Web Services using SOAP over HTTP in the communication.

C.2 Developing MultiRIT web services using Enterprise Architect

The following chapters will describe how travel information web services were developed using a Model Driven Architecture (MDA) approach in MultiRIT.

C.2.1 Establish conceptual model

The conceptual models must be established together with experts on the relevant issues. Use the dependency relation to distinguish the conceptual relations from the relations showing the message structure (defined later).

C.2.2 Generate the conceptual model schema

All classes in the conceptual model must be transformed into a XSD schema. We have chosen to maintain the structure and logic used in the Conceptual Information Models. To generate a XSD schema from the conceptual model right click the relevant package and select 'Transform current package'. Choose XSD. This will create a new package with a stereotype <<XSDSchema>>.This package needs some affiliated information:

- Schema name (E.g. Terminal_XSD)
- Target Namespace (e.g. http://multirit.no/schemas/Terminal)
- Prefix (e.g. Terminal)

We also need to add a tagged value indicating where physical location of the schema file

(e.g. Tag = schemaLocation, value=Terminal_XSD.xsd). The final operation to perform is to generate the XSD schema file. This is accomplished by right-clicking the package choosing code engineering. Then choose to generate XML schema.

C.2.3 Creating a relationship between conceptual models and service models

Decide about the required services and operations to be implemented and the required input and output messages.

Create the Conceptual Service Models package. For each relevant service:

1. Create a new service package and add a new class diagram to this package. (This diagram called the service diagram will define the structure of the input and output messages needed by the operations).

Start the modelling of the input and output messages in the service diagram created in 1:

2. In the Conceptual Information Model package: Open the diagram holding the classes needed in the input and output messages.
3. Select all relevant classes and choose 'Edit-> copy' from the main menu
4. Open up the relevant service diagram and choose 'Edit -> paste object(s) as link' (Whatever changes carried out in either of these classes in the conceptual model will now be propagated to this diagram.)

The same classes are now used in both the Conceptual Information Models and in one or more service diagrams. This may cause some problems since all relations follow the classes. Hence, the service diagram might contain some relations (shown as dependencies) brought with it from the Conceptual Information Model and relations (shown as associations) brought from other service diagrams. These relations should not be a part of the service model. Thus it might be necessary to hide these relations before we can start the service modelling. It is important that the relations are not deleted from the model as they are used by other diagrams!

C.2.4 The input and output modelling

Based on the classes from the Conceptual Information Model and the required operations (and their input and output requirements), the input and output messages have to be modelled in the service diagram.

1. If required add new classes that represent message elements
2. Define the message structure by means of associations between the classes (the new classes and/or the classes from the conceptual model). The association must have a defined direction and a defined multiplicity.

C.2.5 Prepare WSDL generation

The WSDL cannot be generated from the service diagrams as the classes in these diagrams will contain all relations defined in the Conceptual Information Models and in all other service diagrams in the Conceptual Service Model package. We need diagrams with classes that only contain the relations of relevance to each input and output message.

Create the Basic Service Models (PIM) package. For each relevant service:

3. Create a new package.

To remove all connectivity to the conceptual model and other service models:

4. Go to the relevant service diagram in the Conceptual Service Model package and right-click the diagram. In the Project Browser and choose ‘Copy Diagram to Clipboard’.
5. Go to the associated package in the Basic Service Model package, and select ‘Paste diagram’. Select the option ‘Deep (Duplicates ALL elements)’.

All relations that are towards classes that are not present in the current diagram are now removed. However, there may be some un-wanted relations left (between classes used in the diagram - due to that other service diagrams may have defined relations between these classes). These have to be removed:

6. Use the menu option ‘Diagram -> Set visible relations’ to identify these relations
7. Remove the relations from the diagram (they can be deleted since they now are between local copies)

Now as our diagram is copied into the new location, and all un-necessary relations are removed, we may continue with transforming our Basic Service Models to Web Service Models.

8. Define the operations and their input and output by means of an interface.

C.2.6 Transform the Basic Services Models to a Web Service Models

1. Select all (ctrl+a) classes and the interface in the newly created diagram.
2. Right-click in the diagram space, and choose ‘Transform’.
3. Further, select the elements that should be included in the WSDL transformation in the left pane, and select WSDL together with a Target Package in the right pane.
4. Click ‘Do Transform’. The result of this transformation is a WSDL namespace package holding the necessary WSDL sub-packages (Bindings, Messages, PortTypes, Services and Types).
5. Double click the <<WSDLnamespace>> package and set the target namespace (e.g. http://multirit.no/wsdls/Terminal).

C.2.7 Create the WSDL file

To create the resulting WSDL file, EA demands some prerequisite actions to be performed. First of all we need to relate the attribute data types we will use in the Web Service to the XSD schema we have developed. So, for each attribute in all classes found in the <<XSDSchema>> package

we need to specify the data type located in the XSD schema packages we generated in clause C.2.2.

Further we need to attach some tag values to our Web Services Model. Some tag values must be connected to the Binding. Here, the soapAction attribute (I.e. an URI to a description of the action taking place) found in the <soap operation> element, the protocol used, and the transport attribute found in the <soap binding> element must be declared as tagged values. Also, in the association between the Binding and the Service, the soap:address attribute must be declared. All these actions have to be carried out after the transformation, but prior to the WSDL generation. See also appendix A.

1. Copy (as links) the following WSDL components created in the transformation stage into the WSDL diagram.
    - The <WSDLBinding> element
    - The <WSDLPortType> element
    - The <WSDLService> element
    - The <WSDLMessage> elements
2. From the EA Toolbox, below the WSDL elements section, drag a WSDL component into the diagram.

These actions should result in a diagram as shown in Figure 2.

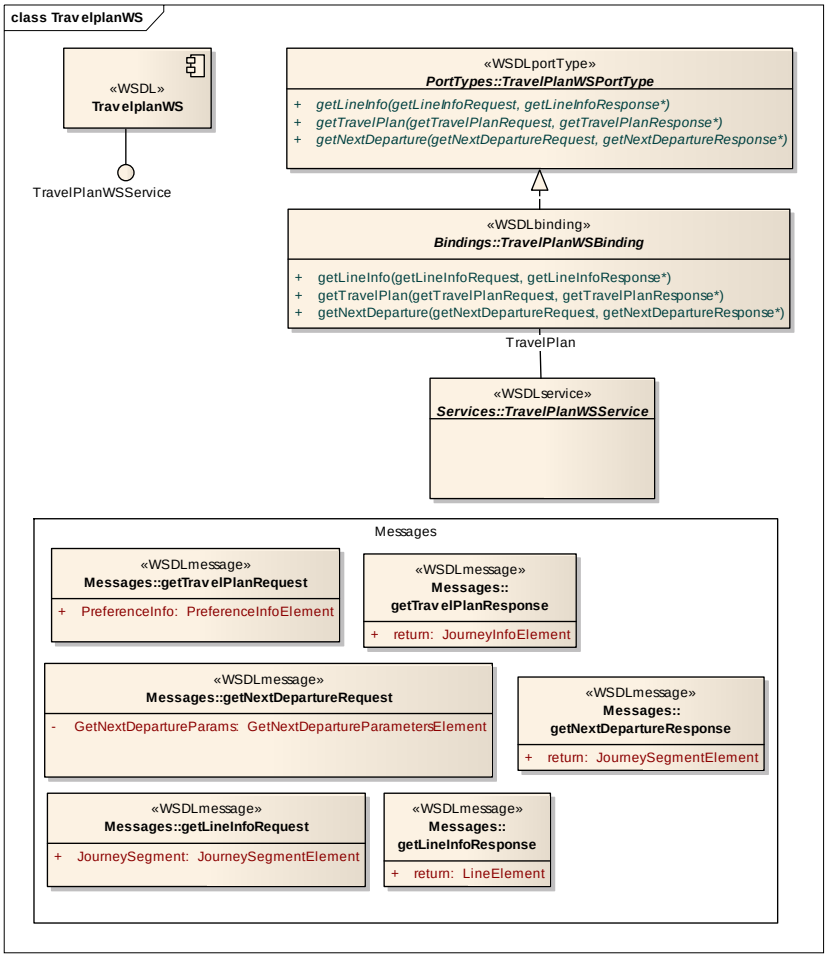

Figure 2 - Overview WSDL components

3. On the main menu, go to ‘view -> Tagged values’ to show the tagged values window.
4. Select the Binding component in the WSDL diagram, and choose the ‘New Tag’ from the Tagged values window. In the tag section enter *protocol*, and in the value section enter *soap*.

Repeat this action and then enter *transport* in the tag section and *http://schemas.xmlsoap.org/soap/http* as the value.

5. For each operation in the Bindings component, add *soapAction* as the tag and some *URL (we have added http://exampleLocation.com)* as the value. You also have to add the tag *style* and the value *document* to each operation.
6. Select the association between the Binding component and the Service component from the WSDL diagram, and add a new tag with *location* as the tag and some *URL (we have added http://exampleLocation.com)* in the value.
7. We also need to specify the WSDL file name and the relevant name spaces. This is achieved by double clicking the WSDL component in the WSDL diagram or the <<WSDLSchema>> package in package explorer. Figure 3 shows an example of this configuration.
8. We also need to add some information to the XSD schema we will use. Double click the <<XSDSchema>> package and add values corresponding to Figure 4.

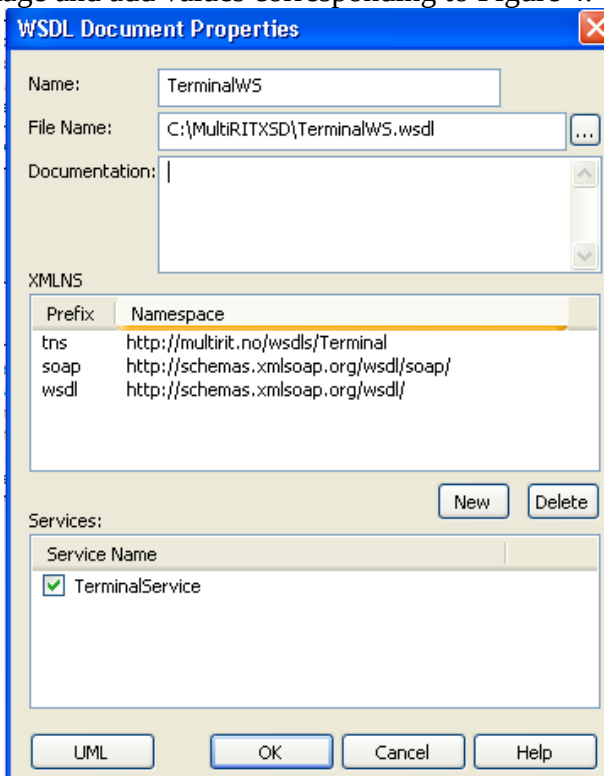

Figure 3 - Configuration of WSDL properties

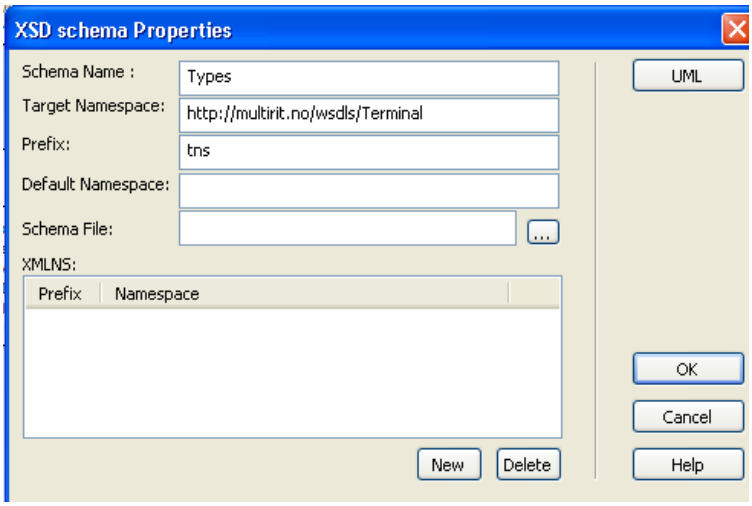

Figure 4 - Configuration of XSD schema properties

9. To be able to generate source code from our soon to be generated WSDL files, we have to create top-level elements for our operations' parameters and return values[1] (See Figure 5). If there is more than one parameter in an operation, we have to combine these into a complex element and then create a top-level element for this complex element.

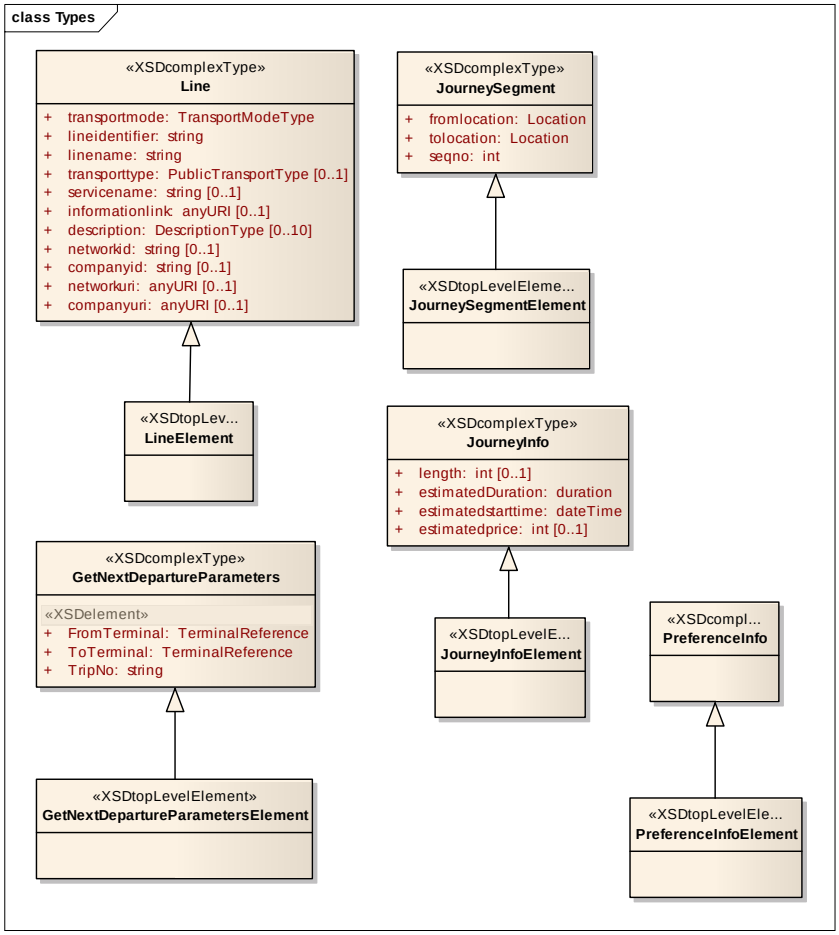

Figure 5 - New XML elements for parameters and return values

10. When all prerequisites are in place, we may generate the WSDL file by right-clicking the WSDL component in the diagram and choose 'Generate WSDL -> Generate'.

[1] To differentiate this project's <<XSDSchema>>Types package from other Types packages used in this EA file, change this Types package name provisorically into another name (e.g. <<XSDSchema>>NSBTypes). Just remember to change it back before the WSDL file generation.

Another tip is when you are creating a complex type or a top level element. Just to right-click in the diagram space → New element or connector → Complex type/Element. When creating a complex type just fill in the sub-elements as attributes. When creating a top level element, just ensure that the type is of the element the top level element will refer to.

C.3 Tag values