Multimodality for people and goods in urban areas

FP7 . CP 284906

WP3.3 – Instant Mobility Use Case scenarios definition & analysis – final report

Feb. 2012

Editor: Yanying Li/ ERTICO

Paul Kompfner / ERTICO

License

This work is licensed under the Creative Commons Attribution-NonCommercial- NoDerivs 2.0 License.

To view a copy of this license, visit http://creativecommons.org/licenses/by-sa/3.0/ or send a letter to Creative Commons, 171 Second Street, Suite 300, San Francisco, California, 94105, USA.

Project co-funded by the European Commission within the Seventh Framework Programme (2008-2013)

© Copyright by the partners of the Instant Mobility Consortium

Project funded by the European Commission under the 7th European Framework Programme for RTD - ICT theme of the Cooperation Programme.

Instant Mobility WP3.3

Instant Mobility Use Case scenarios definition & analysis – final report

WP3.3	Instant Mobility Use Case scenarios definition & analysis – final report
Authors	Yanying Li, Paul Kompfner - ERTICO Cédric Andry, Patrick Gatellier, Jean-Marie Dautelle - THALES Marcus Larsson, Marcus Enered - VTEC Marco Bottero – MIZAR
Short Description	This deliverable provides a detailed functional analysis of three "development scenarios" in the transport & mobility domain, respectively for a Personal Travel Companion, for Smart City Logistics and for Transport Infrastructure as a Service; this analysis is needed for the definition of domain-specific and generic Future Internet enablers needed for .
Dissemination level (select)	PU Public
Date	29 February 2012
Status	Deliverable (final version 1.0)
Contributions by:	Roberto Quasso – Telecom Italia Andrea Carlino - CRF Daniel Thielen - DLRAll consortium members Samson Tsegay - MIZAR David Ferrer - TID Cristina Peña Alcega - TID Ørjan Tveit - STV
Internal review by	
Internally accepted by	Paul Kompfner (WP3 leader)
Date of acceptance	29 February 2012

Document history

Version	Date	Author /Reviewer	Description
V0	25 Oct 2011	Yanying Li	Deliverable content table and template
V1	17 Jan 2012	Marcus Larsson; Marcus Enered; Marco Bottero	Descriptions of Scenario 2 and Scenario 3 have been integrated.
V1.2	30 Jan 2012	Cédric Andry, Patrick Gatellier	Add scenario 1 description
V1.4	21 Feb 2012	Patrick Gatellier	Merge of two diverging 1.3 version from Marco & Patrick
V1.6	26 Feb 2012	Patrick Gatellier	Merge of three versions 1.5 from Thales (sc1), Volvo (Sc2) & Mizar (Sc3). Sc1 completed
V1.7	28 Feb 2012	All consortium members	Collecting contributions from all consortium members
V2.0	01 March 2012	Yanying Li	Final version

Deliverable Abstract

The objective of this document is to provide a set of innovative application scenarios, each providing a rich set of functional characteristics in line with the project's general goal of innovative and Future Internet-driven urban mobility.

The procedure followed to achieve this goal started from reorganizing scenarios and services described in D3.1 into 3 use-case scenarios focused into 3 different, but related, user/business interests:

- Personal travel companion, which pursues to provide travellers and drivers the benefits of dynamic planning and follow-up during multimodal journeys.
- Smart city logistics, which intends to enhance city logistics operations with respect to safety, efficiency, environmental performance and quality of service.
- Transport infrastructure as a service, which allows the rapid deployment of a new generation of traffic management systems by exploiting, among others, Future Internet technologies such as cloud data storage, cloud computing and virtualization.

Each scenario comprises a set of applications addressing the needs of involved actors:

Scenarios	List of Applications
Personal travel companion	Dynamic multi-modal journey
	Dynamic ride-sharing
	Optimized public transport usage
Smart city logistics	Load sharing and optimizing
	Dynamic time/place drop point
	Itinerary booking and real time optimized route navigation
	Eco-optimised driving, vehicle and driveline control
Transport infrastructure as a service	Real-time traffic and route information
	Floating passenger data collection
	Virtualized intersection intelligence
	Cooperative traffic signal control
	Area wide optimization strategies

Each application has been decomposed into use cases of four types (user app processes, long-running processes, human activities and short-running processes) following a common model. The tool used for this purpose has been Enterprise Architect and the modelling language BPMN2.0.

These applications and use cases are the basis for identifying functional and non-functional requirements (D3.5) and for specifying domain specific enablers and components (WP4) to be prototyped (WP5).

Table of Content

Table of Figures

1. Introduction

1.1 Vocabulary

In this document and related ones, the following vocabulary is used with a dedicated meaning:

Term	Meaning
Scenario	the general description of a domain issue and the overall solution for addressing it
(Leading) scenarios	The (five) early scenarios described in D3.1 (following initial DoW and project proposal)
(Use case) scenarios	The (three) definitive scenarios (as described in D3.3) on which the WP4 specifications are based
(Development) scenario	Synonym for use case scenario
Use case	A specific aspect of a scenario (always a part of a scenario), often seen from a specific actor
Function	A function is defined as an operation applied on some specific input resulting in a specific output
Service	A very general term to describe a set of logically related functions. It is the smallest part of a scenario or use-case, before to break it into functions. A service is self-consistent from an outside point of view.
Component	A technical instantiation of a service, build up or orchestrated out of functions
Module	A synonymous for component.
Application	A self-consistent service/components or set of them, along with an HMI allowing a specific actor or set of actors to interact with them. For a user, it is an operational combination of components and/or services.
Enabler	A generic (to all usage areas) or specific (to Instant Mobility) service or grouping of components

1.2 Objectives of D3.3

WP3 (Use Case Scenarios) develops a number of parallel but interwoven scenarios with a user and business-centered focus. Each scenario will describe a number of Internet-supported services that are likely to be used by and to benefit a particular group of stakeholders. By developing the scenarios, functional and non-functional requirements for future internet will be analysed and identified. The Use Case Scenarios definition and analysis will be described in three deliverables:

- D3.1 Instant Mobility Use Case Scenarios Definition & Analysis – Preliminary Report

- D3.3 Instant Mobility Use Case Scenarios Definition & Analysis – Final Report
- D3.5 Instant Mobility Use Case Scenarios Functional and non-Functional Requirements

Each of the use case scenarios has a number of applications. D3.3 provides a foundation for functional and non-functional requirements in D3.5. The process of the use case scenario definition and analysis is shown in Figure 1.

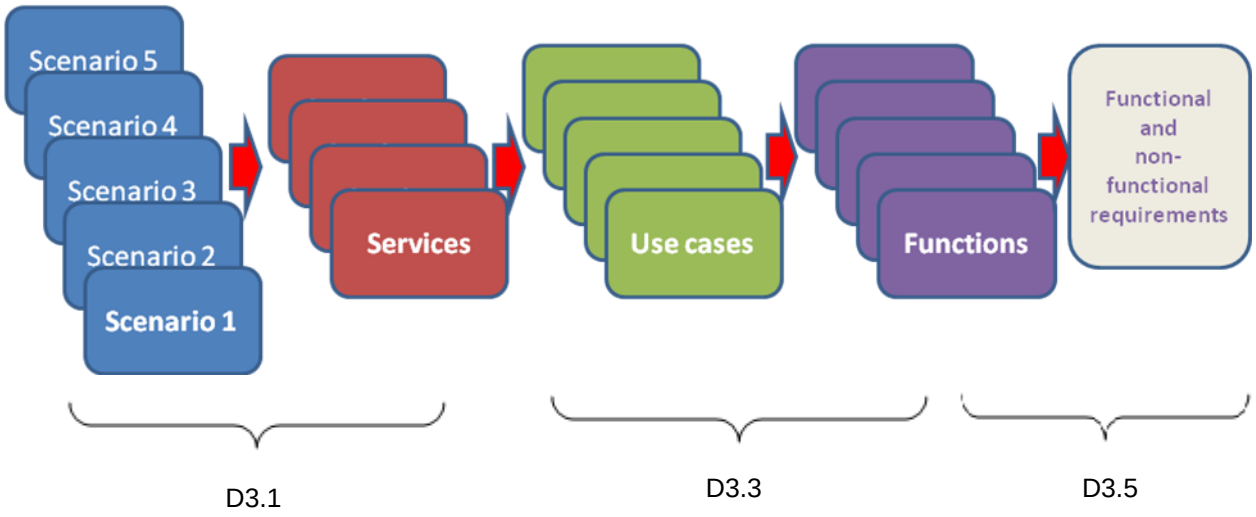

Figure 1: the process of the use case scenario definition and analysis

In D3.1, five leading scenarios are described. Each scenario consists of a number of services. The five leading scenarios are:

- Multimodal travel made easy
- The sustainable car
- Collective transport 2.0
- Trucks and the city
- Online traffic and infrastructure management

Based on the description of services and scenarios in D3.1, D3.3 re-groups these services into three use case scenarios:

- Personal Travel Companion
- Smart city logistics operations
- Transport infrastructure as a service

Each of these three use case scenario, will in turn define a set of applications addressing the needs of one or more actor (or stakeholder) of the scenario.

This deliverable will describe objectives of each of the scenario and applications required. Functions of each application will be decomposed and user experiences for different users will be described.

1.3 Use of the D3.3 Outcomes

The Instant Mobility project is to realize a bouquet of different software systems that are all focussing to assist a traveller to optimize his trip by delivering Future Internet enabled services to assist the traveller to complete his journey with the maximum comfort level and minimum environmental impacts. The project workflow follows a typical development process. WP3 is producing functional and non-functional requirement for such a system by analysing different scenarios and use-cases. This outcome will be used in WP4 to specify the key functionalities (enabler sets) of the targeted system. The specification will then be implemented in WP5. The overall workflow is sketched in Figure 2.

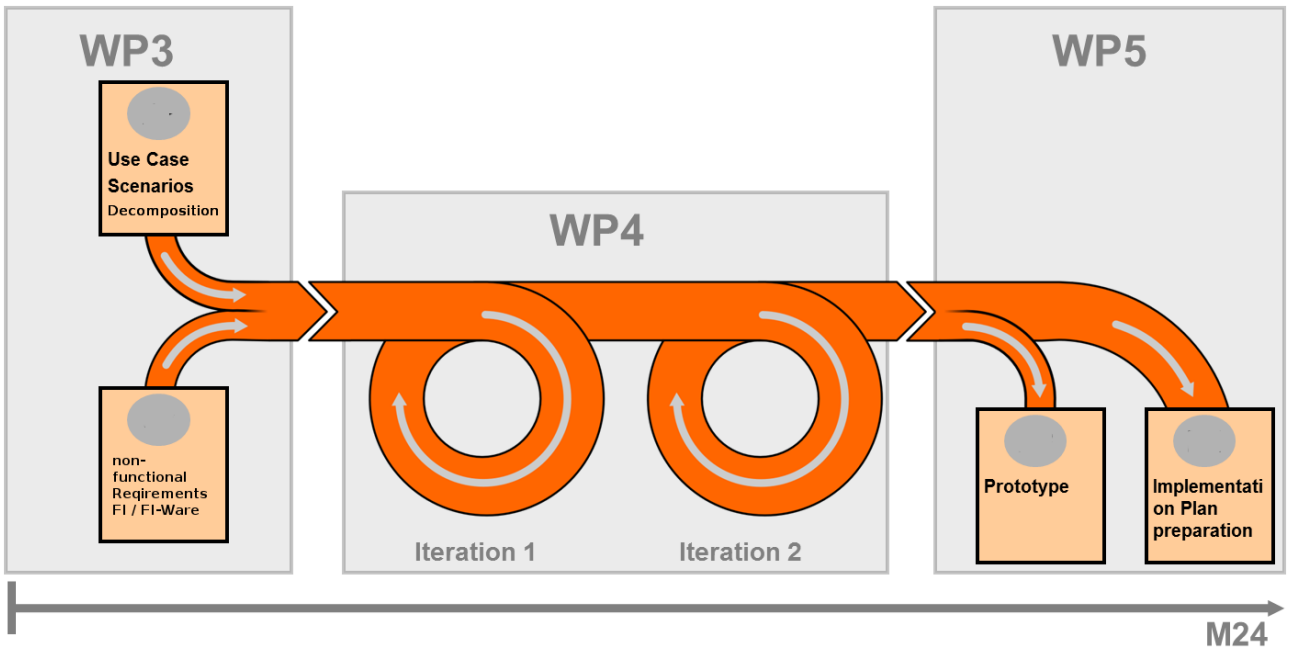

Figure 2: Instant Mobility work flow diagram

2. Methodology of Use Case Scenario Development in D3.3

2.1 Common Definition of Actors

An important task of this deliverable is to describe different user experience of each application. To achieve consistency, potential actors of each application are defined and the definition is used for the three scenarios.

Note that an application may involve different actors as users.

Name		Definition
Traveller		A Traveller, as an actor of the transportation scenarios, is essentially a person with a current geo-location, a geographical destination and preferences. Travellers include public transport users, motorists, private car driver (going to some personal destination) or any passenger.
Driver		General driver role. A person driving a individual means of transportation, able to interact with the others actors in the various scenarios
	Private car Driver	A person owning and driving a private car.
	Professional Driver	Such as lorry drivers, delivery van drivers, public transport drivers, taxi driver, etc.
Passenger		A person using one or several means of transport to travel from one point to another, but doesn't drive a car during his trip.
Consignee		The person to whom a shipment is to be delivered
Consignor		The person who delivers a shipment to consignee
Service provider		Provides, manages and updates the running service, on the server side (e.g. booking services provider, trip planner, ridesharing provider); includes service integrator
Device and system provider		Manufacturers devices (e.g. Apple, Nokia) or provides software
Data provider		Provides traffic data, map contents, location based contents etc; includes map provider and content provider
Mobility information broker		Collect and publish the information coming from all kind of producers, anonymize and transform it so as to make it available under various contractual condition to existing or potential new business services

Transport operators	Operates public transport, air transport, ferry, trains including bus companies, airlines and rental bicycle operators
Terminal operators	Operates transport hubs e.g. airports, ports
Parking manager	Manages a car park
Fleet manager	Manages fleet for logistics company. Vehicle Fleet operator: car sharing, taxi fleet. The fleet operator is a human or organizational entity that uses the facilities of a system to manage a fleet of freight carrying vehicles that are licensed to operate on the road network. The system may be in communication with more than one human entity that is a Fleet and/or Freight Operator. Each entity may belong to the same fleet and/or freight management organization, or to different organizations.
Logistics transport planner	Planning transport and itineraries of goods
Traffic operator	Manages road traffic and infrastructure, e.g. traffic lights Including urban road operator and motorway operator
Vehicle OEM	It integrates the On board unit on the car. It provides vehicle data and features for in-car usage of the application. It can be a car maker or a first level supplier.
Public Authorities	Makes transport planning, strategies and policy including transport planner
Emergency operator	It is a human entity or an organization that uses the facilities of the system to manage some of the activities carried out by the Emergency Services in response to incidents. The scope of activities shall be limited to the management of vehicles belonging to the Emergency Services, plus the provision and receipt of information about the incidents. The system may be in communication with more than one human entity that is and Emergency Operator. Each entity may belong to the same Emergency Service, or to different Services.
Freight operator	Freight operator is a human entity or organization that uses the facilities of the system to manage the transportation of freight. It shall be possible for the human entity that is the Freight Operator to also fulfil the role of a Fleet Operator. The system may be in communication with more than one human entity that is a Freight and/or Fleet Operator. Each entity may belong to the same freight and/or fleet management organization, or to different organizations.
Highway operator	Manage Highways infrastructure (stop area, bridge, tunnel, toll) Organisation responsible for maintaining the roads and managing the traffic on it.

Insurance company	The insurance company is a private company insuring vehicle damages. It wishes to offer to the fleet owners or to private drivers new fares policies based on cooperative systems.

The figure 3 represents a consolidated view of all actors involved in one or more scenarios.

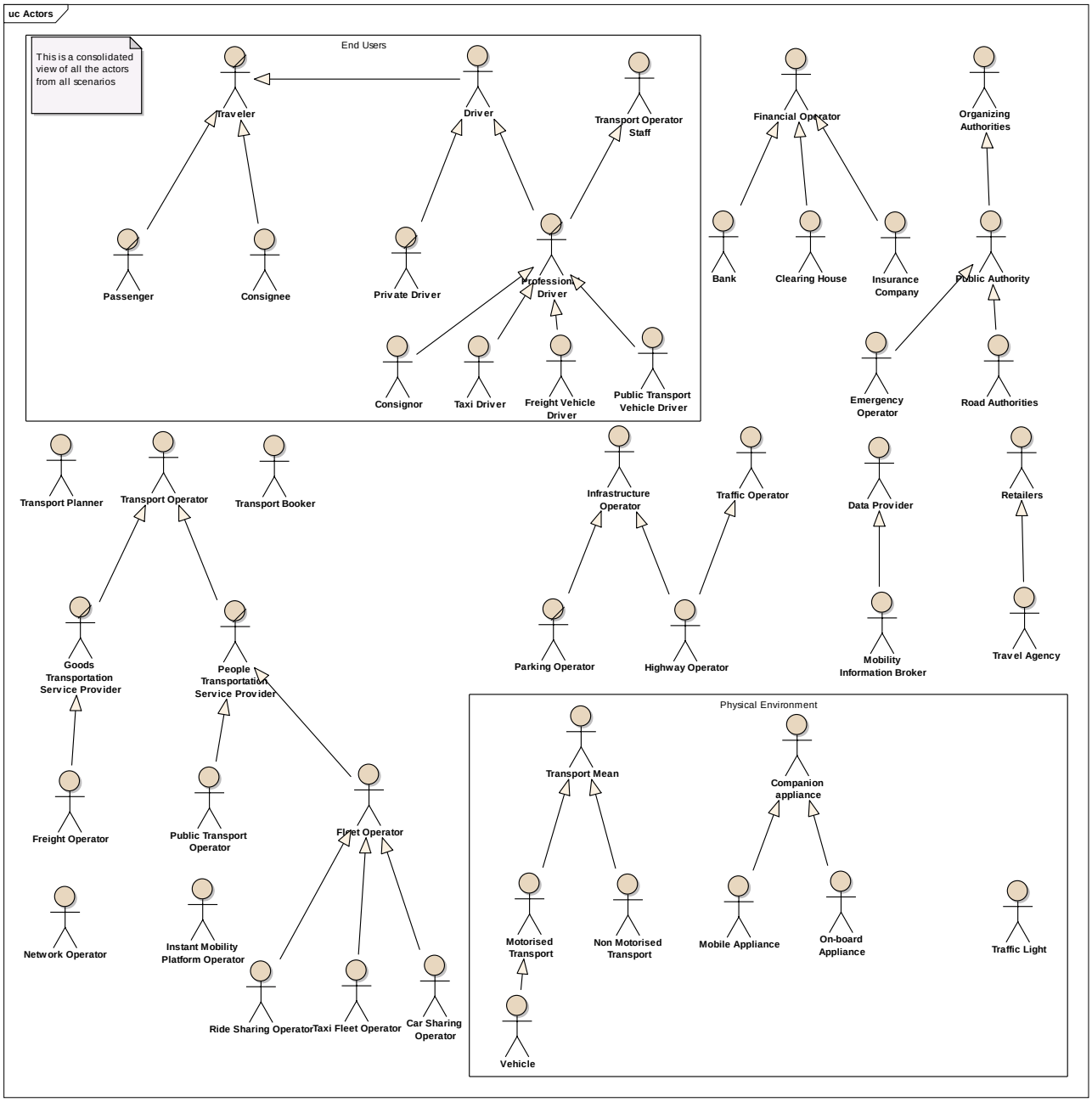

Figure 3: Instant Mobility Actors diagram

2.2 Use case scenario development process

Use Case Scenario development in this deliverable is based on use case scenarios and their services in D3.1. Based on the five scenarios and services of each scenario, D3.3 regroups the five scenarios into three scenarios and transfer services into applications. For each application, systems and components will be described. Use cases and user experiences for different users of each application will also be provided based on systems and components. The process is illustrated in Figure 4.

Figure 4: Use case scenario development process

A key part of this deliverable is to provide functional decomposition which will be used for WP4 to develop components of Instant Mobility. The process of the functional decomposition is illustrated in Figure 5.

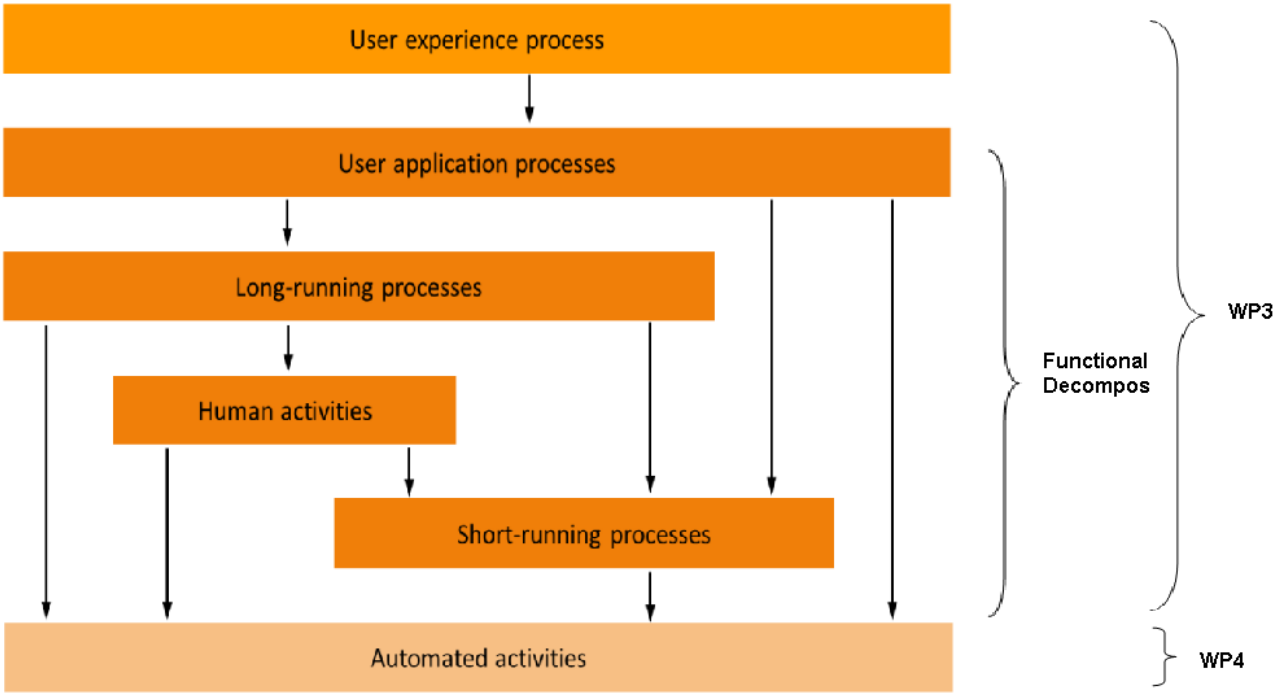

Figure 5: Functional decomposition process

3. Personal Travel Companion

3.1 Objectives of Personal travel companion scenario

The *Personal Travel Companion* scenario aims to demonstrate the capabilities provided by the future Internet technologies for multi-modal travel, mainly in urban and inter-urban areas (long distances journey are also taken into account but as a more straightforward case).

More precisely, this scenario intends to provide to travellers, surface vehicle drivers and transports operators the benefits of dynamic planning and follow-up during multimodal journeys

- To travellers, it will help them to plan and adjust in real time a multi-modal journey from door to door
- To vehicle drivers, it will allow them to easily book and execute ride sharing on their way to their own destination
- To transport operators, it will provide them with the complete information necessary to initiate demand driven transportation

3.2 Applications based on services in D3.1

The scenario features three main different applications with clearly defined scopes. These applications are the result of the consolidation and refinement of services described in D3.1. A rough outline of contributing services is provided.

- **Dynamic multi-modal journey**
  - Origin: D3.1 – Service 1a, 1b, 1c, 1e, 1g, 1h
- **Dynamic ride sharing**
  - Origin: D3.1 – Service 2d, 2e, 3f, 3g
  - New service : parking assistance
- **Optimized public transport usage**
  - Origin: D3.1 – Service 3a, 3b, 3e

3.3 Description of the scenario and applications

3.3.1 The Dynamic multi-modal journey application

3.3.1.1 Description

This application implements the traveller view of the *Personal Travel Companion* scenario.

In essence this application is made of two main parts aiming to provide better (i.e., quicker, more comfortable, cheaper and greener) mobility to daily commuters and other travellers by a

better allocation of the transportation means and a strong real time orientation. These two main parts are the pre-trip planning and the journey execution.

- **pre-trip planning**

  The pre-trip planning part is the preparation phase. During this phase resources are identified and committed on the basis of a traveller's preferences and environment constraints. An individual traveller asks the application to provide him with an optimal (multi-modal) journey proposal. This planning proposal takes into account the current means of transportation, the traveller's context and preferences, the city rules and the current requirements & constraints. If this proposal suits the traveller, he accepts it, thus committing himself and all resources involved.

  The pre-trip planning exists in two different cases, the future journey and the immediate journey. The future journey is needed either to plan a trip needing early reservation of resources (like long distance train or a plane ticket) and to get an overall indication of the trip duration. While this future journey may be from a few hours away up to days, weeks or months, its difference with an immediate planning is the absence of dynamic information within the planning. Historical data may be used to compute an indication of potential optimisation, but the overall journey duration will be essentially relying on timetables for public transports and mean travel time for taxis.

  Before executing a trip, the future plan must be updated just before the trip to check for current conditions, availability of previously expected means of transportation and possible optimization. Thus the normal sequence is as follow:

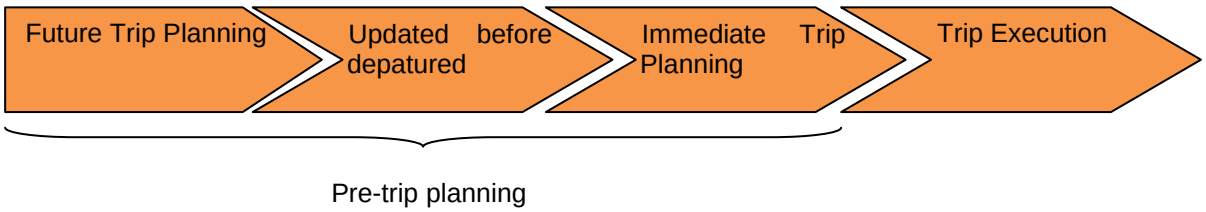

Figure 6: Phase of Pre-trip planning

- **Journey execution**

  Once the immediate planning has been accepted by the traveller, the journey execution automatically starts.

  As the journey may be a multi-modal one, i.e. use more than one mean of transportation (such as bus, train, car, walk,...), it is in fact made up of a succession of segment or steps[1] During the (multi-modal) journey, the events occurring on the transport network or on the planned resources for the current journey or those generated by the traveller itself are monitored and analysed. If they have an effect on the current journey, an automatic update of this journey is pushed to the traveller.

[1] Segment referring more to the geographical parts, and steps to the succession of actions

The journey execution is thus mainly a monitoring of the same loop of events for each modal step of the overall multi-modal journey, namely:

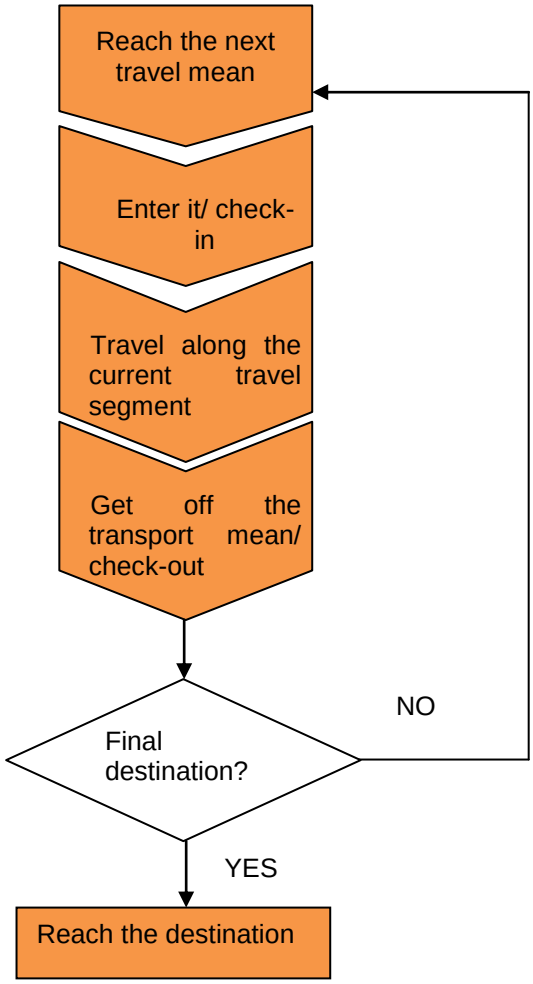

Figure 7: Phase of Journey execution

3.3.1.2 Functional decomposition

From a global viewpoint (see Figure 8), the *Dynamic Multimodal Journey* application addresses the default case of a traveller asking for a multimodal travel:

- The traveller/user first subscribes to the service, and then set up his preferences, before requesting for a journey
- When he receives the planning proposal regarding his journey, he either accepts the offer or declines it, eventually asking for an alternative proposal.
- After starting his trip, he can make one or several transfers if the trip is a multi-modal one.
- He will receive information about the events happening all along the trip, such information eventually forcing a re-planning of the trip.
- He finally can rate his journey. Other actors are able to consult parts of this rating.

- He will be charged with the amount of money needed for his effectively completed journey.

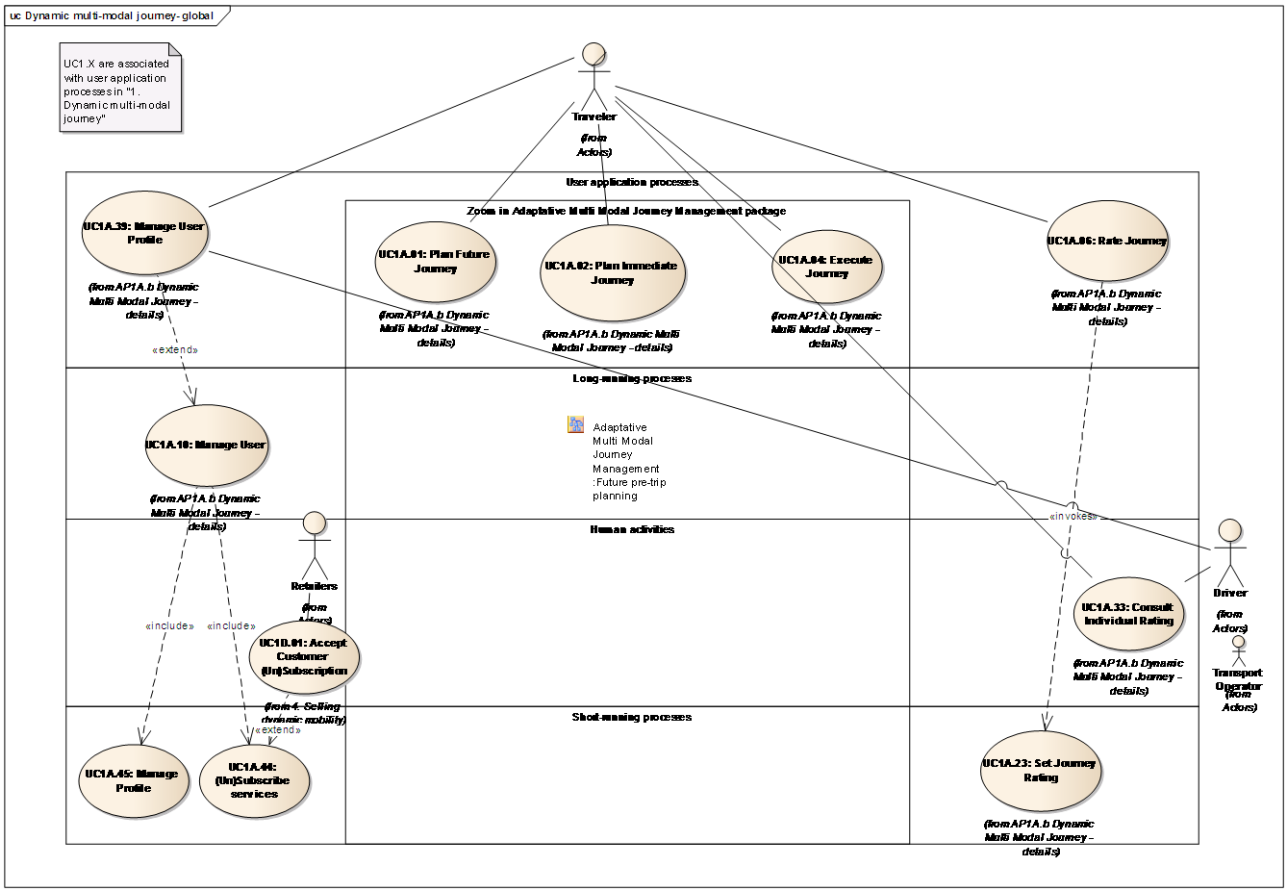

Figure 8: Dynamic multi-modal journey

The following decomposition details the two main parts: pre-trip planning and journey execution.

3.3.1.2.1 Future Journey Planning

As previously said, the planning phase can be done in advance for a future journey or at the time of travel for an immediate journey.

During the planning phase, the traveller provides its journey origin (implicitly from its current position or explicitly) and its destination (implicitly from its favourites or explicitly).

The system then selects from multiple possibilities the optimal itinerary by taking into account the traveller's profile, preferences and the various stakeholder constraints and policies.

The following use case view (Figure 7: Future pre-trip planning) details the future journey planning. From the user interface standpoint, three options are functionally available:

- Plan a future journey corresponds to a new journey request, itself allowing to ask for a brand new request or an alternative one (if the previous proposal doesn't match the traveller expectations)

- Update a future journey allow for a modification of a previous (stored) plan
- Cancel a planned journey is used to release previously reserved or committed resources

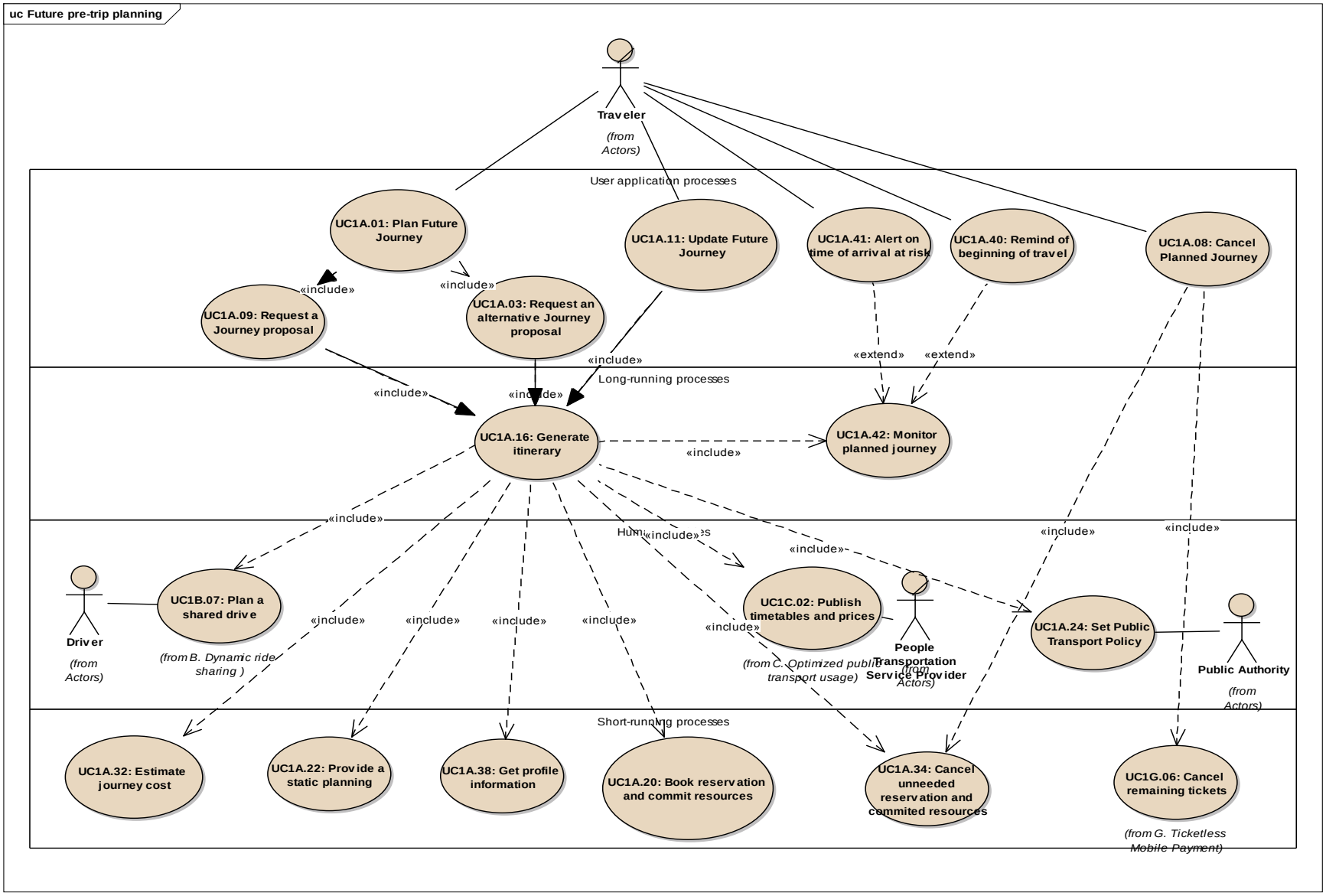

Figure 9: Future pre-trip planning

In all cases (except cancelation), these various traveller entries all lead to the same long running process, Generate itinerary (with different initial context information).

As already mentioned, the future journey capability is needed either to plan a trip needing early reservation of resources (like long distance train or a plane ticket) and to get an overall indication of the trip duration.

Thus the planning provided for a future journey is merely based on timetable data and mean duration values for each segment of the journey. It cannot take into account dynamic or current transportation status information.

The different short term processes involved in a future journey planning are essentially as follow:

- Estimate journey cost (from PTOs pricing data and shared cars standard pricing)
- Provide a static planning (from timetables and statistical data)
- Get traveller profile info (for constraints and preferences, including accessibility)
- Book needed reservations and commit resources

Other actors involved are PTOs (publishing timetables for public transportation and prices), drivers (for shared rides) and local authorities (for transport policies city rules and regulations)

The acceptation of a future journey planning results in this journey to be added to the pool of planned journey but doesn't reserve any dynamic resources.

3.3.1.2.2 Immediate Journey Planning

An immediate journey planning request (UC 1A.02 Plan an immediate journey) will be seen by a traveller through essentially the same HMI as a future journey planning, with the additional option to "use a previously defined future journey planning" (UC1A.15).

It will result in an invocation of the same UC 1A.16 Generate itinerary long running process.

However, the results of its invocation will have very different effects.

The short running processes invoked will all make use of the dynamic and real time capabilities of the system:

- Provide an initial planning is in that respect the dynamic equivalent of provide a static planning (UC 1A.22).
- Get ticket price & multi-modal info will provide effective final pricing (compared to estimate journey cost)
- UC 1E.06 Publish real time information will be used to validate inclusion of dynamic real-time means of transportation.

The only choice provided to the traveller after receiving an itinerary (and eventually asking for one or more alternative planning) will be to accept the journey (UC 1A.21) and start it or to cancel it definitively.

By accepting the journey he will definitively commit the resources temporarily reserved during planning building and contract with all involved actors in his trip (such as share ride drivers, PTOs non dynamic tickets, etc.) via the schedule itinerary long running process.

When the Accept immediate journey proposal is agreed by the traveller, the schedule itinerary long running process will in particular add the journey to the *journey real time monitoring system*

and the traveller will start its journey and to securely report (periodically and automatically) its geo-location.

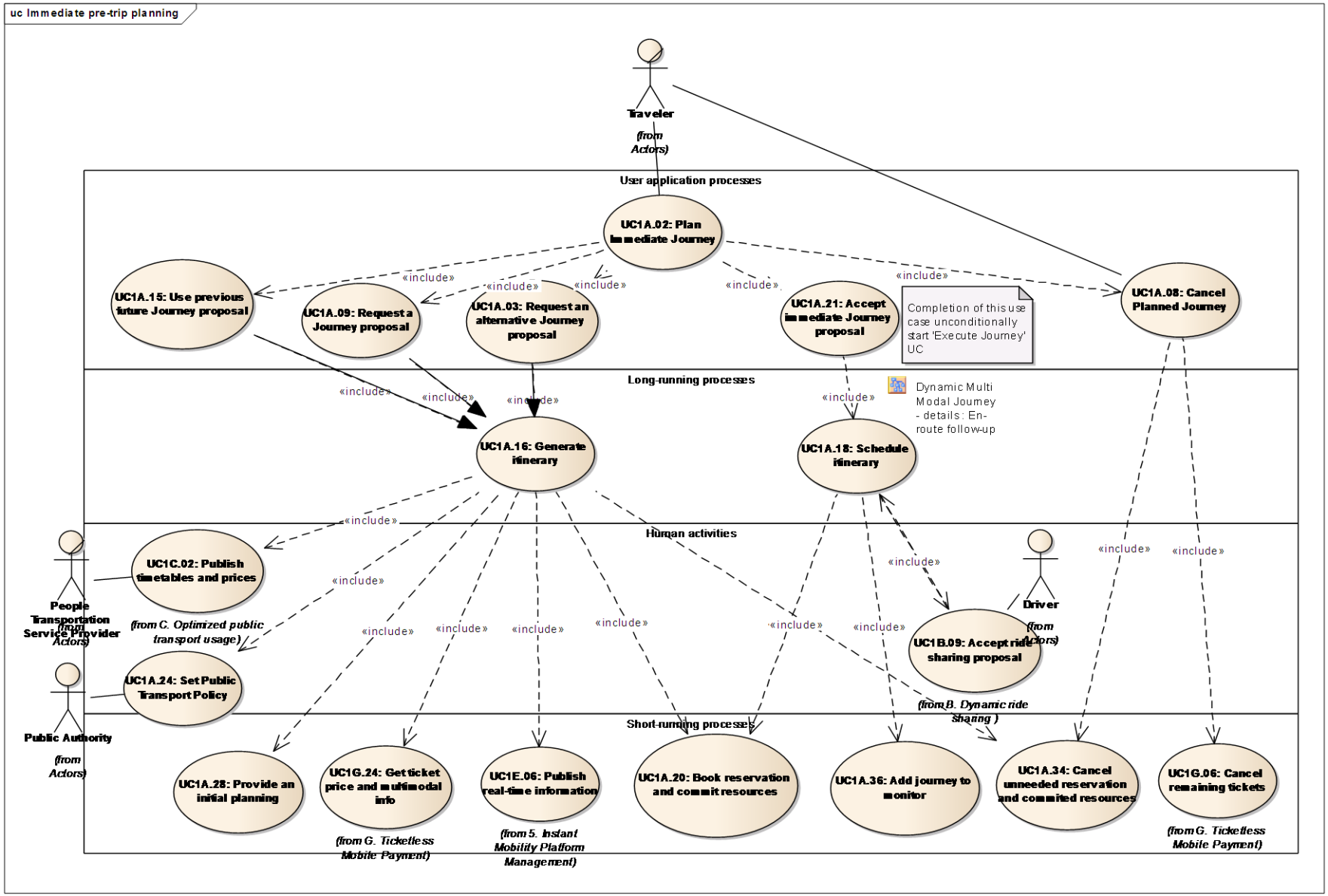

Figure 10: Immediate pre-trip planning

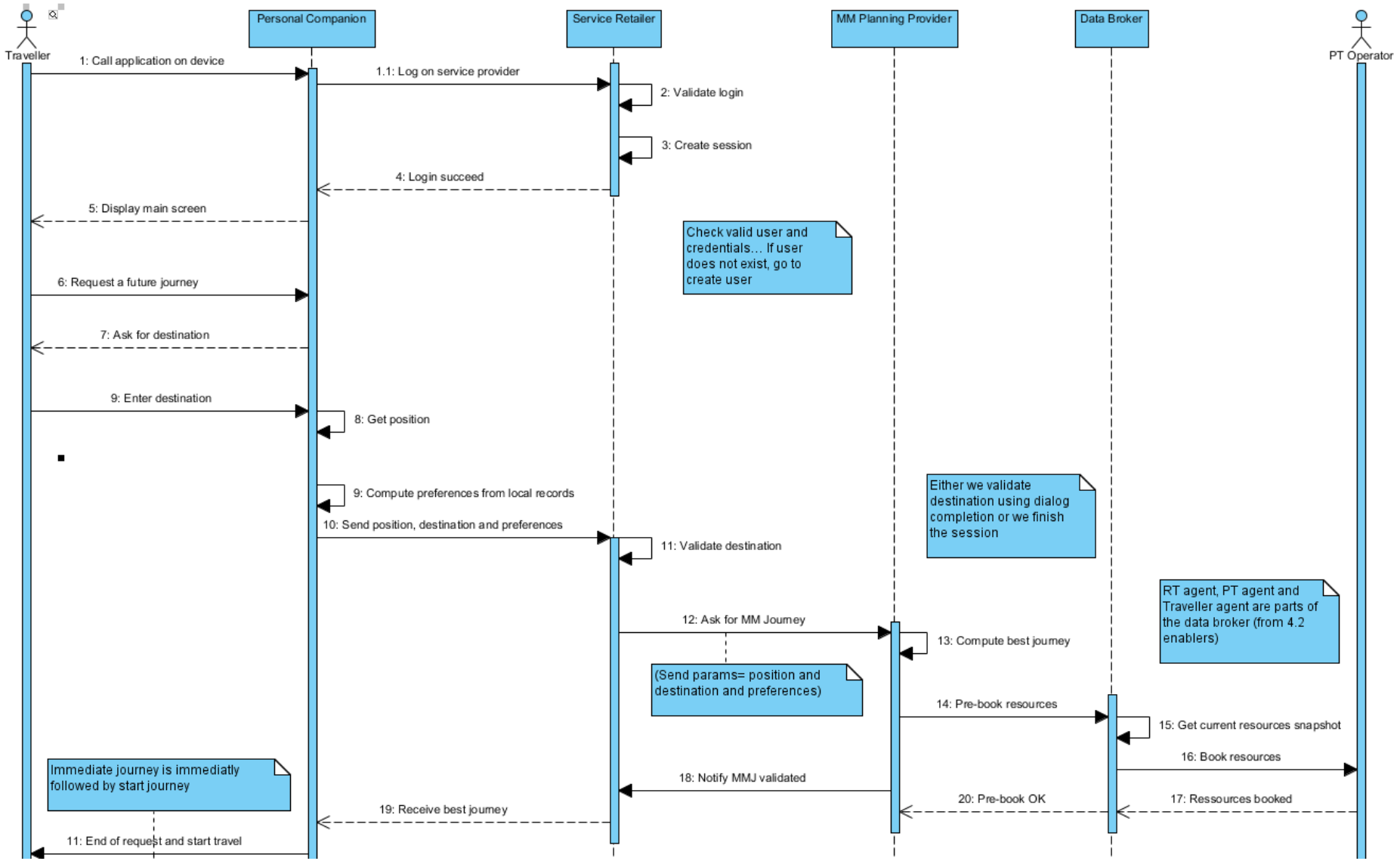

Figure 11: Sequence Plan Future Journey

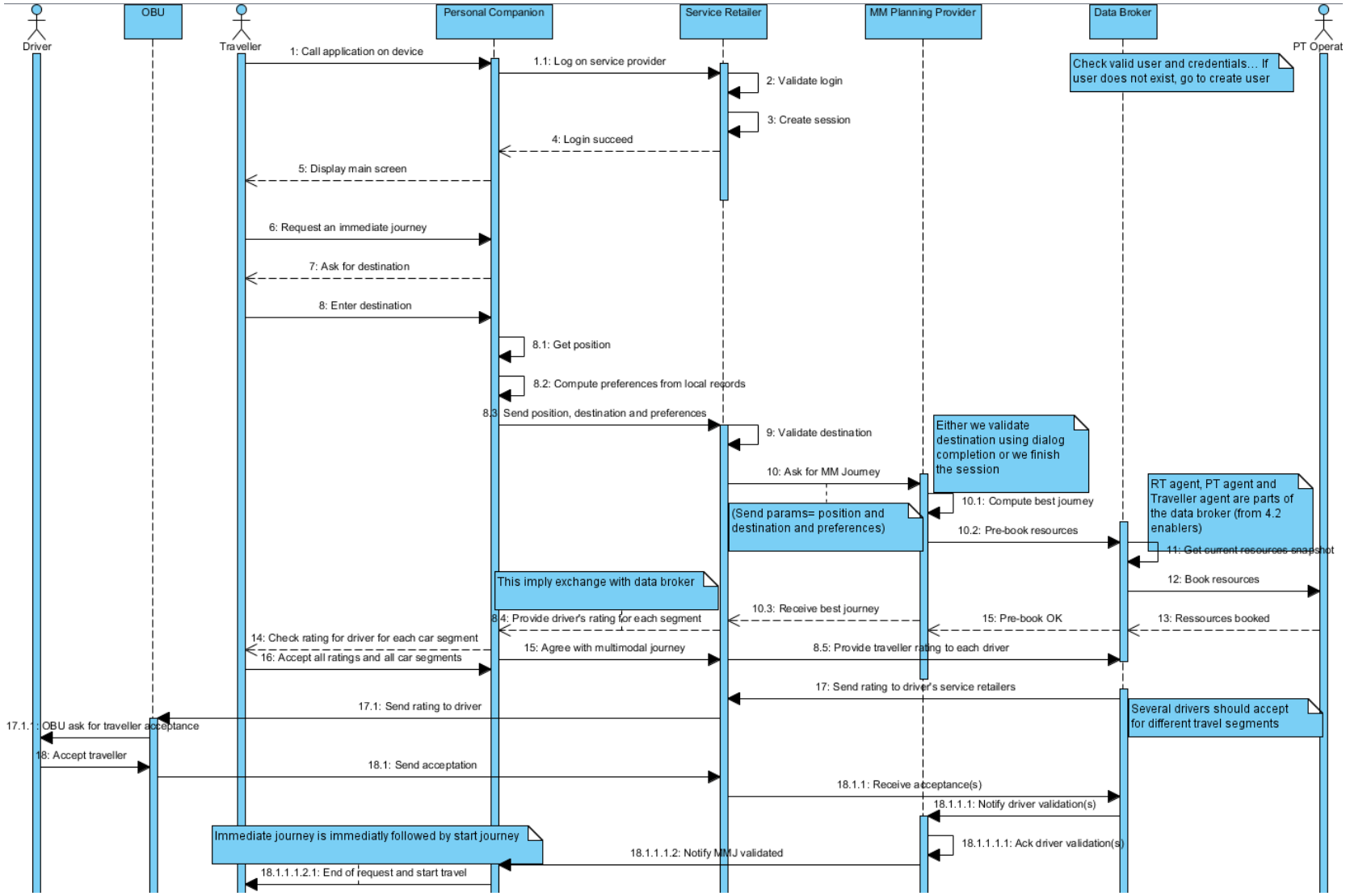

Figure 12: Sequence Plan Immediate Journey

3.3.1.2.3 Journey Execution

Journey execution starts with the successful completion of UC1A.21 (Accept immediate journey proposal).

It is essentially relying on two independent long running processes:

- Monitor travel
- Execute travel segment

Additionally the update itinerary long running process may either force monitor travel to reschedule a new itinerary (if the traveller ask for a new destination or modify its behaviour without notification) or in the opposite way an external event notified via Monitor Travel will force an Update itinerary.

Journey execution is done by repetitively chaining execute travel segment for each segment of the planned multi-modal journey.

Each segment includes:

- Obtaining the segment travel info and the transfer infos
- Getting the needed electronic tickets and cancelling the unneeded ones (if any)
- Doing a check-in step (for payment, safety and security purposes), which may be automatic (in some public transports) or manual (for shared drive...)
- Requesting (before or after check-in) the user expected security measures
- Executing the travel segment (travelling the segment. This is an implicit part)
- Doing the check-out at end of segment (or implicitly in case of event)
- Rating the travel for the segment (if needed or requested)

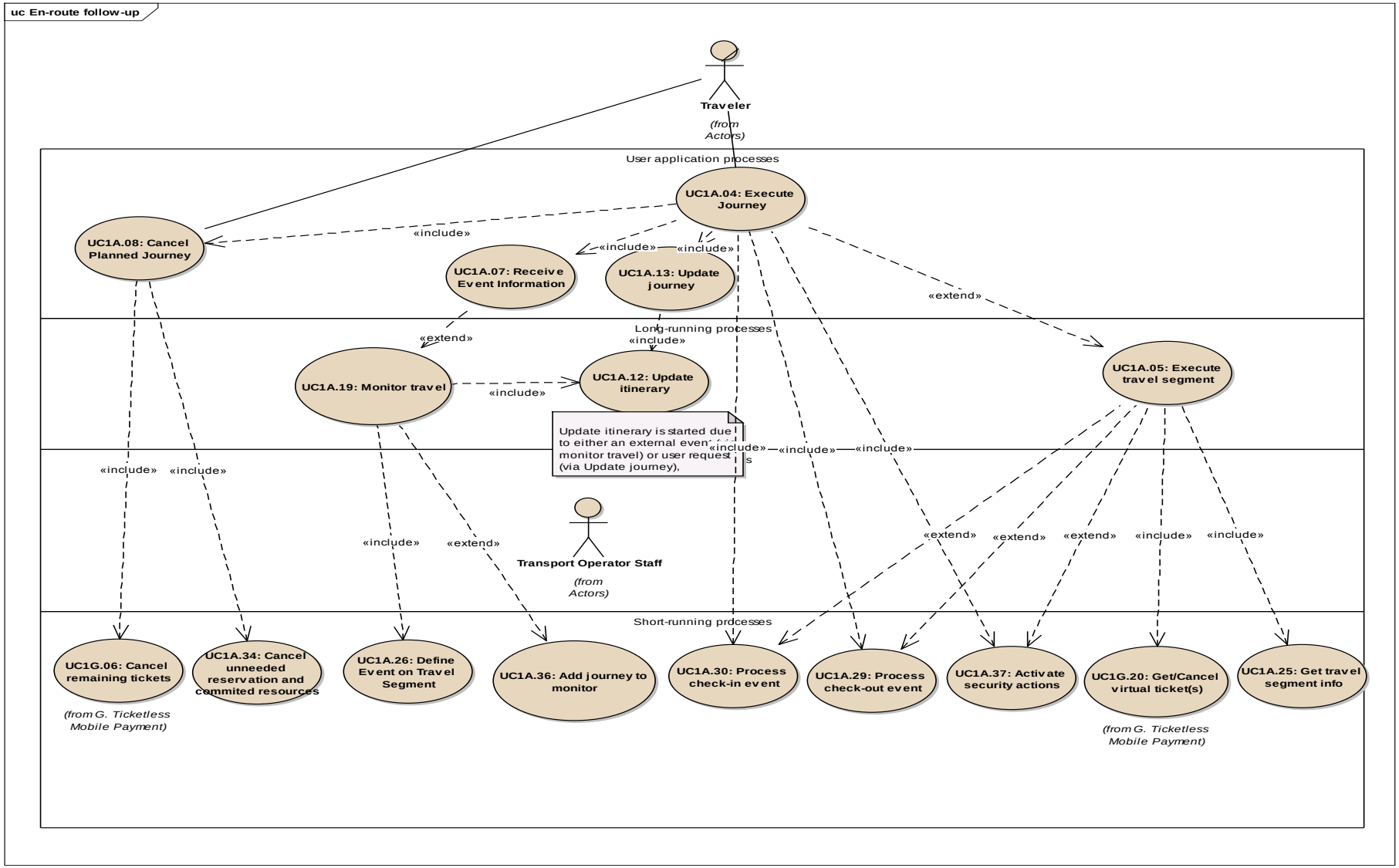

Figure 13: En route follow up

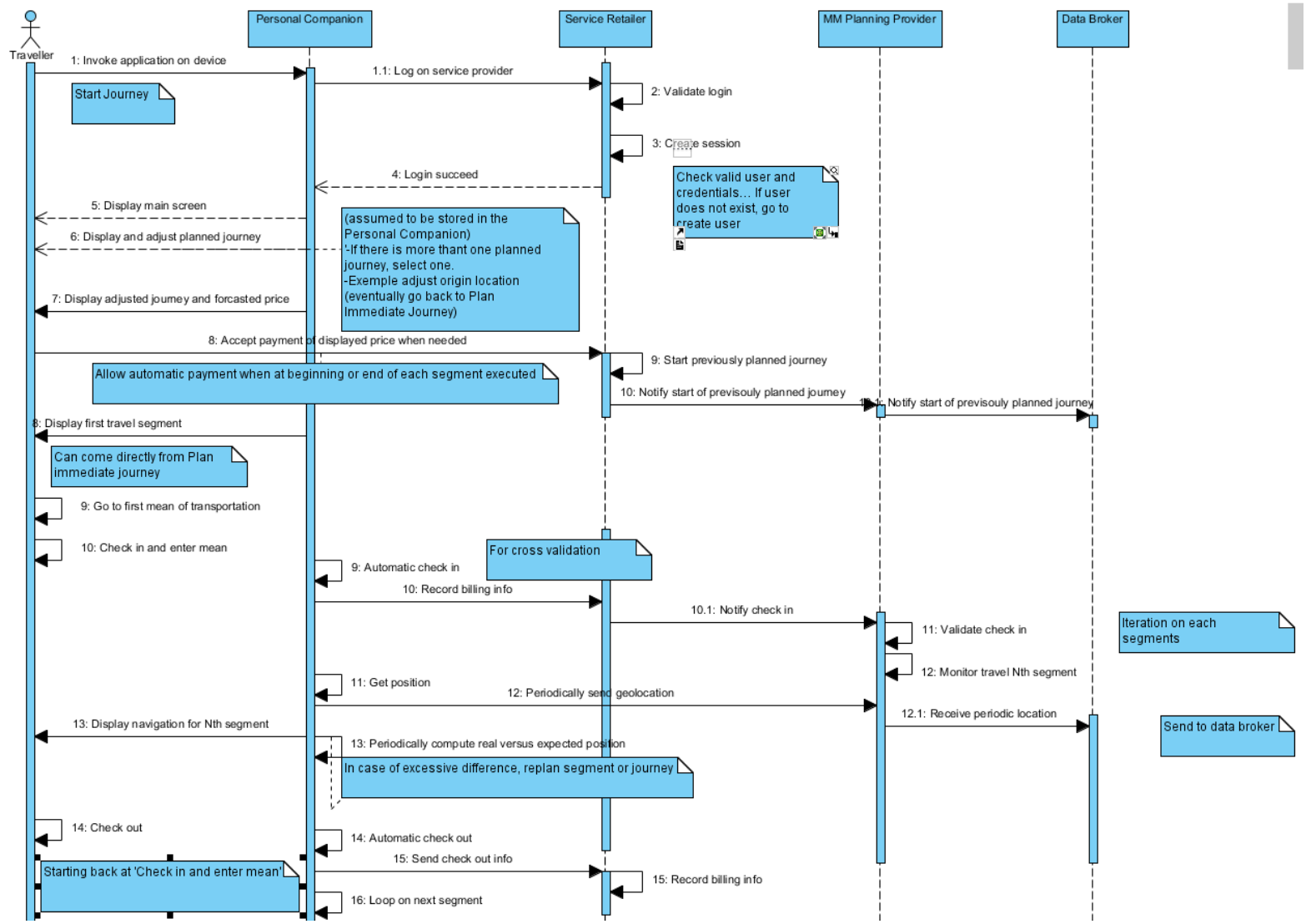

Figure 14: Sequence En Route

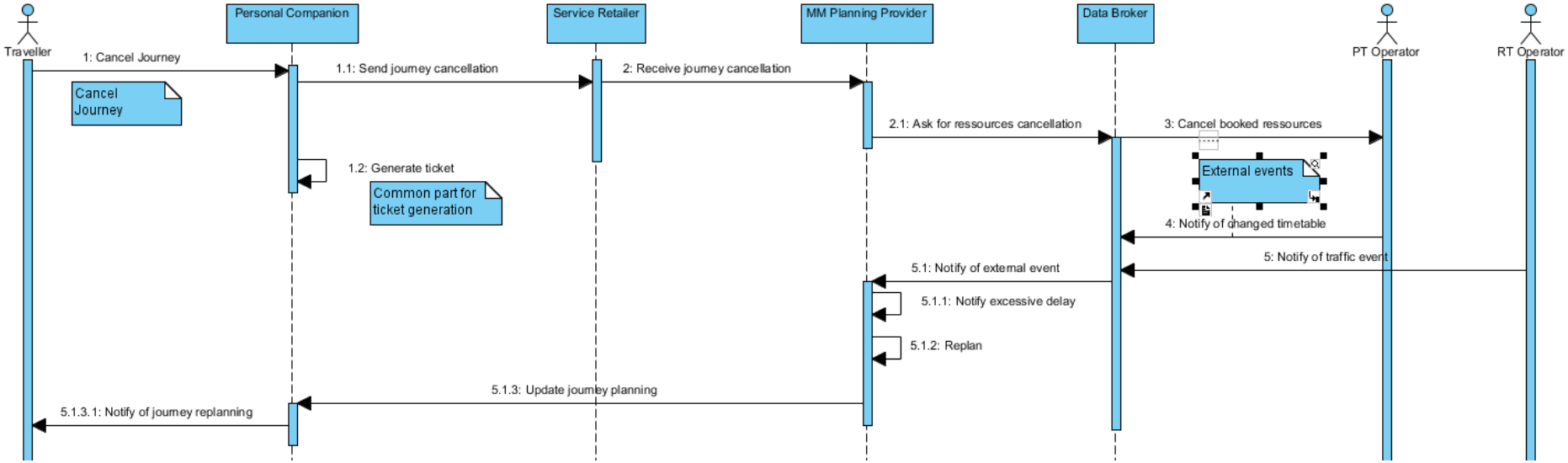

Figure 15: Sequence Cancel Journey

Use case	Goal	Trigger	Pre-condition	Post-condition
UC1A.01	P**lan a future journey**	Traveller request a future journey	Traveller is registered to Instant Mobility Service. The system is up and offer an entry point for journey planning	Traveller get a trip plan based only timetables and statistical information
UC1A.02	**Plan an immediate journey**	Traveller request an immediate journey	Traveller is registered to Instant Mobility Service. The system is up and offer an entry point for journey planning	Traveller get a trip plan
UC1A.03	**Request an alternative request proposal**	Traveller request an alternative trip proposal	Traveller has already requested a journey which he does not accept. He may in some way express new preferences or requirement	Traveller get another trip proposal
UC1A.04	**Execute Journey** Transfer assistance Get journey real time information Check-in/check-out (for ticketing purpose) Emergency call Assistance call	Traveller request a transfer assistance	Traveller is en-route for a multi-modal trip and has to make a transfer between 2 transport means	Traveller has succeeded in accessing the following transport mean.

	Provide social travel information (traffic information, disruption of service,...)			
UC1A.05	**Transfer assistance and travel segment execution** Cover all the activities the traveller has to perform to catch the next transport mean, for the next transport segment. Emergency call Assistance call	Traveller starts his journey	Traveller has selected a multi-modal trip	Traveller has successfully taken the following transport mean.
UC1A.06	**Rate/rank Journey** Access Forum	Traveller want to rate his journey	Traveller used Instant Mobility service for multi-modal journey	Traveller has succeeded in rating his journey
UC1A.07	**Receive event information** This is an information only use case, allowing notification of the traveller about any event that can modify his journey independently of the potential updating of this journey.	Traveller receive incoming event : not POI because out of scope for this application, traffic perturbation, ... Get informed of itinerary change Provide social travel information (traffic information, disruption of service,...)	Traveller used Instant Mobility service for multi-modal journey	
UC1A.08	**Cancel planned journey** The traveller wants to cancel his planned journey.	Traveller decided to cancel his planned journey		Should lead to cancel remaining tickets, committed resources

UC1A.09	Traveller request a journey from origin to destination, from favourites or from scratch or from historical journey			Should lead to cancel remaining tickets, committed resources
UC1A.10	Instant Mobility Registered User Management : Lifecycle of a registered traveller in the Instant Mobility System	Traveller want to register		Traveller has registered to the Instant Mobility system
UC1A.11	At a given time, the traveller wants to change a parameter of his previous forecast journey		Previously defined future journey exists	
UC1A.12	Update remaining travel segment			
UC1A.13	Either : update the current journey or in the same operation cancel it and ask for a new one reusing some information from the cancelled journey.			
UC1A.14	Compute Rating for Statistics	A new journey has been rated or daily trigger	Some journey have been rated	Statistics about journey rating available
UC1A.15	The purpose is to use the previously planned future journey (and in particular the resources committed) as a basis for the planning of the immediate journey. This includes any kind of modification of the previously planned journey (changing destination, time, etc.)	This is needed when reservation or pre-payment exist coming from a future journey plan.	Future Journey Plan	
UC1A.16	Evaluate optimal itinerary depending on			

	user profile and preferences			
UC1A.17	Example information that has to be defined in a travellers profile will deal with (non-exhaustive list): • constraints : baby, children, several persons, luggage, animal, handicap • the preferred transport modes: pure ride sharing route, mix public transportation and ride sharing, no underground, route criteria: minimum time, minimum number of changes, experienced driver, driver already known by the user and validated by the user. ...			
UC1A.18	Schedule all the multimodal related travel segment and book the corresponding resources	The traveller has accepted the multimodal journey proposal	Check traveller solvability (payment capabilities in pre paid mode)	
UC1A.19	Monitor event in real time and check correspondingly if schedule still valid and act consequently			
UC1A.20	Commit resources needing reservation. Validate all pending reservation both for PTO means and drive sharing segments (including acceptation by all drivers of the proposed traveller). Any refusal cancels the whole planning	This short running process may be called at different steps to reserve different kind of resources (depending on their dynamicity)		

	and force requesting an alternative proposal.			
UC1A.21	Traveller accept the proposed journey, resources needing reservation or payment are booked.			Completion of this use case unconditionally start 'Execute Journey' UC
UC1A.22	This is not an optimized vision because dynamic resources are not known at this time			
UC1A.23	Traveller set his journey rating	A traveller journey is finished	Traveller execute a journey	Journey rating available for statistic
UC1A.24	Public authorities define their Transport policy : Traffic management, road closing, road tolling, ...			
UC1A.25	Allow long running process to get information about associated current segment (transfer information, etc, ...)			
UC1A.26	Some events could occur on road/rail segment : closed for work, special speed limit, one way, special event			
UC1A.27	Publish billing information	A traveller journey is finished		
UC1A.28	This planning includes temporary reservation of dynamic resources, waiting for acceptation by all the involved parties.	The validation of this reservation will be done when the traveller will accept the proposed		

		journey.		
UC1A.29	Process check-out event	A segment journey is finished		
UC1A.30	Process check-in event Record check in and execute any synchronous actions related to this event			
UC1A.31	(Un)Subscribe services Subscribe to the Dynamic Multi-modal Journey application			
UC1A.32	This estimate will be mostly based on standard prices for the various PTO and eventually using some statistical info			
UC1A.33	Driver will consult traveller rating Traveller will consult driver or PTO rating			
UC1A.34	Cancel booked parts of travel like long distance train, plane, ... Committed resources may be : shared drive, taxi request, ... without considering pre payment			
UC1A.35	Manage Profile Record or update user preferences and profile			
UC1A.36	Add journey to monitor Add journey to the monitoring system for automatic tracking and follow up			

UC1A.37	Like camera tracking session, silent alarm, ... including call for emergency/assistance			
UC1A.38	Get profile information Get profile information to compute current most appropriate context information			
UC1A.39	Manage User Profile Subscription/registration Unsubscription/unregistration Set up and update personal profile (inherent parameters)	User want to (un)register to Instant Mobility Service	The system is up and offer an entry point for end-user registration Possible entry values : • payment preferences • mobility preferences	The user is registered to the Instant Mobility service
UC1A.40	Remind traveller of beginning of travel The system Instant Mobility warns the user that his trip is about to start	The journey is going to start	During his trip planning the traveller has chosen the option to be notified on the starting of the journey	The traveller is informed of the imminent start of his journey
UC1A.41	Alert on event on planned future travel If the user choose it in its preference, the system send him an alert when it detects that an incident (e.g. strike announcement, weather storm, ...) compromises his planned journey : risk on cost, on departure or arrival time,	An event (certain or potential) on one of his travel segments threaten his trip	The traveller has planned a future journey and the Instant Mobility system monitors it	The IM system won't take any initiative and will let the user decides if he wants another journey planning or to cancel or to maintain his trip.

	duration of travel, others...			
UC1A.42	Monitor planned journey Monitor traveller planned journey to warn the traveller on events on his future planned journey and remind him of journey starting	Future journey planned	The traveller has planned a future journey	The traveller is informed of the imminent start of his journey or that an event has compromised his journey

3.3.1.2.4 Journey Charging

All along the journey, the traveller will be charged for the use of the transport means he "consumes".

To avoid harass the traveller with plenty of tickets and to adjust to the proposed dynamic scheme the Instant Mobility system will manage an integrated ticket concept.

Payment is a key topic in multimodal travel and will be mostly based on the use of mobile phones. The enablers will provide basic means to:

- Pricing. When a multimodal travel is proposed to a traveller, the correct price for every segment of the proposed trip and the total trip price have to be provided.
- Billing. As the trip is dynamically adjusted during its execution (on-the-fly), the effective price for a segment can only be known after segment termination. This implies that the segment execution must be determined using all the possible means available to monitor the traveller's trip. This includes for instance check-in and check-out mechanisms to implement pay-as-you-go policies as well as anonymous location matching with respect to expected route.
- Virtual Ticketing. Electronic proofs of payment must be loaded into mobile phone and accessed on-the-fly by the transport operator infrastructure for passing gates or allowing control operations.

This set of enablers will be built on different components including:

- Mobile phones and proximity technologies such as NFC.
- Infrastructure components like on board NFC devices and Point Of Sales (POS) physical infrastructure.
- Platform based components.

Payments in Instant Mobility may be related to different situations including not only public transport but also other transport means, including ride (car and bike) sharing, limited traffic area access or parking. In some cases the mechanism envisioned for payments, in particular proximity technologies can be used for other scopes that don't imply direct money exchange like accumulating "green points" (for tax rebate mechanism) or access with special permission to limited areas.

One of the most interesting innovations that Mobile Payment enablers will foster is the possibility to make a single payment for a multimodal travel.

Nowadays multimodal ticketing, that is better known as integrated ticketing, is based on the idea that the transport operator that issues the multimodal ticket should make an agreement with any other transport operator possibly involved in the multimodal journey; this is very difficult to carry out and for this reason integrated ticketing is seldom implemented.

To overcome this trouble, the Instant Mobility multimodal ticketing service will relieve transport operators from the burden of reciprocally interfacing because it will act as an intermediate actor between them and the traveller.

When the traveller has found the optimal route with the help of the Multimodal Traveller Companion service, he/she will make a single payment operation to the Mobile Payment service to buy the full set of tickets needed for the journey; the Mobile Payment service will then buy the virtual tickets from the various transport operators and will send them to the traveller's mobile terminal.

In this way the traveller's user experience will be easier and greatly simplified.

The traveller use case related to payment is represented below.

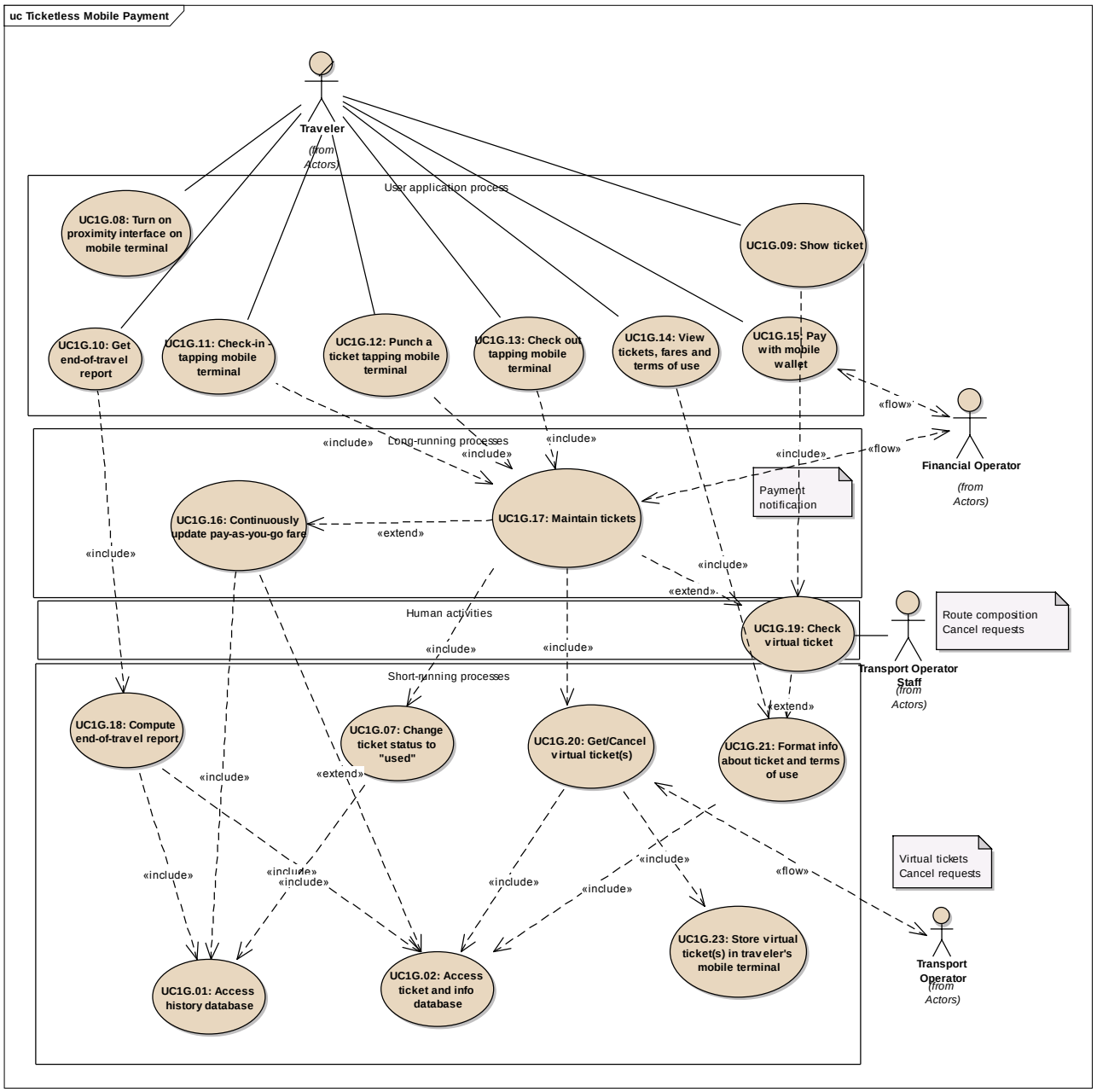

Figure 16: Ticketless Mobile Payment

Use case	Goal	Trigger	Pre-condition	Post-condition
UC1G.01	Access historical database		Database exits and is well maintained	
UC1G.02	Access ticket and info database		Database exits and is well maintained	
UC1G.07	Change ticket statue to ‘used’		Tickes issued	
UC1G.08	Turn on proximity interface on mobile terminal			
UC1G.09	Show ticket	On-board personnel wants to check or punch traveller’s virtual ticket.	Virtual tickets are available in traveller’s mobile phone.	When applicable, virtual ticket is punched (state is switched to “used”).
UC1G.10	To provide to traveler information about final fare, travel time, green credits etc.	Traveler has just finished the travel or a travel leg.	A travel was going on.	The travel's data are stored in history database for future reference.
UC1G.11	To regularly get access to the transport mean	Traveller boards on a pay-as-you-go-priced transport mean, whose price depends in some way from parameters like distance, time etc...	The traveller's mobile terminal contains data that allow the transport infrastructure to trust the traveller (booking, subscription ,etc.).	The traveller's presence on transport mean is stored in the history database.
UC1G.12	To regularly get access to the transport mean	Traveller is boarding on a fixed-price transport mean that must be paid punching a single ticket.	There is at least one ticket available in traveller's mobile terminal.	The ticket status changes from "available" to "used" state in traveller's terminal and in history database.
UC1G.13	To notify the end of the travel's leg	Traveller is leaving a pay-as-you-go-priced transport mean, whose price depends in some way from	Traveler boarded on the transport mean executing a regular check-in (see UG1G.13	The end of traveller's presence on transport mean is stored in the history database.

		parameters like distance, time etc...	"Check in tapping mobile terminal").	
UC1G.14	To provide travel with constant control of past, present and future travel's legs	Traveller wants to review the tickets/bookings stored in his/her mobile terminal and any possible associated info.	Traveller's tickets, bookings, subscriptions are stored in "Ticket and info database".	No change.
UC1G.15	Pay with mobile wallet stored in traveler's mobile terminal.	Traveller wants to book a (multimodal) travel.	Fares calculated from forecast itinerary	Mobile wallet debited from fare value.
UC1G.16	Continuously update pay-as-you-go fare.	The traveller made an action relevant to billing computation in a pay-as-you-go service.	The traveller is using a pay-as-go transport service.	History, ticket and info databases are conveniently updated. When applicable, billing update is sent to traveller.
UC1G.17	To trace all events that are relevant to ticketing and billing and take the consequent actions	The traveller made an action relevant to ticketing or billing computation in a pay-as-you-go service.	Virtual tickets and any other relevant information are stored in service databases and in traveller's mobile phone.	Information on traveller's mobile phone and in service databases are conveniently updated.
UC1G.18				
UC1G.19	A Public Transport controller should be able to control traveller tickets.	Traveller boards on a transport mean.	The traveller's mobile terminal contains data that allow the transport infrastructure to trust the traveller (booking, subscription ,etc.) = virtual ticket	
UC1G.20	Get/cancel virtual ticket		Virtual ticket is purchased	
UC1G.21	Format info about ticket and terms of use			

UC1G.23	Store virtual ticket in traveller's mobile terminal		Virtual ticket is purchased	

3.3.1.3 User experience flow

The following BPMN flows detail specific user processes, related to the update of his itinerary, the transfer and En-Route assistance, his travel execution, the itinerary setup and the consideration of his specific needs.

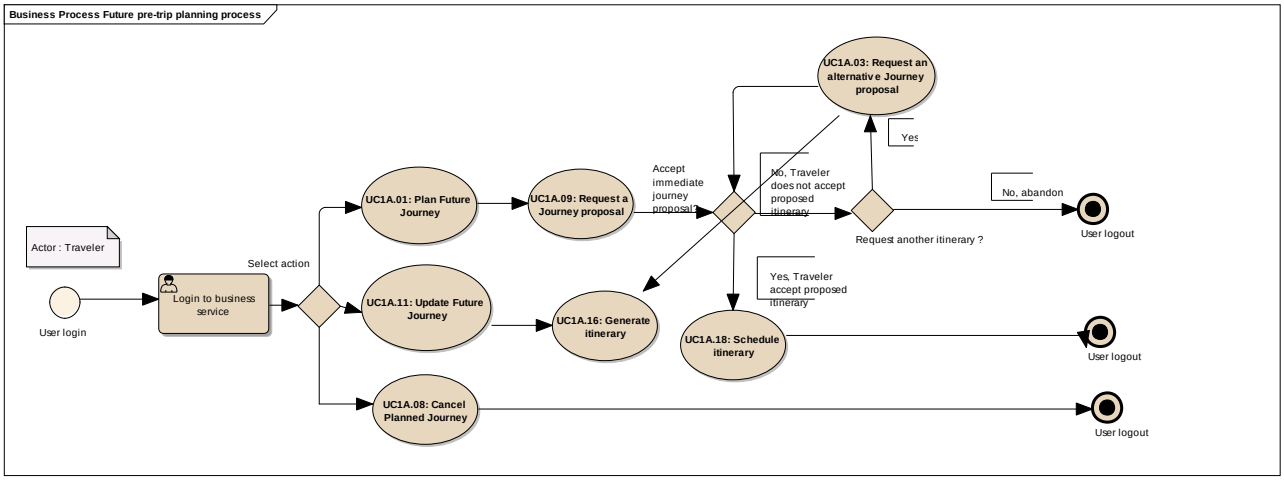

Figure 17: Future pre-trip planning process

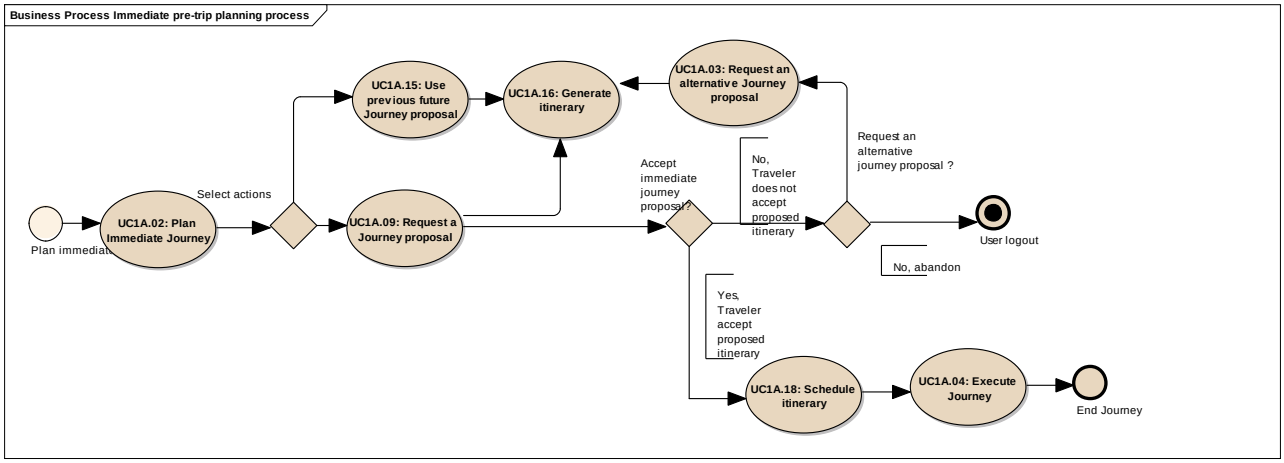

Figure 18: Immediate pre-trip planning process

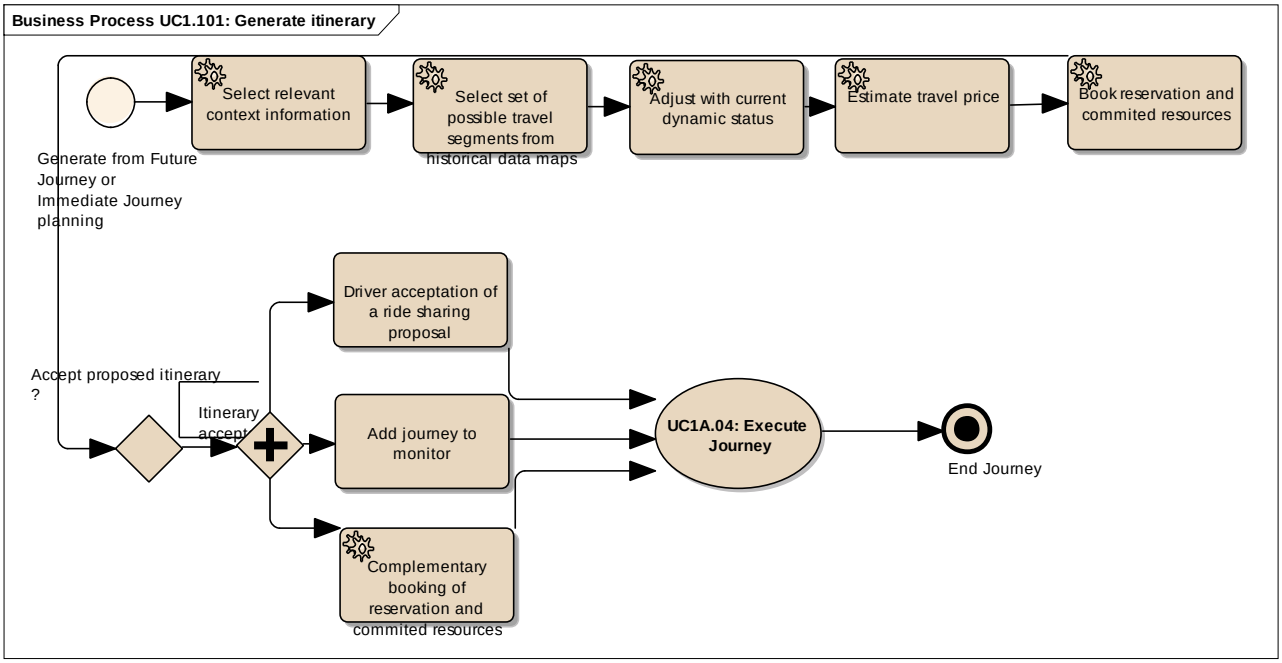

Figure 19: Generate itinerary

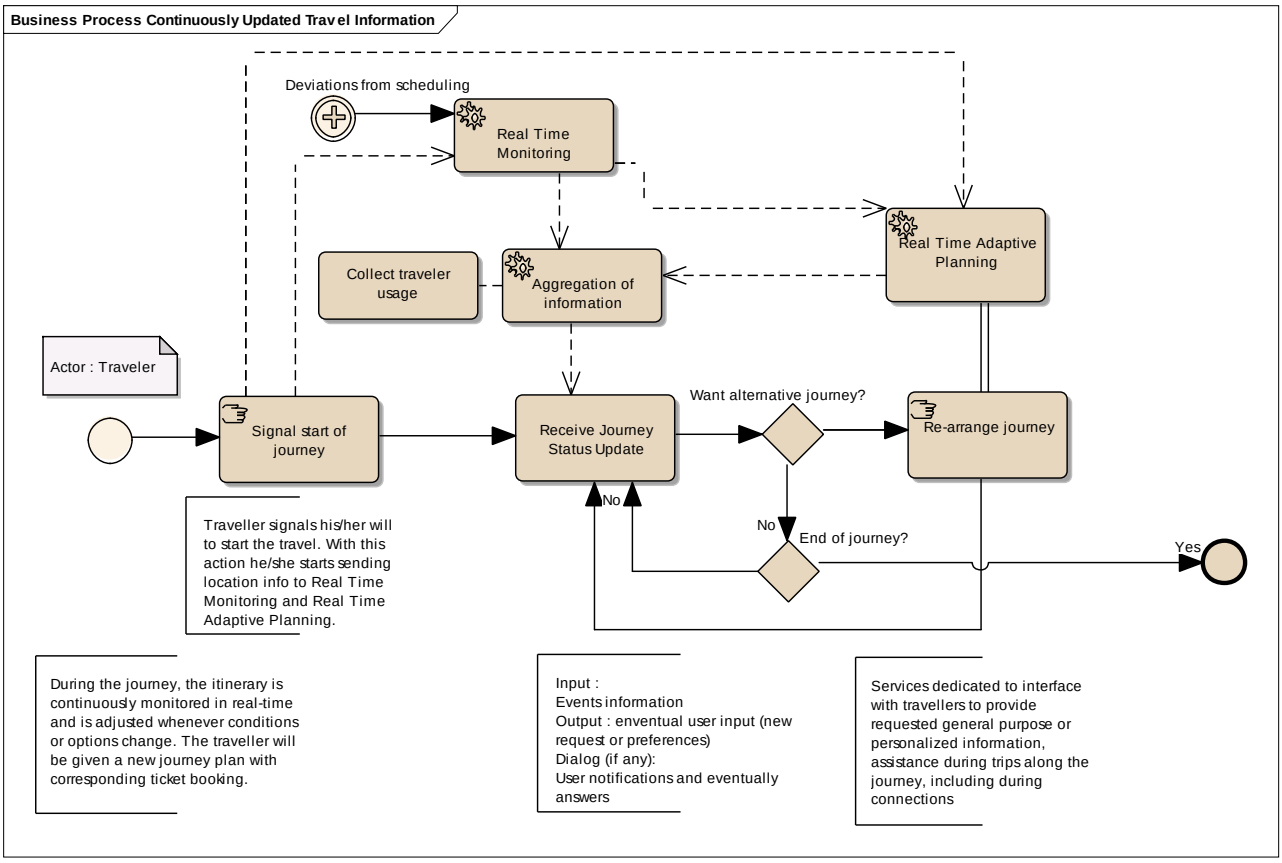

Figure 20: Execute travel

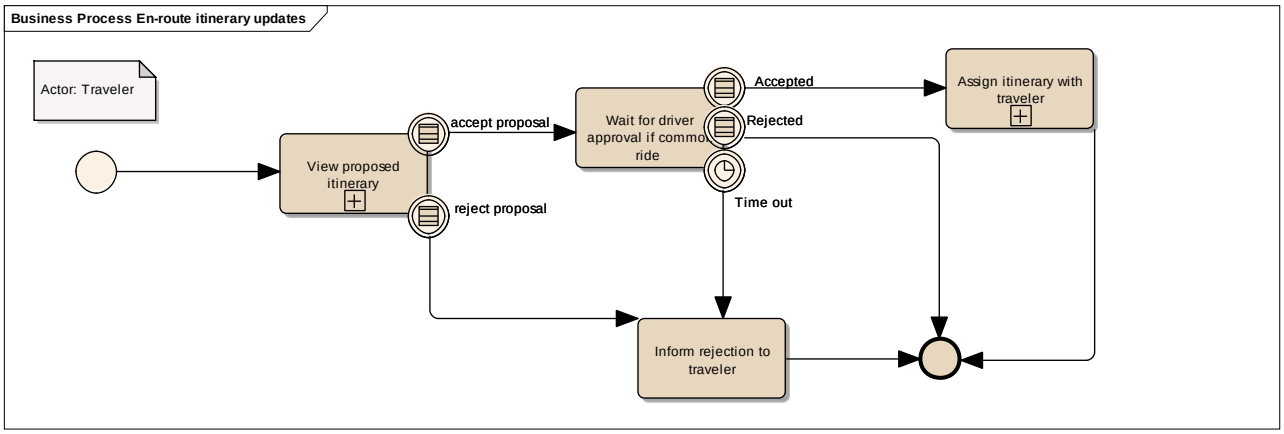

Figure 21: En-route itinerary updates

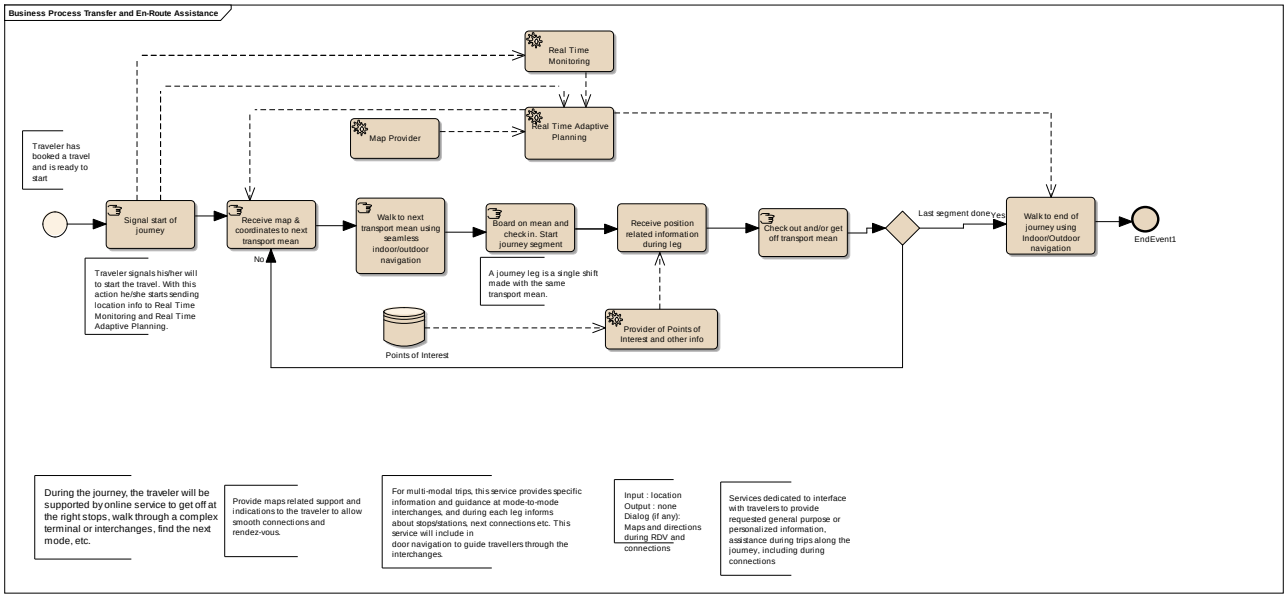

Figure 22: Transfer and En-Route Assistance

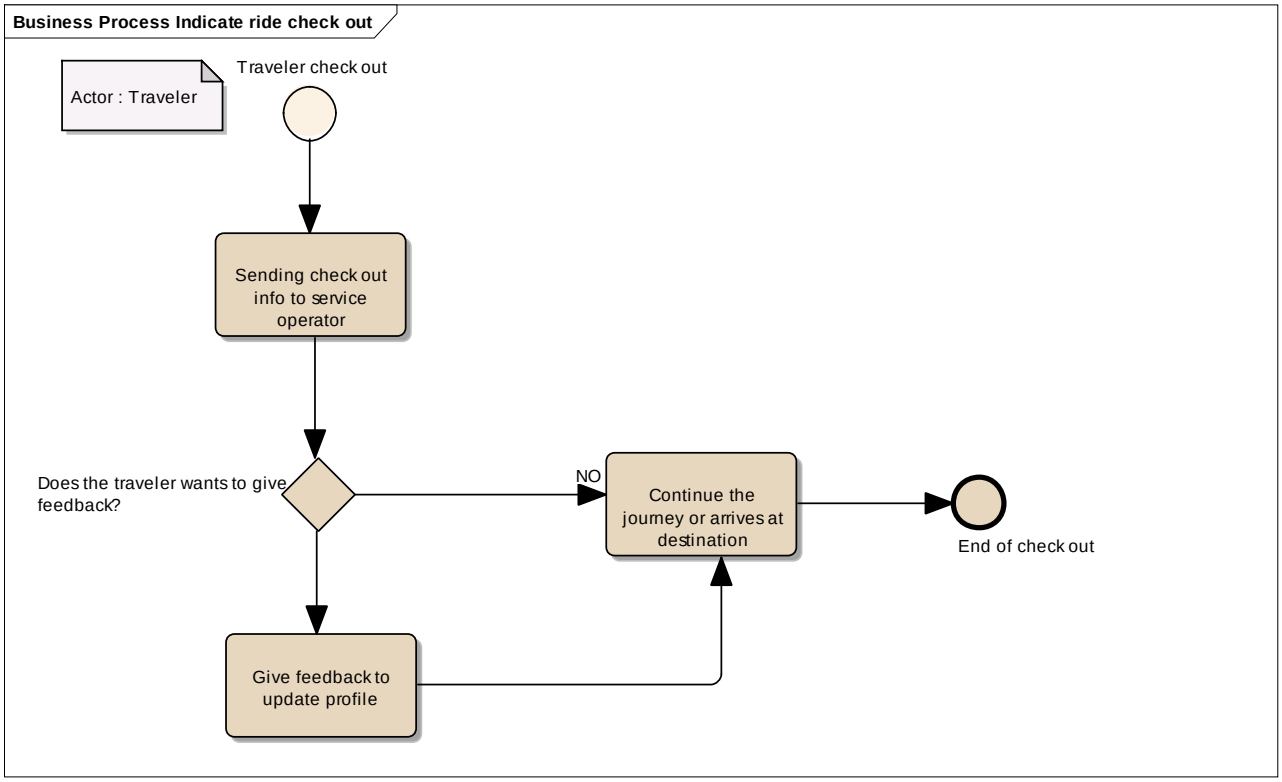

Figure 23: Indicate ride check out

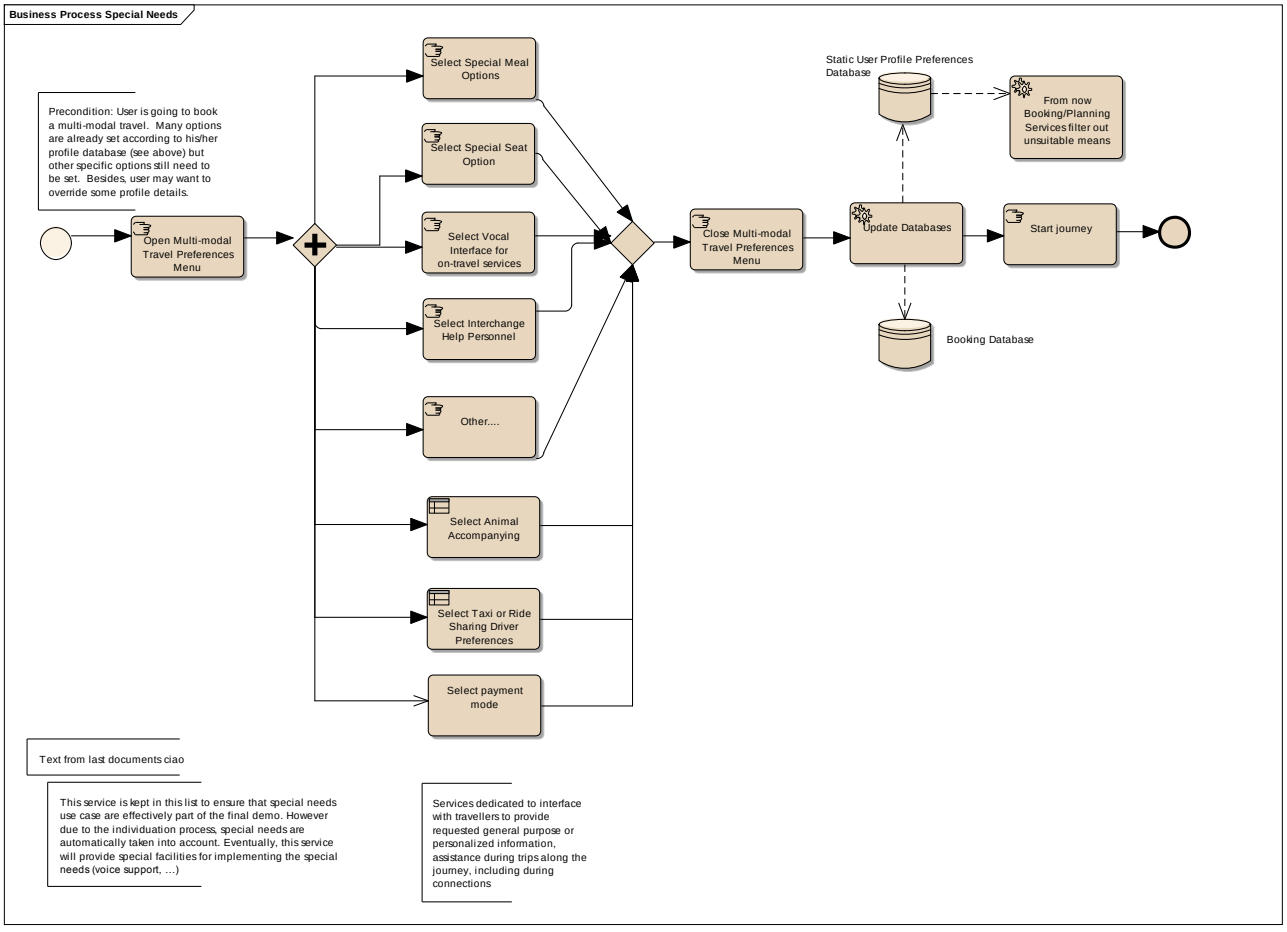

Figure 24: Special needs

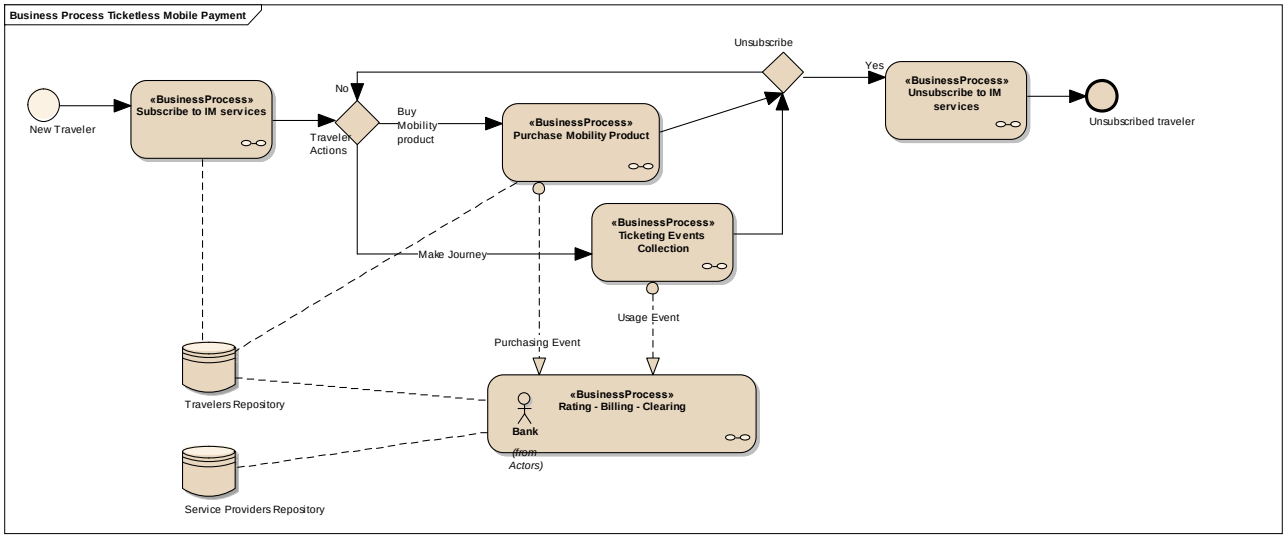

Figure 25: Ticketless mobile payment

The ticketless mobile payment use case details the processing that is relative to payment of the trip, ticketing and billing.

3.3.2 Dynamic ride sharing application

3.3.2.1 Description

This application implements the driver view of the *Personal Travel Companion* scenario. As the purpose of INSTANT MOBILITY is to greatly favour common ride as the most immediate mean to enhance urban mobility, the driver view and ride sharing facilities are an essential aspect of the multi-modal journey facilities and thus of the *Personal Travel Companion* scenario.

For the sake of clarity, let's define a common ride as a travel segment executed by a traveller using the transportation capacity of a car driver (either professional or private), while this driver is on his way to its own, personal destination. This is different from a shared car where both the driver and the traveller agrees in advance on an itinerary and where the driver will eventually fetch the traveller at some pre-defined location outside of the normal itinerary to go to its destination.

Common ride case is useful for on-the-fly pick-up of a traveller by a driver on his way to some destination, while shared car is useful for prepared long distance trip where cost sharing is more important that immediate travel.

The shared car case is also necessary for dynamic time/place pick-up point use case. This case addresses the case where a driver accepts to share his journey. This driver receives early information about the time and location proposal for a traveller that desires to travel to the same destination. He can accept the itinerary change and the traveller, and may receive compensation for this. In Instant Mobility, this is done in UC 1B.07 and is a special case of the more general and frequent Common ride case.

Common ride (essentially a service for private drivers) will correspond to the following sequence:

- Initially a private driver provides its destination to the IM itinerary system. This is independent of any common ride issue. An optimized itinerary is provided to the driver on the basis of the system overall knowledge of the traffic.
- The driver accepts the itinerary. In return to this acceptance (meaning that he agree to follow the proposed path to its destination), he will get updates and news regarding traffic issues.
- Once the driver has accepted the itinerary, he may at any time declare to the IM itinerary system his acceptance to get Common ride proposal from the *Personal Travel Companion* system. In a first version, driver route adjustment is not envisioned
- The system will then add its vehicle to the available sharable vehicle set and the vehicle OBU will start reporting periodically its position until reaching its destination.
- During the trip, Common rides (for all or parts off the driver itinerary) with traveller(s) are proposed to the driver with the rating of the proposed traveller(s).
- For each agreed proposal between the driver and the traveller, the application manages all the Common ride(s), i.e.: the meeting points, the check-in and check-out, the in-journey security and the billing.

The *Dynamic ride sharing* application also aims at managing shared cars. This means that the system will manage the *sharing of a vehicle* between multiple successive drivers (independently of the common ride case) by allowing the rendezvous between a previous and a next to come driver and the handover of the car, including the various checks of car status, etc. shared cars would be extremely useful for rental car companies or city provided electric vehicle fleets.

However, as car sharing needs special facilities for car pick-up and deposit, in particular car collection and drop-off zone for the initial and last driver of a sequence. For this reason, Shared cars will not be specified in the first version of the *Personal Travel Companion* application but are an important optional case to be provided by specific stakeholders (like rental car companies, etc.)

Taxi drivers are another special case of the *Dynamic ride sharing* application. For stability reason, the need to fix the itinerary of a driver willing to provide common ride was previously described:

- Because, by definition an empty taxi is supposed to meet a customer either at a jump-in point (a taxi station) or at a dedicated pick-up point, the rendezvous mechanism for an empty taxi will be based or time or cost for it to reach the traveller pick-up point.
- For no-empty taxi, i.e. taxi having already passenger(s) going to one destination, there is an implicit contract of “best effort” between the taxi driver and its passengers. Taxi sharing is still possible in that case but will only be managed by the system using the fixed itinerary proposed to the taxi driver in the more general multi-modal planning of its existing passengers.
- Of course a direct negotiation is always possible between a taxi driver and its passengers. Such a case should also be managed by the *Dynamic ride sharing* application as well as by the *Personal Travel Companion* for adjustments of the traveller planned multi-modal journey.

All this explain that a dedicated service for taxi handling is needed. Such a service may be an optional one relying on the Instant Mobility platform and not necessarily included in the first version of the *Dynamic ride sharing* application.

3.3.2.2 Functional decomposition

The Dynamic Ride Sharing application is both a complement of the *Dynamic Multimodal Journey* application and a working application in itself. Thus it implements the Driver viewpoint of the *Personal Travel Companion* scenario. From a planning perspective, three different user processes are offered:

- The capability to plan a dedicated Common ride as in any long distance pre-planned shared travel.
- The capability to plan an immediate road journey for which the driver will get an optimized itinerary
- The capability to accept an en-route Common ride offer by the system, provided that he previously asked for an optimized itinerary (for which he gets tracking and follow-up) and that he has declared is availability for Common ride offers.

This is described in the figure below.

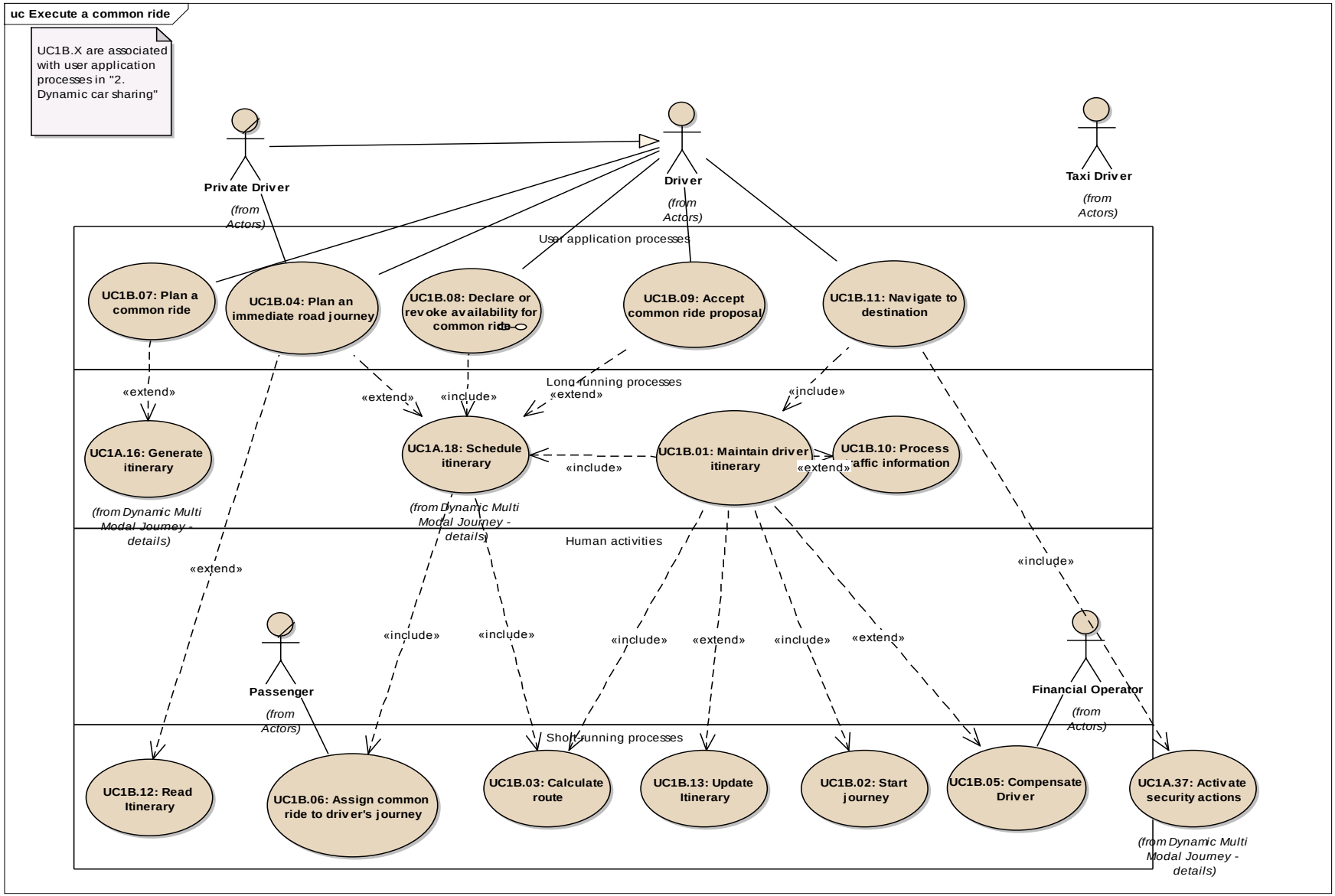

Figure 26: Execute a common ride

Use case	Goal	Trigger	Pre-condition	Post-condition
UC1B.01	Maintain driver itinerary To maintain the itinerary based on traffic information and events.	New traffic information	An itinerary has been setup for a traveller	Itinerary is maintained updated during the whole traveller trip
UC1B.02	Start journey To indicate the start of working on a transport itinerary		A transport itinerary has been assigned to a vehicle	The itinerary status has been updated
UC1B.03	Calculate route To calculate a route to a destination selected by the user	The user has selected "Navigate to destination"	The user has executed "Navigate to destination"	A route has been calculated.
UC1B.04	Plan an immediate road journey Give a destination and ask for an itinerary Driver publish resources available : number of available seats For private driver: The driver is considered as a traveller, and the system does not give him any constraint linked to common ride. The basis hypothesis for	The driver wants to make a journey.	The driver is registered to the Instant Mobility System. This driver previous travels are known and do not need to be published	Driver itinerary published

	private driver is that the system provides him with the optimal itinerary for his journey as would do a GPS system. Based on this itinerary is able to share part of his journey without having to adapt this itinerary (which remains optimal for the driver)			
UC1B.05	Compensate Driver Pay driver for the common ride	The driver has made common ride with at least one passenger	A passenger has made a common ride with the driver	The driver has been paid.
UC1B.06	Assign common ride to the current driver's itinerary	The driver has accepted a common ride	The driver has accepted a common ride corresponding to a passenger travel segment.	The contract between the driver and the traveller is validated
UC1B.07	Plan a common ride Allow the driver to share his journey in advanced for sharing cost, etc ...	The driver informs the system of his willingness to accept in advance future common ride proposal.	The driver is registered in the IM system	The system include this journey in the common ride list of resources
UC1B.08	Declare or revoke availability as common ride resources	The user selects to share his/her itinerary and vehicle The driver informs the system of his willingness not to accept any more common ride proposal. This does not cancel currently accepted or executing one.	The driver has started a journey whose itinerary has been proposed by the system and the vehicle is therefore being tracked The driver has previously declared availability for	The itinerary information is available to the system The system cancels it from the list of available resources for new ride only.

			common ride	
UC1B.09	Accept common ride proposal Receive system proposal for common ride at any given time. Get a proposal for a traveller (his rating, ...) and accept or refuse it.	System found a possible match	A passenger asks for a journey partially corresponding to the driver's one.	The user has accepted or rejected the common ride offer.
UC1B.10	Process traffic information To receive traffic information from several sources such as DAB, floating car data, floating device data and apply the data to the route calculation.	A new traffic event occurred		The traffic information has been applied to the itinerary planning.
UC1B.11	Navigate to destination To receive route guidance to a destination	The user selects to navigate to a destination		The user starts to receives directions from the navigation system
UC1B.12	Read Itinerary Read data from shared itinerary	An itinerary has been shared or updated	The passenger has shared his/her itinerary	Itinerary data has been read
UC1B.13	Update Itinerary Update an itinerary with a new pickup/drop-off point	The driver has changed the pickup/drop-off point for a passenger	The driver has changed the pickup/drop-off point for a passenger	The itinerary has been updated

3.3.2.3 User Experience Flow

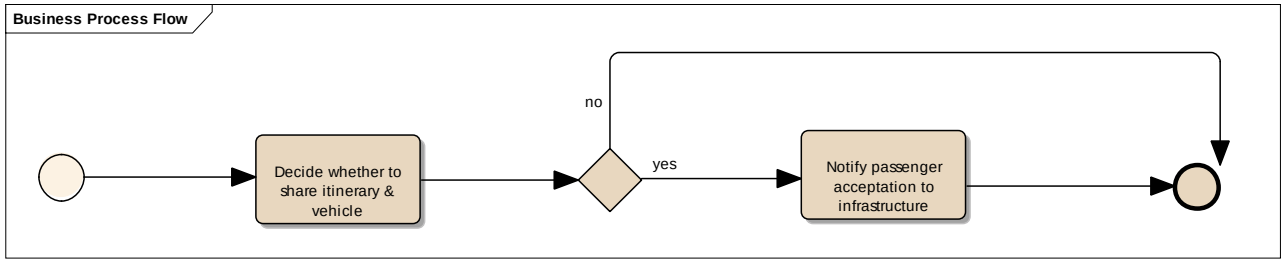

Figure 27: Declare or revoke availability for common ride

3.3.3 Optimized public transport usage

3.3.3.1 Description

The traditional Public Transport Operators will continue to act as key players for collective transport. The concept of collective transport has widened and in it the transport operator may act as a flexible mobility services provider within its radius of action.

Service flexibility is improved by federating complementary offers (such as with taxi companies for taxi sharing, car sharing or car pooling), around the traditional PTOs offering a one stop shop for collective travel.

The collective travel offer of the future is also envisioned to be seamlessly extendable by European-wide cooperation to the geographical and functional areas of responsibility of other (regional) transport operators.

This application expresses a vision where collective transport operators, either public (bus, metro…) or private (car sharing or taxi sharing managers) in the future will use Internet to sense passengers' presence at stops and to register their destination, to offer innovative online services flexibly to match their vehicles, timetables and even routes to the actual demand.

The transport operators will get the set of individual travelling plans corresponding to the set of transport service they will have to provide. Those services either match fixed routes & timetables, or flexible journeys such as On-demand Transport.

Additionally, they are able in real-time to know the position of Instant Mobility passengers, to monitor occupation and vacancy of their own stations & stops and vehicles and to detect any service disruption, evaluate corresponding time delays and previsions to recover normal service.

3.3.3.2 Functional decomposition

Currently this application is only defined as a support application of the Traveller and drivers applications and the overall scenario.

Some simple functions are described to enable multimodal-traveller oriented information exchange between PTO's (itineraries and timetables, effective position or delays of individual means of transportation,etc.). A more far-fetched goal would be an effective demand-driven resources management for PTO's.

Therefore most of the application relies on two functions:

- Update optimization transport strategy
- Publish Timetables and prices

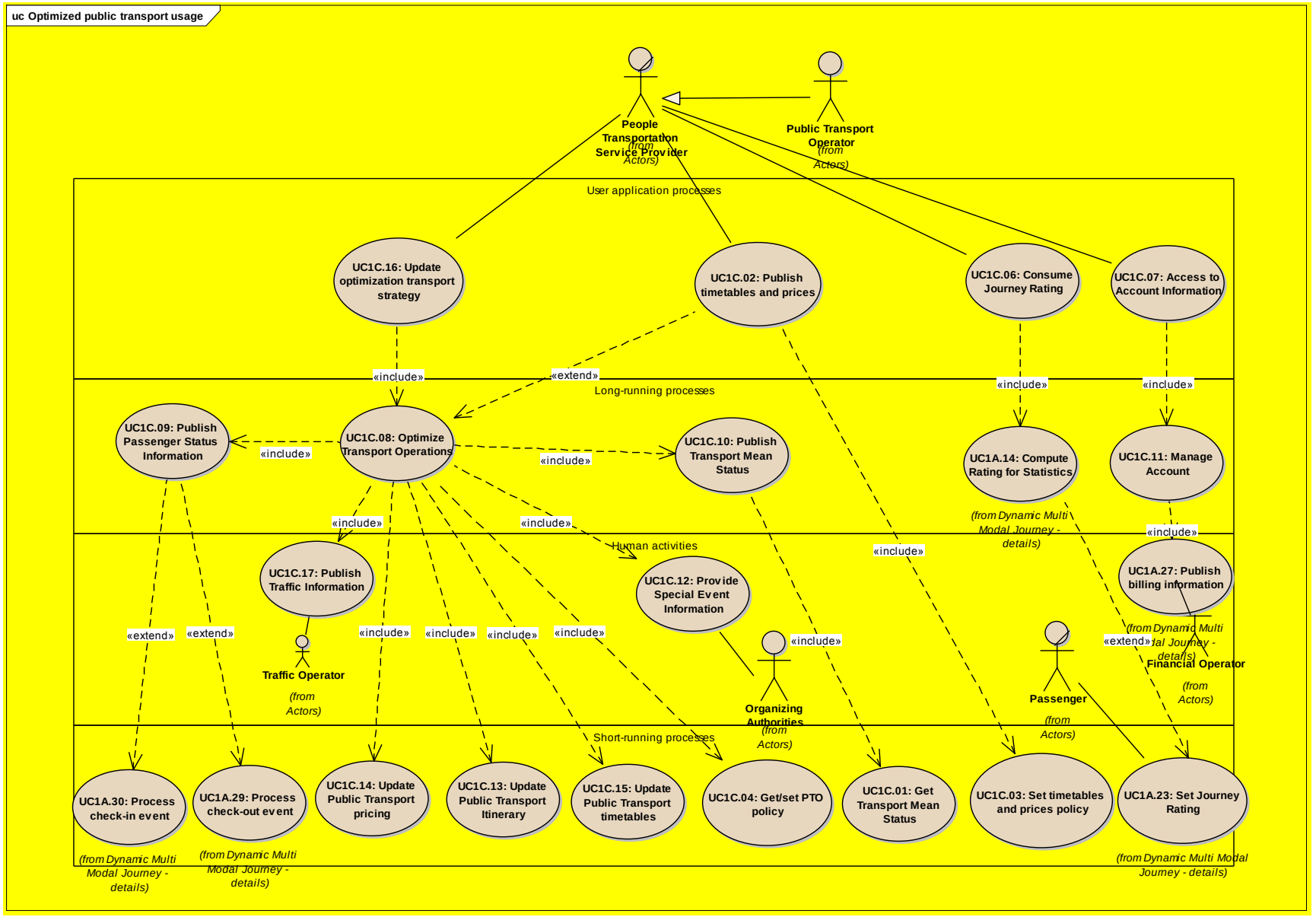

Figure 28: Optimized public transport usage

Use case	Goal	Trigger	Pre-condition	Post-condition
UC1C.01	To get information about each transport means belonging to the PT operator	PTO wants to publish transport mean status		
UC1C.02	PTO (re)schedule planning and itinerary of a Public Transport Vehicle to take into account (new) information about Passenger (valid only when doing demand based optimization)	A planning or a price has changed from previous situation	PTO has established timetables and prices for PT itinerary	Timetables and prices are up to date
UC1C.03	Define timetables and prices policy.	New timetable or price defined		
UC1C.04	Get/set PTO policy			
UC1C.05	Provide official information by PTO	A new information is available		
UC1C.06	Consume Journey Rating : PTO want to know how was the Passenger QoS feeling about its trip.		A passenger has rated the PTO or one segment travel operated by the PTO	
UC1C.07	Manage PTO accounting			
UC1C.08	Dynamically optimize transport operations by adding or removing transport mean depending on demand or on external events.			
UC1C.09	Publish Passenger Status	This information is derived from		

	Information This allows to precisely correlate passenger position and current transport mean.	check-in/check-out automatic operation PTO		
UC1C.10	Publish Transport Mean Status			
UC1C.11	Manage Account			
UC1C.12	Provide Special Event Information Organizing authorities provide information about : strikes, big meetings, special sport/leisure events with crowd, ...	A special event occurs that can have an impact on the transport operations: more passenger flow, more traffic, ...		
UC1C.13	Update Public Transport Itinerary			
UC1C.14	Update Public Transport pricing Optimize prices with respect to passenger load			
UC1C.15	Update Public Transport timetables			
UC1C.16	Update optimization transport strategy Update strategy and rules based on usage evolution.	New real-time or statistical events occurred	A transport strategy is set-up	A new transport strategy is set up

UC1C.17	Publish Traffic Information Publich new traffic information on each road segment and new special events (for example accident, queue detected, ...)	New special events occurs (for example accident, queue detected, ...) or on timer		

4. Smart city logistics operations

It is well known that city goods distribution contributes to problems such as pollution, noise, congestions and unsafe environments within cities. However, if distribution vehicles would be used more efficiently it would theoretically be possible to reduce the amount of vehicles in city centres, thus at the same time reducing the magnitude of the problems caused. Better resource utilization also implies lower cost of transports or improved profit margins for the transport operators.

While using the vehicles more efficiently can be seen as a part of the solution to some of the problems caused, cities will in the foreseeable future still have to rely on distribution vehicles for the supply of goods to stores, material to institutions such as hospitals and the delivery of goods e.g. bought online by the city residents; it is thus not feasible to completely eliminate the distribution vehicles from the city centres.

The *Smart city logistics operations* scenario describes how transport operations can be improved with respect to safety, efficiency, environmental performance and quality of service. It considers pick-up and distribution operations mainly relying on the use of trucks or delivery vans and describes applications used during three phases of the logistics process, see Figure 29.

Figure 29: Phases of the logistics process

4.1 Objectives of the smart city logistics operations scenario

The scenario intends to provide benefits to actors and stakeholders involved in, affected by or dependent on the transportation of goods in urban environments. It describes a limited set of comprehensive Future Internet facilitated applications to enhance city logistics operations with respect to safety, efficiency, environmental performance and quality of service to the end-users of the distribution system.

The main problems addressed are outlined below and often influence each other:

- *Traffic congestions within the city centres and the urban area which amongst other makes delivery times unpredictable and may stress the drivers*
- *A busy traffic climate creates an unsafe environment for the cities' residents*
- *Air pollution (NOx, SOx, CO_2, etc.) and noise pollution within cities caused by distribution vehicles*
- *Consignees of online orders are not at home when the transport operator tries to deliver or is asked to stay home for a substantial part of the day of delivery*
- *Low profit margins in the transport sector*

By addressing the mentioned problems, the scenario in essence aims to:

- *Contribute to sustainability in urban transport operations, not only from an environmental perspective but also from a social and financial perspective*

- *Reduce congestions, noise and environmental pollution caused by urban transportation*
- *Enhance the end-customer quality of service through transport flexibility and adaptability*
- *Improve the competitiveness and profitability of scenario application users (cargo owners, transporters, 3PL, cargo receivers, etc.) through enhanced efficiency*
- *Enhance the mobility and quality of life for urban dwellers and society*

4.2 Applications based on services in D3.1

The *Smart city logistics operations* scenario is mainly based on some of the ideas and services from the *Trucks and the city* scenario described in the preliminary scenario document (D3.1) supplemented by services and ideas from other scenarios in the same document. Compared to D3.1 services have been merged and their functionality slightly changed and enhanced.

The scenario features four applications with clearly defined scopes. The selection of services is based on that they shall bring something new compared to what has been done in previous projects and to what is commercially available and that they shall promote more dynamic and efficient transport operations. A rough outline of contributing D3.1 services for each application of the scenario is provided below:

- *Load sharing and optimising*: D3.1 – Service 4a
- *Dynamic time/place drop point*: D3.1 – Service 4e
- *Itinerary booking and real-time optimized route navigation*: D3.1 – Services 2b,2c,4h
- *Eco-optimised driving, vehicle and driveline control*: D3.1 – Service 4i
    - This service has lots of new functionality compared to D3.1 – Service 4i related to vehicle and driveline control.

The next section will further introduce the scenario and provide richer descriptions of the applications including their functions and logic.

4.3 Description of the scenario and applications

Urban and inter-urban delivery systems depend on good communication and access to information in order to be effective, efficient and to tackle the other problems outlined above. Enhanced communication and improved access to information can be realized through Future Internet capabilities.

By transforming freight vehicles such as trucks and vans, goods items, containers and other logistics units into components of internet of things, more detailed and accurate information can be provided in real-time. Being able to detect and monitor all various kinds of vehicles, goods items and logistics units facilitate better coordination and enhancement of activities such as goods-consolidation.

To transfer data securely and ensuring the robustness and reliability of data is key ingredients of an improved transport system. Large bandwidth and high computational power are also a prerequisite for communication and processing of the large amounts of data needed while e.g. location awareness and smarter search algorithms ensure that information presented and data used for decision-making is relevant to the recipient.

By distributing intelligence all the way down to the vehicles and allowing for peer to peer communication, more flexibility and adaptability can be ensured to coop with e.g. changing prerequisites and unexpected events. All these new possibilities should lead to great opportunities for service and business model innovations and provide the foundation on which new, better, businesses can develop and prosper.

Scalability of the system, allowing for a growing number of users without the need to review architectural fundamentals, and taking benefits from cloud resources to manage increasing computing capability requirements is also important aspects of the Future Internet and to the development of services which can be adopted by everyone.

To summarize, the following FI capabilities are seen as important to solve the identified problems:

- *Internet of things allows for real-time transmission and processing of data*
- *Large bandwidth allows for large amounts of data to be communicated*
- *High computational capacity allows for large amounts of data to be processed*
- *Location awareness allows for better judgments of the relevancy of data*
- *Peer2peer communication allows for ad-hoc connectivity*
- *Cloud computing and scalability is key to be able to cope with a large and growing amount of users*

A more detailed description of the *Smart city logistics operation* scenario's applications including their inherent logic and functional decomposition (represented as use cases) is provided below.

4.3.1 Itinerary booking and real-time optimized route navigation

4.3.1.1 Description

The *Itinerary booking and real time optimized route navigation* application provides key functionalities to the scenario which in particular the *Load sharing and optimizing* and the *Dynamic time/place drop point* applications rely upon. That does however not necessarily mean that all parts of the application is very new or innovative in itself, much of the functionality presented can on the contrary be found in other projects and also in commercial products. Due to the application's central role in the scenario it is however considered justified to provide a comprehensive description of its functionality.

The main goal of a logistics provider or express courier company is to maximize the satisfaction of its customers. Customer satisfaction can be reached by guaranteeing quick and especially on-time deliveries at a low cost. The cost is mainly influenced by fuel and time consumption; in order to minimize both these parameters it is fundamental to optimize the movements of the vehicles, avoiding them to be blocked in traffic jams and taking, when possible, the shortest routes. Given the highly dynamic environment on the roads, especially in an urban environment, it is very important to have updated information in order to maximize the efficiency of the fleet and of each vehicle.

Many times the itinerary of a vehicle can be planned in advance, at least at a high level. The planned itinerary can, further, be communicated with the traffic operator. The itineraries that the traffic operator receives can be used to provide better predictions of the traffic situation during different times of the day. Such predictions should be used by the transport planning system as a parameter when planning subsequent itineraries in combination with other knowledge of the

actual and expected traffic conditions, e.g. considering rush hours, traffic jams at the requested time and for the specific day of the week, special events like concerts, sport matches, and so on. In this way the likelihood that the distribution vehicle avoids traffic jams increase. The itineraries the traffic operator receives can also be used for enhanced traffic flows through better traffic light control.

Once the itinerary has been created, the Transport planner can view it and verify if it satisfy all the desired needs; if it is ok, then it is confirmed by the Transport planner and it is stored for the transmission to the on-board system and to the traffic manager for better traffic predictions. If no particular events occur the distribution vehicle is supposed to reach the planned destinations in the shortest possible time; but sometimes unpredictable events occur. This could be the case of accidents or particular car breakdowns, but even roadwork needed because of sudden needs.

Since the main goal is to minimize the time to complete the deliveries, it is very important to avoid such unforeseeable events. In order to accomplish to provide a complete service, it is fundamental to integrate the Itinerary booking service with a real-time traffic route navigation service. The aim of this service is to modify in real-time the routes planned and booked for a vehicle in case of any unforeseen event; the on-board navigation system shall then be able to present the modified route without the Driver even notice the change. With the interaction with this service, through the vehicle internet connection, the navigation system provides the Driver with directions based on real time information about the traffic situation near the vehicle. The information which the system bases its routing decisions upon comes from various sources such as traffic planners and the emergency service, but also from other vehicles equipped with compatible systems.

Following this paradigm the vehicle is not only an information user, but it acts as a probe for the traffic and road condition, behaving also as an information source for the real-time optimized route navigation service provider. Therefore the data from other vehicles in the vicinity of the distribution vehicle provides accurate information on the traffic situation. Information which the vehicles communicate is for example their average speed and break/throttle usage. The infrastructure itself can also provide useful information. The information is aggregated and used to provide the most efficient route, taking into account e.g. fuel economy, time consumption and the risk of accidents, compared to what was originally planned.

Depending on the real-time traffic situation, even the itinerary may be updated. On-going missions can be re-planned to minimize the impact on the overall schedule. It may be possible to let another truck to take care of one or some of the pick-up/drop-offs originally planned for the first truck or to re-arrange the order of the stops to, as far as possible, avoid arriving late to the different destinations. If traffic runs smooth it may even be possible to add stops to the itinerary based on new customer requests.

4.3.1.2 Functional decomposition

The functional decomposition of the *Itinerary booking and real-time optimized route navigation* application is represented by use case diagrams outlining the different use cases required, see Figure 30 for an overview and the table for more detailed use case descriptions.

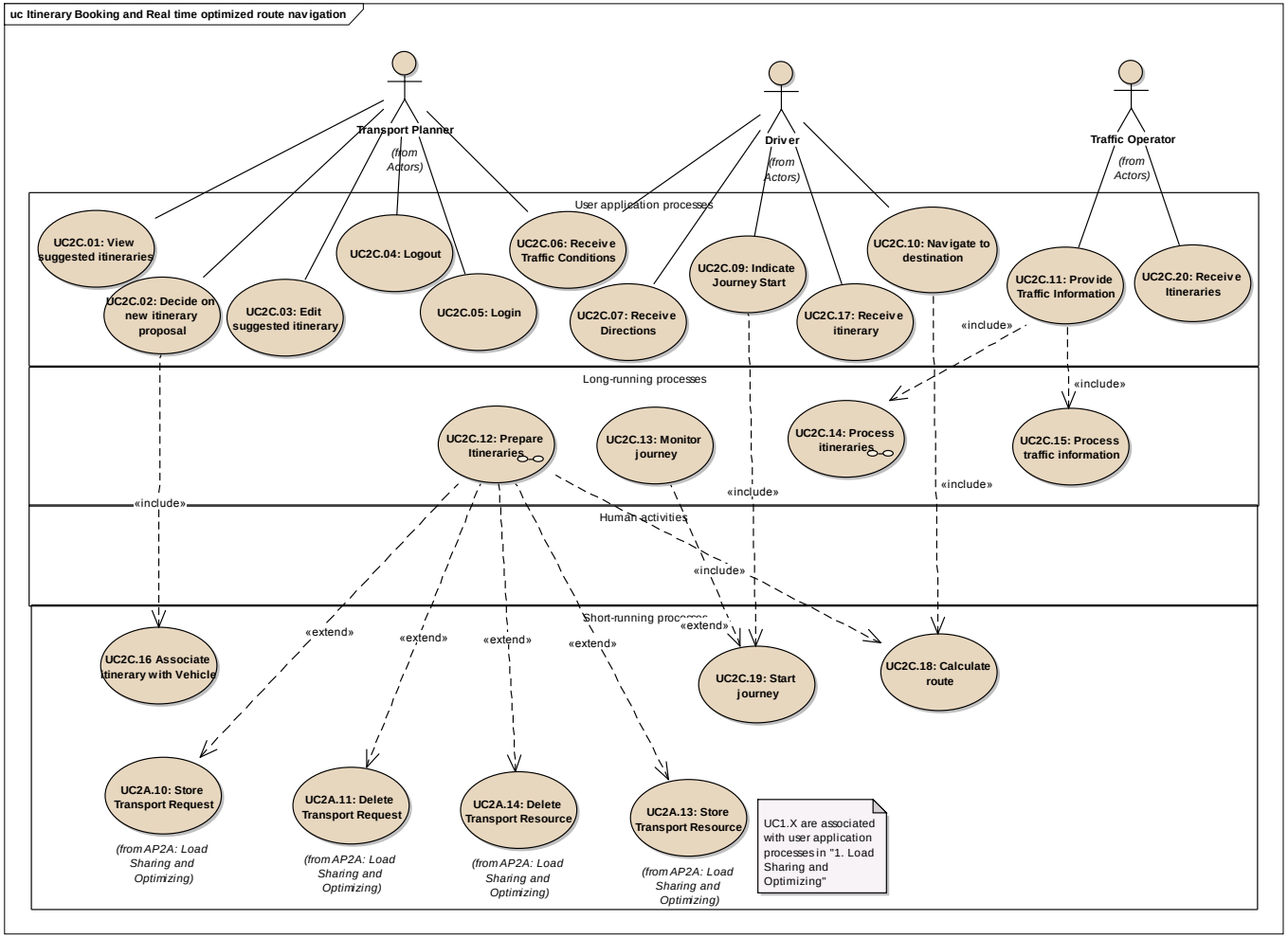

Figure 30: Itinerary booking and real-time optimized route navigation

Use case	Goal	Trigger	Pre-condition	Post-condition
UC2C.01	To view a list of suggested itineraries	The user selects to view itinerary suggestions	The user is logged in to the system	
UC2C.02	To accept a suggested itinerary	The user has selected to accept one of the suggested itineraries	The user is viewing the suggested itineraries	The itinerary has been assigned to a vehicle
UC2C.03	To edit a suggested itinerary	The user has selected to edit one of the suggested itineraries	The user is viewing the suggested itineraries	The itinerary has been updated and the other suggested itineraries which depends on the edited itinerary has been updated
UC2C.04	To logout from the system	The user selects to logout		The user is logged out from the system
UC2C.05	To login to the system	The user selects to login		The user is logged in to the system
UC2C.06	To inform the user about traffic conditions that effects the route		The user has executed "Navigate to destination"	The user has been informed about traffic conditions affecting the travel
UC2C.07	To give the driver directions to a destination		The user has executed "Navigate to destination"	The user has reached its destination
UC2C.09	To indicate the start of working on a transport itinerary		A transport itinerary has been assigned to a vehicle	The driver has started working on an itinerary
UC2C.10	To receive a travel plan	Asynchronous	The transport planner has associated the itinerary with the driver	The driver has received the itinerary

UC2C.11	To receive route guidance to a destination	The user selects to navigate to a destination		The user starts to receives directions from the navigation system
UC2C.12	To receive traffic information from several sources such as DAB, floating car data, floating device data			The traffic information has been received
UC2C.13	To prepare itineraries, which are suggested to the transport planner based on data from both the transport planning system and the transport exchange portal	New or updated transport bookings exists in the system	One or more transport booking exists	
UC2C.14	To continuously receive information about all journeys in progress. This data can be used by traffic management systems for traffic light control etc			The journey status has been updated
UC2C.15	To apply deviations to the itineraries		One or more itineraries has been created	The itineraries has been updated
UC2C.16	To receive traffic information from several sources such as DAB, floating car data, floating device data and apply the data to the route calculation			The traffic information has been applied to the itinerary planning
UC2C.17	To update the itinerary database	The user selects to associate an itinerary with a vehicle		The itinerary database has been updated

UC2C.18	To indicate the start of working on a transport itinerary		A transport itinerary has been assigned to a vehicle	The itinerary status has been updated
UC2C.19	To calculate a route to a destination selected by the user	The user has selected "Navigate to destination"	The user has executed "Navigate to destination"	A route has been calculated
UC2C.20	To receive itineraries, in order to be able to optimize the traffic flow based on information in the itineraries	Asynchronous	The transport planner has associated the itinerary with the driver	The traffic operator has received the itineraries

4.3.1.3 User Experience Flow

The itinerary booking has two main users, the transport planner and the driver. In addition, information about the planned itineraries can also be sent to the traffic manager for traffic flow optimization. Here, the user experience flows of the two main users are presented.

Before the driver starts his or her mission the transport planning system has created itineraries by allocating transport orders from the own booking system and the transport exchange portal to different vehicles. The itineraries are to be viewed, edited and decided upon by the transport planner. If all itineraries look ok, they are distributed to each vehicle respectively. If the transport planner does not want to confirm all itineraries but neither edit them him or herself, he or she can choose to reject selected transport requests or ask the system to reschedule based on the reasons and new constraints indicated by the transport planner.

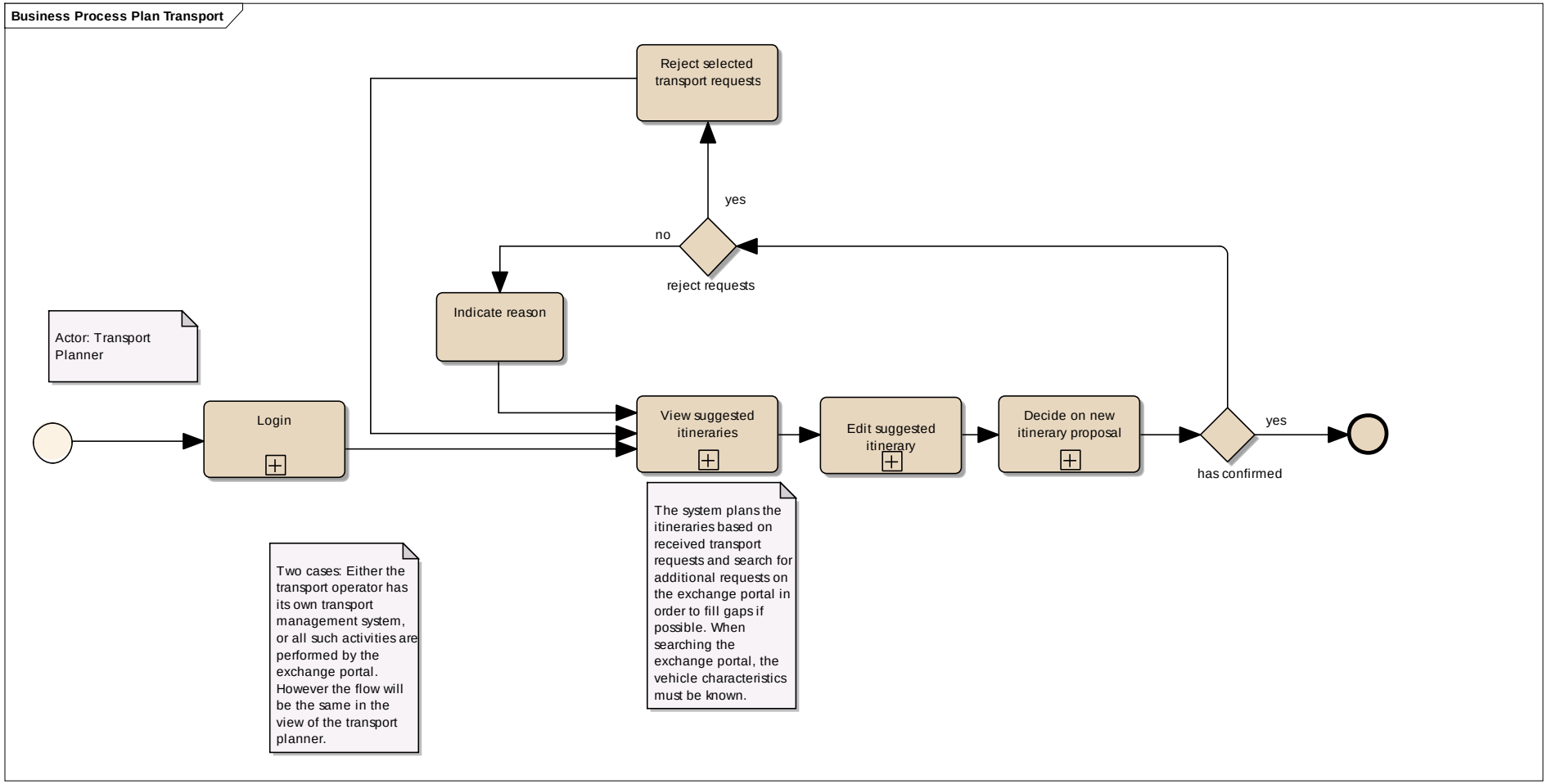

Figure 31: User experience flow of the transport planner when planning the transports

The transport planner may receive suggestions on updated itineraries from vehicles realizing, through vehicle to vehicle communication, that a rearrangement of the itineraries by reallocating transport orders and possibly also already loaded goods from one vehicle to another may be favourable. Both vehicles' transport planner must accept the updated itineraries for them to take effect.

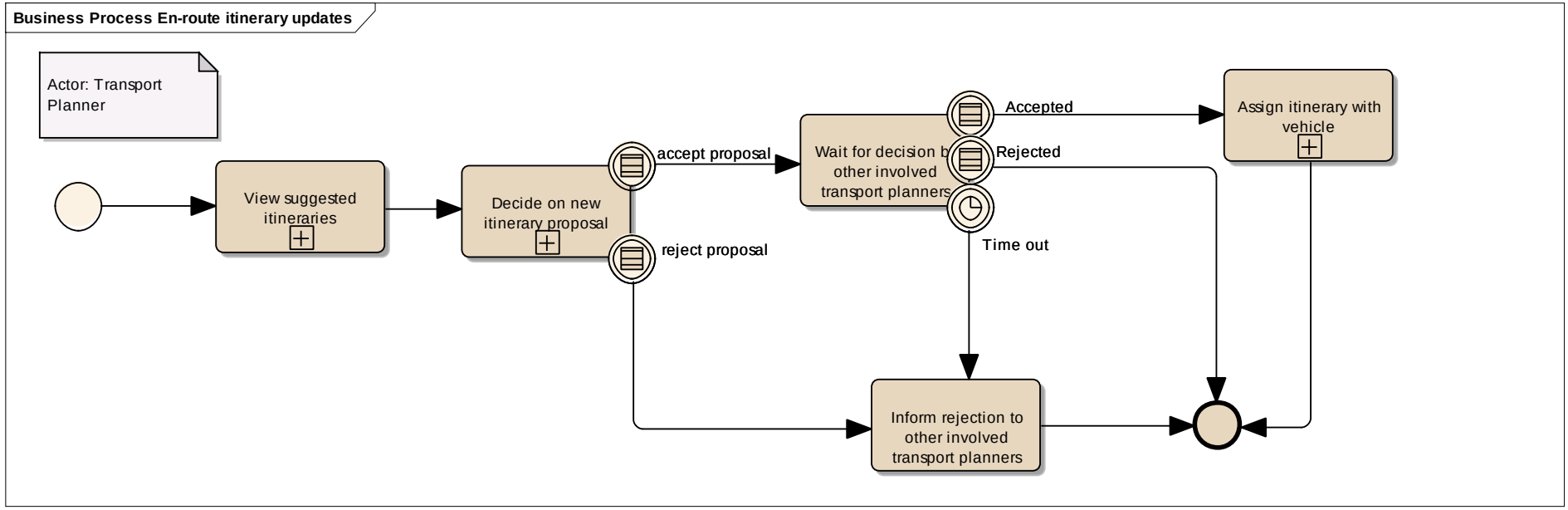

Figure 32: User experience flow of the transport planner

The driver receives an itinerary at the beginning of the day but may also receive updated itineraries along the way as new transport requests or itinerary updates suggested by the vehicle is accepted by the transport planner.

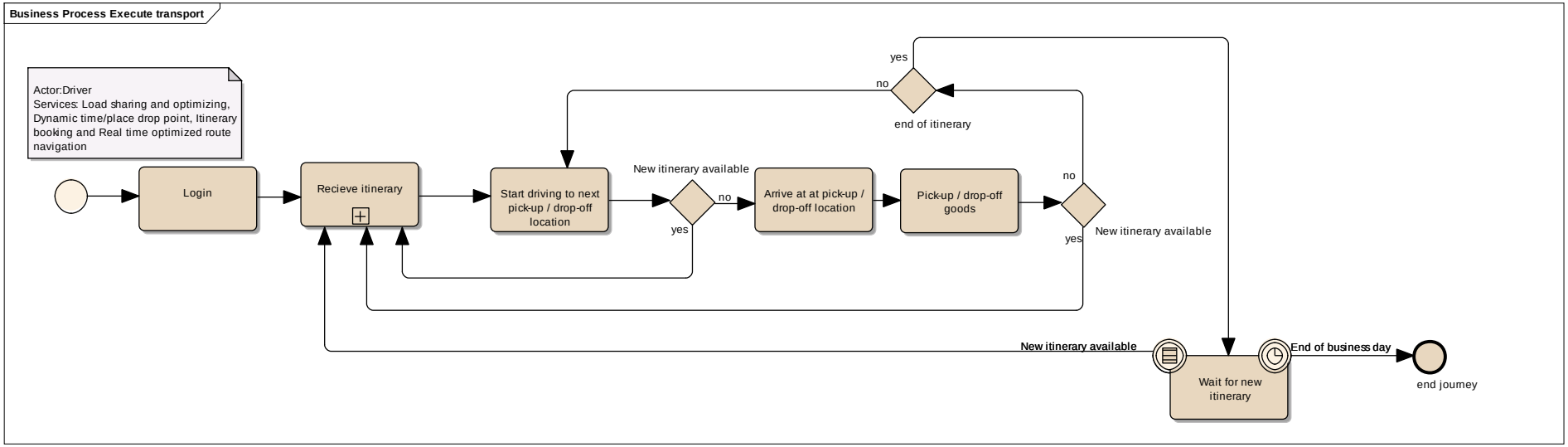

Figure 33: User experience flow of the driver when receiving itineraries and transport missions

4.3.2 Load sharing and optimising

4.3.2.1 Description of the application

A barrier to make better use of the distribution vehicles' capacity is that consignors and consignees are unaware of available transport capacity and that transport operators are largely unaware of the true real-time transport demand. Combining information on distribution vehicles' positions, itineraries and loads with real-time transport need can help allocate shipments to transport vehicles in a better way. Taking this one step further may even imply interconnecting the production plans of factories or the order handling systems of shops and web shops with the transport planning. The application described here will however not take such production plans into account.

The *Load sharing and optimizing* application in essence consists of two different services with the same aim: to better utilize available transport resources by better allocation of goods.

First, there is a centralized load sharing and optimizing service founded in an online exchange portal where transport bookers can add their transport requests. The transport operator can set up their transport planning system to communicate with the transport exchange portal through queries or feed the portal with information on their available transport resources. The exchange portal or the transport planner's system (depending on how the service is implemented) then allocates the transport requests to the most suitable available truck or delivery van.

The second load sharing and balancing service is distributed. Vehicles are aware of their load and itinerary and have the ability to communicate with each other. If vehicles detect that reloading goods from one vehicle to another could be beneficial, a suggestion is sent to the involved vehicles' transport planners for making a decision.

4.3.2.2 Functional decomposition

The load sharing and optimizing application is as mentioned essentially two services with the same aim. The functional decomposition is represented by use case diagrams outlining the different use cases required. Since the load sharing and optimizing applications in essence is two services, two use case diagrams are provided. Figure 34 illustrates the use cases required for the centralized load sharing and optimizing service and covers three actors: the transport booker, the transport planner and the driver.

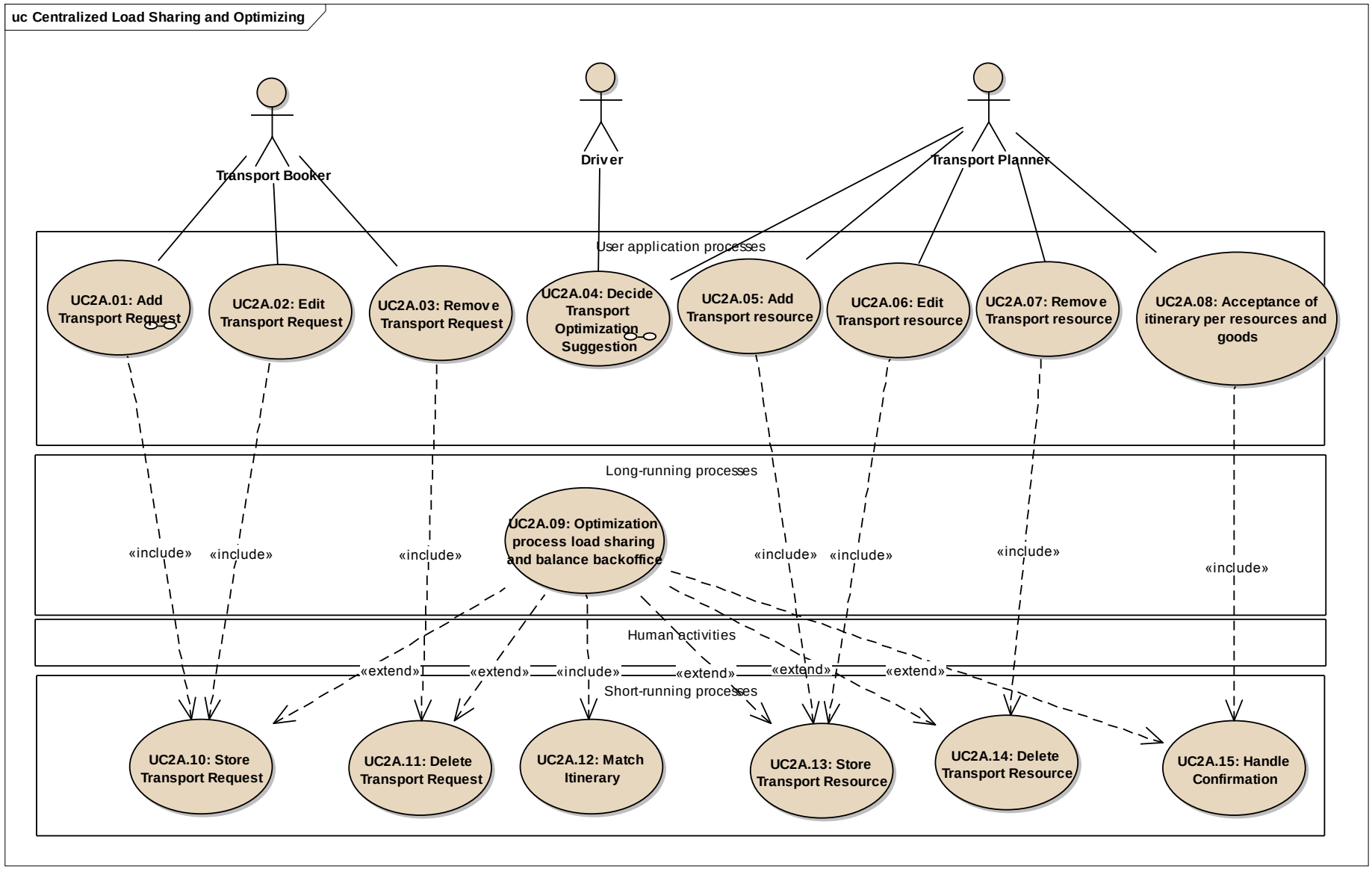

Figure 34: Centralized load sharing and optimizing

Use case	Goal	Trigger	Pre-condition	Post-condition
UC2A.01	Add a new transport request to the exchange portal	User selects to add a new transport request		A transport request has been saved for the optimization process.
UC2A.02	Edit an existing transport request	User selects to edit a transport request	A transport request has been created	A transport request has been updated
UC2A.03	Remove an existing transport request	User selects to remove a transport request	A transport request has been created	A transport request has been removed
UC2A.04	To accept or reject a optimization request suggested by the system	The system suggests a changes to the transport itinerary	The system has discovered a more optimal load balance	A rejected or accepted proposition
UC2A.05	Add a new transport resource	User selects to add a new transport resource	Transport Planner or Driver has to be registered as transport resource user in the system	A transport resource has been saved for the optimization process
UC2A.06	Edit an existing transport resource	User selects to edit a transport resource	A transport resource has been created	A transport resource has been updated
UC2A.07	Remove an existing transport resource	User selects to remove a transport resource	A transport resource has been created	A transport resource has been removed
UC2A.08	Accept or reject a proposed itinerary	The system has notified the transport planner of an updated itinerary	The system has discovered an itinerary optimization	The transport planner has accepted or rejected an itinerary
UC2A.09	To optimize the matching of transport requests onto transport resources in order	A request item has been add/modify or delete or predefined hour to launch the	A transport request has been added/updated or removed	The amount of unused capacity has been detected

	to minimize the number of trucks in the city, CO2, noise, cost and maximize vehicle utilization and effective productivity.	process.		
UC2A.10	Stores a new or updated transport request	User selects to add or edit a transport request		A transport request has been updated or added
UC2A.11	Deletes an existing transport request	User selects delete a transport request	A transport request exists in the system	A transport request has been removed
UC2A.12	Check if vehicles with excess capacity has matching itineraries	Excess capacity has been detected	At least two transport request has been created, and excess capacity has been detected on more than one vehicle.	The amount of unused capacity has been detected
UC2A.13	Stores a new or updated transport resource	User selects to add or edit a transport resource		A transport resource has been updated or added
UC2A.14	Deletes an existing transport resource	User selects delete a transport resource	A transport resource exists in the system	A transport resource has been removed
UC2A.15	Confirms or reject a suggested itinerary	User has replied to a itinerary suggestion	A transport request exists in the system	An itinerary has been accepted or rejected

Figure 35 gives the use cases needed for the distributed load sharing and optimizing service. The main difference is that the transport booker is not included as an actor. Vehicles communicate their itineraries to each other and suggest goods swapping if certain criteria indicate the possibility of more optimal itineraries.

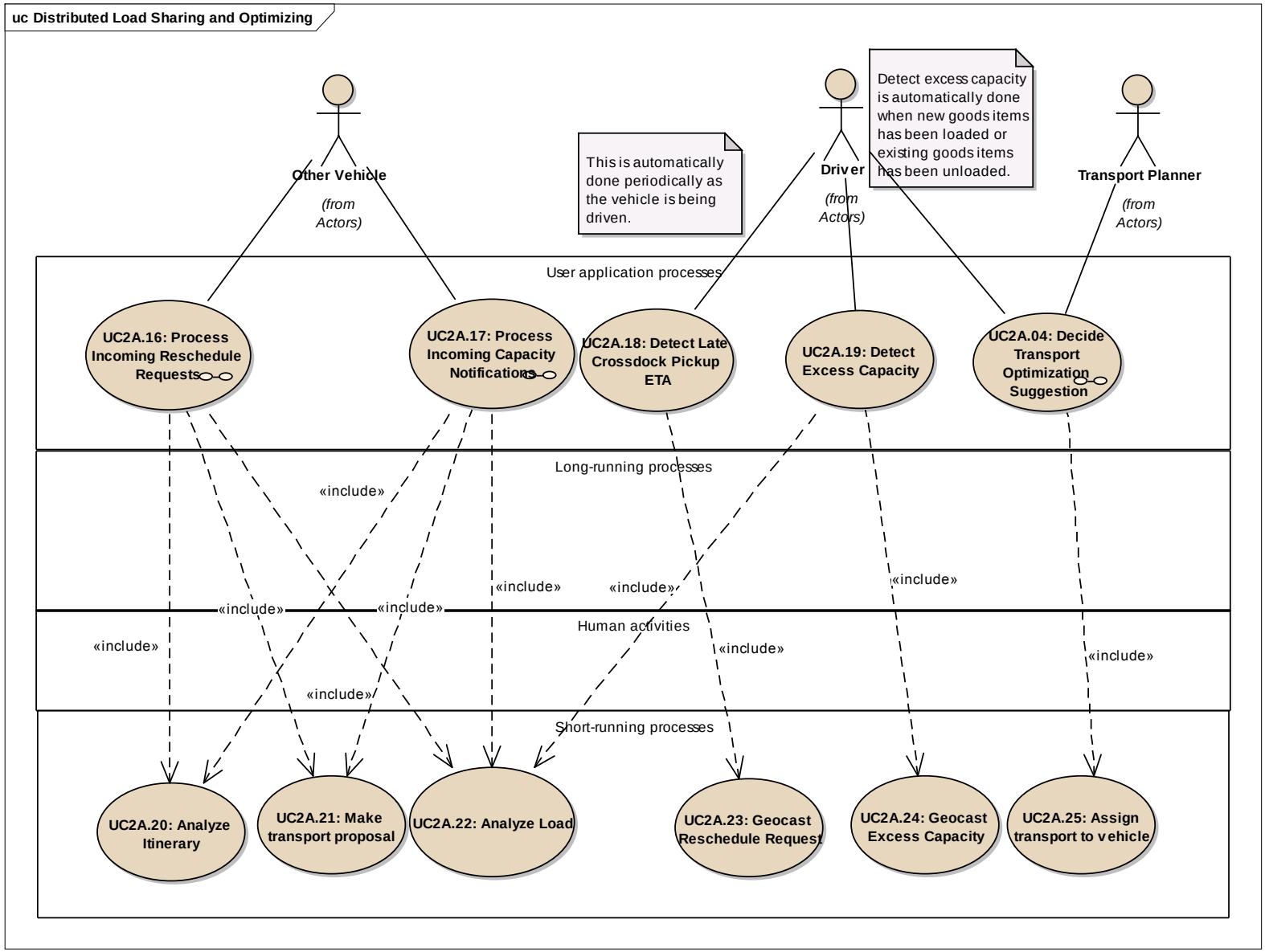

Figure 35: Distributed load sharing and optimizing

Use case	Goal	Trigger	Pre-condition	Post-condition
UC2A.16	To receive and process a reschedule request from another vehicle	A reschedule request message has arrived.	Another vehicle has detected a deviation against its itinerary.	The message was processed and if possible an offer was made.
UC2A.17	To receive and process a notification of unutilized capacity from another vehicle.	A capacity notification message has arrived.	Another vehicle has detected that it has unutilized capacity.	The message was processed and if possible an offer was made.
UC2A.18	To check if given the current progress the vehicle is about to miss a loading/unloading/cross-dock time slot.	Time and location	A change in time and location must have occurred.	If a deviation to the itinerary has been detected, a reschedule request is geocast to vehicles in the same area.
UC2A.19	To check if there are unutilized capacity in a vehicle	A goods item has been loaded/unloaded.	A change in vehicle load must have occurred.	The amount of unused capacity has been detected and broadcast to vehicles in the same area and the transport planning system.
UC2A.20	Analyze if it is possible to extend an itinerary with an existing drop-off/pick-up point without exceeding any time/distance constraints.	An incoming reschedule request or capacity notification has been received		A reply to the itinerary analyze has been calculated.
UC2A.21	Based on incoming capacity notifications or reschedule request, propose a transport to the transport planner	An incoming capacity notifications or reschedule request has been received	An incoming capacity notifications or reschedule request has been received	A transport has been proposed
UC2A.22	Detect non-utilized capacity	A load change has occurred,		The amount of non-used

		or an incoming message has been received		capacity has been calculated
UC2A.23	To geocast a reschedule request to vehicles in a given area.	A deviation against the transport itinerary has been detected.	A eta deviation change notification has arrived.	The reschedule request has been geocast.
UC2A.24	To geocast the amount of unused capacity to vehicles in a given area.	A change in excess capacity has been detected.	A capacity change notification has arrived.	The amount of unused capacity has been geocast.
UC2A.25	Assign a transport to a vehicle	A transport optimization has been accepted	A transport request exists in the system	A transport has been assigned to a vehicle

4.3.2.3 User Experience Flow

The flow of "activities" performed or experienced by the transport booker in the load sharing and balancing application is found in Figure 36. The parts in the shaded area are not covered by the application.

To book a transport the transport booker needs to log in to the transport booking system of choice (may be a web interface or the booker's own order handling system interconnected with the transport exchange portal and/or selected operator's transport planning systems). The booker can choose to book a transport directly with the selected operator/third party logistics operator, such a decision is not part of this scenario, or to add the transport request to the transport exchange portal. Once the request is added to the portal, the operator waits for an operator to accept the transport request. If the request is not accepted within a certain amount of time the booker is asked to update its requests or contact an operator directly. The booker can also choose to remove or edit the request at any time.

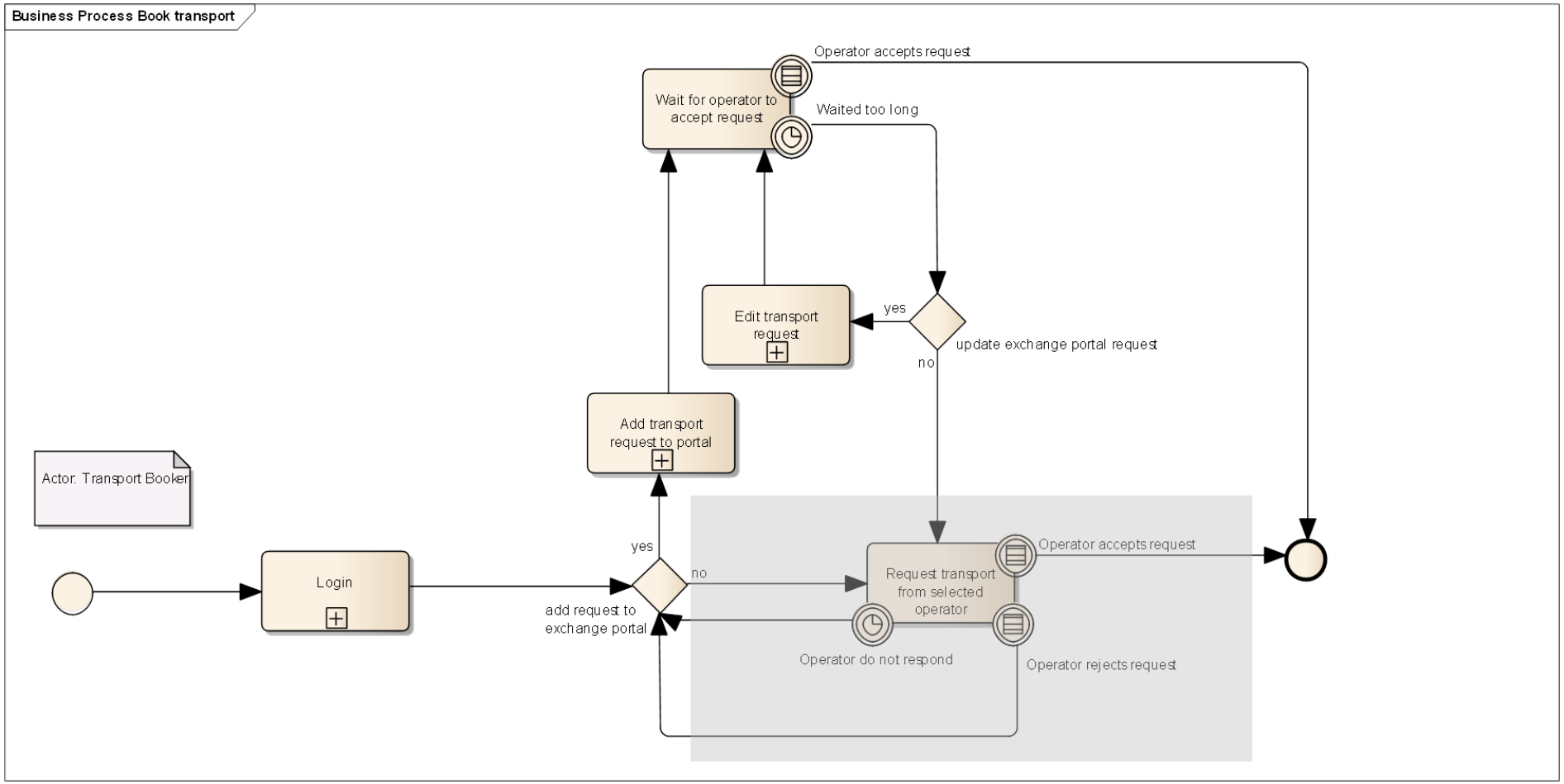

Figure 36: Transport booker's user experience flow when booking a transport

Figure 37 illustrates the flow of activities performed by the transport planner when reviewing and accepting/rejecting itineraries. This flow is the same regardless of if transport requests from the transport portal are included in the itineraries or if only requests received directly from different transport bookers are used.

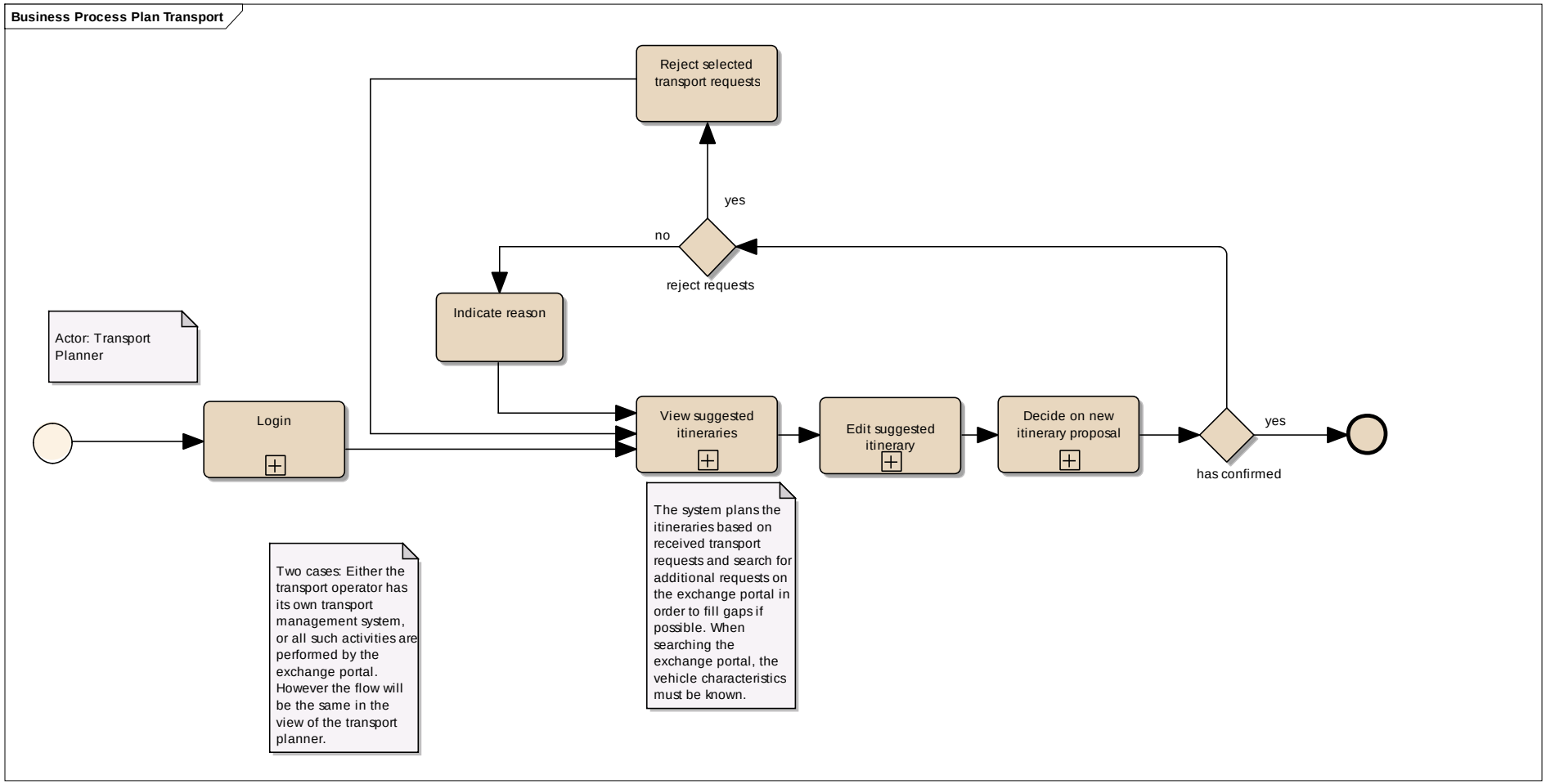

Figure 37: User experience flow of the transport planner when planning the transports

Figure 38 illustrates the flow of actions from the transport planner's point of view when receiving new suggestions from the vehicle which has identified the possibility for a favourable redistribution of goods.

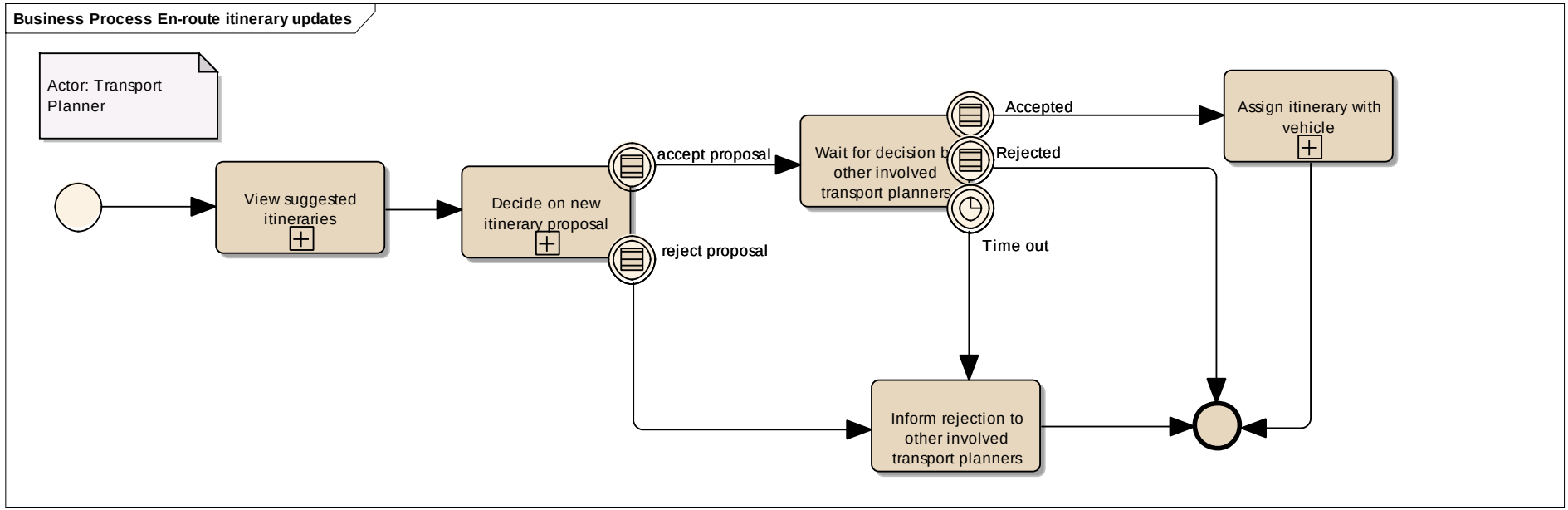

Figure 38: Transport planner's flow of actions in the en-route itinerary updates

Figure 39 illustrates the flow of actions performed/experienced by the driver when receiving new itineraries and executing the transport missions of the current itinerary.

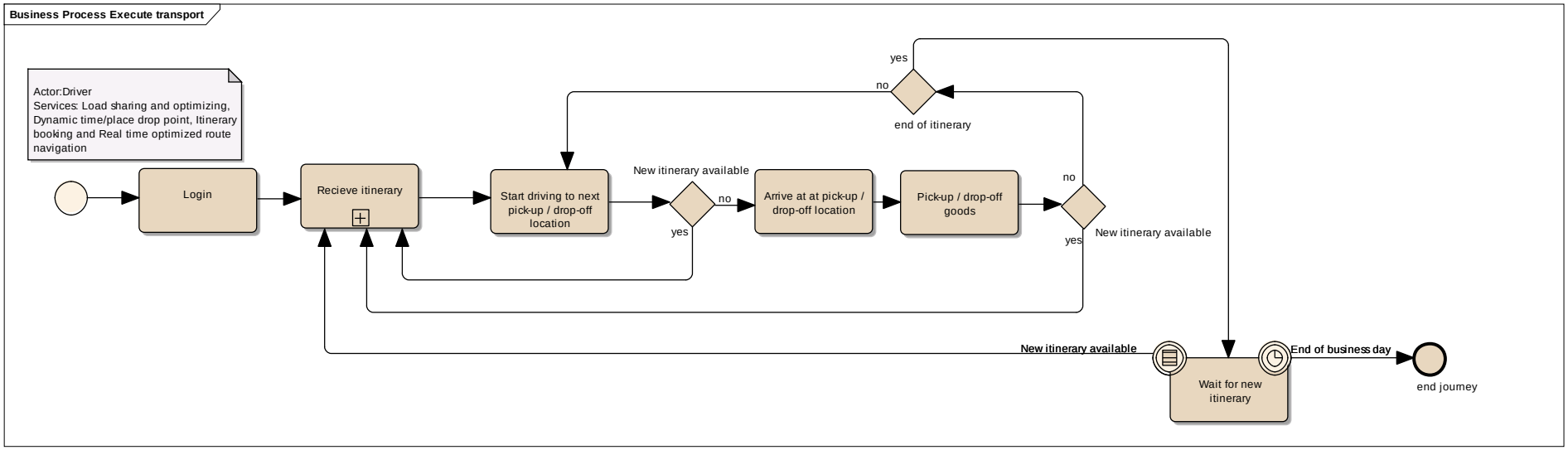

Figure 39: The driver receiving itineraries and executing the transport missions

4.3.3 Dynamic time/place drop point

4.3.3.1 Description

Purchasing goods online has become routine to many of us. In an easy way being able to compare specifications and prices provided by different producers and retailers is one of the major benefits. To order and pay for the goods from home is most of the time simple but having the goods delivered can be trickier. The consignee may be asked to collect the ordered goods at a central pick-up location but home delivery can also be offered. The convenience of home delivery is, however, impeded by constraints; the transport operator provides a several hours long time-slot during which the consignee is expected to be at home. Even if a more precise delivery time could be provided, delivery is usually performed during business hours resulting in the need for the consignee to be at home from work for part of the day. If the consignee fails to be at home when the operator tries to deliver the goods he or she will, anyway, have to pick-up the goods at a central location.

The application aims at increasing the flexibility in the delivery of goods by dynamically pointing out the right time and place for delivering a package. This is achieved by letting the transport operator take part of the consignee's calendar or that the consignee through other means share information on his or her whereabouts, location and plans; information which can be taken into consideration when the transport operator plans the delivery of the goods. If a more suitable time or location for delivery of the goods than the previously agreed is identified, a suggestion which has to be accepted is made to the consignee. Business models for this kind of application can for example be based on charging an additional fee for keeping the time and location of the delivery flexible; if not choosing the "flexible delivery" option, delivery is performed in the traditional manner to the location specified by the consignee at the time suiting the itineraries of the transport operator with the inconveniences it implies to the consignee.

More dynamic rescheduling is also possible if it is realized that the consignee is close to the goods at some point during the transport. This is identified by comparing the location of the vehicle to the location of the consignee, shared by e.g. the consignee's smartphone. If dynamic rescheduling is favourable, the consignee is asked to confirm. The consignee can for example be made aware of the possibility and confirm through exchanging phone text messages (SMS).

4.3.3.2 Functional decomposition

Figure 40 gives an overview of the use cases of the dynamic time/drop point application while the table provides more detailed descriptions.

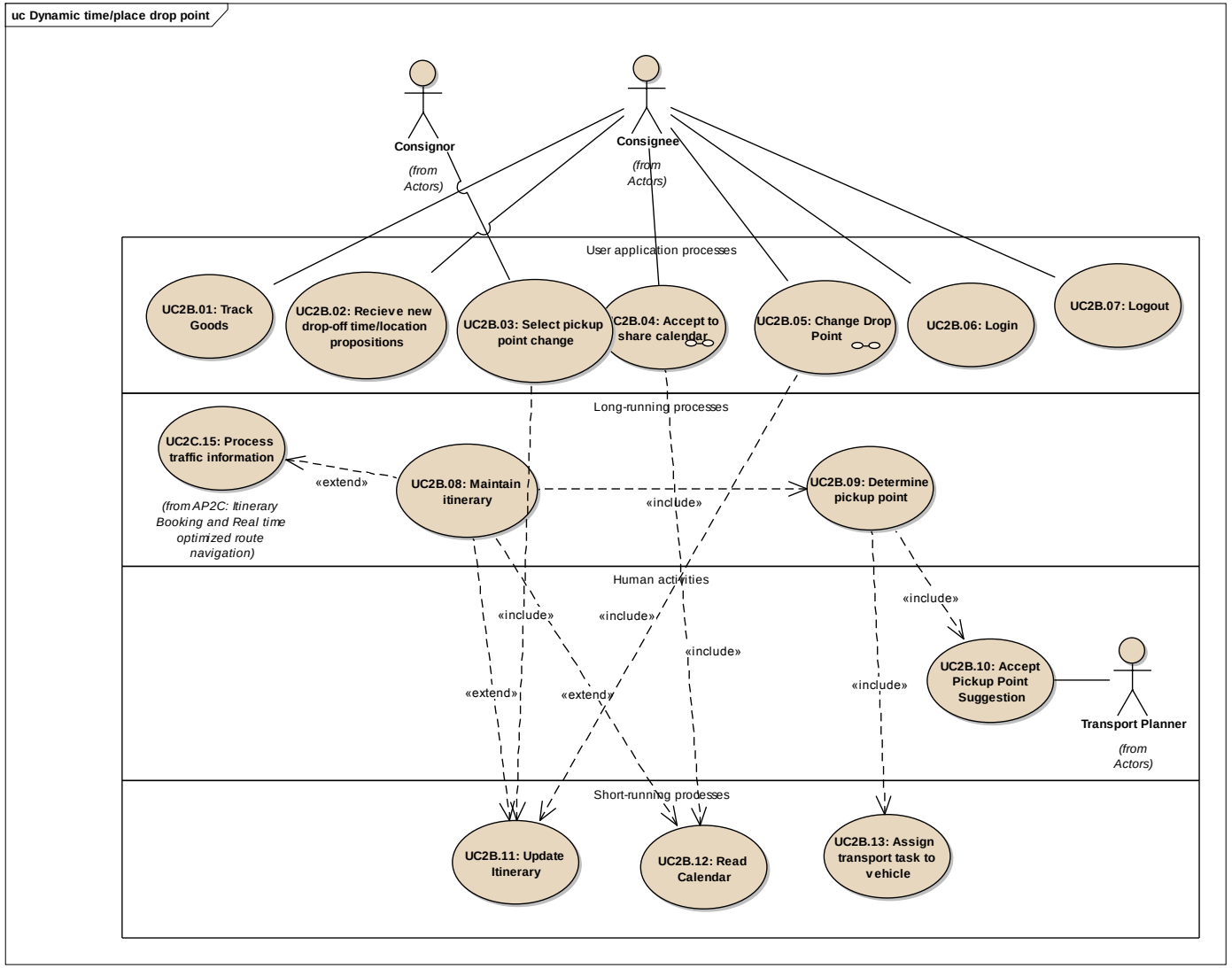

Figure 40: Dynamic time/place drop point

Use case	Goal	Trigger	Pre-condition	Post-condition
UC2B.01	Receive up-to-date information about the location of a goods item at any given time.	User selects to track a goods item	The goods item has been registered	The user has received information about the location of a goods item
UC2B.02	The system has suggested a pickup point to the user, which the user has accepted or rejected	User indicates that he/she cannot perform the planned part of the itinerary	The consignee has shared its calendar	The user has accepted or rejected a pickup-point
UC2B.03	A new pickup point has been selected for a set of goods items	The user selects to change the pickup point	The consignee has ordered goods	The pickup-point has been changed
UC2B.04	Decide which calendar information to make available to the system	The user selects to share his/her calendar	The consignee has ordered goods	The calendar information is available to the system
UC2B.05	A new drop point has been selected for a set of goods items	The user selects to change the drop point	The consignee has ordered goods	The drop-point has been changed
UC2B.06	To login to the system	The user selects to login		The user is logged in to the system
UC2B.07	To logout from the system	The user selects to logout		The user is logged out from the system
UC2B.08	To maintain the itinerary based on updated pickup points and traffic information	New traffic information, or changed pickup points		
UC2B.09	Discover pickup points based	The consignee's calendar has	The consignee has ordered	A pickup point has been

	on consignee calendars and transport itineraries	been updated, the transport itinerary has been updated or traffic information has been updated	goods	discovered
UC2B.10	Accept or reject a proposed pickup point	The system has notified the transport planner of a pickup point	The system has discovered a pickup point	The transport planner has accepted or rejected a pickup point
UC2B.11	Update an itinerary with a new pickup/drop-off point	The consignee has changed the pickup/drop-off point for a transport request	A transport request exists in the system	The itinerary has been updated
UC2B.12	Read data from shared calendars	A calendar has been shared or updated	The consignee has shared his/her calendar	Calendar data has been read
UC2B.13	Assign an updated transport task to a vehicle	The transport planner has accepted a pickup point	The transport planner has accepted a pickup point	The vehicle has received a transport task

4.3.3.3 User Experience Flow

The main user of this application for whom we need to outline the user experience flow is the consignee. If the transport planning system identifies a favourable update of drop-off time or location the transport planner and driver experience it as if two vehicles have identified the possibility of better itineraries. The difference is that the transport planner must first accept the new time/location proposal before the consignee gets notified on the possibility. Just as in the distributed load sharing and balancing service both the transport planner and, in this case the consignee (instead of the other transport planner), needs to accept the proposal.

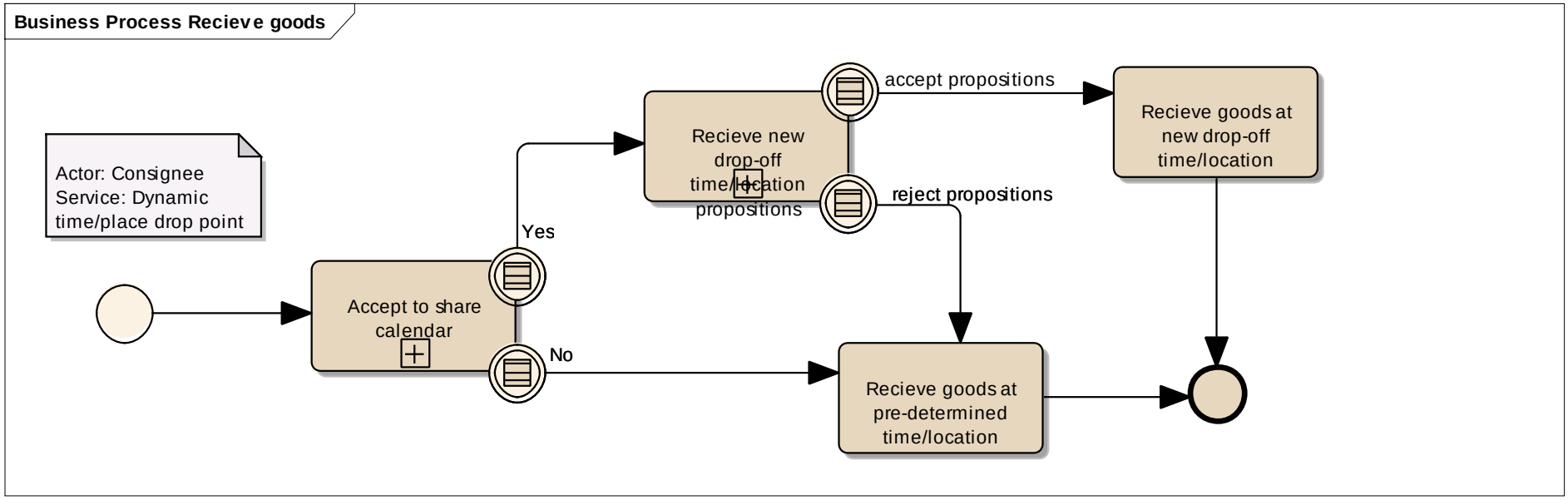

Figure 41: User experience flow of the consignee offered the dynamic time/place drop point offer

4.3.4 Eco-optimised driving, vehicle and driveline control

4.3.4.1 Description

Although it above has been shown how transport operations can become more efficient through for example better allocation of goods to suitable vehicles it is unavoidable that goods will have to be transported within cities and that at least parts of these transports will be conducted by trucks or delivery vans. The eco-optimized driving, vehicle and driveline control service does not intend to lower the total vehicle distance travelled but to ensure that the vehicle consumes as little energy as possible when travelling the given distance. The application contribute among others to reducing emissions and noise within cities and to a calmer and more predictable traffic environment as a result of less acceleration/deceleration. At the same time the application provides commercial benefits to the transport operator in terms of reduced cost of fuel.

The service takes a dual approach to reduce the energy consumption by first coaching and teaching the driver how to drive more efficient and, second, impede the ways in which the vehicle can be driven depending on the surrounding traffic situation. The guiding and coaching aspect can be divided into three phases as seen in Figure 42.

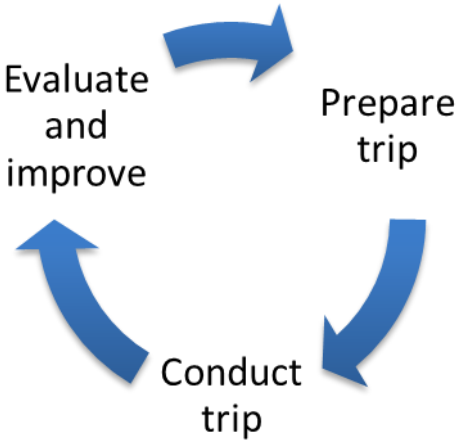

Figure 42: Phases of the eco-driving coaching service

- Automatic and manual checks are to be performed before starting the delivery operation. Such checks can be to ensure correct tire pressure or that no unnecessary weight is loaded to the vehicle.
- While conducting the trip the driver receives coaching through the in-vehicle system on how to drive most efficient given e.g. the topology and current traffic situation. Inertia can also be added to the throttle pedal if accelerating is not recommended from an eco-driving perspective. Using e.g. vehicle CAM data, information from surrounding vehicles and information from the infrastructure, highly accurate eco-driving support can be provided to the driver.
- After the delivery operation the driver's performance is compared to others through an online community and the driver receives tips on how to improve his or her driving behaviour.

The second aspect of the service focuses on assisting the driver in driving efficiently by impeding throttle and break use if acceleration is undesired given the surrounding traffic

situation. It may for instance be that the traffic light is about to change or that vehicles ahead are breaking so that it is better to reduce the speed than maintaining it or even accelerating.

4.3.4.2 Functional decomposition

Figure 43 gives an overview of the use cases within the eco-optimized driving, vehicle and driveline control application; the table provides more details.

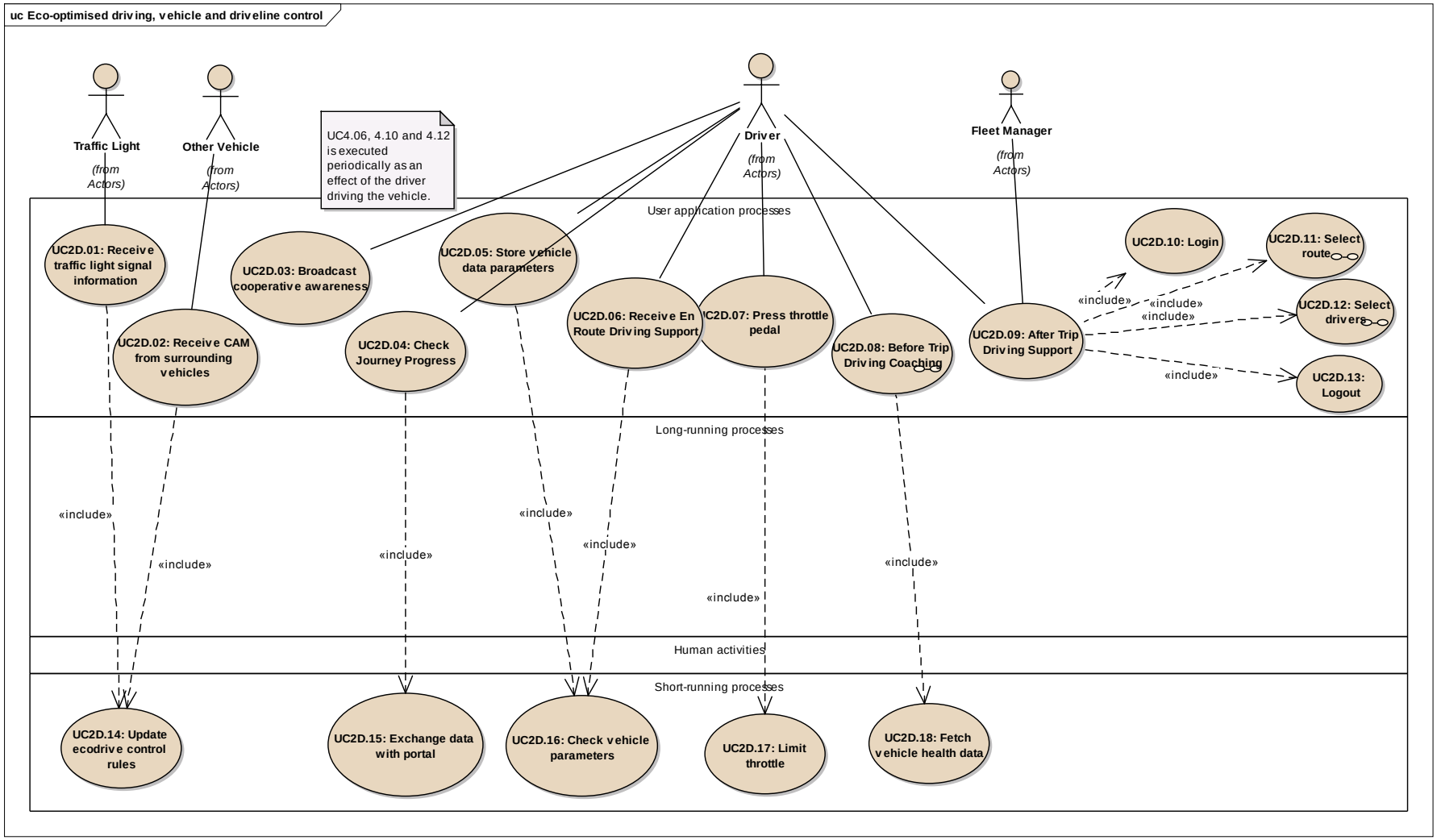

Figure 43: Use case diagram for eco-optimised driving, vehicle and driveline control

Use case	Goal	Trigger	Pre-condition	Post-condition
UC2D.01	To receive the state of the traffic light in front of the vehicle			The user has been informed about traffic conditions affecting the travel
UC2D.02	To continuously receive CAM messages broadcast from surrounding vehicles			CAM messages have continuously been received.
UC2D.03	To continuously broadcast a CAM message.			The CAM messages are continuously broadcast.
UC2D.04	To periodically check progress of the journey to detect if a segment for which eco-drive data can be exchanged has been done.	Time	A journey is in progress	If a segment for which eco-drive data can be exchanged has been passed, data has been exchanged with the portal
UC2D.05	To continuously store relevant vehicle data, for use in "After trip driving support"		A trip is in progress	The vehicle data has been stored
UC2D.06	To give the driver echo-driving guidance	Driving style related conditions	A trip has been started	The driver has received echo-driving guidance.
UC2D.07	To control max allowed acceleration	The driver presses the throttle pedal	The user has executed "Navigate to destination"	The acceleration has been limited to the traffic in front, as well as the traffic lights.
UC2D.08	To check for conditions that affects vehicle performance and advice the driver	The driver indicates that he/she is about to start a trip		The driver has received advice about vehicle health conditions that affects echo driving performance

UC2D.09	To inform the user about the level of eco-driving achieved after the trip.	The user selects to receive after trip driving support.	Use case "Store vehicle data parameters" has been performed	The user has received report data
UC2D.10	To login the user to the "after trip driving support"-system	The user selects to login.		The user has been logged in to the system.
UC2D.11	To select the route for which to compare how good different drivers are at echo-driving.	The user selects to logout	The user is logged in to the system.	The system presents the drivers, for which data exists in the system
UC2D.12	To select the drivers for which data exists for a given route	The user has selected the route	The user has selected the route	The system presents for the selected drivers on the selected route, the fuel consumption related to the vehicle type and -load, together with relevant echo-driving related vehicle data parameters.
UC2D.13	To logout the user to the "after trip driving support"-system	The user selects to logout	The user is logged in to the system.	The user has been logged out to the system.
UC2D.14	To update the eco-drive control rules according to traffic situation. The eco-drive control rules are used for controlling the drive train and to provide coaching tips adapted to the traffic situation.			The drive train control rules has been updated.

UC2D.15	To exchange echo driving performance of a trip to the portal.	A segment of a trip has been finished	A segment of a trip has been finished	Data of the ego-vehicle has been uploaded and data of other vehicles that has driven the same segment has been downloaded.
UC2D.16	To detect echo-driving related conditions from vehicle data parameters	The driver has initiated a trip.		The vehicle data parameters has been checked.
UC2D.17	To apply the drivetrain control rules to the throttle		The driver has pressed the throttle	The throttle limitations has been applied
UC2D.18	To fetch vehicle health data from sensors and cpu:s			The health of the vehicle has been checked

4.3.4.3 User Experience Flow

Figure 44 shows the flow of activities performed by the driver before and during the trip related to the eco-optimized driving, vehicle and driveline control application before and during trip. The driver receives both tips/coaching in the in-vehicle mounted display and haptic feedback from the throttle pedal based on the current traffic environment and his/her driving style.

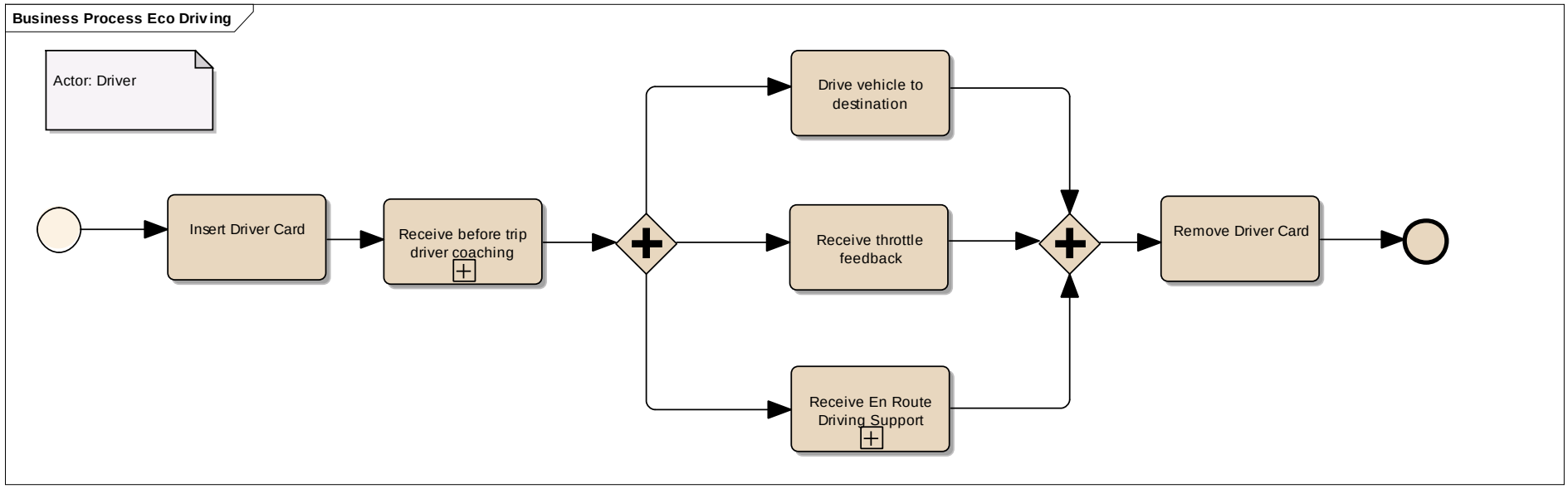

Figure 44: User experience flow related to eco-optimised driving, vehicle and driveline control

Figure 45 shows the flows of actions performed by the driver/fleet manager to compare the performance of a particular driver/transport to other comparable transport operations. This can be based on lots of data collected from similar vehicles driving segments of the same route as the driver to be evaluated. The comparison results in tips on how the driver can improve his/her driving style.

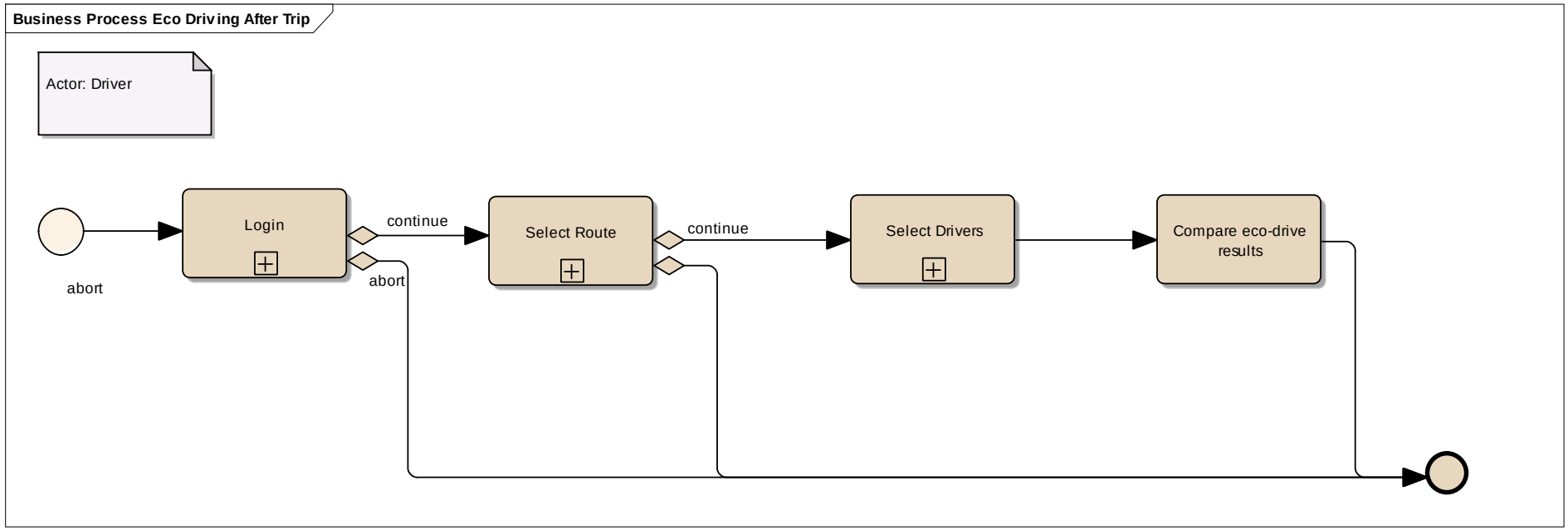

Figure 45: Eco-optimized driving support after trip

5. Transport infrastructure as a service

In order to achieve efficient urban traffic management, cities need to deploy not only the technologies for traffic monitoring, but also dedicated traffic management platforms, which can integrate all the data coming from the different monitoring technologies so as to calculate and provide meaningful real time information and strategies either for their own purpose as operators or for end users. All this has an enormous cost for cities. The innovation proposed by Instant Mobility is to use the cloud capabilities of the Future Internet to create innovative services that reside in the cloud or that use the core platform capabilities. These emerging hybrids of proprietary and cloud applications will result in a new class of distributed applications, and reduce costs by eliminating the need to buy specific platforms. Transport agencies will be able to use all existing infrastructure-based technologies, such as inductive loops, dedicated short-range communication (DSRC) beacon-based technologies, closed circuit television cameras (CCTV), automatic number plate recognition systems (ANPR) etc for data collection. Alongside this data, they will also have access to information from other sources (social networks, Wi-Fi devices, etc…), as all of this data will be available in the 'cloud'.

A company with a traffic management platform able to integrate multiple sources of traffic and mobility data will be able to use it to provide services such as: a complete representation of current traffic conditions over the network, travel time estimations and forecasts, wide area strategic traffic control, Real Time Traffic Information (RTTI) provision for end users and multimodal services (PT, park and ride etc depending on the kind of data provided by the city, etc…), and dynamic routing guidance with different route options depending of the road network condition in real time

5.1 Objectives of transport infrastructure as a service

The main objective of Scenario 3 is to carry out a study of the conditions needed for dynamic traffic & integrated urban space management, on how to use Future Internet technologies such as cloud data storage, Cloud computing virtualization or services-in-the-cloud. The complete Scenario 3, presented in the following sections, has the following advantages:

- For the Traffic Operator:
  - Reduce the cost of local hardware installation.
  - Reduce maintenance costs (local hardware currently resides in a hostile environment, so less hardware will result in less maintenance).
  - In the case of faults, easy intervention in a comfortable environment (server-farm).
  - Seamless configuration, installation and upgrade possibilities.
  - More scalable and modular systems for traffic control centre.
- For the User:
  - Improved safety and fewer accidents at controlled signalized interactions.
  - Reduced delays and congestion, improving the mobility of users.
  - Improved energy efficiency by optimizing traffic demand.

By exploiting the enablers provided by the FI-PPP programme, this scenario will allow the rapid deployment of a new generation of traffic management services. These will result in an

improvement in the levels of mobility on the roads by acting as B2B services, for instance by providing accurate RTTI for mobility services such as routing information, personalized route guidance, eco-driving support. The traffic management centres will be able to create the most suitable strategic action plans only by using available high quality data. The actuation services will run optimal policies which take into account the specific requirements of each zone, region or city.

5.2 Applications based on services in D3.1

The Transport Infrastructure as a Service scenario is mainly based on some of the ideas and services from the Online traffic & infrastructure management scenario described in the preliminary scenario document (D3.1) supplemented by services and ideas from the other scenarios in the same document. Compared to the preliminary document services have been merged and their functionality slightly changed and enhanced. The scenario features five applications with clearly defined scopes. The selection of services is based on that they shall bring something new compared to what has been done in previous projects and to what is commercially available and that they shall promote more dynamic and efficient transport operations. The consolidated Scenario consists of five Services, coming from Lead Scenarios 2, 3 and 5. These services could be divided into two categories: information collection & exchange (Services 2.c and 3.a) and service provision (Services 5.a, 5.b and 5.c).

- Real-time traffic and route information (Origin: D3.1 – Service 2c);
- Floating passenger data collection (Origin: D3.1 – Service 3a**);**
- Virtualized intersection intelligence (Origin: D3.1 – Service 5a);
- Cooperative traffic signal control (Origin: D3.1 – Service 5b);
- Area wide optimization strategies (Origin: D3.1 – Service 5c).

The next section will further introduce the scenario and provide richer descriptions of the applications including their functions and logic.

5.3 Description of the scenario and applications

5.3.1 Real-time traffic and route information

5.3.1.1 Description of the application

The vehicle acts as a probe for traffic estimation sending data to a traffic service on the Internet; these data are mashed-up with other sensor data coming from the road infrastructure to give real-time traffic conditions over the full road network. Drivers can receive the information using their personal device through an on-line and updated map including traffic data (continuous map download and updates).

Specific Objectives of the applications are:

- *Enable user-transparent communication between the vehicle and a personal device, which should receive the data that can be useful for traffic estimation (position, direction, speed, use of braking pedal, gears info, …);*
- *Allow the personal device to communicate with on-the-cloud traffic information center in order to send the relevant vehicle data and to receive real-time traffic information on an always up-to-date map, so that the user can optimize the route.*

5.3.1.2 Functional decomposition

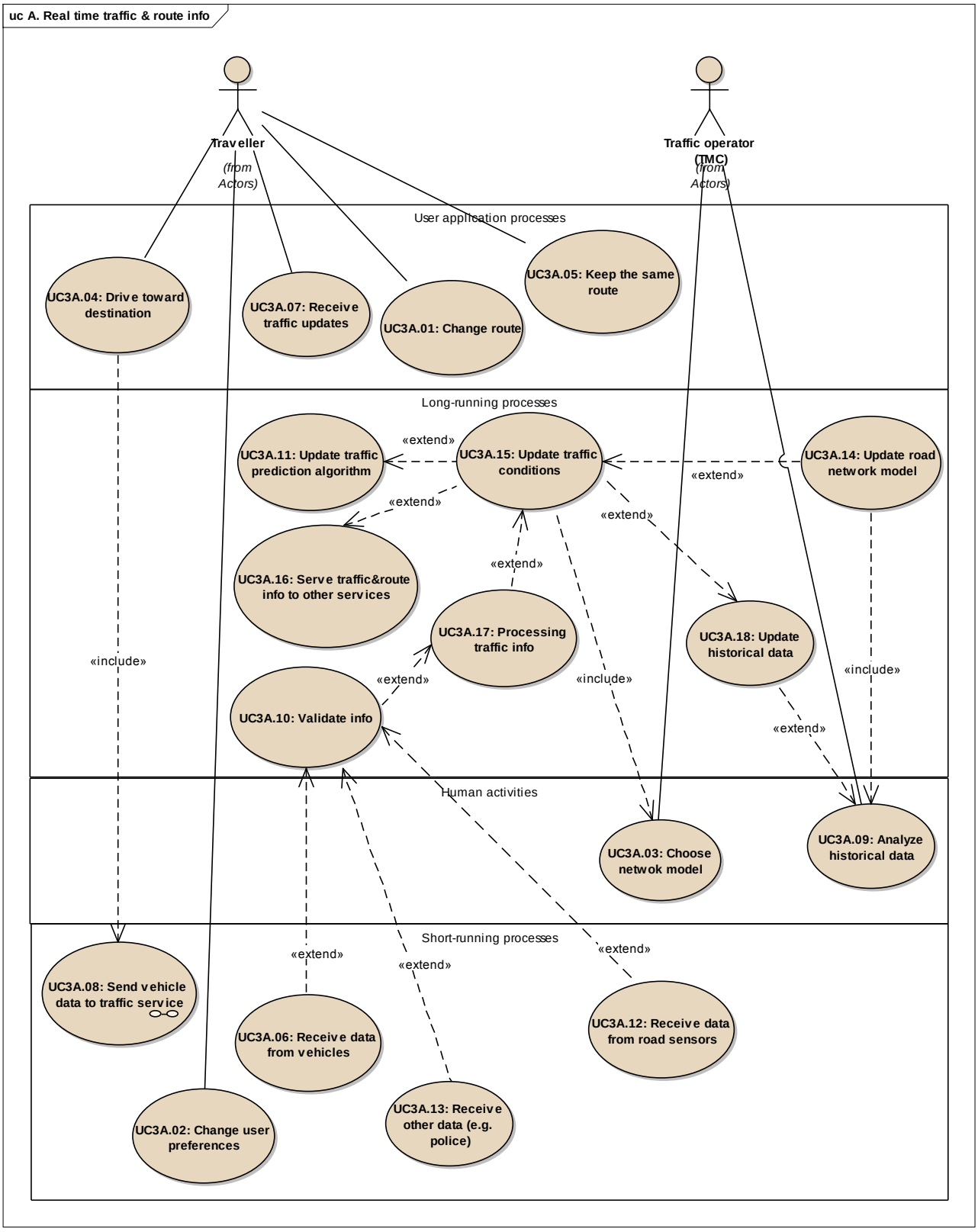

Figure 46: Use case diagram of real time traffic route information

Use case	Goal	Trigger	Pre-condition	Post-condition
UC3A.01	Avoid the traffic jams according to recent received info	A new update is arrived	The service is on and the Traveller has the relative application active	
UC3A.02	To modify application behaviour based on user preferences	User based		
UC3A.03	To represent the reference network		The system is in its initialization phase	The data coming from different sources should tune the parameters of the network model
UC3A.04	Reach the destination according to real time info on traffic and routes			
UC3A.05	Reach the destination in the shortest time	A new update is arrived but no events occur on the foreseen route	The service is on and the Traveller has the relative application active	
UC3A.06	To receive data from vehicle of different type and car makers	Data are sent from vehicles	A service is designed to receive many data from many vehicles	
UC3A.07	To be informed in time about traffic conditions and events		The service is on and the Traveller has the relative application active	The Traveller is informed about traffic situation and can change the route until the last moment
UC3A.08	To send data read from the	New special events (for	Connection to services is	

	vehicle network to the TMC	example accident, queue detected, ...) or timer based	guaranteed and meaningful data can be processed on-board	
UC3A.09	To compare the actual network model with the historical data and verify whether the historical data fit the current model			The historical data can suggest that the current model is not suitable any more
UC3A.10	To validate traffic data, with particular reference to anomalies	Traffic data are received	Data do not have a reliability evaluation	Data have been compared and evaluated and incoherent data have been removed
UC3A.11	To make a prediction of traffic flows	Traffic data are fully processed		Traffic forecasts have been made both for short term and long term period Current forecast has been updated
UC3A.12	To receive data from road sensors of different type (cameras, inductive loops, ...)	Data are sent from road sensors (non continuous sources) or timer based	A service is designed to receive many data from many different components	
UC3A.13	To receive data from other sources	Data are communicated from other authorities	A service is designed to receive phone calls	
UC3A.14	To correct the actual reference network taking into account the last			The reference network is represented into a suitable way (arches and nodes) for queue estimation and

	information			traffic signalling distributed control
UC3A.15	To generate up-to-date traffic information	New special events (for example accident, queue detected, ...) or timer based	Data have been received and validated from a sufficient number of sources	
UC3A.16	To share data with other traffic-based services	New traffic update	Other services registered to have this info	
UC3A.17	To merge and combine non homogeneous data coming from different sources	The received data are valid		
UC3A.18	To update the historical statistics with the last data	Traffic data have been merged and aggregated		New statistics have been generated

5.3.1.3 User experience flows

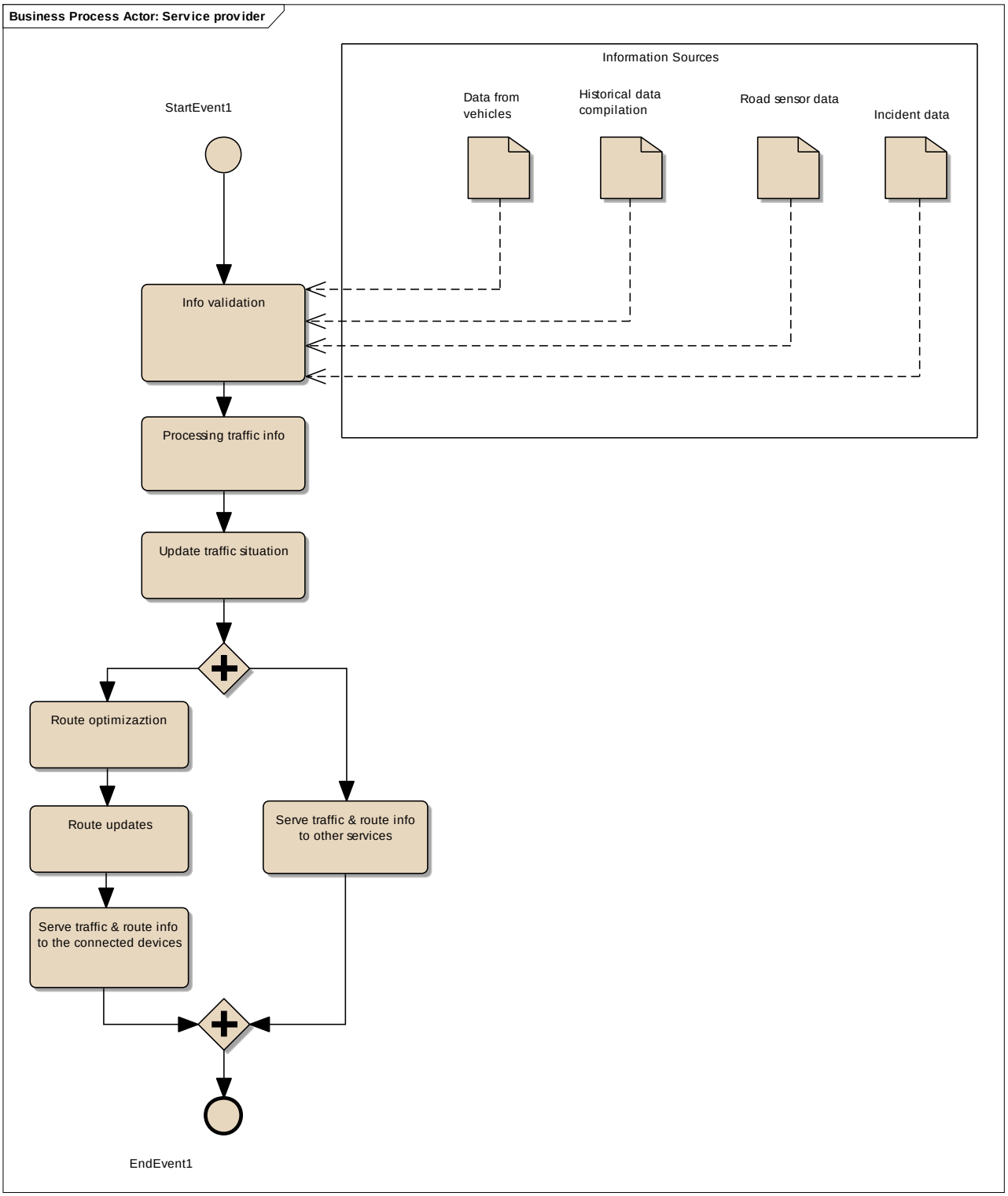

Figure 47: Service Provider's User Experience for Real Time Traffic & Route Info

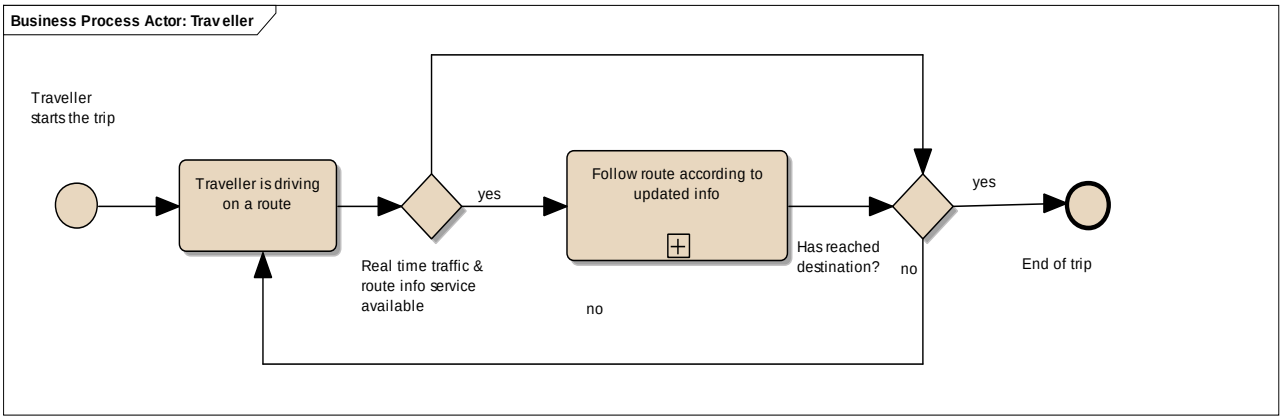

Figure 48: Real Time Traffic & Route Info User Experience flow for Traveller

5.3.2 *Floating passenger data collection*

5.3.2.1 *Description of the application*

This service will provide passenger density and position measurements over the transport network, and will be able to perform accurate predictions on passenger density, based on a wide range of input data. These measurements are then used by the Transport Operators and the Organizing Authorities to optimize and regulate instantaneous quality of service. This service has two aspects:

- *Gather all the available information, from various sources to make an accurate estimate of passengers' density, within the transport network.*
- *Distribute the relevant information to Transport Operators and Organizing Authorities*.

Specific objectives of the application are to collect and distribute data from different sources in order to improve the traffic service, making an adequate use of the available resources.

5.3.2.2 Functional decomposition

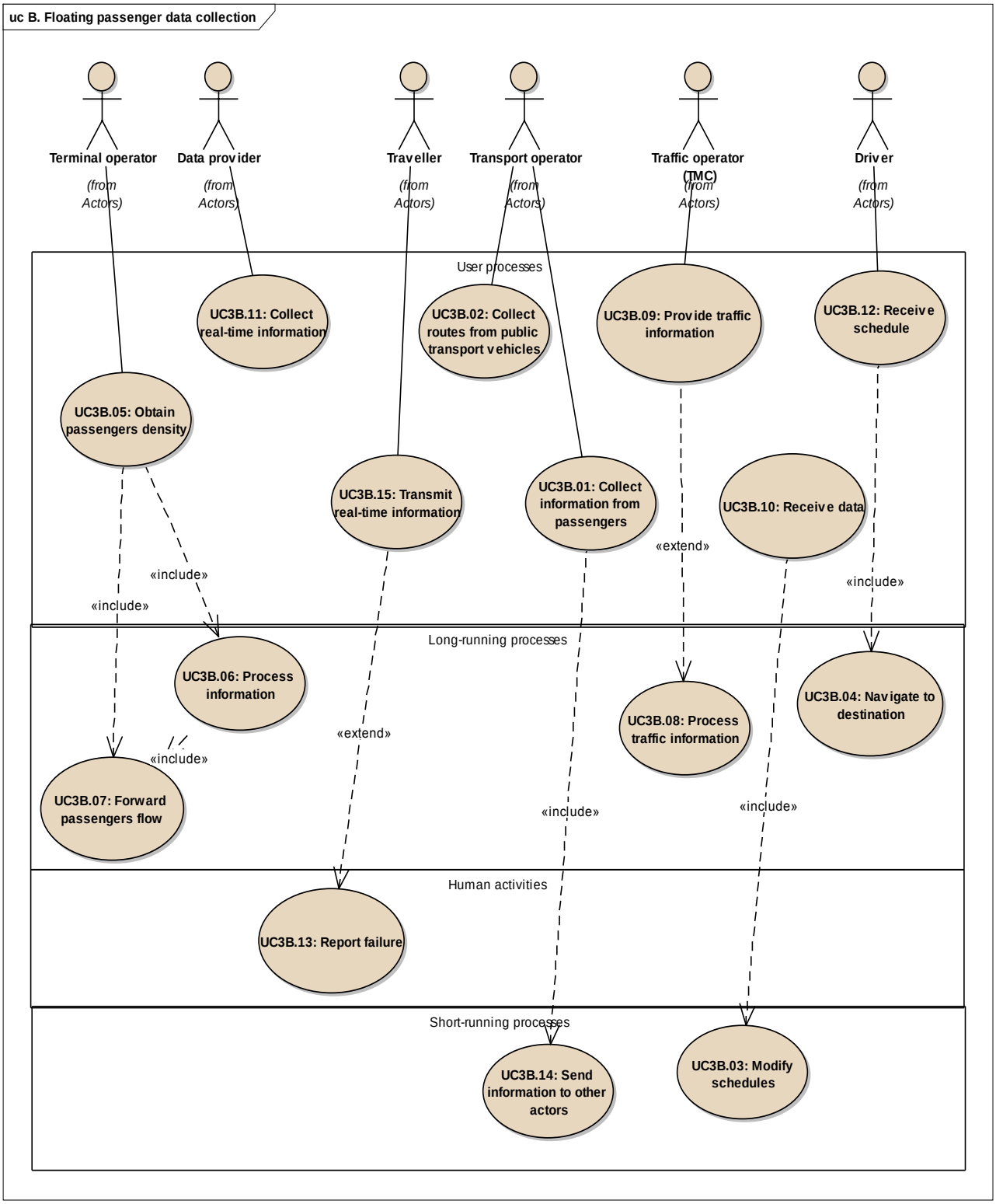

Figure 49: Use case diagram of floating passenger data

Use case	Goal	Trigger	Pre-condition	Post-condition
UC3B.01	Obtain information from passengers			The information from passengers regarding the traffic operator has been collected
UC3B.02	Obtain the routes of the public transport vehicles			The routes of the public transport vehicles are collected
UC3B.03	Obtain information from passengers	Information related to a necessary change in the schedules is received	There exists routes for the public transport vehicles	The schedules of the public transport are modified
UC3B.04	Transport the passengers to the destination point	It is received an schedule for the driver, indicating the route and timetable (if necessary)	The driver has a route to follow	The vehicle arrives to the destination point
UC3B.05	Obtain passengers density information on terminals			It is obtained a real time information regarding the passengers density at the terminals
UC3B.06	Process the information previously collected at the terminals	Information regarding passengers density has been collected at the terminals	There exists information to process collected by terminal operator	The schedules of the public transport are modified

UC3B.07	Transmit the information received regarding the passengers flow at the terminal		Passengers density information has been collected and processed	The passengers flow information is sent to Transport Operator and Service Provider
UC3B.08	Provide to other actors real-time information regarding traffic			Transmits real time traffic information
UC3B.09	Transmit real-time traffic information		Real-time information regarding traffic has been collected and processed	Real-time information regarding traffic is sent to other actors
UC3B.10	Obtain information from other actors			The service provider has data that allows him to modify the schedules
UC3B.11	Collect historical and real-time information from other actors.			The received information is received and processed
UC3B.12	Change the schedule	Schedules have been modified	The driver is in the vehicle	The driver has received a new schedule and is ready to navigate to destination
UC3B.13	Report a failure	Service disruption or bad behaviour found in the transport service	Passenger is using the service	The failure is reported to the corresponding actor

UC3B.14	Sends the information to other actors		Information has been received from passengers and public transport vehicles	The collected information is processed and sent to other actors
UC3B.15	Provide real-time information regarding the itinerary that the passenger is following		The traveller is using the transport service	The information from passengers is collected

5.3.2.3 User experience flows

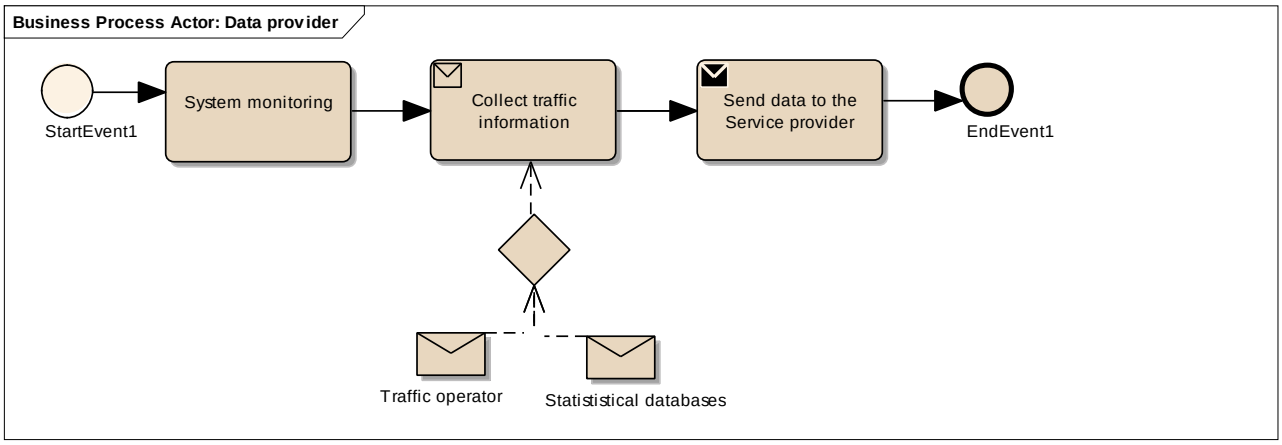

Figure 50: Floating Passenger Data Collection User Experience Flow for Data Provider

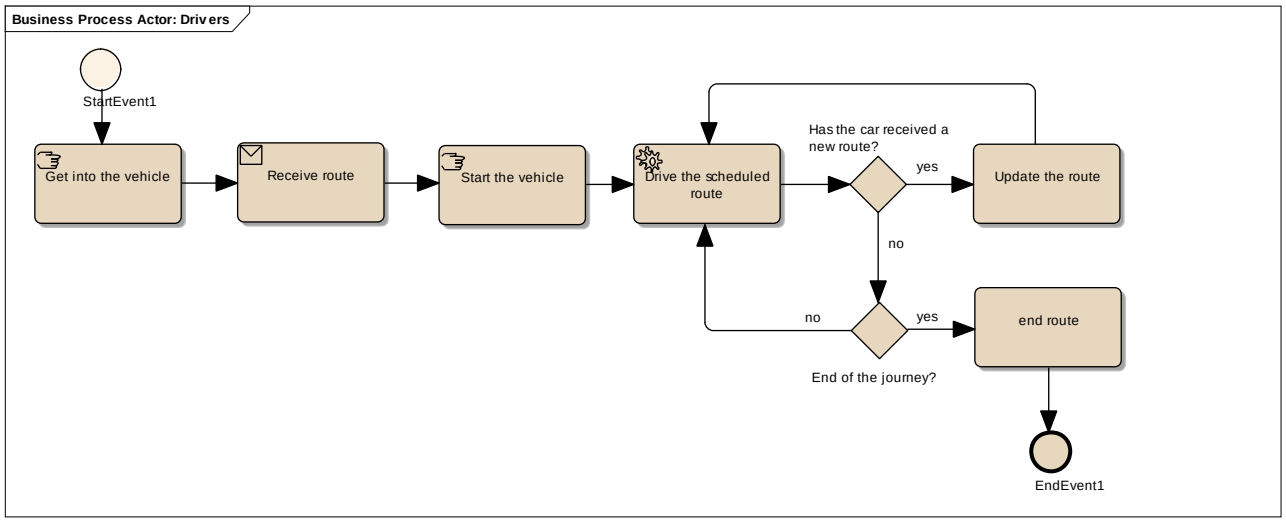

Figure 51: Floating Passenger Data Collection User Experience Flow for Service Provider

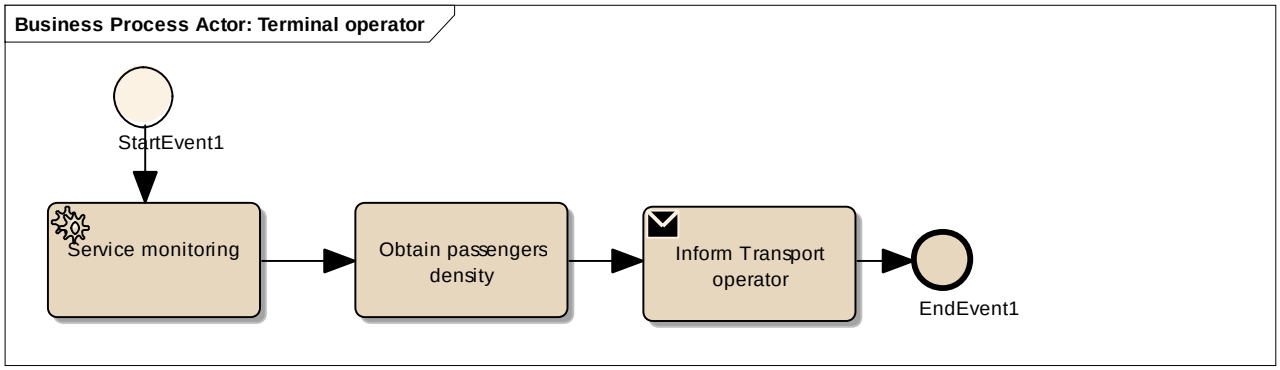

Figure 52: Floating Passenger Data Collection User Experience Flow for Terminal Operator

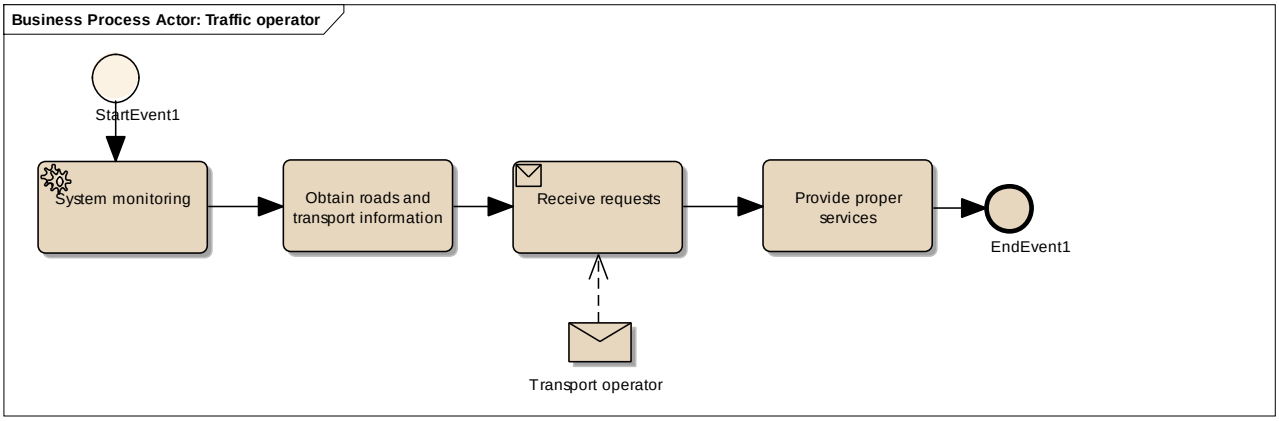

Figure 53: Floating Passenger Data Collection User Experience Flow for Traffic Operator

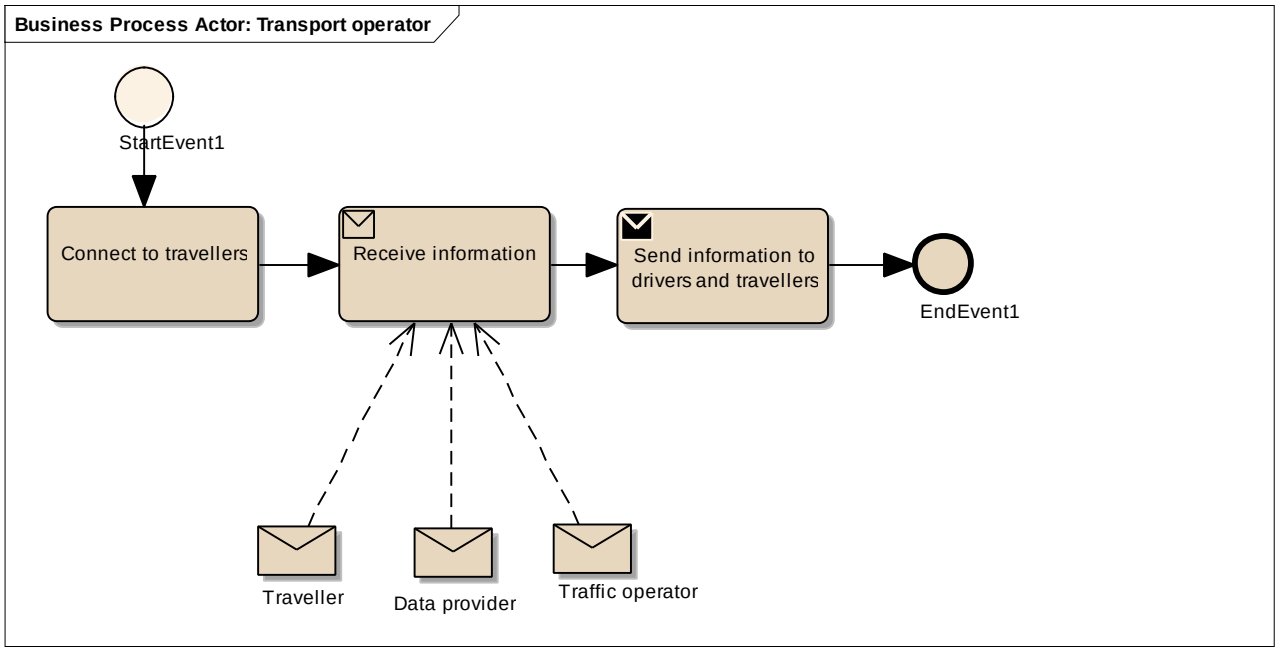

Figure 54: Floating Passenger Data Collection User Experience Flow for Transport Operator

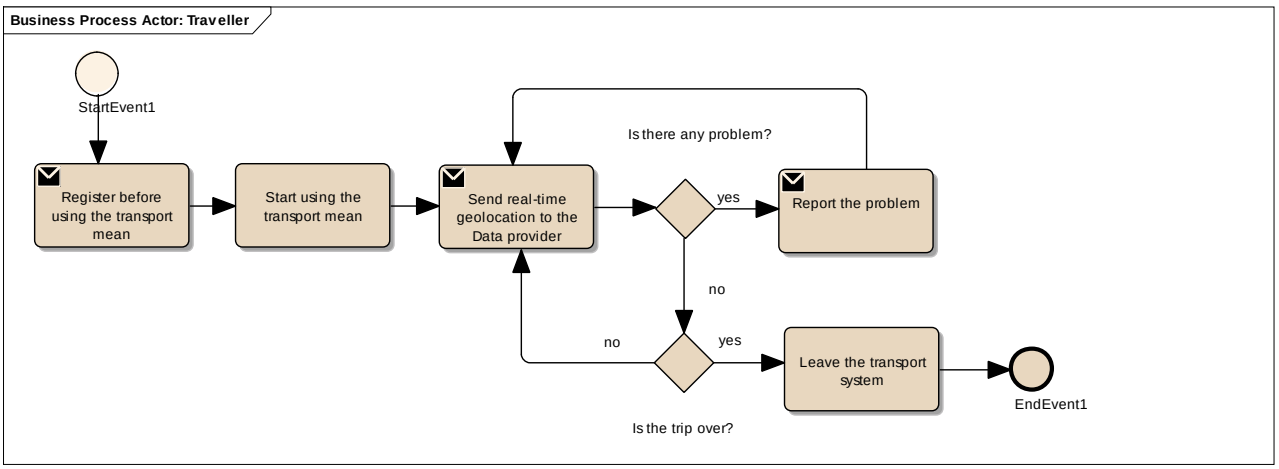

Figure 55: Floating Passenger Data Collection User Experience Flow for Traveller

5.3.3 Virtualized intersection intelligence

5.3.3.1 Description of the application

This Service concentrates in the adaptive and distributed traffic control technique, giving the fact that is one of the most complex ones and it has demonstrated to be one of the best solutions in the case of heavy and unpredictable traffic conditions. This service consists of having the traffic control operations hosted in the cloud, and at the same time use the adaptive and distributed technique by means of secure virtual local traffic light controllers connected with the traffic centre, leaving local virtual systems the task of providing safety controls and communications. Specific objective of the application is to improve traffic control systems by using the facilities provided by FI-PPP for having a high quality traffic control as well as for reducing the amount of hardware (and the costs) required for each intersection.

5.3.3.2 Functional decomposition

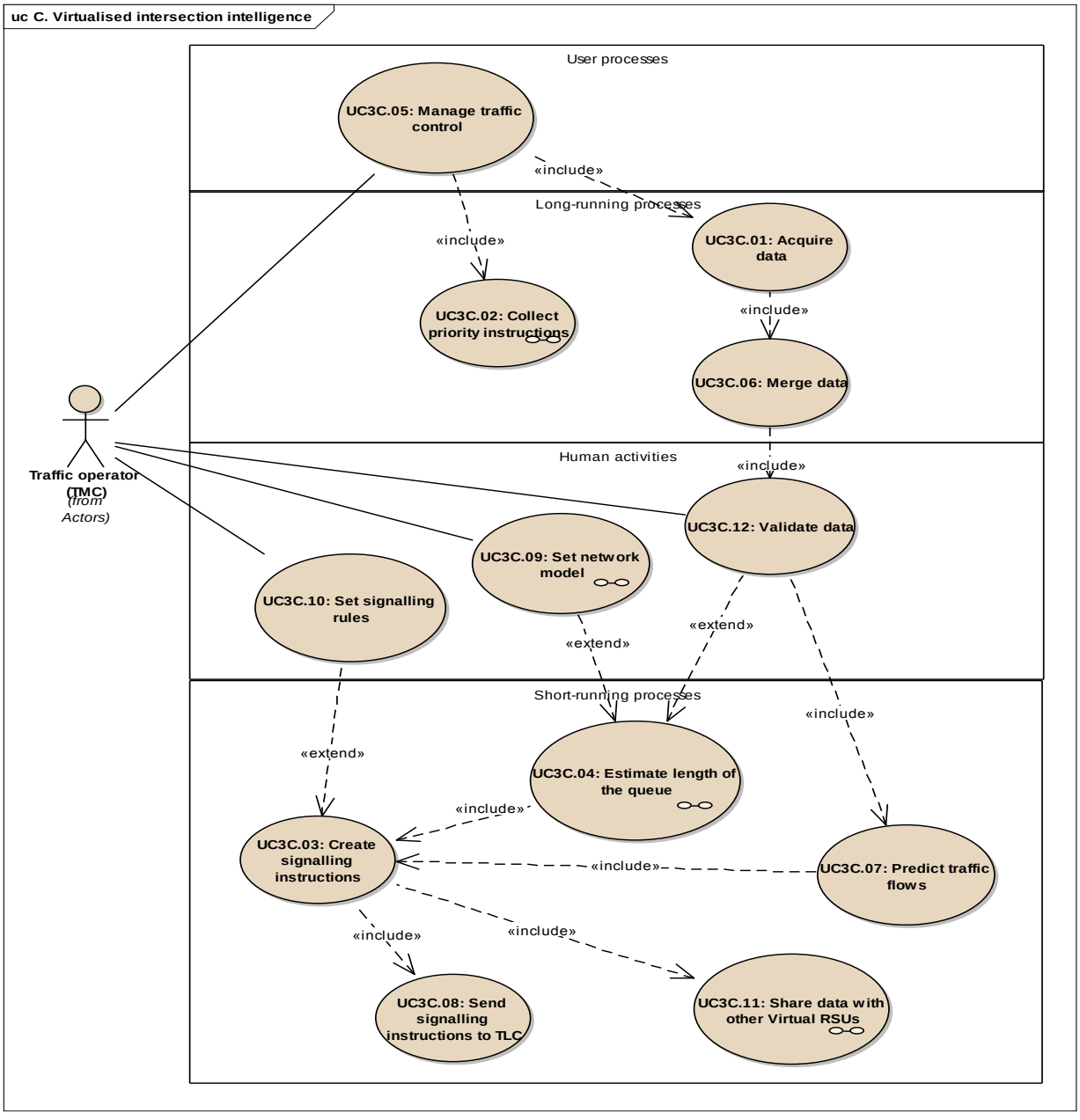

Figure 56: Use case diagram of virtualised intersection intelligence

Use case	Goal	Trigger	Pre-condition	Post-condition
UC3C.01	To acquire traffic data	The traffic signalling system starts working		Data have been acquired and stored into an effective way for virtual RSUs processing
UC3C.02	To receive priority information from PT vehicles	PT vehicles are sending information		priority information have been collected and stored in the main traffic database
UC3C.03	To create instructions for traffic lights controllers	Queue estimation has been updated	Traffic light controllers are working in non-adaptive mode	Adaptive signalling information have been created, according to the actual traffic flows and to the queue estimation performed and continuously updated
UC3C.04	To estimate the length of the queue	Traffic data are fully processed	The length of the queue is not known	The estimation of the length of the queue in each intersection of the reference network has been updated
UC3C.05	To manage traffic signalling platform	The traffic operator starts the system		The traffic signalling management platform has started monitoring
UC3C.06	To merge traffic data	Traffic data are acquired	Only raw data were available	Data have been merged and aggregated, according to spatial and chronological

				criteria
UC3C.07	To make a prediction of traffic flows	Traffic data are fully processed		Traffic forecasts have been made both for short term and long term period Current forecast has been updated
UC3C.08	To send traffic data to traffic light controllers	Signalling instructions have been created	Traffic light controllers are working in non-adaptive mode	Signalling instructions have been sent to traffic light controllers
UC3C.09	To represent the reference network			The reference network is represented into a suitable way (arches and nodes) for queue estimation and traffic signalling distributed control
UC3C.10	To set the main policies of the traffic signalling system			The traffic signalling platform policies have been determined, in terms of working principle and automated response in case of unpredictable events (e.g. incidents or emergency/special vehicle presence)
UC3C.11	To share data with other virtual RSUs	Signalling instructions have been created	Virtual RSUs are not synchronised	Traffic and adaptive signalling data have been sent to other virtual RSUs and the system has started

				working coordinately
UC3C.12	To validate traffic data, with particular reference to anomalies	Traffic data are merged and aggregated	Data do not have a reliability evaluation	Data have been compared and evaluated, and incoherent data have been removed

5.3.3.3 User Experience Flows

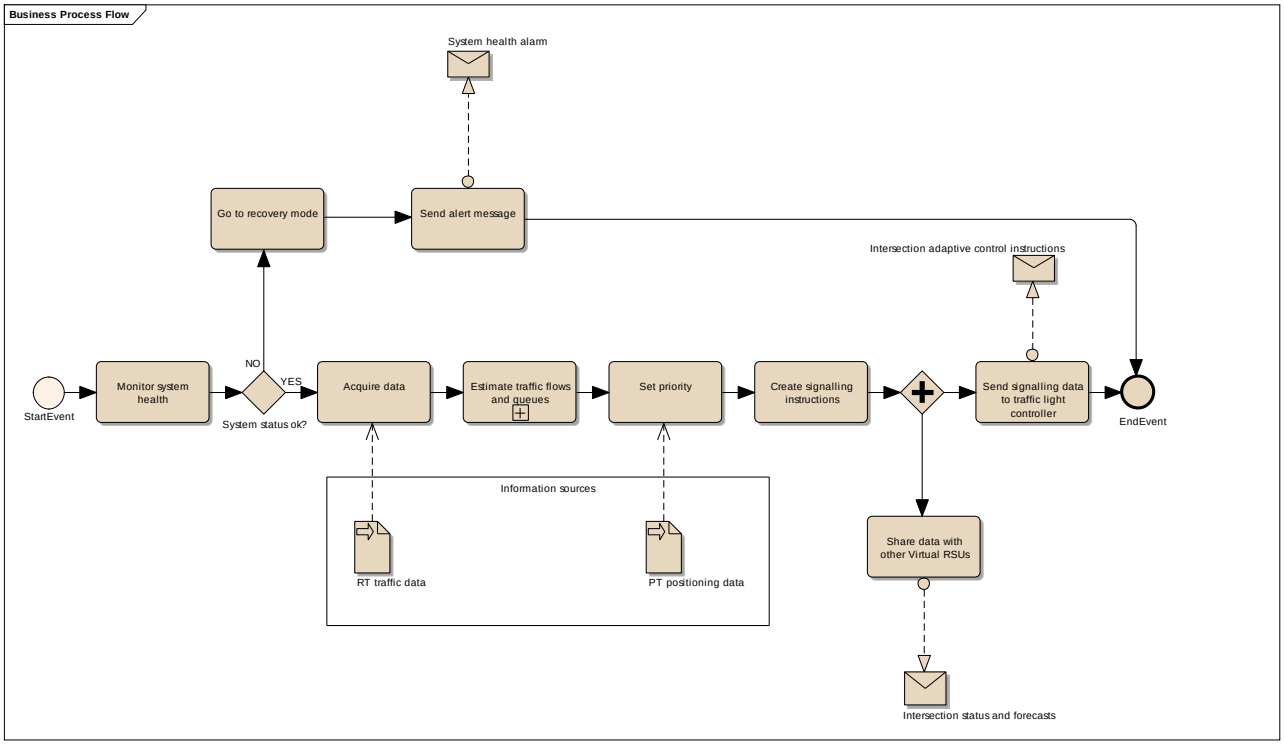

Figure 57: Virtualised Intersection Intelligence User Experience Flow For Traffic Operator

5.3.4 Cooperative traffic signal control

5.3.4.1 Description of the application

Cooperative traffic signal control is ad-hoc networks created in the cloud between clusters of vehicles and the traffic management infrastructure, offering drivers a recommended speed to avoid stopping, and the adapting the traffic signals to the real demand in real time. The service will use information from both vehicles and infrastructure to formulate strategies to achieve the optimization of the network operation. The service makes use of traffic signal control systems available in the network.

Special objectives of the application are:

- To minimize fuel consumption and CO2 emission and to improve traffic flow fluency by avoiding sudden increasing and decreasing speed by informing and instructing approaching drivers about the traffic light approaching speed in order to harmonies vehicles speeds with the traffic control strategies;
- To maximize safety by avoiding sudden speed decrease or violence of red traffic light through use of information between vehicles and traffic signal control units.

5.3.4.2 Functional decomposition

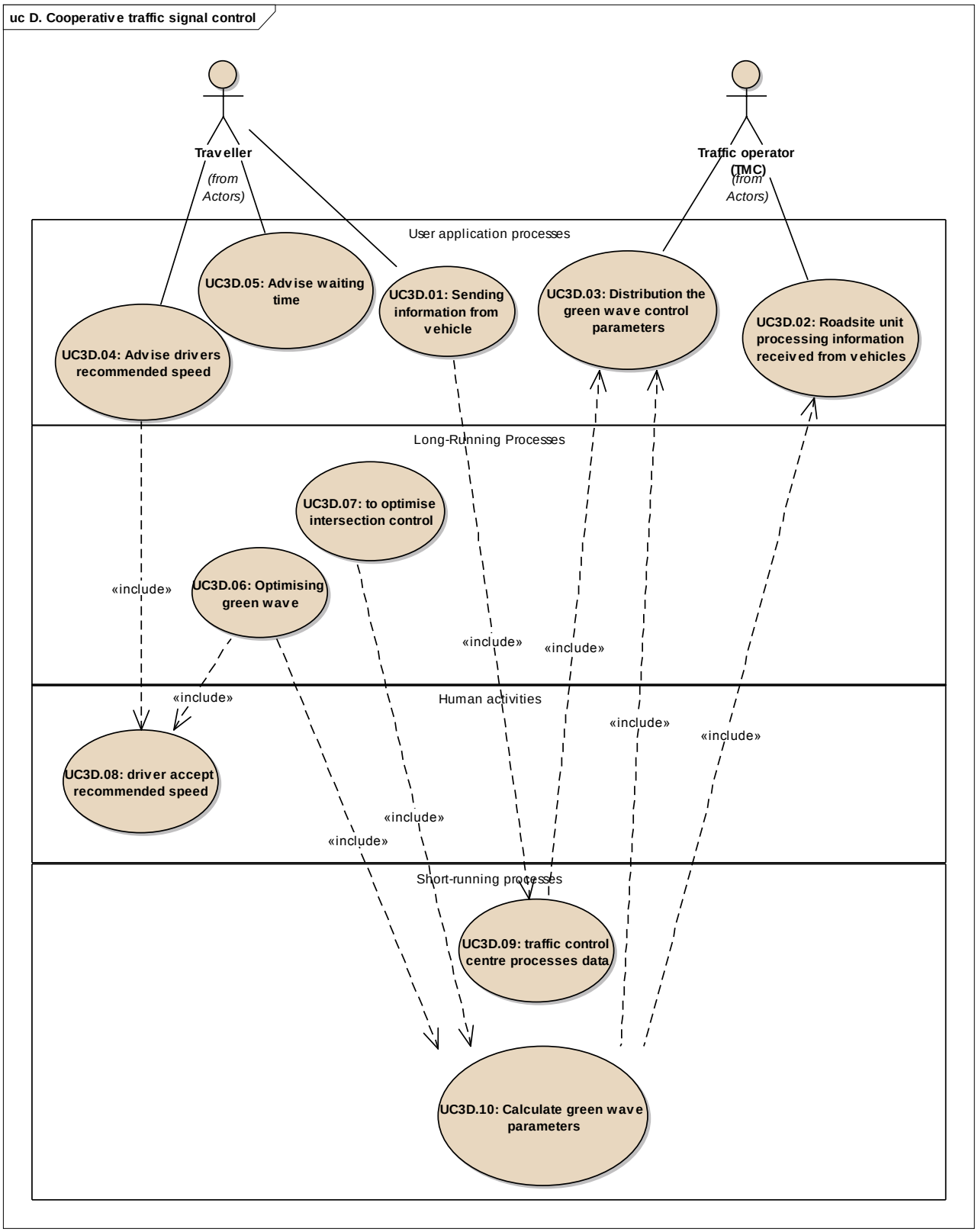

Figure 58: Use case diagram of cooperative traffic signal control

Use case	Goal	Trigger	Pre-condition	Post-condition
UC3D.01	To send information from vehicles in order to drive through intersection at the most efficient way.	A request from vehicles to roadside unite	vehicles have been equipped with communication unite to send and receive information; dynamic traffic signal control is available	drivers accept the recommended speed
UC3D.02	To receive information from vehicles and forward the information to traffic control centre.	request from vehicles received	vehicles have been equipped with communication unite to send and receive information; dynamic traffic signal control is available	drivers accept the recommended speed
UC3D.03	To distribute green wave control parameters to roadside units and the roadside units will use the parameters to calculate recommended speeds to vehicles.	A request from roadside unit	Roadside units have been equipped with communication unite to send and receive information; able to calculate recommended speeds to vehicles	drivers accept the recommended speed
UC3D.04	To send recommended speeds to vehicles.	A request from vehicle	Roadside units and vehicles have been equipped with communication unite to send and receive information	drivers accept the recommended speed
UC3D.05	To distribute waiting time to vehicles.	A request from vehicles	Roadside units and vehicles have been equipped with	

			communication unite to send and receive information	
UC3D.06	Minimize fuel consumption and CO_2-emission for a road section of subsequent urban intersections by maintaining acceptable circumstances for all road users; Use (microscopic) vehicle generated data to get a more detailed picture of the traffic situation (e.g. the concrete shape of vehicle platoons and their evolution in time); Enable new dynamic green wave control procedures that - besides waiting times and number of stops - explicitly take into account fuel minimising objective functions. Use short range communication to inform and instruct approaching drivers about green wave coordination speed and red traffic light approaching		Roadside units and vehicles have been equipped with communication unite to send and receive information	drivers accept the recommended speed

	speed in order to shape vehicle platoons and to harmonise vehicle speeds with the traffic control strategy;			
UC3D.07	Maximise safety by avoiding sudden speed decrease or violence of red traffic light through use of information between vehicles and traffic signal control units		Roadside units and vehicles have been equipped with communication unite to send and receive information	drivers accept the recommended speed
UC3D.08				
UC3D.09	traffic control centre to receive information from roadside units	request from roadside units	Roadside units have been equipped with communication unite to send and receive information; dynamic traffic signal control is available	
UC3D.10	To calculate the green wave parameters.	information from roadside units received	Dynamic traffic signal control is available	traffic signal control unit is able to use the parameters to calculate recommended speed

5.3.4.3 User Experience Flows

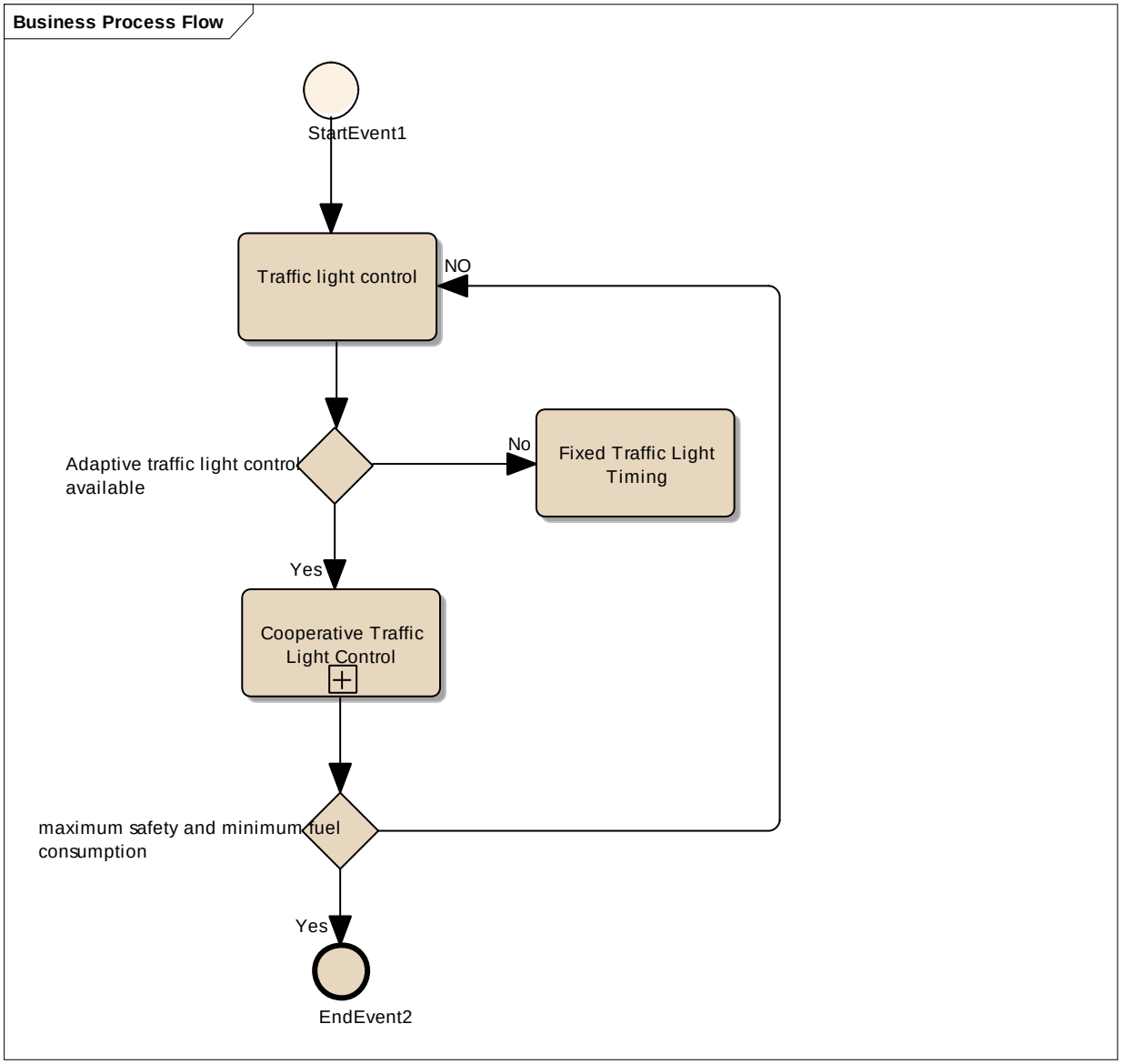

Figure 59: Cooperative Traffic Signal Control User Experience Flow for Traffic Operator

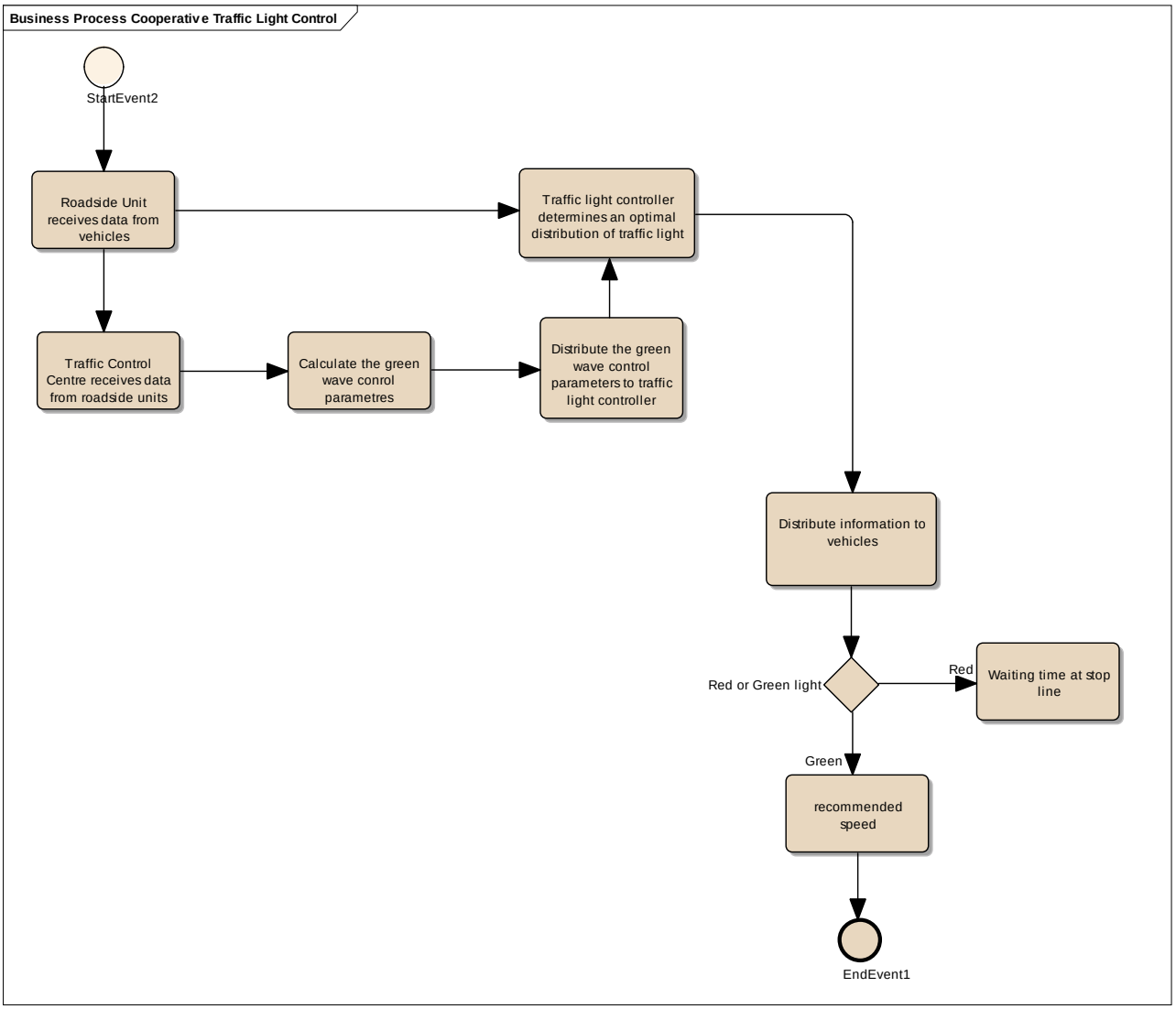

Figure 60: Sub-Flow of Cooperative Traffic Light Control

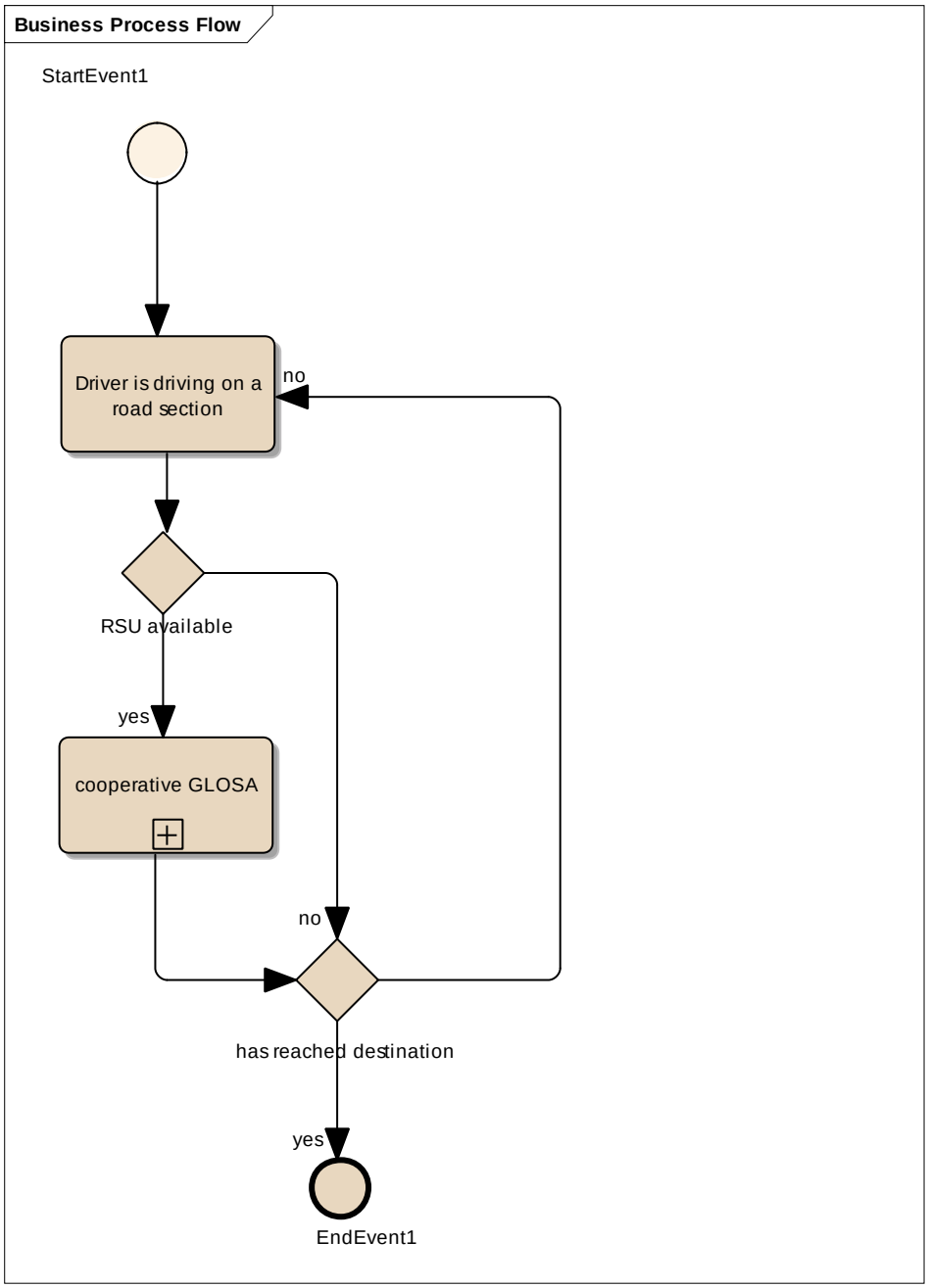

Figure 61: Cooperative Traffic Signal Control User Experience Flow for Traveller (Motorist)

5.3.5 *Area-wide optimization strategies*

5.3.5.1 *Description of the application*

This application will focus in the provision of a modular solution that can collect data from different sources and mash-up it by applying different strategies of aggregation. Furthermore, this service will concentrate into provide as an outcome analyzed data from different perspectives and summarizing it into useful information that can feed algorithms and strategies of traffic management. Strategies of self–learning will be applied and algorithms for traffic network flow prediction. Specific objective of the application is to collect, aggregate and validate data from different and innovative sources, in order to give traffic information and forecasts in non-monitored zone, for example linking to any 3rd party data in a city that

directly or indirectly collects traffic info, creating specific APIs that link cloud content providers and making use of mash-up technologies.

5.3.5.2 Functional decomposition

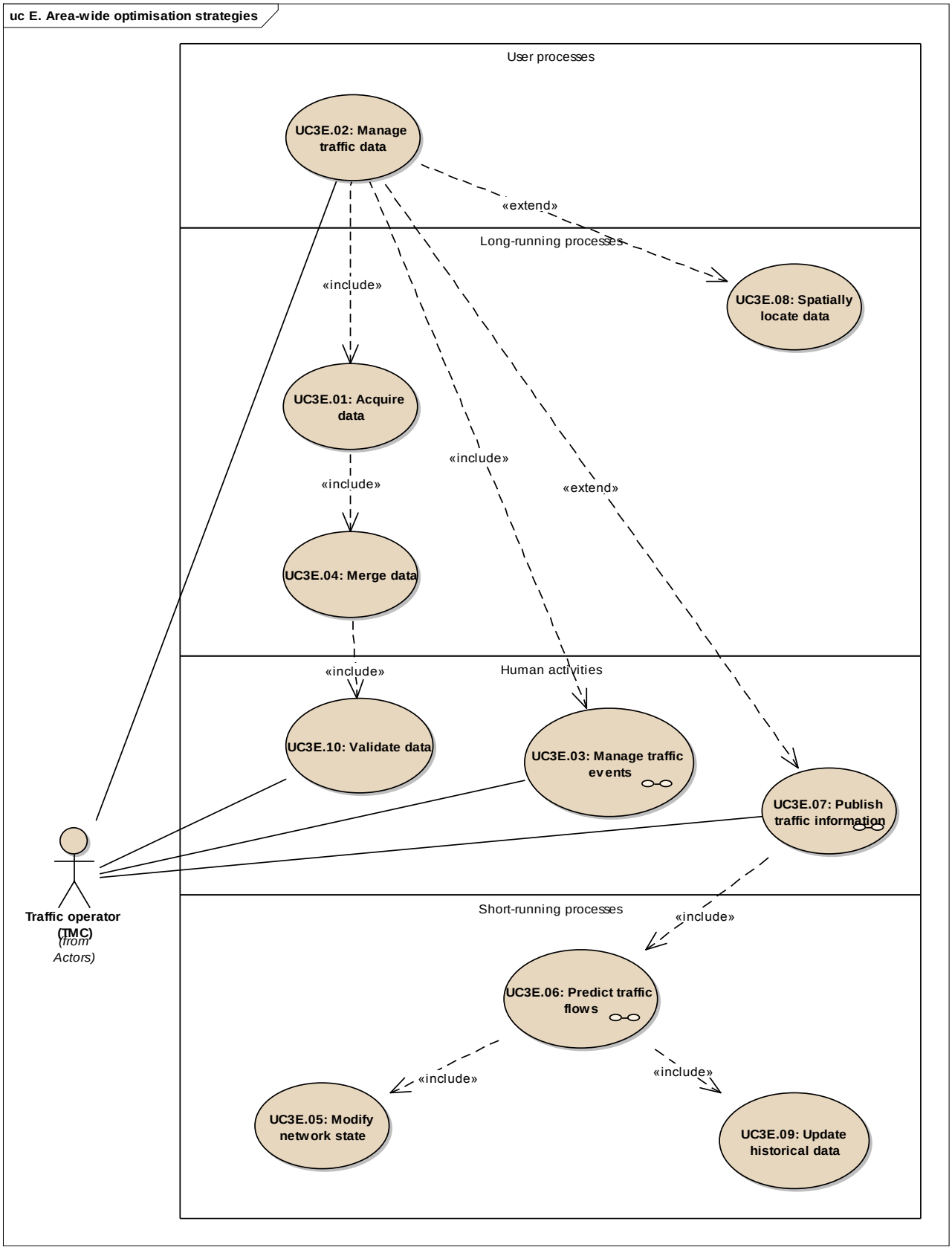

Figure 62: Area-wide Optimisation Strategies

Use case	Goal	Trigger	Pre-condition	Post-condition
UC3E.01	To acquire traffic data	The traffic management system starts working		Data have been acquired and stored with a common standard
UC3E.02	To manage traffic data	The traffic operator starts the system		The traffic management platform has started monitoring
UC3E.03	To create, edit and delete traffic events	traffic monitoring thresholds are overrated	Events are not represented on the reference cartography	Traffic events have been categorised, confirmed through cross comparison and represented on the reference map
UC3E.04	To merge traffic data	Traffic data are acquired	Only raw data were available	Data have been merged and aggregated, according to spatial and chronological criteria
UC3E.05	To represent the status of the network	Traffic forecasts have been published	There are no direct info on the network status	The status of the network (e.g. in terms of traffic flows or congestion) has been represented on the reference network, according to a defined colour code
UC3E.06	To make a prediction of traffic flows	Traffic data are fully processed		Traffic forecasts have been made both for short term and long term period

				Current forecast has been updated
UC3E.07	To share traffic information with actors and other services	Current traffic data analysis is complete		Data have been sent to sharing devices (e.g. mobile apps, web pages, ...)
UC3E.08	To geolocate traffic data	The traffic platform starts working	Data are geolocated with different methods and reference systems	The traffic data have been depicted on the common reference map
UC3E.09	To update historical data	Traffic forecasts have been published	Traffic data are not updated	Traffic data have been updated
UC3E.10	To validate traffic data, with particular reference to anomalies	Traffic data are merged and aggregated	Data do not have a reliability evaluation	Data have been compared and evaluated, and incoherent data have been removed

5.3.5.3 User experience flows

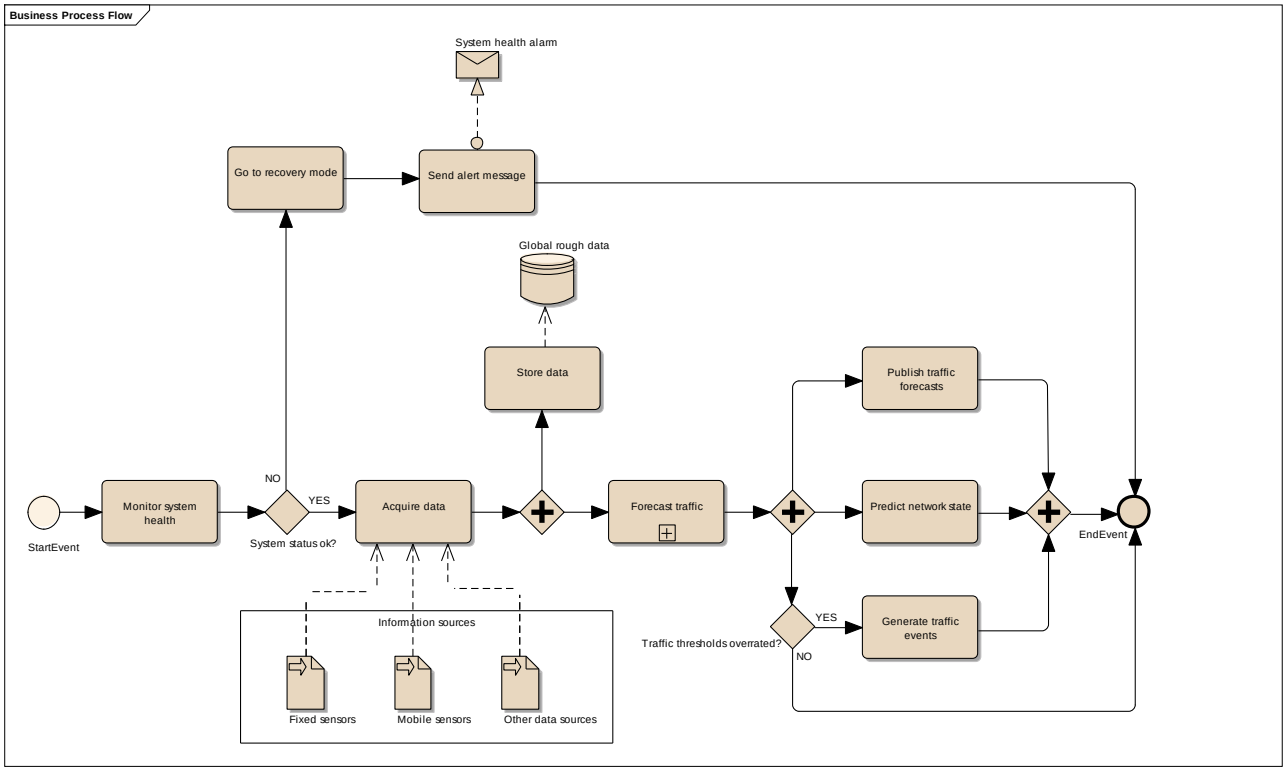

Figure 63: Area-wide Optimisation Strategies Use Experience Flow For Traffic Operator

6. Summary

6.1 Summary of Scenarios

The objective of this document is to provide a set of innovative application scenarios, each providing a rich set of functional characteristics in line with the project's general goal of innovative and Future Internet-driven urban mobility.

The procedure followed to achieve this goal started from reorganizing scenarios and services described in D3.1 into 3 use-case scenarios focused into 3 different, but related, user/business interests:

- Personal travel companion, which pursues to provide travellers and drivers the benefits of dynamic planning and follow-up during multimodal journeys.
- Smart city logistics, which intends to enhance city logistics operations with respect to safety, efficiency, environmental performance and quality of service.
- Transport infrastructure as a service, which allows the rapid deployment of a new generation of traffic management systems by exploiting, among others, Future Internet technologies such as cloud data storage, cloud computing and virtualization.

Each scenario consists of a set of applications addressing the needs of involved actors:

Scenarios	List of Applications
Personal travel companion	Dynamic multi-modal journey
	Dynamic ride-sharing
	Optimized public transport usage
Smart city logistics	Load sharing and optimizing
	Dynamic time/place drop point
	Itinerary booking and real time optimized route navigation
	Eco-optimised driving, vehicle and driveline control
Transport infrastructure as a service	Real-time traffic and route information
	Floating passenger data collection
	Virtualized intersection intelligence
	Cooperative traffic signal control
	Area wide optimization strategies

Each application has been decomposed into use cases of four types (user app processes, long-running processes, human activities and short-running processes) following a common model. The tool used for this purpose has been Enterprise Architect and the modelling language BPMN2.0.

6.2 Use of the scenarios and applications

The descriptions of the scenarios and associated applications will be used for two purposes:

- To form the basis for identifying functional and non-functional requirements which will be presented in D3.5. Functional requirements of Instant Mobility enablers will be identified

based on descriptions of each application and user experiences. The applications will be presented to different groups of stakeholders in order to identify non-functional requirements.

- To specify domain specific enablers and components (WP4) which will be prototyped (WP5). WP5 will integrate the functional descriptions of each application with design of enablers and components. Technical development of the enablers and components will be done in WP5.