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Cooperative dynamic formation of platoons for safe and energy-optimized goods transportation

COMPANION

D3.2 Information Model for Platoon Services

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Abbreviations

3G	Short form of third generation of mobile telecommunications technology
AP	Assignment Plan – Plan for the truck with route, speed profile and merge/split points for platooning
ACC	Adaptive Cruise Control
BPMN	Business Process Model and Notation
CAM	Cooperative Awareness Message
CACC	Cooperative Automatic Cruise Control
CC	Cruise Control
ETA	Estimated time of arrival
HMI	Human-Machine Interface
MOE	Monitoring and Optimization Engine
NDS	Navigation Data Standard
RCE	Route Calculation Engine
TA	Transport Assignment – Assignment issued by the dispatcher with Start, Destination and preferred time of arrival
V2V	Vehicle to Vehicle
V2X	Vehicle to Infrastructure
WGS84	World Geodetic System 1984

Executive summary

The objective of the COMPANION project is to develop co-operative mobility technologies for supervised vehicle platooning, in order to improve fuel efficiency and safety for goods transport. The potential social and environmental benefits inducted by heavy-duty vehicle platoons (or road trains) have been largely proven. However, until now, the creation, coordination, and operation of such platoons have been mostly neglected. The COMPANION project aims to develop a new energy efficient and user-friendly integrated framework for coordinated driving of heavy-duty vehicles.

This document represents the deliverable D3.2 – Information Model for Platoon Services.

The document contains the descriptions of the processes and information exchange between components from the point of view of vehicles, facilities, and systems, according to the scenarios defined in the deliverable D2.1, the user requirements expressed in the deliverable D 2.3 and the technical requirements captured in D2.4. Furthermore, the overall component architecture is described in detail in deliverable D3.1. This component architecture will be sketched in chapter 2 of the document, a more detailed description of the regarding components and services can be found in deliverable D3.1.

This deliverable focuses on the refinement of processes described in the use cases of D2.1. These business processes are described in chapter 3 of this document. To this end, the processes of the use cases from D2.1 are modeled as business processes, using BPMN, while also referring to the concrete used services. While a use case captures the mere functionality, the purpose of this document is to provide a mapping of the processes to the concrete services of the component architecture.

Chapter 4 consists of the data definitions used throughout this document and has mainly the purpose to serve as a reference section, as these data definitions are mentioned in several places of the document and to have a central place in this document.

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1. Introduction

The objective of the COMPANION project is to develop co-operative mobility technologies for supervised vehicle platooning, see Figure 1-1, in order to improve fuel efficiency and safety for goods transport. The potential social and environmental benefits inducted by heavy-duty vehicle platoons (or road trains) have been largely proven. However, until now, the creation, coordination, and operation of such platoons have been mostly neglected. The companion project aim to develop a new energy efficient and user-friendly integrated framework to coordinated driving of heavy-duty vehicles.

Figure 1-1 A heavy-duty vehicle platoon

Proposed is a new real-time coordination system, which will define an optimized flow of vehicles in order to dynamically create, maintain and dissolve platoons according to an online decision-making mechanism, also taking into account historical and real-time information about the state of the infrastructure. With such a technology, platoons will no longer be composed just of vehicles with common origins and destinations, but rather created dynamically on the road, by merging vehicles (or sub-platoons) that share only parts of their routes.

Platooning

According to the BASt definition[1], the levels of automation of the driving task can be classified as follows:

No Automation—Driver is in complete control of the vehicle.

Driver Assistance—Partial automation of either longitudinal control (e.g., ACC) or lateral control (e.g., lane-keeping) while the driver controls the other functions and remains fully engaged in the driving task.

Partial Automation—Both longitudinal and lateral control are automated, but the level of automation is sufficiently limited in capability that the driver needs to continuously monitor its behavior and be prepared to take over control at any time.

High Automation—Both longitudinal and lateral control are automated but at a higher level such that the driver no longer needs to continuously monitor its behavior and only needs to be prepared to take over control within a "certain" (currently unspecified) time interval.

Full Automation—The system has a sufficiently high level of automation that when it requests the driver to regain control (because of a condition it cannot handle), and the driver fails to respond, it can return to a minimum-risk condition (such as stopping the vehicle) by itself.

The focus of the COMPANION project is to coordinate trucks into platoons on the automation level "Driver assistance". The longitudinal control will be automated. The driver will be responsible for lateral control, steering the vehicle and all other functions in the truck.

[1]Legal consequences of an increase in vehicle automation
http://www.bast.de/DE/FB-F/Publikationen/Download-Publikationen/Downloads/F-legal%20consequences.pdf?__blob=publicationFile

About this Document

This document represents the deliverable D3.2 – Information Model for Platoon Services. These processes and information models have been derived from:

1. The use scenario and use cases defined in the delivery D2.1 - Potential scenarios for new platooning concepts [1],
2. The user requirements defined in the delivery D2.3 - Final user requirements [2],
3. The technical requirements defined in the deliverable D2.4 [3],
4. The business requirements defined in the deliverable D2.5 [4],
5. The overall architecture defined in D3.1 [6],
6. Interviews with potential end users.

The flow is illustrated in Figure 1-2. This deliverable along with deliverable D3.1 is essential for the subsequent refinement of the design of the architecture, implementation, testing and validation of the actual COMPANION system.

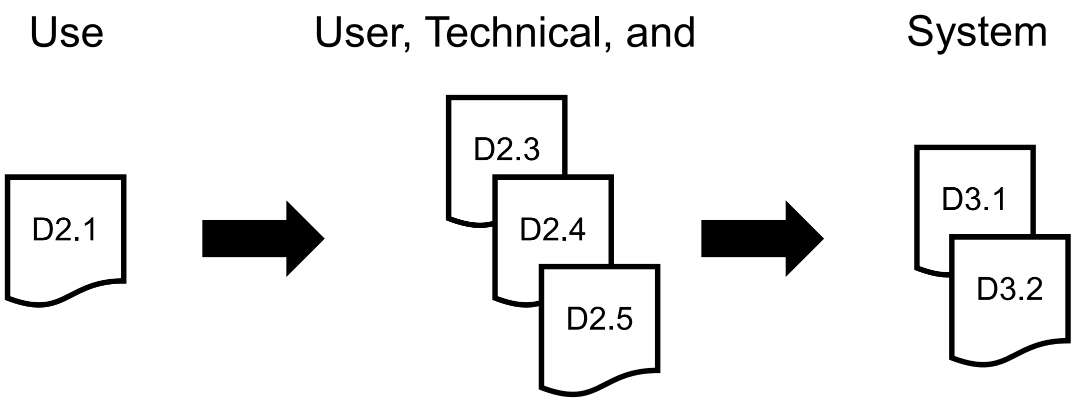

Figure 1-2 Overview of COMPANION deliverables

The document follows the logical structure of deliverable D2.1: “Potential scenarios for new platooning concepts” and is partitioned in three sections: before trip, platooning and recalculation.

The processes sketched in the use cases are modelled in BPMN 2.0 (Business Process Model and Notation), which is specified by the Object Management Group (OMG)[2] .

Furthermore, the information exchanged between components is described in tables that specify the parameters, their description and data types.

Users and Stakeholders

The users and stakeholders of the COMPANION system were defined in deliverable D2.1 and are shown in this document for reference. In this document mainly the driver and the dispatcher are concerned, because they are the users interacting with the COMPANION system.

Users are all parties that interact directly with the system whilst stakeholders are all parties that have an interest in the system and are directly or indirectly affected by it. The users and stakeholders are illustrated in Figure 1-3 and described in the following sections.

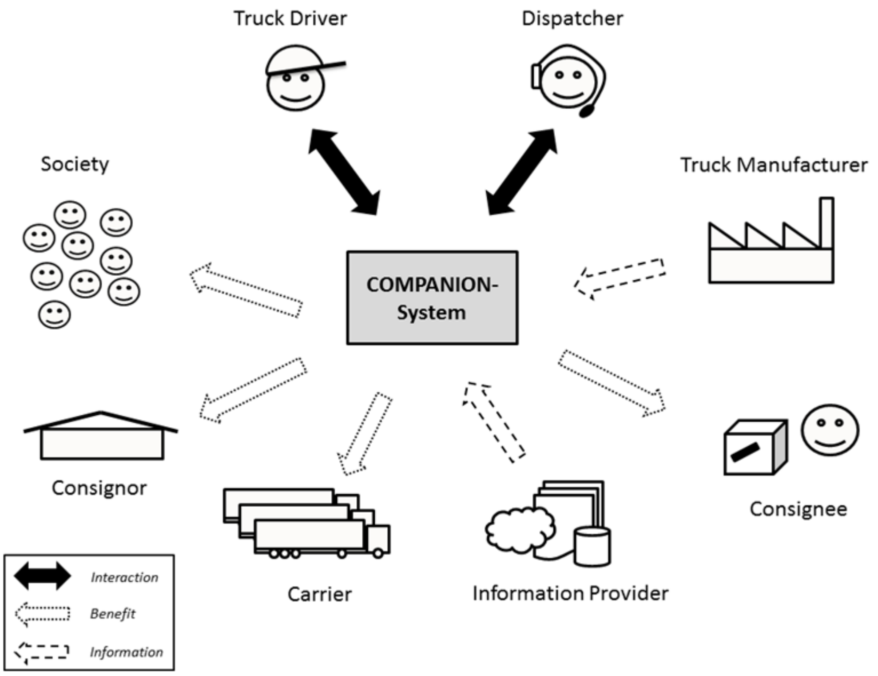

Figure 1-3 Users and Stakeholders of the COMPANION-system

[2] BPMN 2.0 Reference: http://www.omg.org/spec/BPMN/2.0/

Users of the COMPANION-System

Dispatcher

The dispatcher is responsible for coordination of transports within a carrier company. By communicating relevant information and tracking the vehicles, the dispatcher assures that the transports are carried out according to desired service levels at a minimal cost. The COMPANION-system will support the dispatcher to find an optimal transport plan, with respect to minimal fuel consumption, for all trucks in the fleet, by means of coordinated platooning.

Truck Driver

The truck driver is responsible for maneuvering the truck from its origin to its destination according to given time constraints at a minimal cost. The COMPANION-system will support the truck driver in his/her efforts to minimize the cost of driving the truck from its origin to its destination, by means of coordinated platooning. The system will help the driver to calculate the route and speed prior to and during the transport assignment in order to form platoons in a fuel optimal way and to reach the destination in time.

Stakeholders of the COMPANION-system

Carrier

A carrier is a company transporting goods for a client (e.g. a consignor). The objective of the carrier is to complete the transport assignments according to agreed time constraints at a minimal cost. The COMPANION-system will contribute to a lowered total cost of transport with retained level of service, which will benefit the carrier.

Consignor

Consignor is the party sending a shipment. The consignor has contracted the carrier to transport goods according to an agreed time constraints and cost. The COMPANION-system will contribute to a lowered total cost of transport with retained level of service, which will benefit the consignor.

Consignee

The consignee is the person to whom the shipment is to be delivered. The consignee has contracted the consignor to provide goods at an agreed time and cost. The consignee will be the one determining the preferred service level (time constraints, flexibility etc), affecting the minimal cost of transport. The COMPANION-system will contribute to a lowered total cost of transport with retained level of service, which will benefit the consignee.

Truck Manufacturer

The truck manufacturer will provide the COMPANION-system with information about the characteristic and current state of the truck required for optimizing the fuel consumption, by coordinating trucks into platoons. The truck manufacturer will also make use of the information from the COMPANION-system, by informing the driver or controlling the vehicle according to the speed recommended by the system.

Information Providers

Information providers will provide the COMPANION-system with information about the characteristic and current state of the road infrastructure and traffic situation (weather information, traffic flow information etc.), required for optimizing the fuel consumption by coordinated platooning.

Society

The COMPANION-system will contribute to reduced environmental impact from transports by lowering the emission.

2. Overall Architecture

This chapter sketches the overall components architecture of the COMPANION system and the flow of information for the nominal use case, which is the strategic planning of Assignment Plans for the vehicles. This document mainly addresses the Route Management Layer of the layered architecture described in *D3.1 - Component Specifications for the Overall Architecture* [6], because the focus of the COMPANION project lies on the off-board plattform for creation and coordination of platoons.

For the sake of clarity, the lower 2 layers of the layered architecture will therefore be addressed in a cursory fashion.

For further details on the components architecture, please refer to deliverable *D3.1 - Component Specifications for the Overall Architecture*.

Figure 2-1 depicts the main components of the overall architecture and the main flow of information between these components.

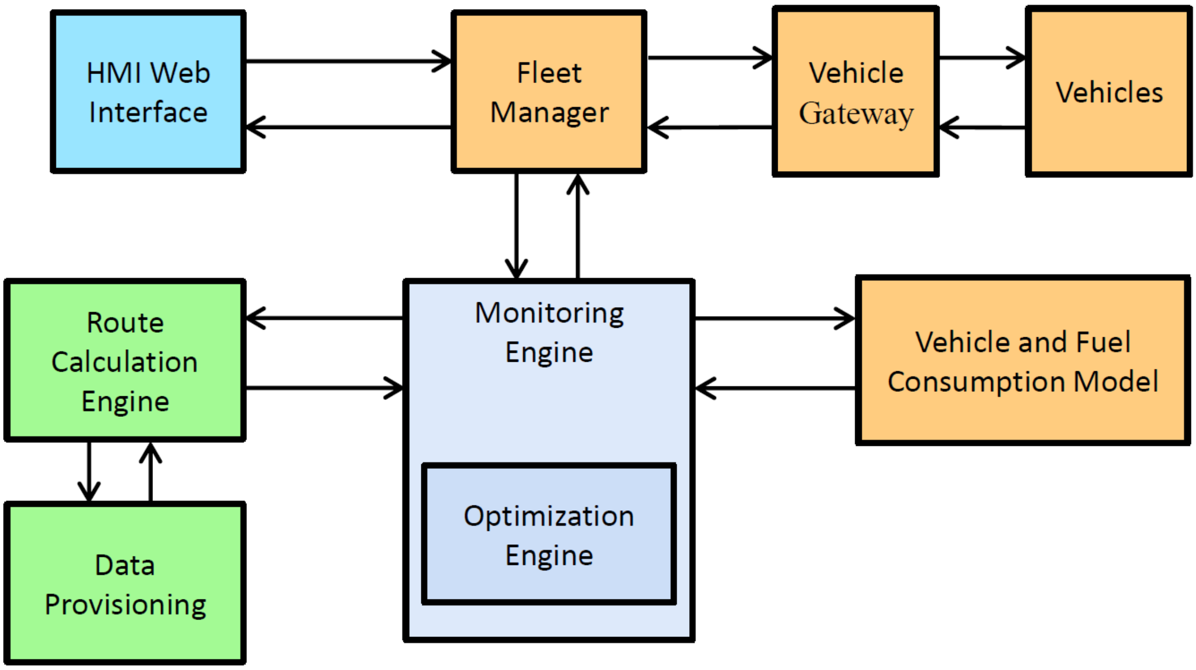

Figure 2-1: COMPANION Overall Architecture

Main Flow of Information

As the architecture above only captures the components of the system but not how these interact during the operation of the COMPANION system, it is also vital to model the dynamic part of such system: processes and the interaction with its users. To this end, the nominal use case of the strategic planning phase is described here with a sequence diagram, shown in **Fel! Hittar inte referenskälla.**.

The nominal use case of the system shows the main flow of information during the strategic planning phase. The term nominal use case indicates, that the main process is described for the sake of clarity, without going into detail how to handle how the system should behave, if an error needs to be handled in this process.

The nominal use case starts with the dispatcher of a company entering a Transport Assignment into a web-application, which the dispatcher can use with a Web-Browser. The Transport Assignment consists of all the data needed for the planning of a transport such as start and destination of the transport, and departure and arrival times.

When the dispatcher chooses to store the Transport Assignment, it is sent to the off-board platform. The Fleet Manager Service is responsible for storing, managing and updating the Transport Assignments.

As the Transport Assignment has been submitted to the COMPANION system by the dispatcher, it is now time to start the optimization process of finding the optimal route, speed profile and other trucks to platoon with in order to minimize the fuel consumption of the vehicle for this transport.

After the Fleet Manager received and stored a Transport Assignment, it sends the assignment to the Monitoring and Optimization Engine. The optimization process for an assignment starts with calculating the initial optimal route, a coarse speed profile and fuel consumption for this single transport. The Monitoring Engine asks the Route Calculation Engine for the optimal route, which is then returned to the Monitoring Engine. This route already contains a coarse speed profile. In order to get a more detailed speed profile for this route, the Monitoring Engine queries the Vehicle and Fuel-Consumption Model for the traversal time of this transport. In a second query to the Vehicle and Fuel Consumption Model the Monitoring Engine gets an estimate for the fuel-consumption of the transport.

With the detailed speed profile and the optimal route for an individual transport, the Monitoring and Optimization Engine is now able to look for other transports and platooning opportunities for this transport. The optimization process consists of finding possible transports to platoon with and subsequently calculating, which combination of trucks to platoons yield in a global minimal fuel consumption. During the optimization the speed profiles of the trucks have to be adapted so that the trucks are able to meet on the highway. Furthermore, merge and split points are introduced, which are the calculated points, where the trucks merge and split from a platoon.

The result of the global optimization in the Monitoring and Optimization Engine is a Platooning Plan for each truck. This Platooning Plan incorporates the route and speed profile for the vehicle and the merge and split-points for the according platoons. When the Optimization Engine has calculated the Platooning Plan, this plan is sent to the Fleet Manager.

The Fleet Manager stores this Platooning Plan and calculates an even finer speed profile for this transport. The Platooning Plan with this refined speed profile is called Assignment Plan. After the Fleet Manager calculated the Assignment Plan, this plan is sent to the truck.

When the truck starts with the transport, the vehicle starts sending its status (position, velocity, etc.) to the Fleet Manager, which is also responsible for storing the vehicle's track, meaning the historical data. Furthermore, the dispatcher can get information about the current state of the transport via the web interface.

Because the traffic is dynamic and introduces deviations from the Assignment Plan, for example due to a traffic jam, a recalculation of the Assignment Plan can be triggered by the Monitoring and Optimization Engine, which gets the information of the current state of a transport from the Fleet Manager. The next chapter contains a detailed description of processes concerning the strategic planning, platooning and the recalculation of the Assignment Plan due to unpredicted events.

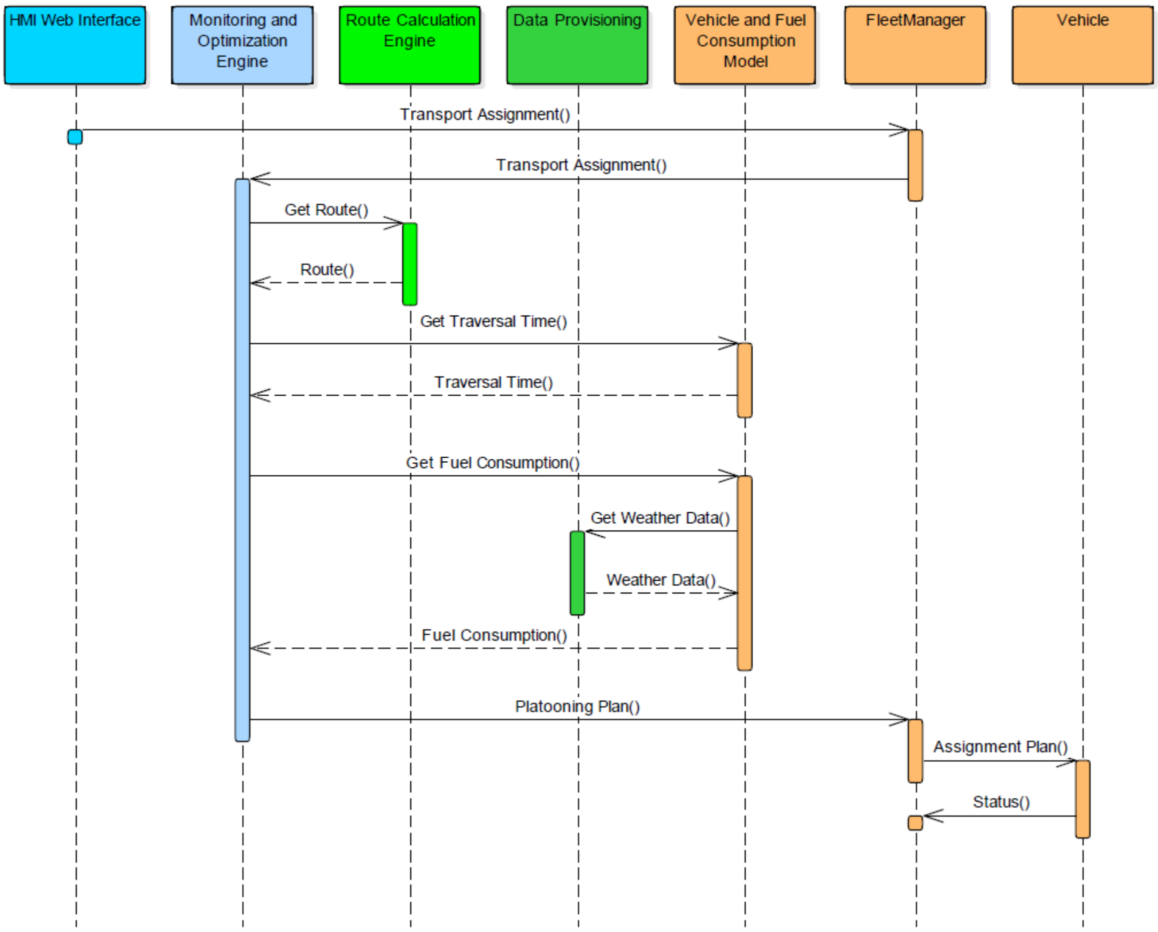

Figure 2-2: Main Flow of Information during Planning

3. Main Business Processes

This chapter describes the main business processes in the COMPANION system.

The processes are structured in the sections:

- Before trip
- Platooning
- Recalculation

Before Trip

This section includes the main business processes concerning the strategic planning. In this planning phase the dispatcher submits a Transport Assignment to the system and the COMPANION system looks for other vehicles to platoon with prior to the actual transport. The result of this planning and optimization process is an Assignment Plan, which consists of an optimal route, fine grained speed profile, merge points and split points for platooning.

Before Trip 1 – Add Separate Planned Transport Assignment

The use case *Before Trip 1 – Add Separate Planned Transport Assignment* from deliverable D2.1 describes the use case for the dispatcher submitting a Transport Assignment to the COMPANION system. Figure 3-1 depicts the according business process of the use case *Before Trip 1* modeled in BPMN. A *Transport Assignment* contains all data needed for a single transport, for example origin, destination and planned timed of arrival (see Table 1: Transport Assignment).

The web interface is responsible for handling the access to the Transport Assignment database and sends the Transport Assignment to the Fleet Manager Service.

The Receiving Transport Assignment process at the Fleet Manager is responsible for checking the validity of the transport assignment received from the dispatcher. For example, the Earliest Time for Departure of the *Transport Assignment* cannot be previous to the current time.

After the Receiving Transport Assignment process has handled the *Transport Assignment*, the service sends a *Confirm Assignment* notification (see Table 2) to the dispatcher. This *Confirm Assignment* notification indicates if the assignment was successfully stored at the Fleet Manager. This notification reports success, if the data set was successfully stored by the Fleet Manager or contains an error message, which points out what went wrong.

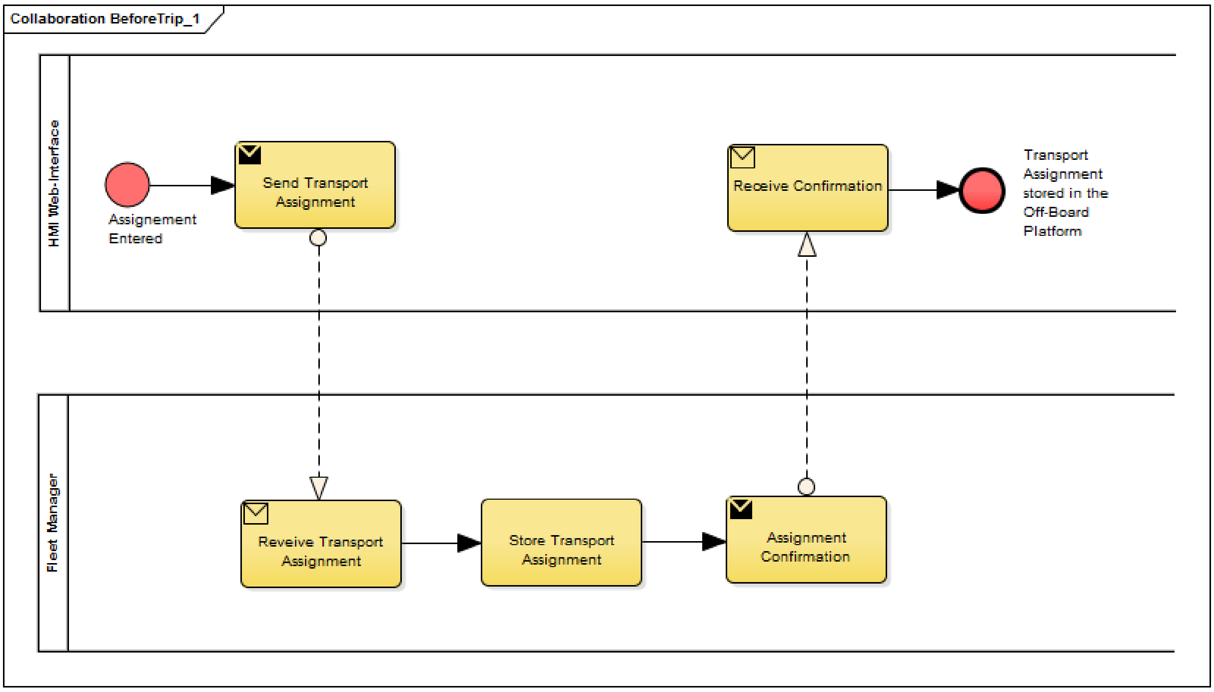

Figure 3-1: Process of Use Case *Before Trip 1 – Add separate planned transport assignment*

Before Trip 2 – Assignment of Optimal Route

A certain time before a transport the Assignment Plan is calculated. This plan consists of the optimal route, speed profile and merge and split points for platooning.

This is achieved by matching trucks witch overlapping routes together to platoons and adapting their speed profiles in such a way, that they are able to meet on a highway during a transport.

To this end, a scheduling service selects transports from the Transport Assignment database and notifies the dispatcher that a certain transport is due. If the dispatcher confirms, that the given constraints still hold, this Transport Assignment is given to the Monitoring and Optimization Engine, which calculates in cooperation with the Route Calculation Engine the optimal platooning strategy for this set of vehicles. The optimal strategy is in the case of the COMPANION system the strategy with minimal global fuel consumption.

After the optimal route and speed profile for such a set of vehicles has been calculated, the Assignment Plan is sent to the driver and the truck and stored in a database in the off-board platform. Both, truck and driver have to send a notification to the dispatcher, that this information has been received successfully.

The BMPN diagram in Figure 3-2 depicts this business process. Please note, that this diagram essentially captures the same process as the sequence diagram **Fel! Hittar inte referenskälla.**, but focuses on the interaction of the users with the system and does not depict all services in detail.

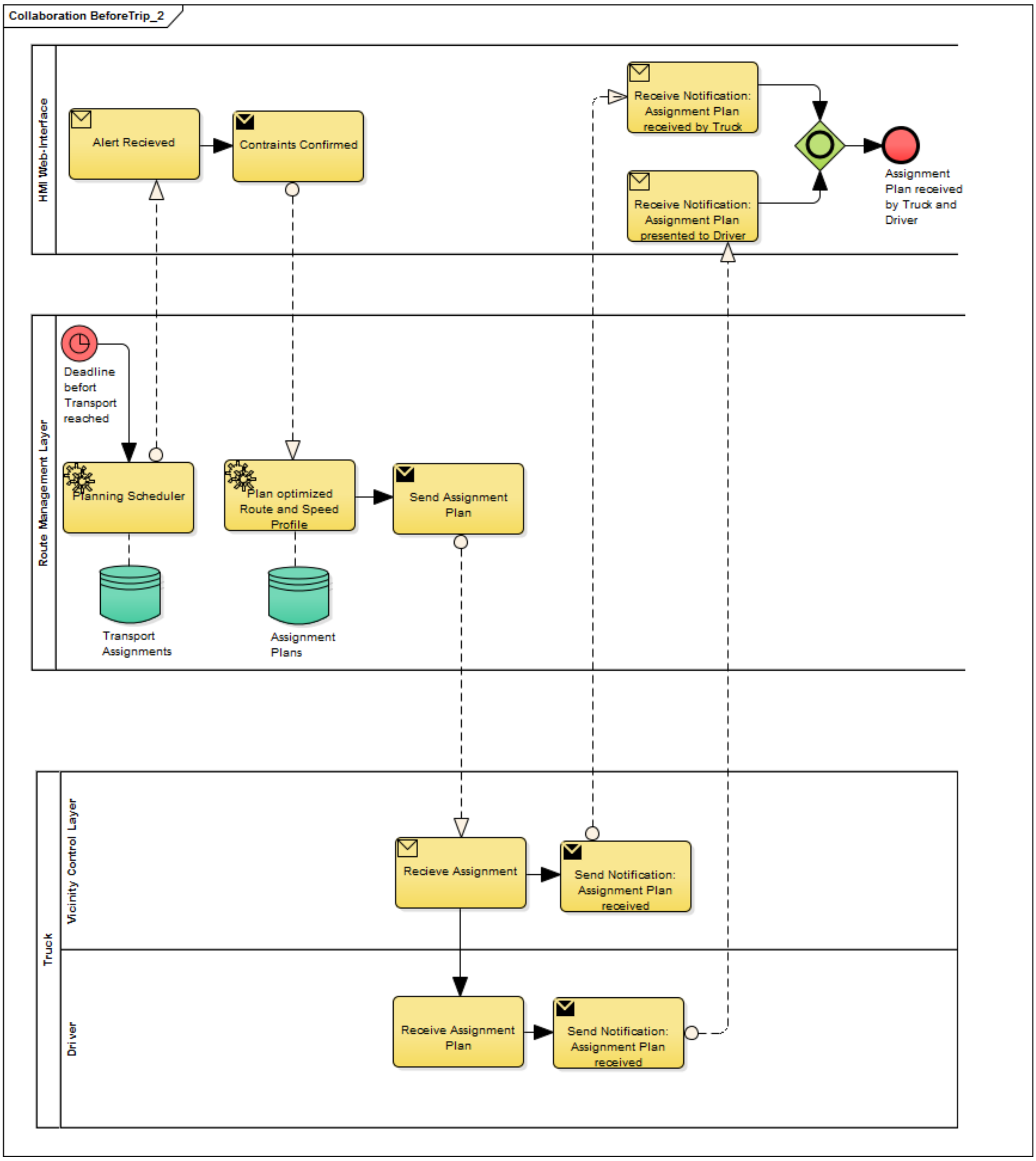

Figure 3-2: Process of Use Case *Before Trip 2 – Assignment of Optimal Route*

Before Trip 4.1 – Start Trip with Automatic Speed Control

The use case *Before Trip 4.1 – Start Trip with Automatic Speed Control* is addressing the driver entering the highway and activating the cooperative automatic cruise control (CACC). The business process for this use case is depicted in Figure 3-3.

Before activating the CACC, the truck driver has to start the trip and drive the truck to a highway. Only, when the truck is on a highway, the CACC of the vehicle can be activated. The automatic activation of an automation in a vehicle is not allowed, therefore the driver has to engage the CACC manually. The automatic speed control follows the speed profile of the Assignment Plan.

Of course the truck has to mind the surrounding traffic when following the speed profile of the Assignment Plan. This is realized by an arbiter in the CACC that follows the speed profile of the Assignment Plan if no vehicle is in front of it and adepts the speed of the truck in case another vehicle is driving in front of it with a slower speed than planned according to the speed profile of the Assignment Plan.

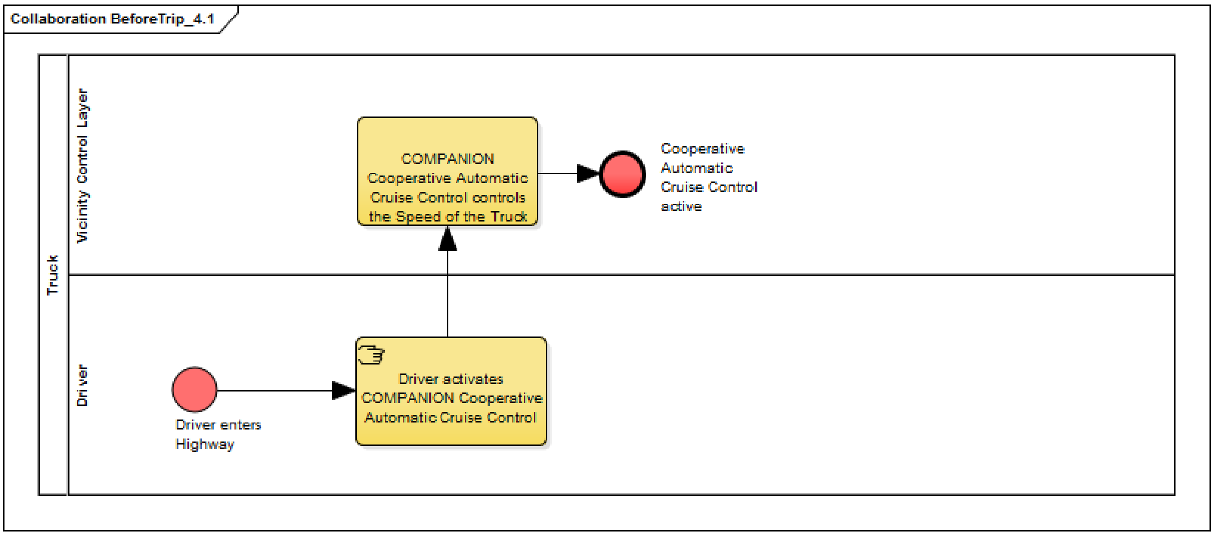

Figure 3-3: Process of Use Case *Before Trip 4.1 – Start Trip with Automatic Speed Control*

Platooning

This section describes the business processes related to the use cases for platooning.

Platooning 1.1 – Automatic Platoon Formation

This use case describes the process of joining a platoon. While the truck joining a platoon is driving to the merging point, the distance and estimated time to join the platoon is calculated and shown to the driver.

This information is calculated in the Road Segment Governing Layer of the architecture. The information exchange between the trucks position and other vehicles of the platoon is taking place over the internet and the off-board platform.

When the truck is in vicinity of the platoon (~500m for V2V communication) the truck can start to share information with the platoon via V2V communication. From this point the merging process is handled by the vehicles.

In vicinity of the platoon the CACC activates the merging process and is automatically closing the gap to the truck in front it. If the truck is merging from behind of the platoon, the joining truck for example automatically moves to a predefined distance (for example 15m) to the last truck. When the platooning distance is reached the state of the controller goes from merging to platooning and it is shown to the driver that the truck is now platooning.

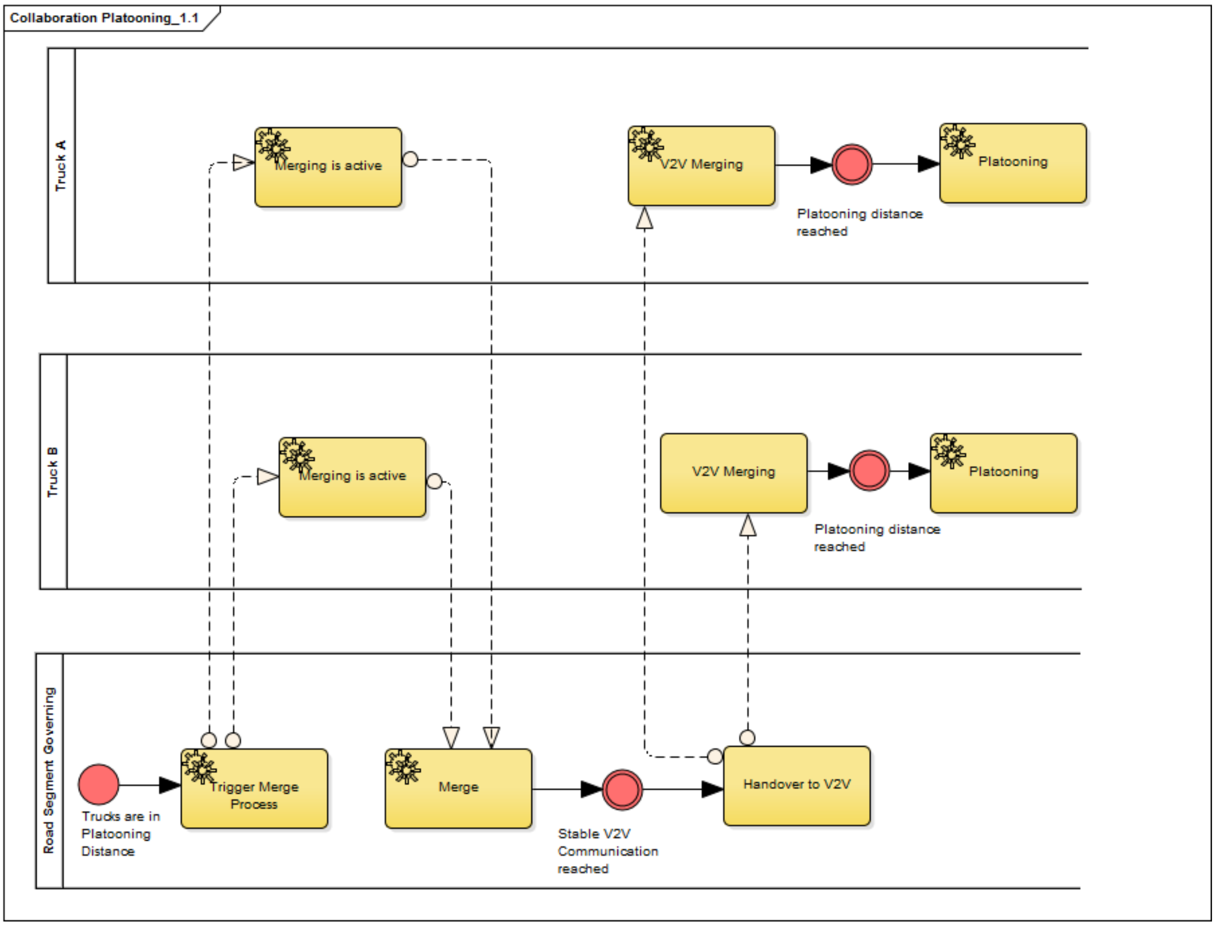

Figure 3-4: Process of Use Case *Platooning 1.1 – Automatic Platoon Formation*

Platooning 2 – Platooning under Normal Conditions

The use case *Platooning 2 – Platooning under Normal Conditions* considers the platooning scenario. Precondition is that vehicles have already merged to a platoon and the distance to each other is held by the CACC. Trucks are exchanging information via V2V-communication ETSI G5 Standard [5] (Position, etc.).

Every vehicle reports its state to the Fleet Manager Service in the off-board platform via mobile communication. The according dispatcher can track the position of the truck he is responsible for in his HMI Web-Interface. He is not able to see the position of other trucks not belonging to his company.

Note, that the safe operation of platoons in not depending on a connection to the off-board platform. The trucks report only telemetry data to the Fleet Manager in the operational phase. Due to a recalculation of an Assignment Plan an update of the plan may happen, but this is not a safety-critical event.

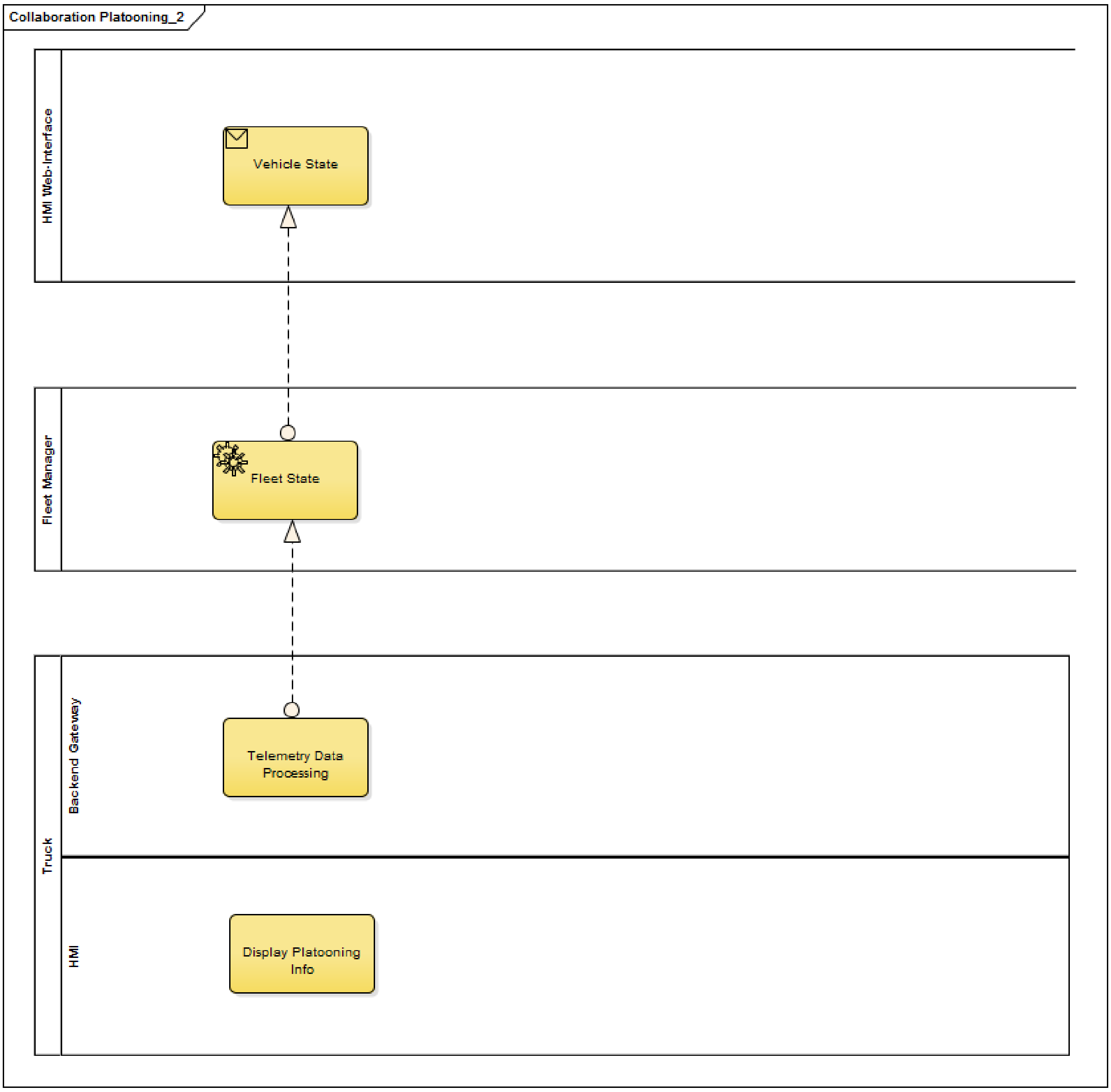

Figure 3-5 Business Process - Platooning under normal Conditions

Platooning 3 – Emergency Braking

The use case Platooning 3 – Emergency Braking considers heavy braking of a vehicle in the platoon due to an unforeseen event (for example another vehicle in the lane of the platoon is significantly slower).

If one of the trucks in the platoon has to brake heavily, the following trucks need to be informed of this event, in order to brake in time to avoid a collision. The distributed control system signals to all following trucks in the platoon via V2V communication to brake.

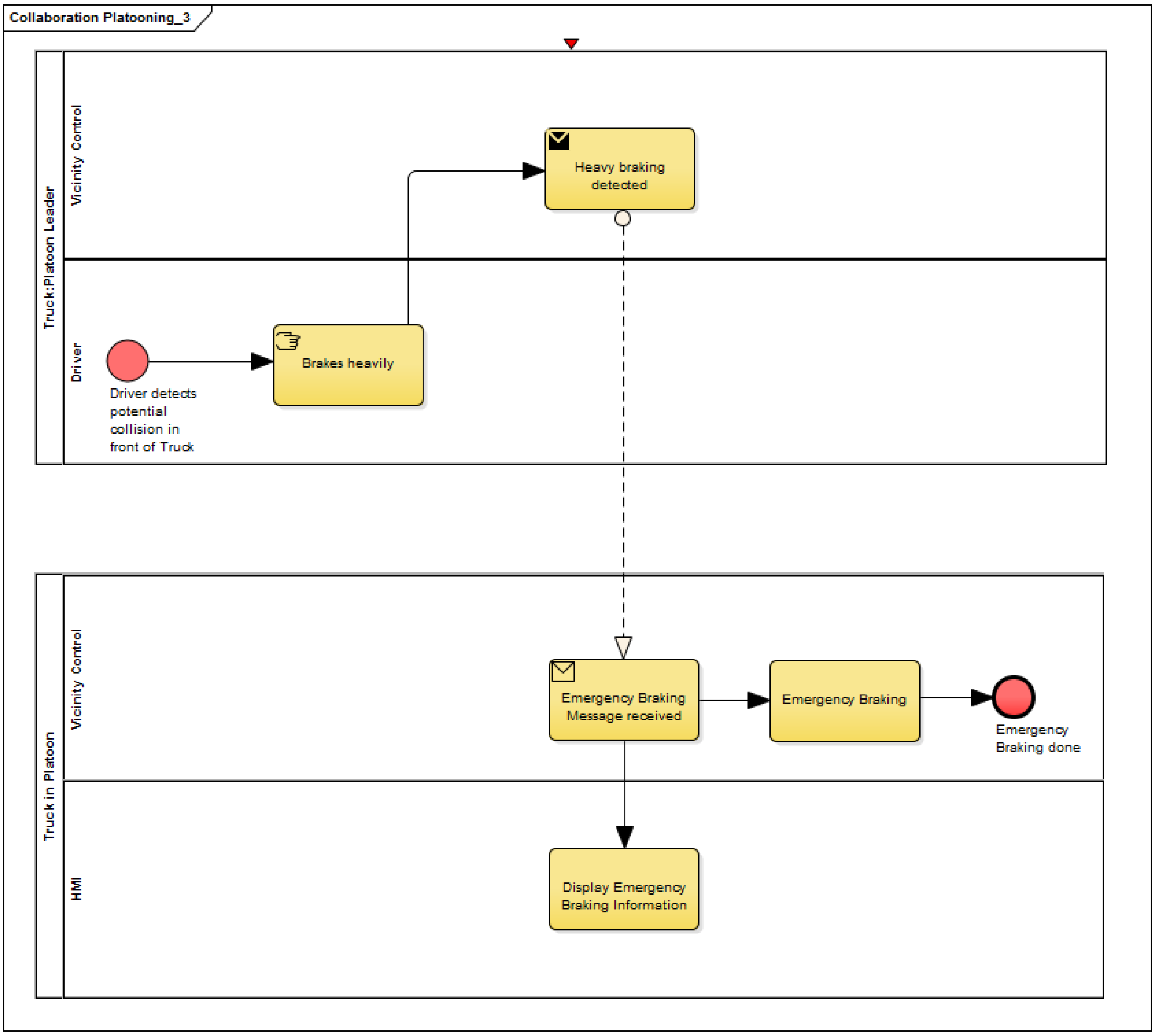

Figure 3-6: Emergency Braking

Platooning 4 – Vehicle Interferes Platoon

Figure 3-7 depicts the BPMN diagram for the use case *Platooning 4 – Vehicle Interferes Platoon*. When the trucks are platooning, an intersecting vehicle poses a potential threat to the safety of the platoon. The interfering vehicle does not have V2V communication and a CACC matching the one of the COMPANION system.

In case a vehicle interferes with a platoon, it has to be ensured that a safe distance to the interfering vehicle is established by the trucks. Also the driver of the truck has to be made aware, that a vehicle is cutting in. After the interfering vehicle has left the lane, the control of the platoon re-establishes the nominal platooning distances between the trucks.

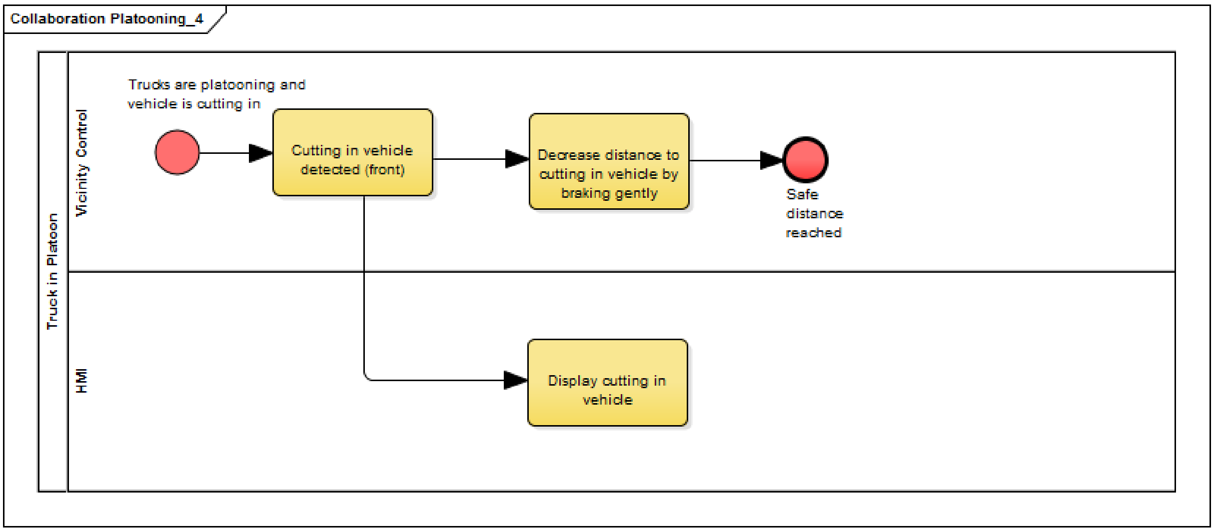

Figure 3-7: Vehicle interferes with Platoon

Platooning 5 – Platoon Passes Motorway Entrance

Figure 3-8 depicts the process of use case *Platooning 5 – Platoon Passes Motorway Entrance*. When a platoon is about to pass a highway entrance, the gaps between the trucks in the platoon have to be increased, to allow for other traffic to change from the highway entrance safely into the lane of the platoon and then to overtake the platoon. After the platoon has passed the highway entrance and other traffic has cleared from the platoon, the gaps between the trucks can be decreased to the nominal platooning distance again.

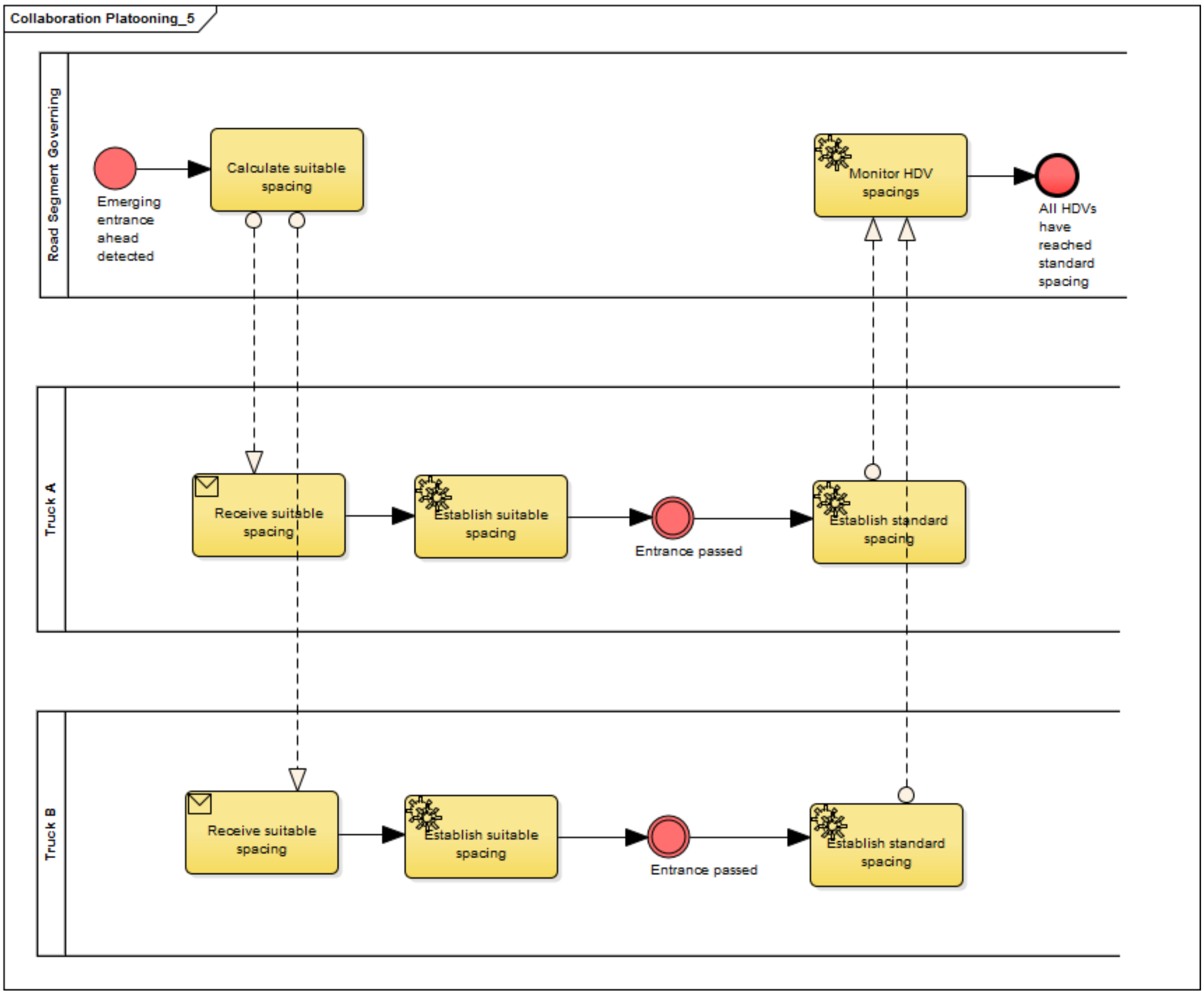

Figure 3-8 Process for a Platoon passing a highway entrance

Platooning 6 – Platoon Passes Motorway Exit

Figure 3-9 shows the process of use case *Platooning 6 – Platoon Passes Motorway Exit*. This process is analogue to the previous process of a platoon passing a highway entrance. The gaps between the trucks have to be increased ahead of the highway exit and decreased to the nominal platooning distance, when other traffic has cleared from the platoon.

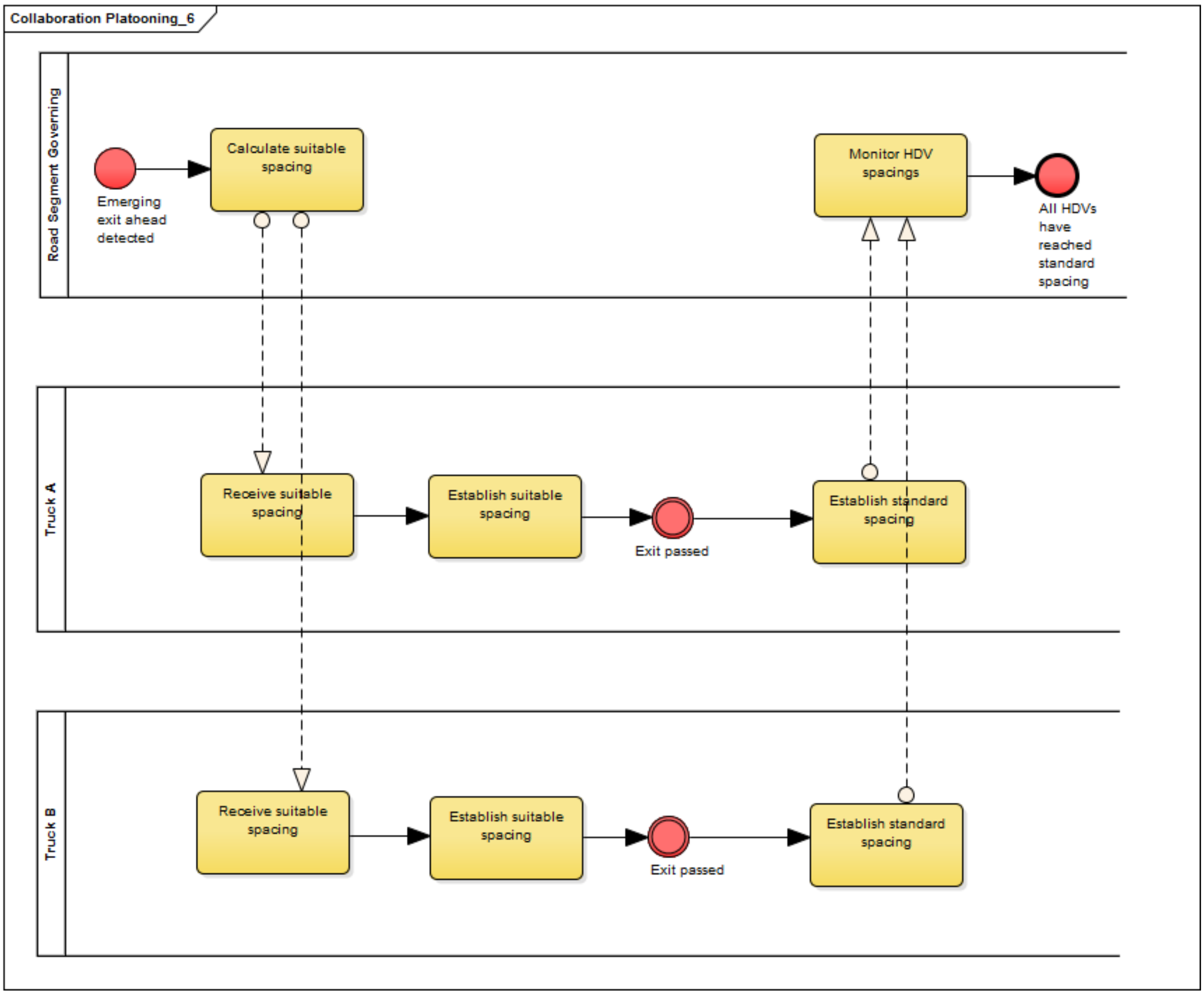

Figure 3-9 Process for a Platoon passing a Highway Exit

Platooning 9 – Truck Leaves Platoon

Figure 3-10 depicts the process of the use case *Platooning 9 – Truck Leaves a Platoon*. When a driver comes into the vicinity of a split point - a place where he is about to leave the platoon - the driver is informed of this upcoming event via the onboard HMI.

When leaving a platoon, the CACC automatically increases the distance to the leading vehicle and the driver can leave the platoon at a highway exit or highway split.

It is shown to the other drivers that the truck is about to leave the platoon and after splitting from the platoon the truck follows its individual route.

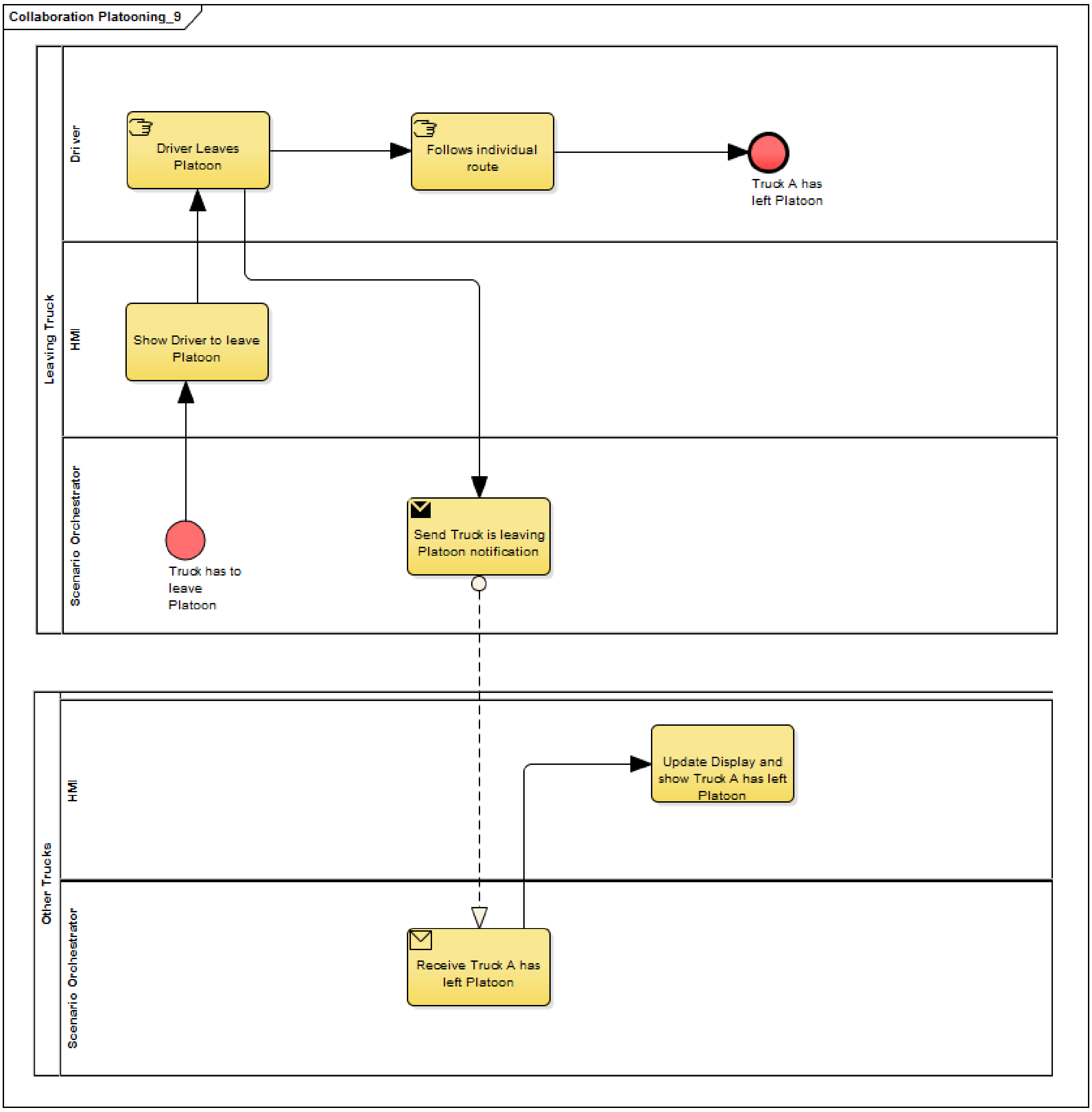

Figure 3-10 Process of a Truck leaving a Platoon

Recalculation

This section consists of the processes that include a recalculation of the Assignment Plan during the transport. A recalculation can be triggered by a deviation from plan, for example due to predicted and actual traffic jams. Furthermore, a recalculation may affect only parts of the Assignment Plan. For example it may suffice in some cases to adjust the speed profile of an Assignment Plan, in other cases it is necessary to recalculate the whole Assignment Plan, including route, speed profile and platooning parameters.

Recalculation 1 – New Route due to Deviation from Plan

Figure 3-11 shows the process for the recalculation of an Assignment Plan due to a deviation from the initial plan. The Monitoring Engine is responsible for monitoring an ongoing transport and can detect, if a transport is able to follow its plan. A deviation from the initial plan can have several causes: a predicted traffic jam, adverse weather conditions, road works, etc.

When the Monitoring Engine detects that the truck will not be able to follow its current plan, the Monitoring Engine triggers a recalculation of the Assignment Plan for the vehicle. The Fleet Manager stores the new Assignment Plan and sends it to the truck.

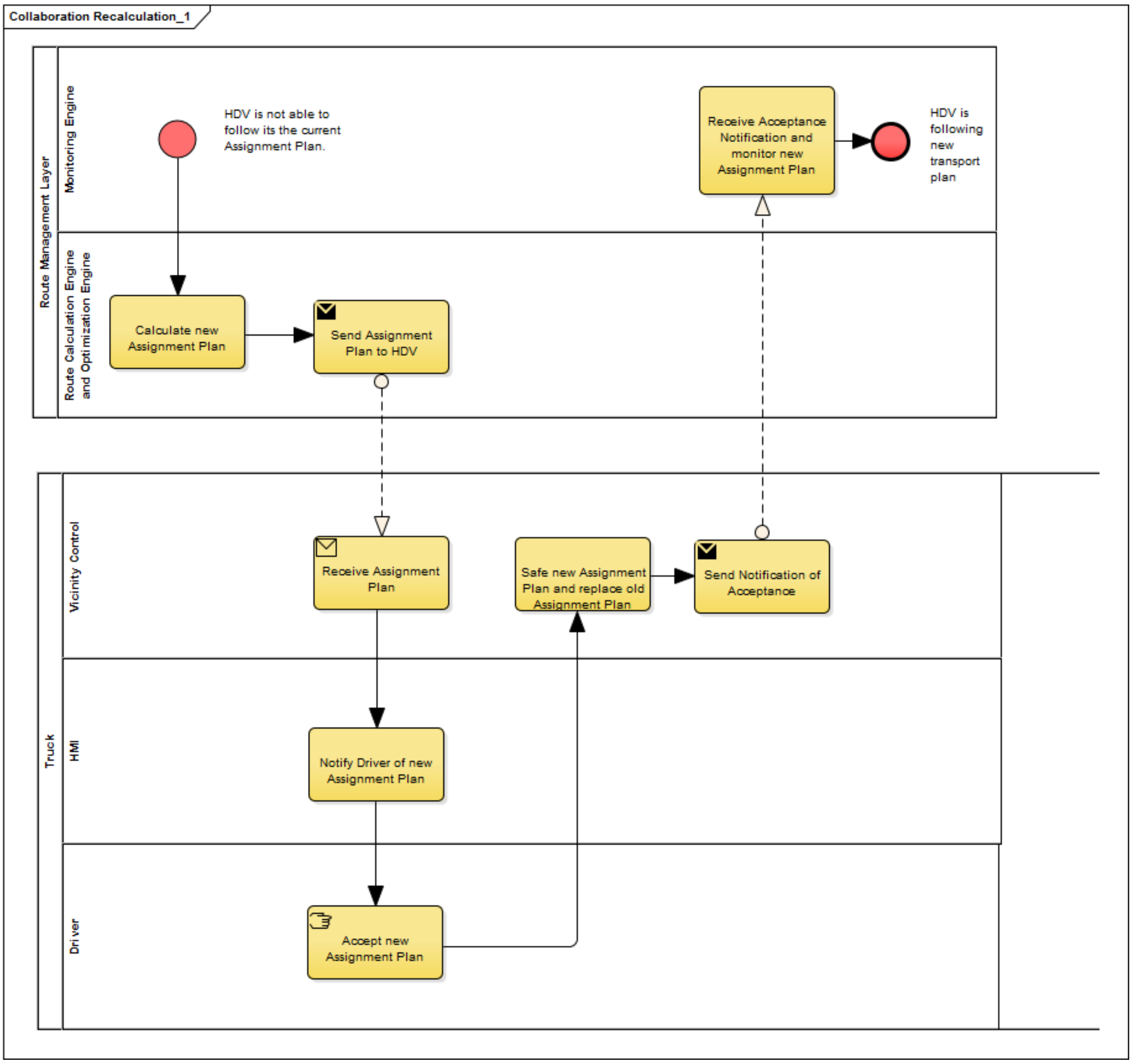

Figure 3-11 Process of a recalculation due to a deviation from the Assignment Plan

Recalculation 2 – Changed Platooning Possibilities due to Deviation from Plan

Figure 3-12 depicts the process for new platooning possibilities due to a deviation from plan. This process is very similar to the previous process but in this case only a new speed profile and platooning parameters have to be calculated.

The Monitoring and Optimization Engine detects that the truck is not able to follow its intended speed profile and will miss its planned opportunities to platoon. Therefore, the Monitoring and Optimization Engine has to check for new platooning opportunities and transmit the new merge and split points to the truck.

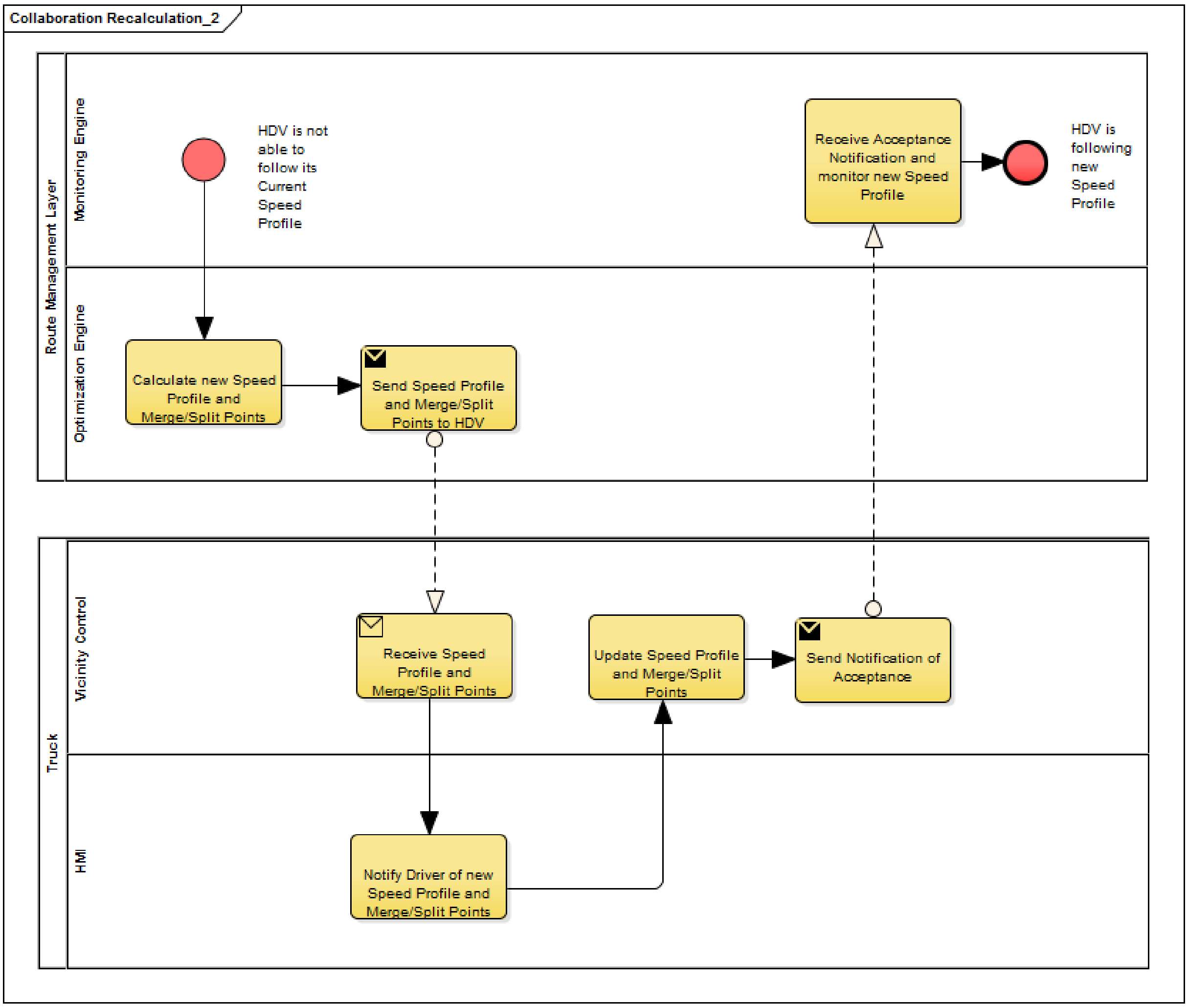

Figure 3-12 Process for new platooning possibilities due to deviation from plan

Recalculation 3 – Delay due to Deviation from Plan

So far the interaction between truck and off-board platform were addressed in the shown processes. This process captures the interaction between the dispatcher, off-board platform and truck. This process is also applicable to all other processes in the recalculation section of this document.

Figure 3-13 depicts the process of keeping the dispatcher in the loop about recalculations and deviations. The diagram just shows the messages for a deviation from the intended plan and says nothing about a possible recalculation. In case of a recalculation the dispatcher is informed of this event and also why a recalculation was necessary (for example, a traffic jam ahead of the transport).

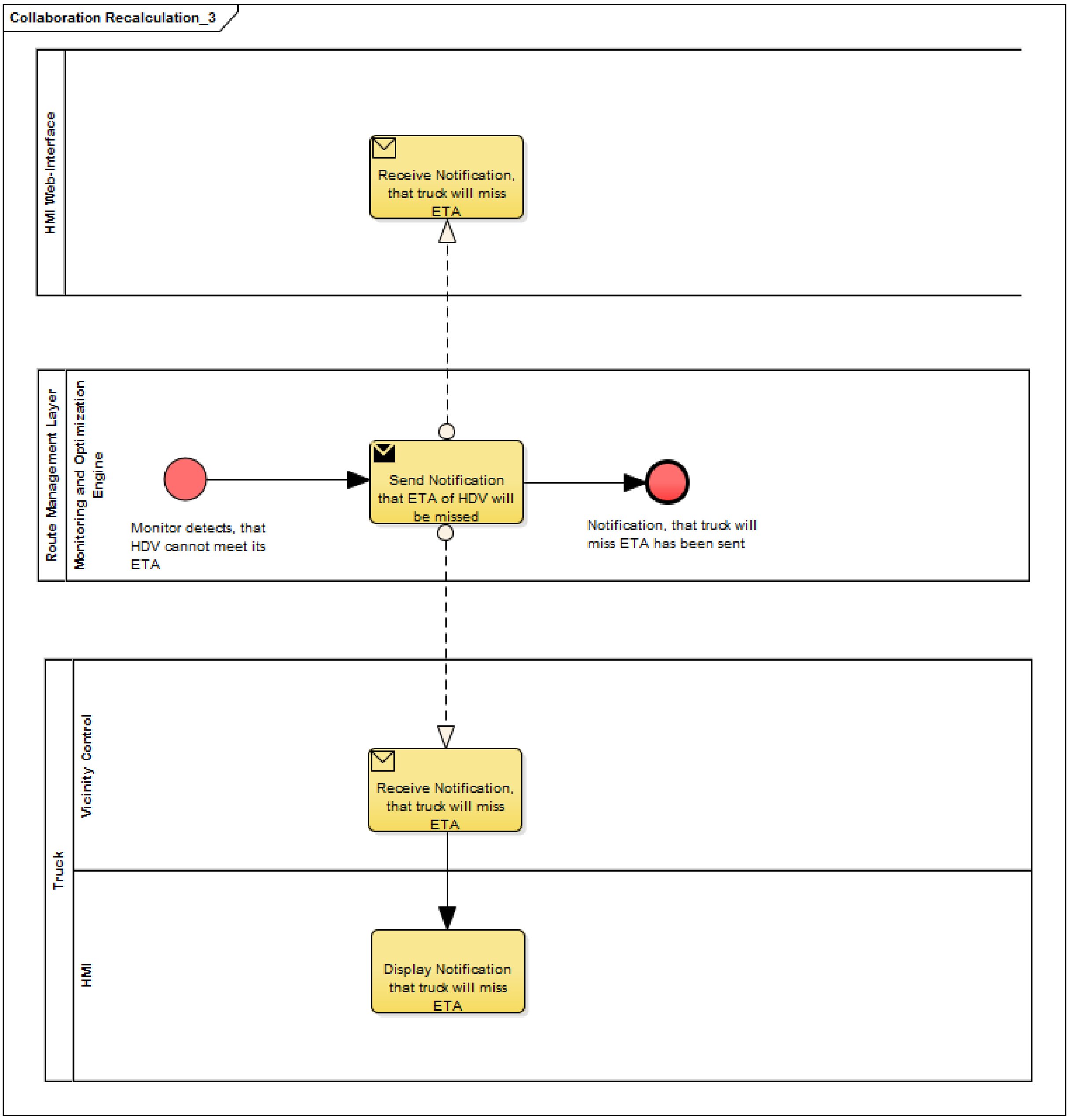

Figure 3-13 Process for delay due to deviation from plan

Recalculation 4 – New Route due to Added Transport

Figure 3-14 shows the process for a recalculation that is triggered by an added transport while another transport is already on the road. This process is also similar to the previous recalculation processes and only the cause for the recalculation has changed.

Supposing a transport is already on the road and a dispatcher chooses to submit an urgent Transport Assignment to the system, that is about to start, the Monitoring and Optimization Engine can take transports into consideration that are already on the road. This new optimization run can find a new optimal plan for transports that are already taking place and adapt the route, speed profile and platooning parameters.

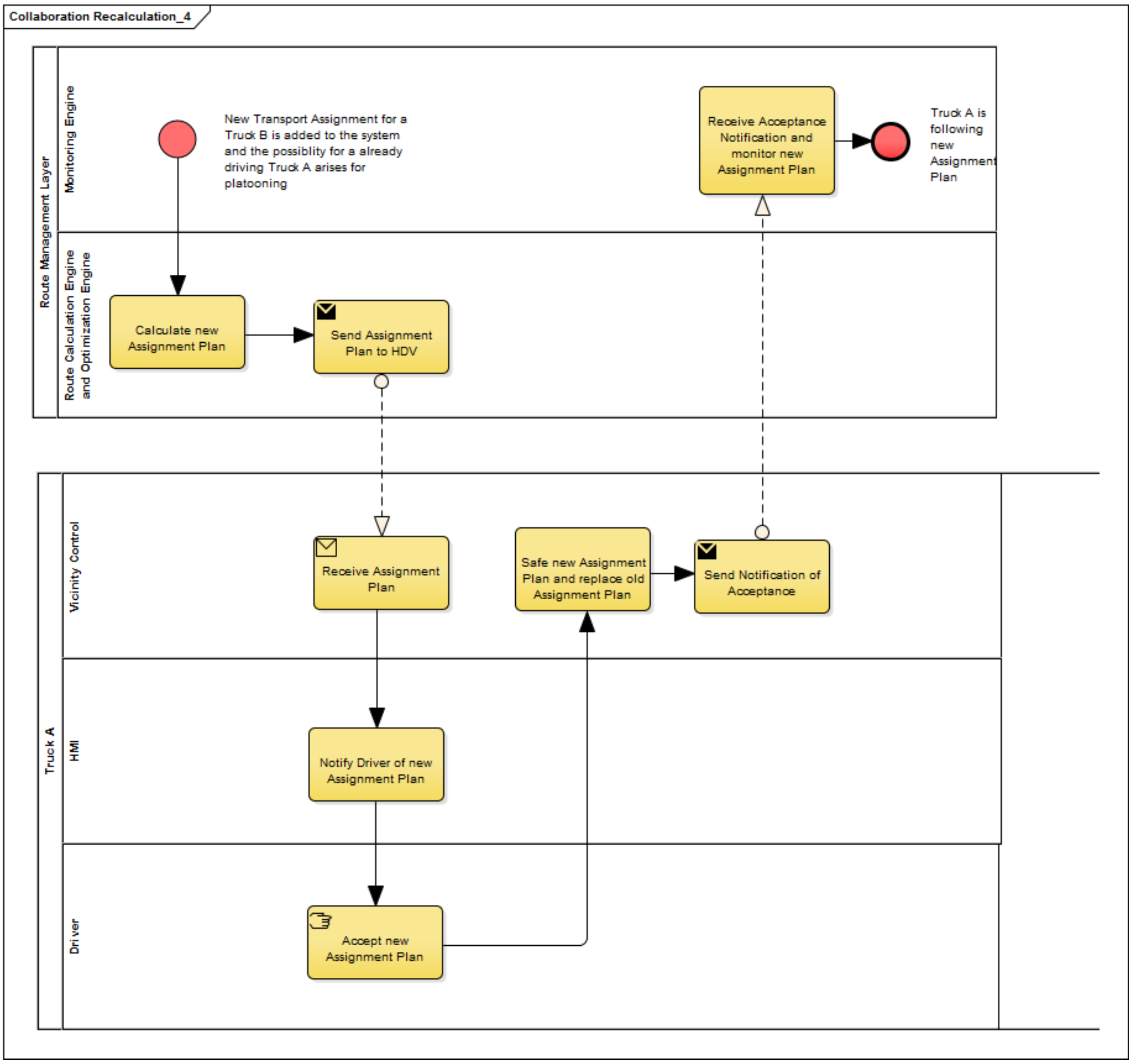

Figure 3-14 Process for a new route due to an added transport

Recalculation 5 – Changed Platooning Possibilities due to Added Transport

This process is a slight variation from the previous recalculation of an Assignment Plan. As before, the recalculation is triggered by an added Transport Assignment while a transport is already on the road. In the previous recalculation the optimization also calculated a new route for the initial transport. In this process the route is staying the same, but the speed profile and platooning parameters of the initial transport have to be adapted due to the added transport, as the platooning possibilities change for the transport that is already on the road.

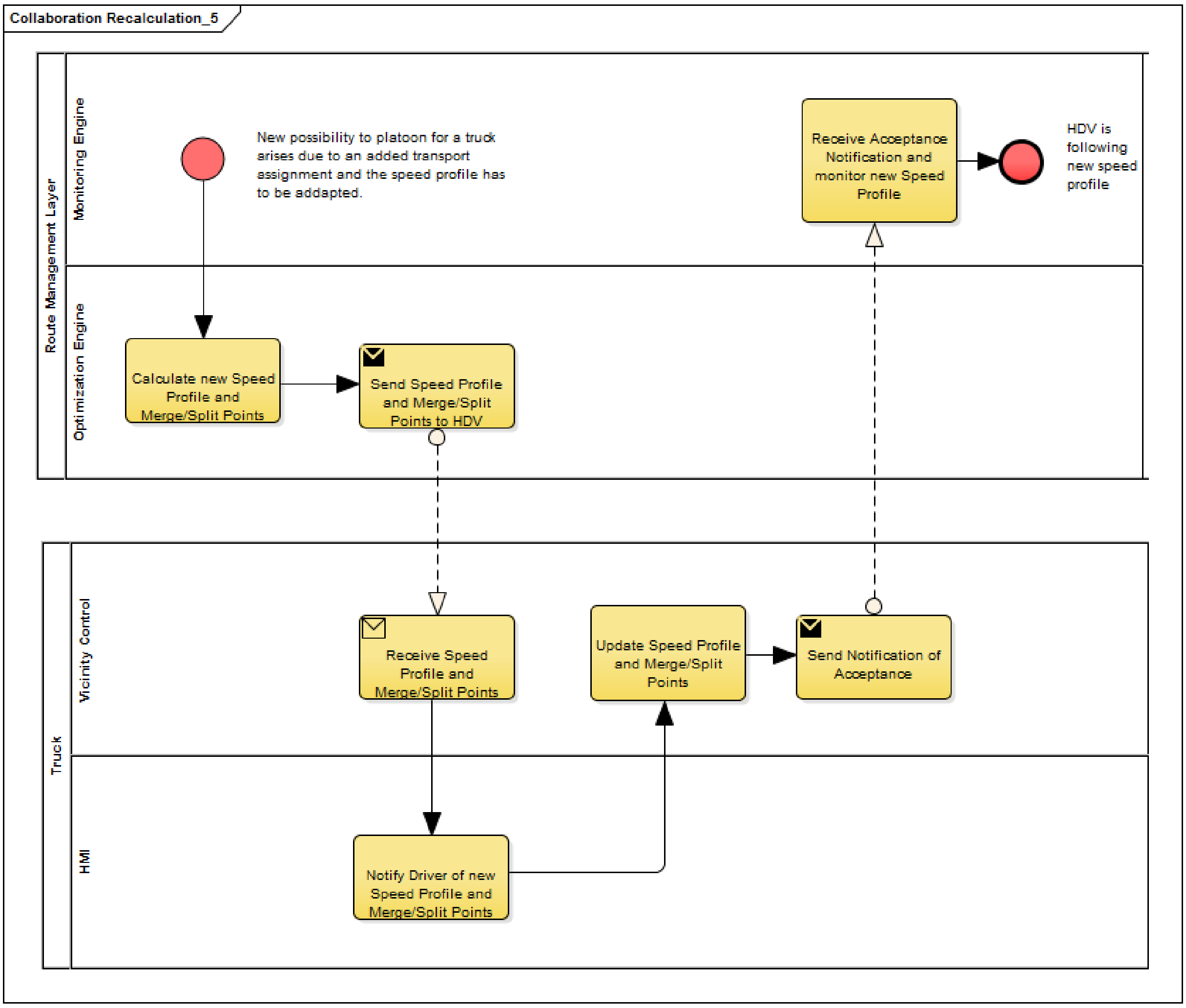

Figure 3-15: Process for changed platooning possibilities due to an added transport

4. Data Definitions

In this section the most common used data definitions used in the COMPANION system are described. This section is meant for reference in order to have a central place in the document for the data definitions.

Transport Assignment

The *Transport Assignment* is the main object, when a dispatcher is submitting a transport to the system. It contains all information needed for the subsequent services that are involved in the strategic planning process.

Table 1: Transport Assignment

Parameter	Description	Data Type
Transport Assignment ID	Automatically assigned by the backend when receiving an assignment.	long
Vehicle ID	ID of the vehicle.	long
Total weight	The weight of the freight.	int [kg]
Earliest Departure Time	Date and time for the earliest departure of the truck.	{Date: YYYY-MM-DD, Time: hh:mm:ss}
Latest Departure Time	Date and time for the latest departure of the truck.	{Date: YYYY-MM-DD, Time: hh:mm:ss}
Earliest Arrival Time	Date and time for the earliest arrival of the truck.	{Date: YYYY-MM-DD, Time: hh:mm:ss}
Latest Arrival Time	Date and time for the latest arrival of the truck.	{Date: YYYY-MM-DD, Time: hh:mm:ss}
Origin	Start location of the transport, usually not at the consigner, as the truck starts its trip from a different location (logistics company or last consignee). Reference-System: WGS84	{double Longitude, double Latitude}
Destination	The location of the consignee. Reference-System: WGS84	{double Longitude, double Latitude}

Assignment Confirmation

Table 2: Assignment Confirmation

Parameter	Description	Data Type
TransportAssignmentID	The ID of the transport assignment.	long TransportAssignmentID
ConfirmationStatus	Indicates, whether the transport assignment was successfully stored in the database.	{Successful, Canceled, ErrorCode}

Route

The following objects describe the request object to the Route Calculation Engine and the result object. The *Request Object* contains the parameters that are needed by the Route Calculation Engine to search for an eco-optimal route.

The *Result Object*, the actual route, returns a route from the start to the destination and consists of a list of *Road Section Objects*. The properties of the *Road Section Object* are also described here.

Request Object

The Request object contains all data needed by the RCE to calculate a route.

Attribute	Datatype	Description
start	WGS84Coord	The wgs84- coordinates of the route start
destination	WGS84Coord	The wgs84- coordinates of the route destination
departure	int64	The earliest possible time of departure(in number of seconds since 1970-01-01T00:00:00Z) in UTC
arrival	int64	The latest possible time of arrival(in number of seconds since 1970-01-01T00:00:00Z) in UTC
TruckWeightInMetricTons	float	The weight of the truck in metric tons used for consumption-calculations
maxVelocityInKmH	float	The maximum velocity the truck will drive [km/h]

Result Object

The *Result Object* contains the data defining the calculated route.

Attribute	Datatype	Description	Derived from
sections	List<RoadSection>	the ordered list of roadsections representing the requested route	Based on the link within the NDS map
lengthInMeters	float	the length of the complete route in meters	sum of the lenght of the links of the resulting route in the nds map
durationInSeconds	int32	the duration of the route-travel in seconds	lengthInMeters and maxVelocityInKmH

eta	int64	the estimated time of arrival at the destination in unix-time (seconds since Thursday, 1 January 1970) in UTC	
departure	int64	the estimated time of departure at the start (in number of seconds since 1970-01-01T00:00:00Z) in UTC	departure of the Request
minVelocityInKmH	float	the minimum velocity on this route in km/h to reach the destination in time	maxVelocityInKmH and the arrival time of the Request
maxVelocityInKmH	float	the maximum velocity on this route based on the vehicle-data, speedlimits, weather ,etc.	static map data (e.g. historical speed profiles, average speeds, speedlimits),maxVelocityInKmH in Request and live traffic-information

Road Section Object

The underlying NDS map uses sections of roads called links. These are the smallest parts used to describe the geographic location of the route. Each *Road Section Object* represents a NDS link.

Attribute	**Datatype**	**Description**	**Derived from**
geometry	List<WGS84Coord>	The linear-geometry represented by a ordered list of WGS-84-coordinates	Geometry of the NDS link
roadName	string	The road name	Roadname or-number of the NDS link
lengthInMeters	float	The length in meters of this link	Length of the NDS link
altitudeDifferenceInMeters	float	The altitude difference between start and end of the link	Length and average slope of the NDS link

eta	int64	The estimated time of arrival at the start of the link (in number of seconds since 1970-01-01T00:00:00Z) in UTC	Currently based on maxVelocityInKmH
minVelocityInKmH	float	The minimum velocity on this link in km/h to reach the destination in time	Based on the maxVelocityInKmH and the arrival time of the Request distance to target, speed on other links
maxVelocityInKmH	float	The maximum velocity on this link based on the vehicle-data, speedlimits, weather ,etc.	static map data (e.g. historical speed profiles, average speeds, speedlimits),maxVelocityInKmH in Request and live traffic-information
durationInSeconds	int32	The duration of the link-travel in seconds	lenght of the NDS link and maxVelocityInKmH
directedLinkId	int64	The nds link id. The direction is ecoded in the sign. a positive id means positive direction, a negative id means negative direction.	Unique id in the NDS map

Assignment Plan

The *Assignment Plan* is the actual plan sent to the truck. It contains besides the route a fine grained speed profile and the merge/split points needed for platooning.

Attribute	Datatype	Description
Origin	Waypoint	Origin longitude and latitude
Destination	Waypoint	Destination longitude and latitude
Load	int	Cargo weight, kg
Planned departure time	DateTime	Planned departure time, UTC
Planned arrival time	DateTime	Planned arrival time, UTC
Route	List<Waypoint>	Planned vehicle route
Speed profile	List<Waypoint, Speed>	Planned vehicle speed profile
Planned platooning merge/split segments	List<Segment>	List of segments for merge/split platoons

Fleet State and Vehicle State

The *Fleet State* is a list of *Vehicle State* objects. The *Vehicle State* object describes the current position (Longitude/Latitude) and if applicable a deviation from the current *Assignment Plan*.

Fleet State Object

Attribute	Datatype	Description
VehicleStateList	List<VehicleState>	Vehicle state list

Vehicle State Object

Attribute	Datatype	Description
VehicleId	long	Vehicle ID
Latitude	decimal	Vehicle Latitude
Longitude	decimal	Vehicle Longitude
CompanionsVehicleIds	List<long>	List of the currently platooning vehicles, in order
DeviationTime	long	Deviation in sec, +/-
Deviated	bool	True then deviated

References

[1] COMPANION, "Deliverable D2.1 Potential scenarios for new platooning concepts," 2014.

[2] COMPANION, "Deliverable D2.3 Final User Requirements," 2014.

[3] COMPANION, "Deliverable D2.4 Technical Requirements," 2015.

[4] COMPANION, "Deliverable D2.5 Business Requirements and Business Opportunities," 2015.

[5] ETSI, "Intelligent Transport Systems (ITS) Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service," ETSI, 2014.

[6] COMPANION, "Deliverable D3.1 Component Specifications for the Overall Architecture," 2015.

[7] COMPANION, "Deliverable D4.3 Vehicle Models for Fuel Consumption," 2015.

[8] COMPANION, "Deliverable D5.1 Report on fuel-efficient Route Calculation," 2015.