ART-04-2016 - Safety and end-user acceptance aspects of road automation in the transition period

H2020-ART-2016-2017

Improved Trustworthiness and Weather-Independence of Conditionally Automated Vehicles in Mixed Traffic Scenarios

D3.1

Requirements for the co-simulation framework

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

The content of this report reflects only the authors' view. The Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains.

DOCUMENT INFORMATION

D3.1 - Requirements for the co-simulation framework	Public
Editors	Georg Stettinger (VIF), Pamela Innerwinkler (VIF)
Authors	Georg Stettinger (VIF), Pamela Innerwinkler (VIF)
Responsible person	Georg Stettinger (VIF)
Nature	Report
Status	Final

Change History

Version	Date	Description	Issued by
1.0	14.06.2018	Initial Version	VIF
2.0-8.0		Minor changes	VIF
9.0	06.02.2018	Introduction included	VIF
10.0	09.02.2018	Inputs from FO, TF, US, VCC integrated; Conclusion; final changes for review	VIF
11.0	16.02.2018	Inputs from VCC and VIF	VIF
12.0	28.02.2018	Last corrections	VIF
13.0	27.03.2018	Final version including disclaimer	VIF
14.0	14.06.2018	Adaption of Disclaimer	VIF

REVIEWERS

Version	Date	Reviewer
11.0	26.02.2018	Berzah Ozan (FO)

.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Table of Contents

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

List of Figures

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

List of Tables

This report is part of a project that has received funding from European Union’s Horizon 2020 research and innovation programme under grant agreement No 723324.

Executive Summary

This deliverable D3.1 serves as a basis for the upcoming work packages WP5 and WP6 in terms of use case specifications together with the agreed/used domain specific simulation tools and models in combination with the intended in- and output signals. It summarizes the requirements, respectively subsystem collection for the Ford Otosan, Tofaş and Volvo use cases. Every use case is described and its key performance indicators are detailed. A first specification for each of the used models is given in terms of a brief description and its in- and outputs, as well as software and hardware specific information. Based on the information already collected in deliverable D3.1, the use cases including their used tools and interfaces will be further defined.

Key Words: Automated Driving, Co-simulation, Modular architecture

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

1 Introduction

1.1 Background

This document serves as a basis for the upcoming work packages WP5 and WP6 in terms of use case specifications together with the agreed/used domain specific simulation tools and models in combination with the intended in- and output signals (subsystem interface specification). The co-simulation approach is well suited to realize the different use cases in different stages of the V-cycle starting from use case specification including test cases for validation in the left branch of the V-cycle followed by the multi-domain simulation part (model-in-the-loop (MiL) simulations) which forms the basis for the right branch of the V-cycle, see Figure 1.

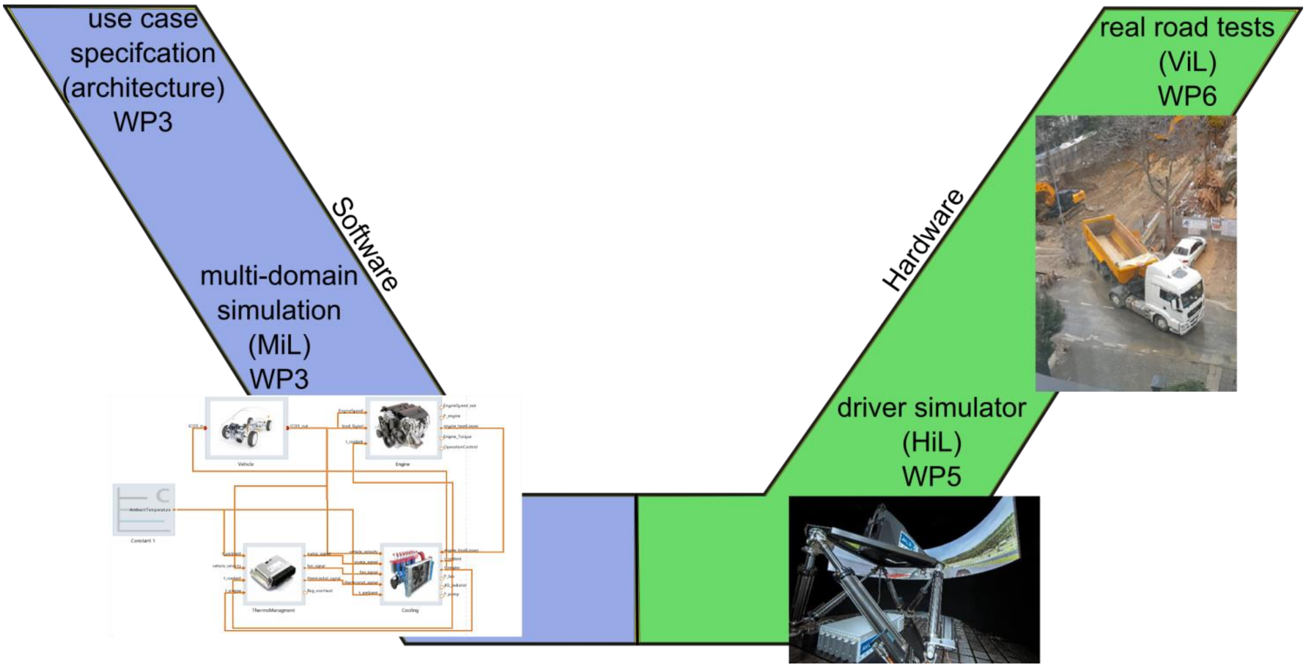

Figure 1 Use case V-cycle

The right branch of the V-cycle additionally incorporates real hardware in terms of hardware-in-the-loop (HiL) simulation, finishing with the real road test with the entire vehicle. WP3 is related to the left branch (software side) of the V-cycle including the use case specification and the multi-domain simulation applying classical offline co-simulation techniques. In contrast, WP5 focuses on the driving simulator which is related to the HiL-simulation part, while WP6 focuses on real road tests using the demonstrator vehicles (vehicle-in-the-loop, ViL). The latter two work packages are dealing with real hardware and are therefore related to the right branch. To ensure a consistent transition between the different stages in the V-cycle all interfaces of the involved subsystems have to be specified accordingly. Those common agreed interfaces in terms of in- and outputs save a lot of reconfiguration effort and ensure realizable HiL simulations due to the face that hardware interfaces are not as flexible as software interfaces and typically cannot be changed in such a wide range.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

To perform those multi-domain simulations, the co-simulation platform Model.CONNECT^{TM} can be used to set up and execute entire mechatronic system simulations, which are composed of different subsystems in the form of simulation models from different domains. Models can be integrated based on standardized interfaces (e.g. Functional Mockup Interface, FMI) as well as specific interfaces to a wide range of well-known simulation tools especially for the automotive industry [1].

In the context of real-time co-simulation (e.g. HiL simulation), a distinction between real-time and non-real-time systems is commonly used. Real-time systems, e.g. in the form of real hardware, have to satisfy the so-called hard real-time conditions (e.g. guaranteed response-time, deterministic runtime behavior). Non-real-time systems (non-RT) in the form of offline simulation models do not satisfy these conditions in general, but have to be executed faster than real-time for synchronization purposes [2]. The Model.CONNECT^{TM} co-simulation platform can be used to interconnect offline simulation models with the driver simulator as well.

1.2 Structure of the report

This report addresses every use case separately. Section 2.1 is dedicated to the Ford Otosan (FO) use case, section 2.2 describes the Tofaş (TF) use case and section 2.3 depicts the Volvo use case. In every one of these sections, there is a short general description of the use case, followed by its goals and key performance indicators (KPIs) and concluded by a tabular description of each of its used subsystems for the simulation. Finally, Chapter 3 wraps up this report by giving a short conclusion.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

2 Co-Simulation requirements

In this section, for each use case, defined within the project, a short outline is given. This outline includes not only a description of the used vehicle and its components, but also the scenarios considered as well as the intended aims and KPIs. Subsection 2.1 presents the Ford Otosan use case dealing with backing scenarios for trucks, subsection 2.2 is dedicated to the Tofas use case, which considers urban scenarios for light commercial vehicles (LCVs), and the Volvo use case, considering sensor monitoring systems, is discussed in subsection 2.3.

Table 1 shows the template used to collect the KPIs for the use cases. In each use case description, this table is adapted accordingly.

Table 1 Template for the collection of the KPIs

Name	The name is a unique alphanumeric combination to identify the KPI.
Type	The type describes how the KPI is designed, i.e. as a numeric value, an ordinal scale or a ratio scale
Range/Scale	The range delineates the range of values that the KPI can take on. For example, for a numeric KPI, the range would include a minimum and a maximum value, whereas for an ordinal scale KPI, this would be the range of possible values that the KPI can take on.
Weight	The weight is a numeric value that expresses the importance of this KPI. The higher the value, the more important the KPI. The value of weight goes from 1 (interesting) through 2 (important) to 3 (very important)
Status	This attribute shows in a simple visual manner the status of the measured item using color. The color green represents a positive status, the color yellow represents an average status and the color red represents a negative status. 
Trend	The trend attribute describes the estimated progress of the measured item visually. The chosen representation is an arrow that can point upwards, horizontally or downwards. An upward pointing arrow represents: *Positive* A downward pointing arrow represents: *Negative* A horizontal arrow represents: *Neutral*
Actual Value	The actual value shows the current value of a measured item.
Target Value	The target value represents the desired value at the end of the measurement period

The description of the subsystems involved in the use cases is collected using the template shown in Table 2. As it is very early in the project, some of the information may not be available yet. Still first

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

drafts for each subsystem description could be put together by the involved partners. Part of these descriptions are the required in- and outputs for each subsystem, which may need to be adapted in order to provide all the needed signals.

Table 2 Meta-Information on Subsystem

Subsystem model specific information						
Name of subsystem	e.g. LiIonBattery					
From Partner	ViF, AVL, FO, US, CISC, TF …					
Use Case affilation	Use Case 1 (Volvo XC90), Use Case 2 (Fiat Doblo EV), Use Case 3 (Linkker ebus), Use Case 4 (Ford Cargo)					
Short description	purpose, usage, additional information, … (Alt+Enter for line break)					
Known limitations	for specific simulations only - valid in specific operating conditions, …					
…	individually list extentions					
Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Outputs of the subsystem (at least the relevant ones)						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	

Simulation specific information	
Simulation tool & version	Matlab/Simulink 2010a, MSC-Adams 2010, …
Numerical solver	Ode45, Dassl, Euler, …
Kind of numerical step-sizes	fixed, variable, both, …
Numerical step-size	fixed step-size - max step-size in case of variable step-size solver
Real-time capable	yes/no
Project licence available	yes/no
…	individually list extentions

Hardware specific information	
Hardware description	dSPACE MicroAutoBox, Testbed, HiL, ECU, …
Communication step-size	fixed step-size
Communication medium	UDP, CAN, …
…	individually list extentions

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

2.1 Ford Otosan use case scenario

Driving trucks with trailers can be a very challenging task. Due to its dimension, keeping track of the environment and maneuvering precisely is often hard and time consuming. Automation of defined driving tasks therefore provides relief for the truck driver and can also enable a more fluent traffic flow in cities since driving maneuvers can be performed more quickly.

2.1.1 Overall description

In this use case, two scenarios for trucks with trailers are considered: parking in a docking station and backing in a construction site. For both scenarios it is common that the driver needs several manoeuvres to bring the trailer in the correct position, either to park correctly to the dedicated slot in the docking station, or to bring the truck in position on the construction site. While the main concern when considering the docking station scenario is the time spent to position the trailer, the problem with construction sites is also the surrounding traffic and other road users, such as pedestrians.

For the docking station scenario three sub-scenarios are considered: obstacle-free environment, environment with static obstacles and one where static as well as dynamic obstacles occur.

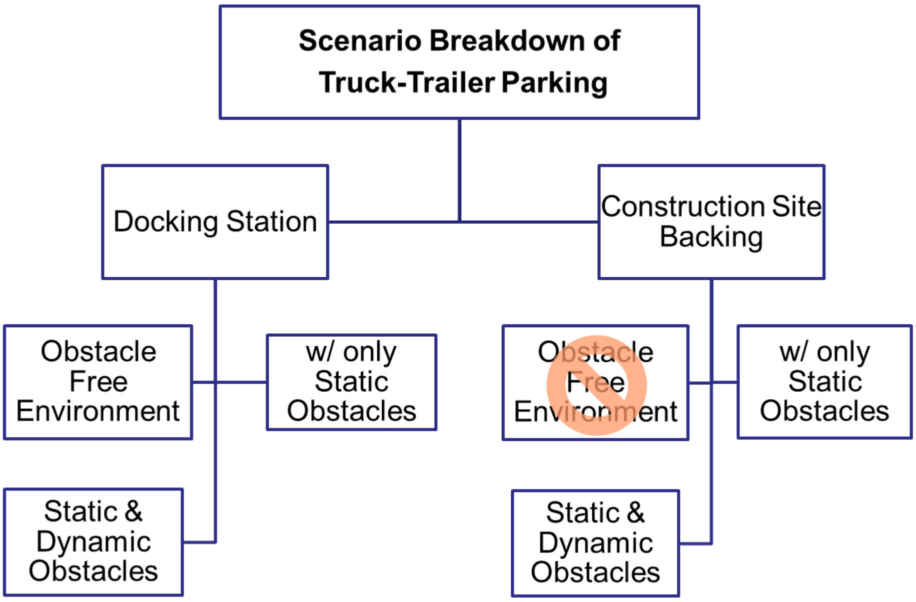

Figure 2 Sub-scenario overview

The docking area represents a controlled environment (i.e. no external traffic participants need to be considered), even though possible other vehicles and workers still need to be taken into account. As mentioned above, obstacle-free environments do not occur on construction sites. Therefore, the sub-scenarios for construction site backing are with static obstacles and with static and dynamic obstacles. The construction site scenario is considered an urban scenario. Figure 3 depicts a basic backing scenario as it is needed for both docking station and construction site backing. The environment is altered varying the starting point of the truck (see Table 3) as well as the location of additional road participants (see Table 4). Figure 3 depicts such a backing scenario.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

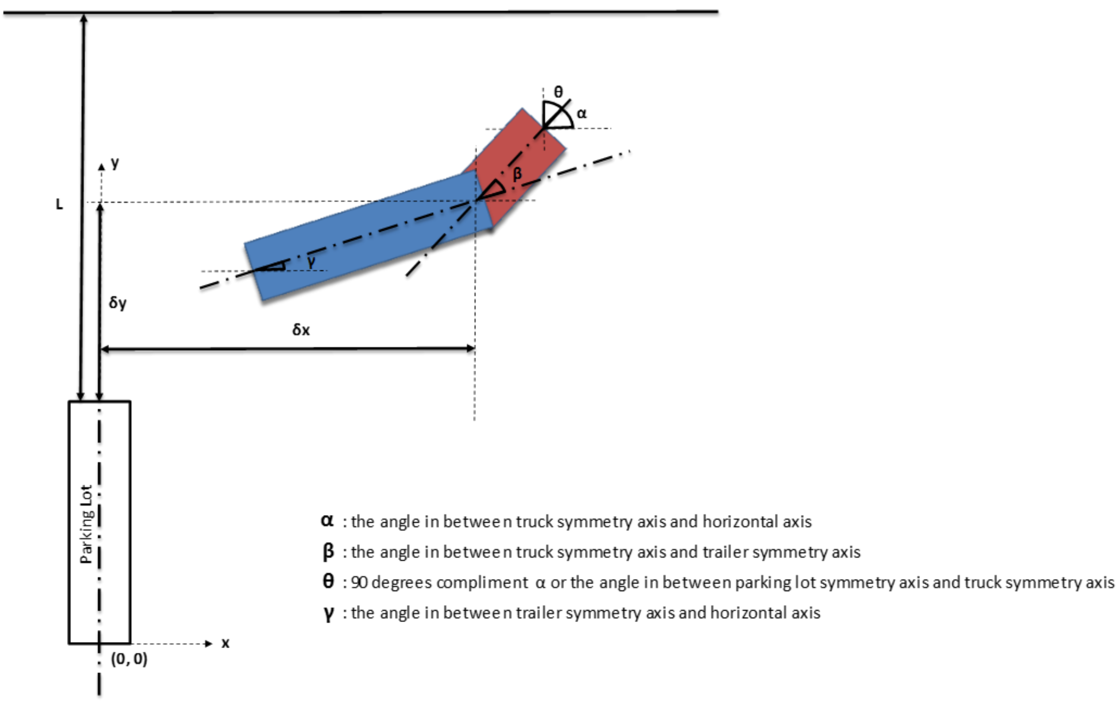

Figure 3 Example for backing scenario with a truck-trailer combination

Table 3 Truck-trailer Starting Points

	L	α	γ	θ	δx	δy
1	30 m	0^0	0^0	90^0	-2 m	17 m
2	30 m	30^0	10^0	60^0	2 m	17 m
3	30 m	-10^0	0^0	110^0	-2 m	17 m
4	30 m	-30^0	-10^0	-60^0	0 m	20 m
5	30 m	0^0	0^0	90^0	-30 m	30 m

This report is part of a project that has received funding from European Union’s Horizon 2020 research and innovation programme under grant agreement No 723324.

Table 4 Obstacle Locations

	Obstacle Locations	Long. Speed (x-dir)
	(x,y)	[km/h]
car -1	(0,23)	0
car -2	(10,21)	-10
pedes-1	(-2,16)	2
cyc-1	(-2,16)	4

In order to provide the needed surround view for these backing scenarios, the sensor set will consist of a time-of-flight camera, several ultrasonic sensors around the vehicle and lidars at the front and back of the truck and trailer. These sensors will later on be integrated in the demonstrator vehicle, but for the simulation ideal sensors are assumed.

2.1.2 Goals and KPIs

As mentioned in section 2.1.1 the aim of this use case is to make backing scenarios with truck-trailer combinations more efficiently. The vehicle should be positioned precisely and the manoeuvre should become less time-consuming. A key-point in this context is also user acceptance, since the truck driver should feel comfortable using the driving function performing the backing manoeuvre. Therefore, a HMI guaranteeing smooth transitions from manual to automated driving and vice versa has to be considered and the automated function has to be reliable and robust.

The system has to perform in various environmental conditions. In the docking station, different weather conditions have to be taken into account. In case of construction sites, the sensors additionally have to deal with dirt and dust covering the sensors so that the sensor availability is decreased. Sensor robustness and availability consequently form another KPI (see also Volvo use case in section 2.3).

Table 5 - Table 9 list the key performance indicators for the FO use case together with the intended targets for each of these indicators.

This report is part of a project that has received funding from European Union’s Horizon 2020 research and innovation programme under grant agreement No 723324.

Table 5 FO use case KPI 1 – Environmental Perception

Name	environmental_perception
Type	Daytime detection, tracking and classification of traffic objects with perception sensors like lidar, radar or camera.
Range/Scale	Minimum value: % 0 Maximum value: % 100
Weight	3 (very important)
Status	
Trend	An upward pointing arrow represents: *Positive*
Actual Value	Vehicles: N/A Pedestrians: N/A
Target Value	Vehicles: Minimum value: % 90 Maximum value: % 100 Pedestrians: Minimum value: % 70 Maximum value: % 100

This report is part of a project that has received funding from European Union’s Horizon 2020 research and innovation programme under grant agreement No 723324.

Table 6 FO use case KPI 2 – Lateral Parking Deficiency

Name	lateral_parking_deficiency
Type	Lateral deficiency from a final parking point in centi-meters
Range/Scale	0 – 100 cm
Weight	3 (very important)
Status	
Trend	An upward pointing arrow represents: *Positive*
Actual Value	30 cm
Target Value	20 cm

Table 7 FO use case KPI 3 – Longitudinal Parking Deficiency

Name	longitudinal_parking_deficiency
Type	Longitudinal deficiency from a final parking point in centi-meters
Range/Scale	0 – 100 cm
Weight	3 (very important)
Status	
Trend	An upward pointing arrow represents: *Positive*
Actual Value	50 cm
Target Value	30 cm

This report is part of a project that has received funding from European Union’s Horizon 2020 research and innovation programme under grant agreement No 723324.

Table 8 FO use case KPI 4 – Vehicle Localization

Name	vehicle_localization
Type	Simulataneous localization of the vehicle in an unknown environment with GNSS, perception sensors and onboard odometer sensors.
Range/Scale	0 – 100 cm
Weight	3 (very important)
Status	
Trend	An upward pointing arrow represents: *Positive*
Actual Value	25 cm
Target Value	10 cm

Table 9 FO use case KPI 5 – Maximum Number of Parking Maneuver

Name	max_number_of_parking_maneuver
Type	Self truck-trailer parking to a docking station with a speed slower than 20 kph
Range/Scale	0 – 10
Weight	3 (very important)
Status	
Trend	An upward pointing arrow represents: *Positive*
Actual Value	5
Target Value	5

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

2.1.3 Subsystems

The subsystems for the FO use case consist of the two subsystems depicted in Figure 4. However, the Truck/Trailer & Environment subsystem consist of a subsystem representing the truck/trailer dynamics and one representing the environment. Both are TruckMaker models, which is why they are treated as one in this context. The trajectory planners and controllers are two models as well, both implemented in Matlab/Simulink. They are depicted as one in Figure 4, although in section 2.1.3.2 there is a separate specification sheet for each of the models.

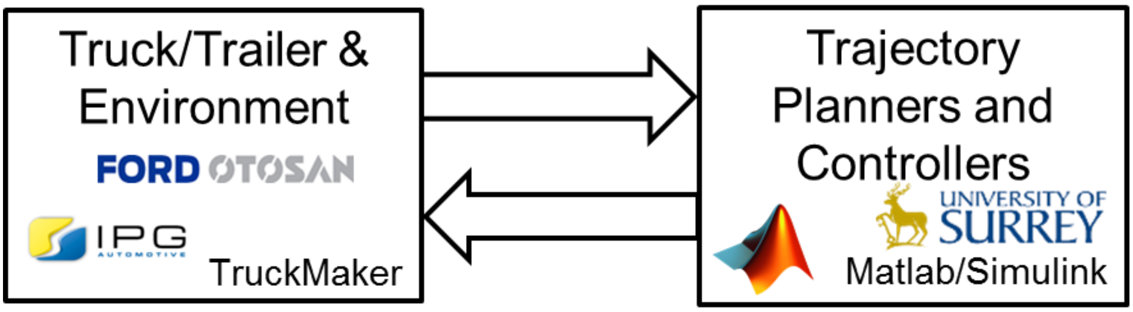

Figure 4 Subsystem overview of Ford Otosan use case

2.1.3.1 Truck Trailer & Environment

Subsystem model specific information						
Name of subsystem	Truck Trailer and Environment					
From Partner	FO					
Use Case affilation	Use Case 1 (FO)					
Short description	enviromental modelling of trailer backing and construction site backing problems with static and dynamic obstacles vehicle dynamic and kinematic modelling and correlation of demo vehicle					
Known limitations	for specific simulations only - valid in specific operating conditions, …					
Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Vehicle characterization data	various					
obstacle list for each scenario	[m] [degrees] [m/s]					

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Outputs of the subsystem (at least the relevant ones)						
Name / Description	Unit	Lower Limit	Upper Limit	Data Type	Dimensio n	

Simulation specific information	
Simulation tool & version	Matlab/Simulink 2016a, IPG TruckMaker 6.0
Numerical solver	ode3
Kind of numerical step-sizes	fixed
Numerical step-size	fixed step-size - max step-size in case of variabel step-size solver: 0.01
Real-time capable	Yes
Project licence available	Yes

Hardware specific information	
Hardware description	Na
Communication step-size	Na
Communication medium	Na

2.1.3.2 Trajectory Planners and Controllers

Subsystem model specific information						
Name of subsystem	Trajectory Planners and Controllers					
From Partner	US					
Use Case affilation	Use Case 1 (FO)					
Short description	Trajectory Planner Development for the Truck-Trailer Reverse Maneuvering for i.) Static Obstacles ii.) Dynamic Obstacles					
Known limitations	Computational time of the algorithm					
Disturbances	Sensor noise, or Model mismatch					
Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Vehicle States	m	N/A	N/A	int	6	
Desired Deceleration	m/s2	0	-5	int	1	
Desired Acceleration	m/s2	0	5	int	1	
Desired Yaw Rate	rad/s			int	1	

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Outputs of the subsystem (at least the relevant ones)						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
Steering Angle	deg	-900	900	int	1	
Braking Torque	Nm	0	-5	int	1	
Acceleration Torque	Nm	0	5	int	1	

Simulation specific information	
Simulation tool & version	Matlab/Simulink 2016a, IPG TruckMaker 6.0
Numerical solver	Ode45/Ode 3
Kind of numerical step-sizes	fixed
Numerical step-size	fixed step-size: 0.01
Real-time capable	yes
Project licence available	yes

Hardware specific information	
Hardware description	ECU(dSPACE MicroAutoBox)
Communication step-size	fixed step-size
Communication medium	CAN

Subsystem model specific information	
Name of subsystem	Trajectory Planners and Controllers
From Partner	US
Use Case affilation	Use Case 1 (FO)
Short description	Trajectory Controller Development for the Truck-Trailer Reverse Maneuvering for i.) Static Obstacles ii.) Dynamic Obstacles
Known limitations	Computational time of the algorithm, Road Boundaries, Limitation due to the vehicle
Disturbances	Sensor noise, or Model mismatch

Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Boundries (Road)	m	N/A	N/A	int	2	
Vehicle States	m	N/A	N/A	int	6	
Position of the obstacles	m	N/A	N/A	int	2	

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Outputs of the subsystem (at least the relevant ones)						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
Desired Deceleration	m/s2	0	-5	int	1	
Desired Acceleration	m/s2	0	5	int	1	
Desired Yaw Rate	rad/s			int	1	

Simulation specific information	
Simulation tool & version	Matlab/Simulink 2016a, IPG TruckMaker 6.0
Numerical solver	Ode45/Ode 3
Kind of numerical step-sizes	fixed
Numerical step-size	fixed step-size: 0.01
Real-time capable	yes
Project licence available	yes

Hardware specific information	
Hardware description	ECU(dSPACE MicroAutoBox)
Communication step-size	fixed step-size
Communication medium	CAN

2.2 Tofaş use case scenario

Automated door to door delivery concepts belong to the most trending topics for commercial vehicles. Light commercial vehicles have a big portion of urban delivery missions. Automation of delivery duties is being investigated by logistics companies for a while. Tofaş will implement two or more urban traffic scenarios to investigate and increase user acceptance of L3AD for light commercial vehicle customers. According to received feedbacks from LCV customers two critical urban road scenarios have come forward.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

2.2.1 Overall description

<u>Door to door delivery scenarios:</u>

- Scenario 1: Backward and forward approaching to dedicated points for loading/delivering and automatically departing/approaching to pre-defined wireless charging stations.
- Scenario 2: Fine-tuned low speed maneuvers for narrow street delivery duties with complex traffic (vehicle+pedestrian+parked vehicles). Hand over situations will be implemented for high density urban traffic scenarios.

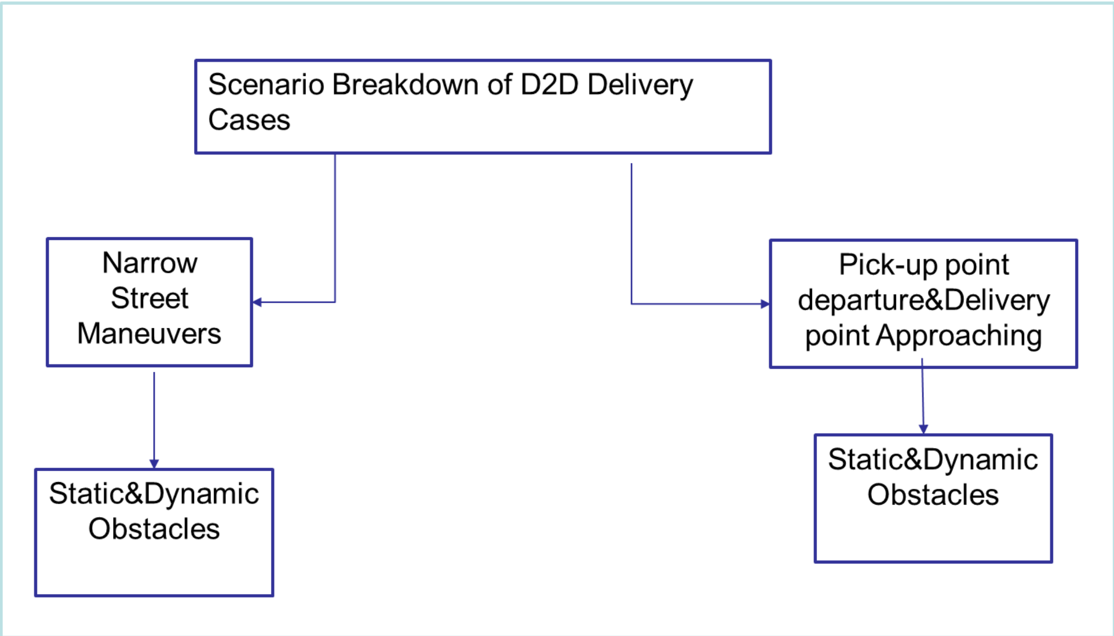

Figure 5 Sub-scenario overview

2.2.2 Goals and KPIs

The dedicated scenarios in 2.2.1 aim to increase acceptance of L3AD light commercial vehicles by covering some critical urban traffic issues. Increasing efficiency for urban delivery duties and reducing driver efforts are other aims for the commercial user's perspective. Manoeuvres which will be realised by controller models shall be maintained within less time than normal operation and shall be smooth enough to fulfill user acceptance.

Most important points for urban delivery duties are automated control of back and forward approaching manoeuvres, which should be precise and smooth, and narrow road manoeuvres within high intensity traffic conditions. Dedicated scenarios aim to cover these critical points. After realisation of these use cases, reliability growth cycles for each scenario and tuning activities are planned. Possible hand-over conditions for dedicated scenarios will be determined. For increasing user acceptance and

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

reliability of L3AD, scenarios will be performed not only under clear weather conditions but also harsh environmental effects are planned to be taken into account.

Table 10 TF use case KPI 1 – Automated Parking

Name	Automated Parking
Type	Maximum targeted maneuvers when approaching delivery point and targeted gap difference between actual and planned.
Range/Scale	Maneuvers for backside parking : 0 -8 Gap between actual vs planned : 0- 50 cm
Weight	3 (very important)
Status	
Trend	*Positive* ↑
Actual Value	7 maneuvers/40 cm (both longitudinal&lateral)
Target Value	<= 5 maneuvers, <30 cm

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Table 11 TF use case KPI 2 – Environmental Perception

Name	Environmental Perception
Type	Daytime detection, tracking and classification of traffic objects with perception sensors like lidar, radar or camera.
Range/Scale	Minimum value: % 0 Maximum value: % 100
Weight	3 (very important)
Status	
Trend	↑ *Positive*
Actual Value	N.A.
Target Value	Vehicles: >90% Pedestrians:>90%

Table 12 TF use case KPI 3 – Handover Time

Name	Handover Time
Type	Mean duration of the transfer of control between operator/driver and vehicle (turning automated driving system on/off, manual overrule and when requested by the vehicle)
Range/Scale	Mean value (manual takeover) : 3-5 seconds Mean value (takeover request from vehicle) : 5-7 seconds
Weight	2 (important)
Status	
Trend	*Positive* ↑
Actual Value	N.A.
Target Value	To be optimized.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Table 13 TF use case KPI 4 – Lateral Position Variation

Name	Lateral Position Variation
Type	Standard deviation of distance from the center of the lane while travelling within a lane
Range/Scale	Minimum value: 0 Maximum value: 0,5 m
Weight	3 (very important)
Status	
Trend	*Neutral* ←→
Actual Value	0,5 m
Target Value	<0,5 m

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Table 14 TF use case KPI 5 – Longitudinal Acceleration/Deceleration

Name	Longitudinal Acceleration/Deceleration
Type	Mean and maximum longitudinal acceleration and deceleration while travelling within lane
Range/Scale	Mean value (acceleration): 0-1.06 m/s^2 Maximum value (acceleration): 2 m/s^2 Mean value (deceleration): 0-1.22 m/s^2 Maximum value (deceleration): 2.2 m/s^2
Weight	3 (very important)
Status	
Trend	*Positive* ↑
Actual Value	1.06-1.22 m/s^2
Target Value	To be optimized.

Table 15 TF use case KPI 6 – Minimum Accepted Time Gap

Name	Minimum Accepted Time Gap
Type	Minimum accepted time gap at intersections
Range/Scale	Min.Value : 0s Max. Value : 7 s
Weight	2 (important)
Status	
Trend	*Positive* ↑
Actual Value	1-7 seconds
Target Value	To be optimized.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

2.2.3 Subsystems

Figure 6 gives an overview of the TF use case subsystems. The respective specification sheets are provided in the following sections, where again Trajectory Planners and Controllers are given as separate subsystems.

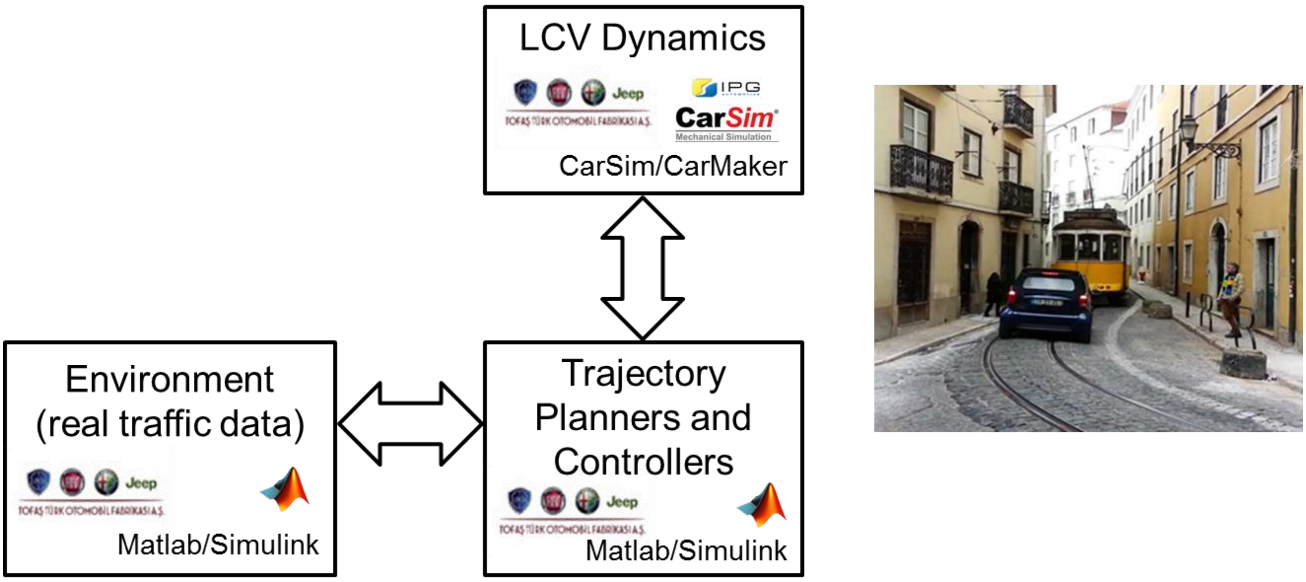

Figure 6 Subsystem overview of Tofaş use case

2.2.3.1 LCV Dynamics

Subsystem model specific information						
Name of subsystem	LCV Dynamics					
From Partner	Tofaş					
Use Case affilation	Use Case 2 (TF)					
Short description	Subsystem will be used for modelling vehicle dynamics on simulation environment. Baseline reference vehicle will be modelled and 2 dedicated scenarios will run according to this model.					
Known limitations	Vehicle model with base parameters. High fidelity simulation will be modelled additionally.					
Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Shifter lever	-	0	3	Double	1	Neutral (0)
upshift request	-	-	-	Bool	1	FALSE
downshift request	-	-	-	Bool	1	FALSE
Throttle	%	0	100	Double	1	0

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Brake Force	Nm	0	tbd	Double	1	0
Ground height level	m	10	100	Double	1	0
Grip level at wheel	%	10	100	Double	1	100
Steering Wheel Angle	Degree	-489	489	Double	1	0
Outputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
Longitudinal acceleration	m/s2	-2.2	2	Double	1	
Vehicle Speed	m/s	0	145	Double	1	
Vehicle position	m	0	tbd	Double	1-by-n	
Vehicle orientation	deg	0	360	Double	1	
wheel travel	mm	0	120	Double	1	
wheel speed	rpm	0	1200	Double	1	
e-motor speed	rpm	0	12000	Double	1	

Simulation specific information	
Simulation tool & version	CarSim or CarMaker
Numerical solver	Carsim/CarMaker Solver
Kind of numerical step-sizes	Fixed
Numerical step-size	1ms
Real-time capable	Yes
Project licence available	

Hardware specific information	
Hardware description	NA

2.2.3.2 Trajectory Planners and Controllers

Subsystem model specific information	
Name of subsystem	Trajectory Planning
From Partner	Tofaş
Use Case affilation	Use Case 2 (TF)
Short description	Subsystem will be used for for controlling visual models. Trajectory planners and control alghorithms will be developed for 2 different scenarios.
Known limitations	Trajectory planners and controlling alghorithms will be developed according to L3AD SW requirements and when a sensor fail or an uncoverable condition occurs, the system will hand over to driver. No limitation has been foreseen additionally.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Object Lists from sensors	-	-	-	Double	n-by-m	-

Outputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Automated system status	**-**	**0**	**1**	Bool	1	FALSE
Lateral offset request	M	-0,30	0,30	Double	**1**	0
Vehicle speed	m/s	0	40,3	Double	1	0
Obstacle detected	**-**	**0**	**1**	Bool	**1**	**FALSE**
distance to target vehicle	M	0	255	double	1	0
look-ahead distance (LAD)	M	0	80	double	1-by-n	0
lateral offset at LAD	M	-0,3	0,3	double	1-by-n	-
angular deviation at LAD	rad	-	-	double	1-by-n	-
road curvature at LAD	1/m	-	-	double	1-by-n	-
Target vs Ego vehicle velocity difference	m/s	-100	50	double	1	0
Max acc @longitudinal	m/s^2	>0	-	double	1	2
Min acc @longitudinal	m/s^2	-	<0	double	1	-2,2
desired time gap to target vehicle	S	1	2,2	double	1	1
desired ego velocity	m/s	0	40,3	double	1	16
max. ego velocity	m/s	0	40,3	double	1	36
actual ego velocity	m/s	0	40,3	double	1	-
minimum cleareance to target	M	0	-	double	1	2
Steering Wheel Angle	Degree	-489	489	Double		0

Simulation specific information	
Simulation tool & version	Matlab/Simulink
Numerical solver	Ode
Kind of numerical step-sizes	Fixed
Numerical step-size	1ms
Real-time capable	Yes
Project licence available	

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Hardware specific information	
Hardware description	NA
Communication step-size	NA
Communication medium	NA

Subsystem model specific information						
Name of subsystem	Controlling Alghorithms					
From Partner	Tofaş					
Use Case affilation	Use Case 2 (TF)					
Short description	Subsystem will be used for for controlling visual models. Trajectory planners and control alghorithms will be developed for 2 different scenarios.					
Known limitations	Trajectory planners and controlling alghorithms will be developed according to L3AD SW requirements and when a sensor fail or an uncoverable condition occurs, the system will hand over to driver. No limitation has been foreseen additionally.					
Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Enable signal	-			Bool	1	FALSE
Lateral offset request	m	tbd	tbd	Double	1	0
Vehicle speed	m/s	0	37	Double	1	0
Obstacle detected	-	-	-	Bool	1	FALSE
distance to target vehicle	m	0	-	double	1	0
look-ahead distance (LAD)	m	0	80	double	1-by-n	-
lateral offset at LAD	m	-	-	double	1-by-n	-
angular deviation at LAD	rad	-	-	double	1-by-n	-
road curvature at LAD	1/m	-	-	double	1-by-n	-
Ego vs Target velocity difference	m/s	-	-	double	1	0
Maximum acc @longitudinal	m/s²	>0	-	double	1	2
Minimum acc @longitudinal	m/s²	-	<0	double	1	-2,5
desired time gap to target vehicle	s	1	2,2	double	1	1
desired ego velocity	m/s	0	50	double	1	16

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

max. ego velocity	m/s	0	50	double	1	36
actual ego velocity	m/s	0	50	double	1	-
minimum cleareance to target	m	>0	-	double	1	2
Steering Wheel Angle	Degree	-489	489	Double		0
Outputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
actual look-ahead distance	m	0	80	double	1	
actual lateral offset	m	-	-	double	1	
desired longitudinal acceleration	m/s²	-2,2	2	double	1	0
actual angular deviation	rad	-	-	double	1	

Simulation specific information	
Simulation tool & version	Matlab/Simulink 2017a
Numerical solver	Ode
Kind of numerical step-sizes	Fixed
Numerical step-size	1ms
Real-time capable	Yes
Project licence available	

Hardware specific information	
Hardware description	NA
Communication step-size	NA
Communication medium	NA

2.2.3.3 Environment

Subsystem model specific information	
Name of subsystem	Environment
From Partner	Tofaş
Use Case affilation	Use Case 2 (TF)
Short description	Subsystem is the simulation environment itself for virtual use case validations.
Known limitations	Simulation environment a number of moving and static obstacles in its library to create realistic environmental conditions,but might not cover all the real life conditions.

This report is part of a project that has received funding from European Union’s Horizon 2020 research and innovation programme under grant agreement No 723324.

Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Sensor specific model inputs	-	-	-	-	-	-
Outputs of the subsystem (at least the relevant ones)						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
Sensor specific model outputs	-	-	-	-	-	

Simulation specific information	
Simulation tool & version	IPG CarMaker
Numerical solver	-
Kind of numerical step-sizes	Fixed
Numerical step-size	1ms
Real-time capable	Yes
Project licence available	

Hardware specific information	
Hardware description	Mule Vehicle for sensor data collection/correlation activities will be built.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

2.3 Volvo use case scenario

2.3.1 Overall description

In order to conduct safe automated vehicle maneuverers, vehicle controllers are highly dependent on trustworthy data from the vehicle sensors. The sensor output must ensure that lines, objects, VRU's and so on within the driving path are detected and reported. However, ensuring 100% detection rate is unlikely, often due to external disturbance and not necessarily sensor performance. Degradation of the sensor output can result in false detections, late detections or even missed detections. The degradation of sensor output also impacts the availability of the intended function, i.e. the automated driving function is available less than expected. By monitoring sensor faults, the trustworthiness of sensor output can be increased and by that better utilize the performance advantage of each sensor in different driving scenarios and environmental conditions.

Failure scenarios reported to Sensor Monitoring Module

- Fault Scenario 1: Sensor health and communication quality

  Diagnostics of components, such as reporting heart beat or signal quality, is already vital part of sensor implementation. The Sensor Monitoring Module can use diagnostic information as a confidence value to measure the trustworthiness of the sensor outputs.

- Fault Scenario 2: Environmental conditions

  The availability of vehicle sensors is dependent on environmental conditions and different sensors react differently depending on the conditions. Conditions such as harsh weather or reduced visibility can highly degrade the sensor and this has to be reported to the Sensor Monitoring System.

2.3.1 Goals and KPIs

The KPIs for the Volvo use case are mainly related to improvement of the availability of the used L3AD system in various environmental conditions. It is intended to decrease the number of take-over scenarios and therefore improve the user acceptance. Table 16 presents a first KPI for this purpose. Others may be provided later on within the project.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Table 16 Volvo use case KPI 1 – Impact availability of automated function due to sensor faults

Vehicle Type	Truck☐ Bus ☐Light commercial vehicle☐ Passenger vehicle☒
Name	Impact availability of automated function due to sensor faults
Definition	Impact on availability of automated function due to sensor faults and difficult driving situations
Unit	Percentage
Type	Ordinal
Range/Scale	0% to 100% of function availability
Weight	3: very important (--)
Status	Not applicable yet
Trend in literature	Negative trend. Sensor degradation and difficult driving situations can result in limited automated functionality.
Trend	-
Test Environment	Simulation, Driving Simulator and Vehicle Demonstrator
Actual Value	-
Target Value	85%

2.3.2 Subsystems

Figure 7 presents an overview of the planned subsystems for Volvo use case. Since Volvo's activities are scheduled mainly in the last third of this project, subsystem descriptions may be less elaborate than in FO or TF use case. Nevertheless preliminary specification information is given in the following subsystems.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

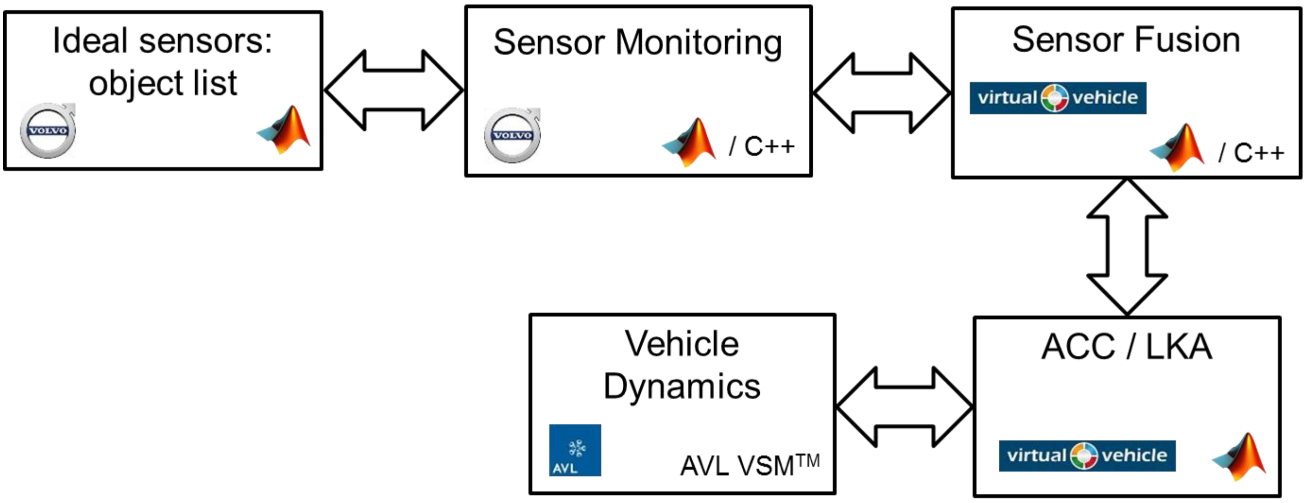

Figure 7 Subsystem overview of the Volvo use case

2.3.2.1 Vehicle dynamics

Subsystem model specific information						
Name of subsystem	Vehicle Dynamics					
From Partner	AVL					
Use Case affilation	Use Case 3 (Volvo)					
Short description	Simulation of dynamic vehicle behaviour (incl. tires, suspension, aero dynamics, engine model, powertrain model)					
Known limitations	not suitable for high frequency NVH simulations					
Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Steering wheel angle	deg	-270	270	double	1	0
Accelerator pedal	%	0	100	double	1	0
Brake pedal	%	0	1	double	1	0
Selector lever position	-			integer	1	
Upshift pedal signal	-			bool	1	false
Downshift pedal signal	-			bool	1	false
Ground height at wheel	m	10	100	double	4	0
Grip level at wheel	%	10	100	double	4	100
Outputs of the subsystem (at least the relevant ones)						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
vehicle accelerations	m/s²			double	3	

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

vehicle speeds	m/s²			double	3	
vehicle rotational speeds	deg/s			double	3	
Vehicle position	m			double	3	
vehicle orientation	deg			double	3	
wheel travel	mm			double	4	
wheel speeds	rpm			double	4	
engine/motor speed	rpm			double	1 to 4	
tyre forces	N			double	12	

Simulation specific information	
Simulation tool & version	Matlab/Simulink (2007b to 2017a), Model.CONNECT (2017)
Numerical solver	Euler
Kind of numerical step-sizes	fixed
Numerical step-size	0.0005 sec
Real-time capable	yes
Project licence available	

Hardware specific information	
Hardware description	PC, Real-Time environment, Testbed, HiL
Communication step-size	fixed step-size
Communication medium	UDP

2.3.2.2 ACC

Subsystem model specific information						
Name of subsystem	ACC (Adaptive Cruise Control)					
From Partner	ViF					
Use Case affilation	Use Case 3 (Volvo)					
Short description	maintain a desired ego vehicle’s velocity considering a maximum velocity or, if present, maintain a desired time gap to a leading target vehicle considering a minimum clearance					
Known limitations	does not consider low friction situations					
Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
is active	-	-	-	bool	1	false
target vehicle detected	-	-	-	bool	1	false
distance to target vehicle	m	0	-	double	1	0
difference v_Target - v_Ego	m/s	-	-	double	1	0

This report is part of a project that has received funding from European Union’s Horizon 2020 research and innovation programme under grant agreement No 723324.

minimum cleareance to target	m	>0	-	double	1	2
ax_max	m/s²	>0	-	double	1	2
ax_min	m/s²	-	<0	double	1	-2,5
desired time gap to target vehicle	s	1	2,2	double	1	1
desired ego velocity	m/s	0	50	double	1	16
max. ego velocity	m/s	0	50	double	1	36
actual ego velocity	m/s	0	50	double	1	-
Outputs of the subsystem (at least the relevant ones)						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
desired longitudinal acceleration	m/s²	ax_min	ax_max	double	1	

Simulation specific information	
Simulation tool & version	Matlab/Simulink 2012a
Numerical solver	ode3
Kind of numerical step-sizes	fixed
Numerical step-size	0.01 sec
Real-time capable	yes
Project licence available	

Hardware specific information	
Hardware description	dSPACE MicroAutoBox
Communication step-size	fixed step-size
Communication medium	CAN

2.3.2.3 LKA

Subsystem model specific information	
Name of subsystem	LKA
From Partner	ViF
Use Case affilation	Use Case 3 (Volvo)
Short description	Based on vision systems like Mobileye, the LKA system calculates outputs related to a specific look-ahead distance for the low-level control within the ego-vehicle's lane.
Known limitations	-
Inputs of the subsystem	

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Name / Description	Unit	Lower Limit	Upper Limit	Data Type	Dimension	Init Value
is active	-	-	-	bool	1	false
desired lateral offset	m	-0,25	0,25	double	1	0
look-ahead distance (LAD)	m	0	80	double	1-by-n	-
lateral offset at LAD	m	-	-	double	1-by-n	-
angular deviation at LAD	rad	-	-	double	1-by-n	-
road curvature at LAD	1/m	-	-	double	1-by-n	-
vehicle velocity	m/s	0	50	double	1	-
Outputs of the subsystem (at least the relevant ones)						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
actual look-ahead distance	m	0		double	1	
actual lateral offset	m	-		double	1	
desired lateral offset	m	-0,25	0,25	double	1	
actual angular deviation	rad	-	-	double	1	

Simulation specific information	
Simulation tool & version	Matlab/Simulink 2012a
Numerical solver	ode3
Kind of numerical step-sizes	fixed
Numerical step-size	0.01 sec
Real-time capable	yes
Project licence available	

Hardware specific information	
Hardware description	dSPACE MicroAutoBox
Communication step-size	fixed step-size
Communication medium	CAN

2.3.2.4 Sensor monitoring / fusion

Subsystem model specific information	
Name of subsystem	Sensor Fusion
From Partner	ViF
Use Case affilation	Use Case 3 (Volvo)
Short description	This subsystem tracks and fuses sensor level and global fusion tracks. In order to be useable for sensor level tracks, the sensors must provide a non-empty subset of the state vector x, y, vx and vy for each object.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Known limitations	Performance heavily depends on the computational power of the platform on which it is executed, and on the total number of objects in the vicinity of the ego vehicle.

Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
relative time (t)	s	0.0		float	1	0.0
count		0		int	1	0
fusion time (tf)	s	0.0		float	count	0.0
longitudinal position (x)	m	0.0		float	count	
lateral position (y)	m	0.0		float	count	
longitudinal velocity (vx)	m / s	0.0		float	count	
lateral velocity (vy)	m / s	0.0		float	count	
object class				float	6 x count	1 / 6
state covariance				float	4 x 4 x count	
observability				bool	4 x count	

Outputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
relative time (t)	s	0.0		float	1	0.0
count		0		int	1	0
fusion time (t)	s	0.0		float	count	0.0
longitudinal position (x)	m	0.0		float	count	
lateral position (y)	m	0.0		float	count	
longitudinal velocity (vx)	m / s	0.0		float	count	
lateral velocity (vy)	m / s	0.0		float	count	
object class				float	6 x count	1 / 6
state covariance				float	4 x 4 x count	

Simulation specific information	
Simulation tool & version	Standardized C++ 2011 Compiler
Numerical solver	Forward Euler
Kind of numerical step-sizes	Fixed step-size
Numerical step-size	Fixed step-size is configurable
Real-time capable	yes (depends on the concrete settings)

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Project licence available	yes (only open source tools and libraries with non-restrictive licenses were used)

Hardware specific information	
Hardware description	N/A
Communication step-size	N/A
Communication medium	N/A

Subsystem model specific information						
Name of subsystem	Sensor Monitoring Module					
From Partner	Volvo					
Use Case affilation	Use Case 3 (Volvo)					
Short description	The Sensor Monitoring Module shall report potential sensor faults and critical driving situations to Sensor Fusion Module to ensure a driveable area with safe stop margins or deactivate automated function.					
Known limitations	-					
Inputs of the subsystem						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	**Init Value**
Failure Scenario: Diagnostic Trouble Code Concept						
Heart Beat - Sensor / ECU	**-**	**-**	**-**	**Bool**	**1**	**WAHR**
Signal Quality - Sensor / ECU	**%**	**TBD**	**TBD**	**Double**	**-**	**100**
Object Stream List	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**
Sensor Fault	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
ECU Fault	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
Failure Scenario: Environmental Conditions						
Camera Sensors						
Liquid occulsion	**%**	**>49**	**100**	**Double**	**-**	**100**
Solid occlusion	**%**	**>49**	**100**	**Double**	**-**	**100**
Low light	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Blooming	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
Reduced visibility	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
Lidar Sensors						
Liquid occulsion	**%**	**>49**	**100**	**Double**	**-**	**100**
Solid occlusion	**%**	**>49**	**100**	**Double**	**-**	**100**
Reduced visibility	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
Radar Sensors						
Solid occlusion	**%**	**>49**	**100**	**Double**	**-**	**100**
Reduced visibility	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
Interference	**%**	**TBD**	**100**	**Double**	**-**	**0**
Ultrasonic sensors						
Occlusion	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
Reduced visibility	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
GPS						
Signal loss	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
Cloud information						
Signal loss	**-**	**-**	**-**	**Bool**	**1**	**FALSCH**
General for all sensors						
Extreme temp	-	-1	1	Intg	-	0
Outputs of the subsystem (at least the relevant ones)						
Name / Description	**Unit**	**Lower Limit**	**Upper Limit**	**Data Type**	**Dimension**	
Trusted Detection Area: Short Range - Front						
Camera	**-**	**-**	**-**	**Bool**	**1**	**WAHR**
Lidar	**-**	**-**	**-**	**Bool**	**1**	**WAHR**
Radar	**-**	**-**	**-**	**Bool**	**1**	**WAHR**
Ultrasonics	**-**	**-**	**-**	**Bool**	**1**	**WAHR**
Trustet Detection Area: Short Range - Rear						
Camera	**-**	**-**	**-**	**Bool**	**1**	**WAHR**
Lidar	**-**	**-**	**-**	**Bool**	**1**	**WAHR**

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Radar	-	-	-	**Bool**	**1**	**WAHR**
Ultrasonics	-	-	-	**Bool**	**1**	**WAHR**
Trusted Detection Area: Short Range - Side, Right						
Camera	-	-	-	**Bool**	**1**	**WAHR**
Lidar	-	-	-	**Bool**	**1**	**WAHR**
Radar	-	-	-	**Bool**	**1**	**WAHR**
Ultrasonics	-	-	-	**Bool**	**1**	**WAHR**
Trusted Detection Area: Short Range - Side, Left						
Camera	-	-	-	**Bool**	**1**	**WAHR**
Lidar	-	-	-	**Bool**	**1**	**WAHR**
Radar	-	-	-	**Bool**	**1**	**WAHR**
Ultrasonics	-	-	-	**Bool**	**1**	**WAHR**
Trusted Detection Area: Long Range - Front						
Camera	-	-	-	**Bool**	**1**	**WAHR**
Lidar	-	-	-	**Bool**	**1**	**WAHR**
Radar	-	-	-	**Bool**	**1**	**WAHR**
Trusted Detection Area: Long Range - Rear						
Camera	-	-	-	**Bool**	**1**	**WAHR**
Lidar	-	-	-	**Bool**	**1**	**WAHR**
Radar	-	-	-	**Bool**	**1**	**WAHR**
Trusted Detection Area: Long Range - Side, Left						
Camera	-	-	-	**Bool**	**1**	**WAHR**
Lidar	-	-	-	**Bool**	**1**	**WAHR**
Radar	-	-	-	**Bool**	**1**	**WAHR**
Trusted Detection Area: Long Range - Side, Right						
Camera	-	-	-	**Bool**	**1**	**WAHR**
Lidar	-	-	-	**Bool**	**1**	**WAHR**
Radar	-	-	-	**Bool**	**1**	**WAHR**
GPS and Cloud Information						
Trusted Localization Data	-	-	-	**Bool**	**1**	**WAHR**
Critical Road - Construction	-	-	-	**Bool**	**1**	**FALSCH**
Critical Road - Low friction	-	-	-	**Bool**	**1**	**FALSCH**

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

Simulation specific information	
Simulation tool & version	Matlab/Simulink, C/C++
Numerical solver	-
Kind of numerical step-sizes	-
Numerical step-size	-
Real-time capable	?
Project licence available	-

Hardware specific information	
Hardware description	ECU
Communication step-size	-
Communication medium	UDP, CAN, Ethernet

2.3.2.5 Sensor model / object list

For the tests intended to be conducted on the driving simulator in WP5, the object list representing an ideal sensor model will be provided by Vires VTD, which is used for the environment simulation on the AVL driving simulator. For a detailed description of the AVL driving simulator see D2.2 [3]. In order to test the sensor monitoring system, it is planned to decrease the detection ranges of the respective sensors accordingly.

In WP6 this subsystem will be replaced by real sensors integrated in the Volvo demonstrator vehicle.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

3 Conclusion

This deliverable summarizes the requirements, respectively subsystem collection for the Ford Otosan, Tofaş and Volvo use cases. Every use case is described and its key performance indicators are detailed. A first specification for each of the used models is given in terms of a brief description and its in- and outputs, as well as software and hardware specific information.

As mentioned in section 0, the described models will later on be replaced by real hardware in WP6. The co-simulation approach which WP3 aims at is exceptionally suitable for this modular design using simulation models in various tools. Since the AVL driving simulator also works with Model.CONNECT™, the same modular structure can be used there as well with little to no extra effort. Further the substitution of the real hardware for the models is designed to be as easy as possible.

In the next step a modular architecture has to be established in order to make full use of the co-simulation potential, namely the easy exchange of individual modules (e.g. simulation tool vs. real hardware).

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

4 References

[1] Model.CONNECT™ User Manual

[2] Stettinger, G., Benedikt, M., Thek, N., & Zehetner, J. (2013). On the difficulities of real-time co-simulation. *V International Conference on Computational Methods for Coupled Problems in Science and Engineering, COUPLED PROBLEMS 2013.* Ibiza, Spain.

[3] Troglia Gamba, M. et.al. (2017). D2.2 Specification of Traffic Scenarios and Questionnaires, TrustVehicle Deliverable.

This report is part of a project that has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.