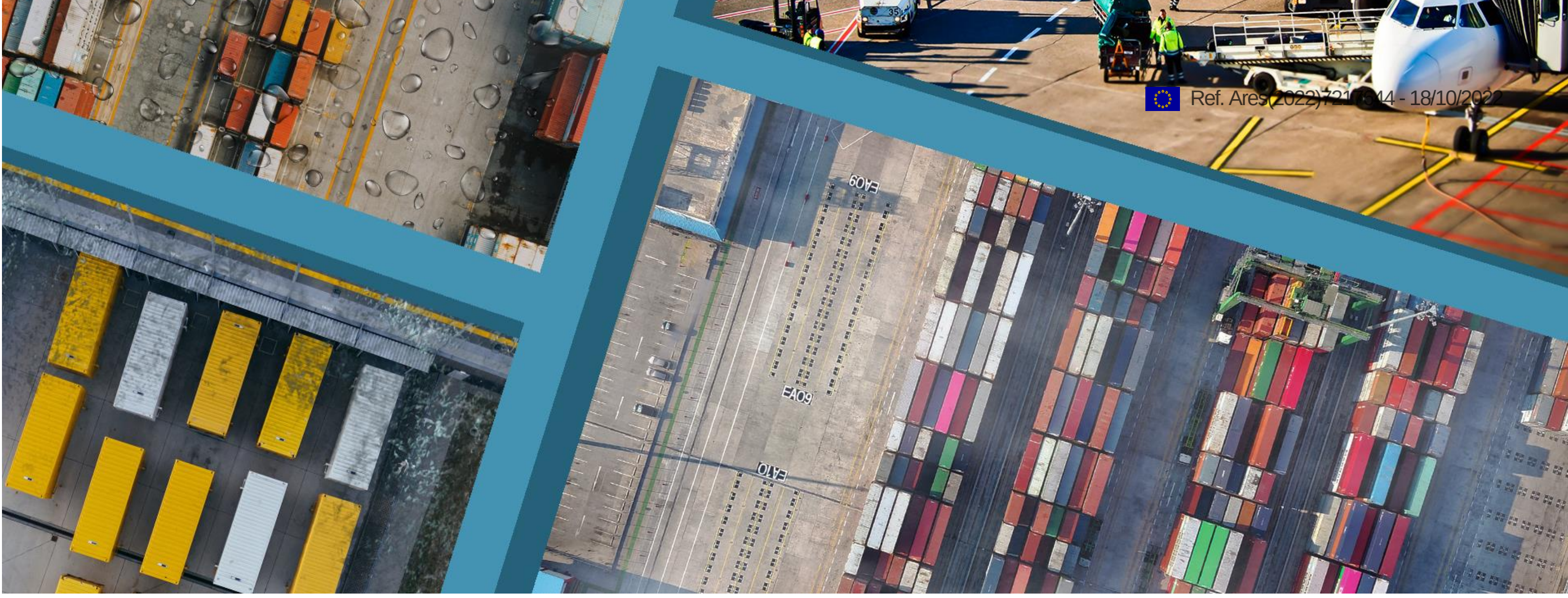

AWARD

Scaling autonomous logistics

D2.1
System scope

Lead: EasyMile

Due date: September 2021

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0.1	28/01/2021	Peter Fröhlich	AIT	Initial content structure and responsibility allocation for each section
0.2	19/07/2021	Inès Guth	EasyMile	Sections completion and re-wording
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1.3	18/10/2022	Stéphane Potiron	EasyMile	Quality review

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ADS	Automated Driving System
ADS-DV	Automated Driving System – Dedicated Vehicles
AGV	Automated Guided Vehicle
AGTS	Automated ground Goods Transportation System
ASIL-D	Automotive Safety Integrity Level D

ATS	Automated Transport Systems
D	Deliverable
ECU	Electronic Control Unit
FMS	Fleet Management System
GNSS	Global Navigation Satellite System
HDV	Heavy-Duty Vehicles
MQTT	Message Queuing Telemetry Transport
N/A	Not Applicable
OBU	On-Board Unit
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
OS	Operational Scenario
RSU	Road Side Unit
RTK	Real Time Kinematic
RTO	Research and Technology Organisations
SI	Supporting Infrastructure
SLS	Supporting Logistics System
SOI	System of Interest
SoS	System of Systems
SOTIF	Safety Of The Intended Functionality
SPAT	Signal Phase and Timing
T	Task
TOS	Terminal Operating System
TPO	Traffic Participants and Obstacles
UC	Use Case
V2I	Vehicle-to-Infrastructure
V2X	Vehicle-to-Everything
WP	Work Package
WMS	Warehouse Management System

Glossary

Automotive Safety Integrity Level D	Automotive Safety Integrity Level D (ASIL) is a risk classification scheme defined by the ISO 26262 - Functional Safety for Road Vehicles[1]. D is the highest grade.
Operational Design Domain	A Fleet Management System supports the management of a fleet of ADS-equipped vehicles deployed in driverless operation. This includes collecting transport orders from logistic systems, information from auxiliary systems (e.g. road sensors, cameras, etc.) and status from the fleet vehicles (breakdowns, data collection for curative and preventive maintenance. etc.), disseminating dispatch information to the fleet (e.g. trip routes and other order details, managing emergencies) and status information to vulnerable road users, and activating teleoperation when needed. The Fleet Management System may serve as the responsible agent vis-a-vis law enforcement, emergency responders and other authorities for vehicles.
Operational Scenario	Different ways in which one, vehicle or user, interacts with autonomous guided vehicles. E.g. AGV is driving if X amount to dock, AGV is waiting for loader, etc.
System of Interest	– The system whose life cycle is under consideration. A system-of-interest is a collective set of all elements of any system considered by a lifecycle, this may include both operational and enabling systems (ISO/IEC/IEEE 2015) – The system of interest to an observer[2].
System of Systems	A "System of Systems" (SoS) is a SOI whose elements are managerially and/or operationally independent systems. These interoperating and/or integrated collections of constituent systems usually produce results unachievable by the individual systems alone. Because an SoS is itself a system, the systems engineer may choose whether to address it as either a system or as an SoS, depending on which perspective is better suited to a particular problem[3]. The following characteristics can be useful when deciding if a particular SOI can better be understood as an SoS[4]: – Operational independence of constituent systems – Managerial independence of constituent systems – Geographical distribution – Emergent behavior – Evolutionary development processes
Automotive Safety Integrity Level D	Automotive Safety Integrity Level D (ASIL) is a risk classification scheme defined by the ISO 26262 - Functional Safety for Road Vehicles[5]. D is the highest grade.

[1] ISO 26262-9:2018, Road vehicles — Functional safety — Part 9: Automotive Safety Integrity Level (ASIL)-oriented and safety-oriented analyses, 2018
[2] Ludwig Von Bertalanffy, General System Theory, *New York, George Braziller*, 1986
[3] International Council On Systems Engineering (INCOSE), Systems engineering handbook a guide for system life cycle processes and activities, *INCOSE-TP-2003-002-04,* 2015.
[4] Maier M., Architecting principles for systems-of-systems, Systems Engineering, 1998
[5] ISO 26262-9:2018, Road vehicles — Functional safety — Part 9: Automotive Safety Integrity Level (ASIL)-oriented and safety-oriented analyses, 2018

1. Executive Summary

This deliverable "D2.1 – System scope" sets the pillars of AWARD project development, as the first deliverable of the "WP2 – Identification of end-users' needs and requirements". The task "T2.1 – Scope definition and refinement" lays out a solid ground for the project by reassessing and refining the overall scope of the targeted System of Systems, the selected overall use cases, ecosystem(s) of stakeholders and value chains, as well as innovation objectives.

The content of the report focuses on the Use Cases (UC) description, users and stakeholders' analysis of the 4 demonstrators, which will be used to develop and assess the AWARD Autonomous Driving System (ADS) innovative technology. A proper definition of the UC among the Consortium is key to set a common understanding of the UC needs and requirements that will be necessary as input to the subsequent project work packages.

Then, the AWARD's System of Systems (SoS) is introduced and detailed into its main components and subsystems interactions. The SoS definition will serve as an input for the subsequent WP2 tasks dedicated to the operational scenarios' definition and to the functional requirements to be fulfilled by each subsystem described in this document. Then, the technical work packages will use the SoS breakdown and WP2 output analysis to achieve the safety studies based on SOTIF and ISO 26262, and the safety goals identified and classified according to the risk or hazard of ISO 26262.

Finally, the AWARD value chains and the project innovative objectives are detailed, supporting the "T10.3 – Innovation management and impact monitoring" in the analysis of the scientific and technological achievements of the project.

A Project Memorandum, synthesizing the outputs of the T2.1, is available in Annex 2 and will be visible on the project website.

2. Introduction

This document discusses the general scope of the use cases in the AWARD project. The project's four use cases deal with pilot operations of automated industrial trucks. They include an automated forklift, a swap-body truck as warehouse shuttle, an airport baggage truck, and a port terminal tractor. The trucks and forklift are to be able to continue operations in nearly all-weather conditions, night and day. The AWARD project will examine the feasibility of automating a set of use cases and will carry out a comprehensive evaluation of the results.

The stakeholders and users of each of these use cases have been analysed in section 5. The stakeholder grouping has been compiled based on previous studies[6][7]. The stakeholders and users have been then reviewed by each use case leader specifying if they apply or not to their environment.

The overall use cases and project demonstrations will require integration of several systems and processes. The project uses a System-of-Systems (SoS) concept to describe these elements. The subsystems and interrelations are described in section 6.

In addition, project value chains have been identified, enabling to identify the first value flows leading to the project exploitable results and innovations.

This report documents the results of the use case specifications together with stakeholders and users of Automated ground Goods Transport Systems (AGTS).

As figure 1 shows, the main scope and terms have been defined in T2.1. The work in this task consists in building up on the use cases definition and system of systems description, taxonomy, the definition of the AGTS system of systems and of the use cases. As a first development towards "T2.2 – User and stakeholder requirements analysis", "T2.3 – Definition of operational scenarios for the pilots" and "T2.4 – Functional requirements", T2.1 input serve the identification of users and stakeholders and operational scenarios, directly feeding into the definition of functional requirements, as well as several subsequent activities of the project, most importantly the integration and demonstration (WP6), business modeling (WP8) and exploitation (WP9).

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[6] Cooperative Connected and Automated Mobility (CCAM), C-ITS Platform Final Report, *https://ec.europa.eu/transport/sites/transport/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf*, 2016

[7] Atzmüller, B., Neubauer, M., Pell, A., Saleh, P., & Stieninger, M., DigiTrans: Bedarfsanalyse Logistik und Fahrzeugtechnologie - Deliverable 3, 2017

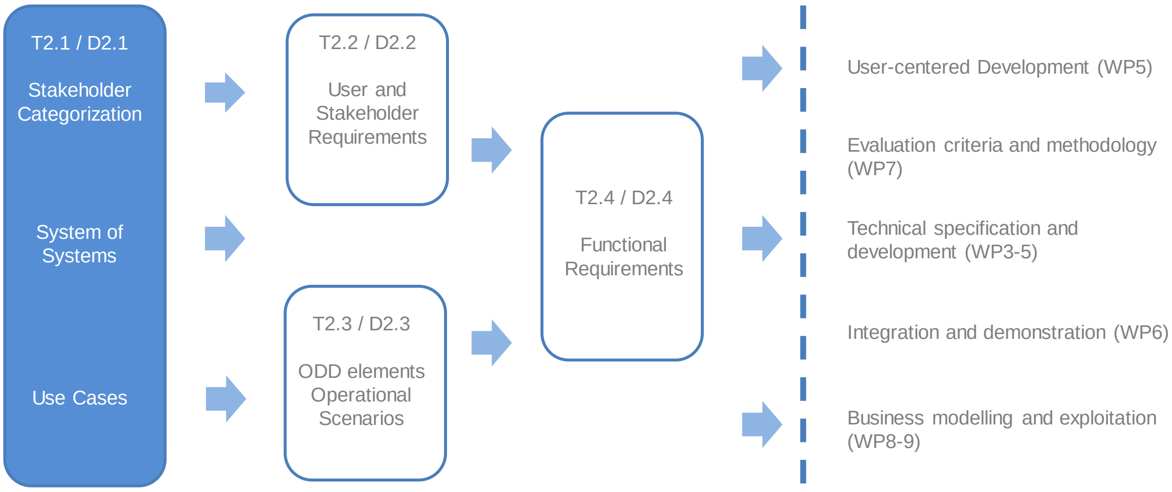

Figure 1: Overview of the relationship of the scope definition task and deliverable (T2.1 and D2.1) within the overall requirements analysis activities (WP2), and their contribution to subsequent activities in the AWARD project

3. The technical vision for the AWARD Project

The AWARD project aims at developing an Autonomous Transport Solution (ATS) based on autonomous heavy-duty vehicles. To be economically viable, the designed solution must support 24/7 operations, in mixed traffic, on private or public road and be robust to various weather conditions.
Moreover, the autonomous logistic transport solution must be part of an existing logistic transport system and consequently it shall be interoperable with existing logistic systems and handle external inputs.

To achieve these high-level goals and to overcome technical challenges, the AWARD project focuses on:

At vehicle level:

- A safe and reliable drive-by-wire solution for the platform automation.
- The design of an ADS relying on a unique multi-sensor architecture and performing in all AWARD autonomous heavy-duty vehicles under various weather conditions.
- A scalable hardware and software solution ensuring a high level of adaptability and fast optimization to various industrial platform (from the forklift to the semi-trailer).
- The use of automotive standard and robust communication protocol for internal and external communication (e.g.: CAN, V2X).

At system of systems level:

- The design of a fleet management and supervision system to interact with the autonomous vehicles and the existing environment.
- Scalable and adaptable software interfaces for logistics applications.

Figure 2 highlights the interactions between all AWARD systems and already existing systems (depicted in grey). The AWARD solution shall be generic to provide a single solution to the different use case objectives which are detailed in the next chapter.

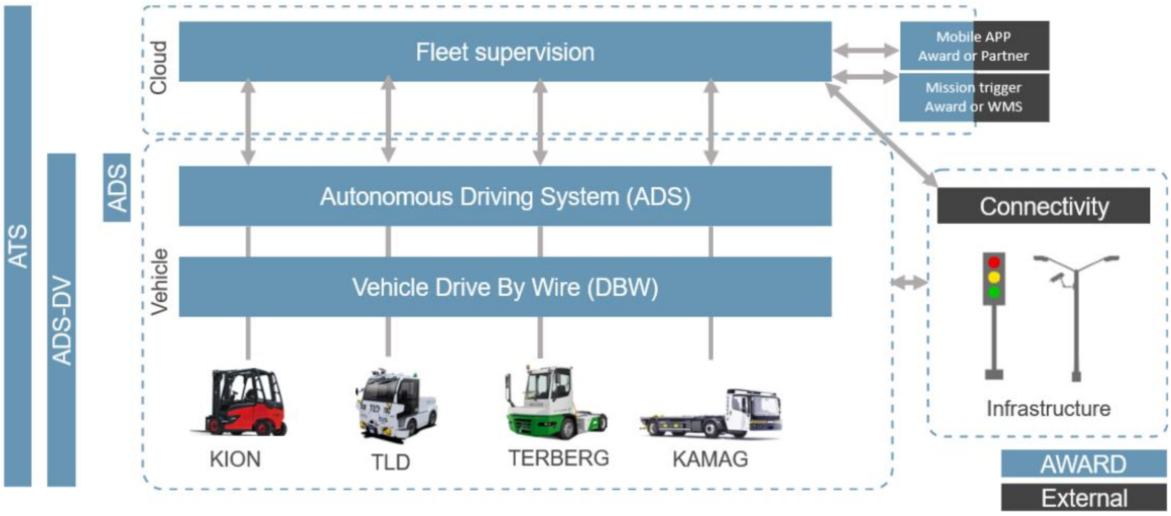

Figure 2: Overall AWARD system architecture

4. Scope of the use cases

4.1. Overview

In order to demonstrate and evaluate the technical improvements for all-weather operations of automated vehicles, the AWARD concept includes specific real world use cases. The use cases address vehicle tasks in different settings, from industrial sites to public roadways as well as scenarios with different automated vehicles and users. The AWARD project aims at demonstrating the automated vehicles working in all-weather conditions and addressing challenges related to the deployment of these vehicles in real logistics operations through several strategic use cases that meet market needs, from the factory to logistics hubs.
The following section describes the general scope of the use cases, planned within the AWARD project, as:

- Use Case 1 (UC 1): Loading and transport with an automated forklift.
- Use Case 2 (UC 2): Hub-to-hub shuttle service from warehouse/production site to logistics hubs.
- Use Case 3 (UC 3): Automated baggage tractor on airside in Avinor OSL Gardermoen airport.
- Use Case 4 (UC 4): Trailer transfer operations and automated ship loading in Rotterdam port.

Each use case defines elements within an Operational Design Domain (ODD) and parties (users and stakeholders) associated with its site and its operational scenarios. Each use case has several operational scenarios.

Progresses of each use case and respective internal phases will be subject to validation and approval from the project members, in particular from the end-users and the legislating entities.

4.1.1. Purpose of a use case

A use case in AWARD outlines a general goal and how an automated vehicle is expected to interact with users and other systems. The purpose of a use case description is to have an initial, semi-formal description of the system of interest to specify the system scope and the project details. For further details, the project uses operational scenarios and the System of Systems concept.

From a use case, formal more detailed operational scenarios can be derived in “T2.3 – Definition of operational scenarios for the pilots”. Use cases are applicable for any abstraction level within the system hierarchy to capture the needs of the stakeholders (e.g. the automated driving vehicle in its environment in certain situation to fulfill a specific purpose or intended behavior).

4.1.2. Purpose of an operational scenario

Operational scenarios are refined, more detailed, formalized, and structured descriptions of the system of interest in its context (environment), linked to a specific use case. Operational scenarios can be used to trigger requirements elicitation, detailed system development, test case definition and test development.

4.1.3. Basic elements of the UC environments

The scope of the use cases is described based on basic elements of the UC environments for automated driving. The taxonomy for roadway elements is derived from NHTSA[8], aspects are based on findings from previous European projects, such as Enable 3S and PEGASUS.

4.2. Use case descriptions

4.2.1. Autonomous loading & unloading forklift operations

This use case will be deployed to address technological challenges related to outdoor logistics flow automation operations within factories, at Linde Aschaffenburg Material Handling (Germany):

- Use-Case Name: Autonomous loading & unloading forklift operations
- Use-Case ID: UC 1
- Type of site: Private.

There will be 2 phases within the UC 1:

- Phase 1: Empty racks transport and yarding on Linde Aschaffenburg Material Handling private site
- Phase 2: Phase 2 will be defined at a later stage of the project.

Phase 1

The objective of Phase 1 is to demonstrate empty racks transport and yarding on Linde Aschaffenburg Material Handling private site.

Figure 3 and Figure 4 hereafter present an overview of Phase 1.

[8] NHTSA, A Framework for Automated Driving Systems in Testable Cases and Scenarios, *Washington, DC: US DOT, National Highway Traffic Safety Administration*, 2018

Figure 3: Industrial site – Phase 1 trajectory

Figure 4: Forklift truck (left), Block stack in storage yard (right)

The factory relies on a system of racks in which all parts are brought to the production lines. The racks are owned by Linde. They are shipped back and forth between Linde and their parts suppliers.
Full racks are brought to the production lines by manual forklift trucks. The products within them are consumed during the production process. Once a rack is empty, it is removed by a manual forklift driver and brought to the storage yard.
At the storage yard, all empty racks are buffered, sorted per type. Once a sufficient number of racks is reached, a transport is organized to have them shipped to parts suppliers.

The automatic transport will focus on the empty racks returned to the storage yard (figure 4). A single, frequently used rack type is selected for demonstration: the steering axle rack. The retrieval of empty racks from the production lines will be handled by manual forklift drivers. They will collect empty racks and bring them to a transfer location just outside the factory hall. From the transfer location, the automated forklift truck will retrieve the racks and bring them to the storage yard where they will be stored in a block stack (figure 3). This process is repeated 2 to 3 times per hours.

Phase 2

The Phase 2 will be defined at a later stage of the project. Deliverable D2.1 will be updated accordingly.

4.2.2. Hub-to-hub autonomous logistics

This use case aims at demonstrating autonomous heavy-duty vehicles working between the Engine Factory of BRP-Rotax and the Logistic Hub of DB Schenker (in Gunskirchen, Austria). The hubs are connected via factory areas, public side roads, public main roads and public crossing areas.

- Use-Case Name: Hub-to-hub autonomous logistics
- Use-Case ID: UC 2
- Type of site: Public and private.

Figure 5 hereafter presents an overview of UC 2.

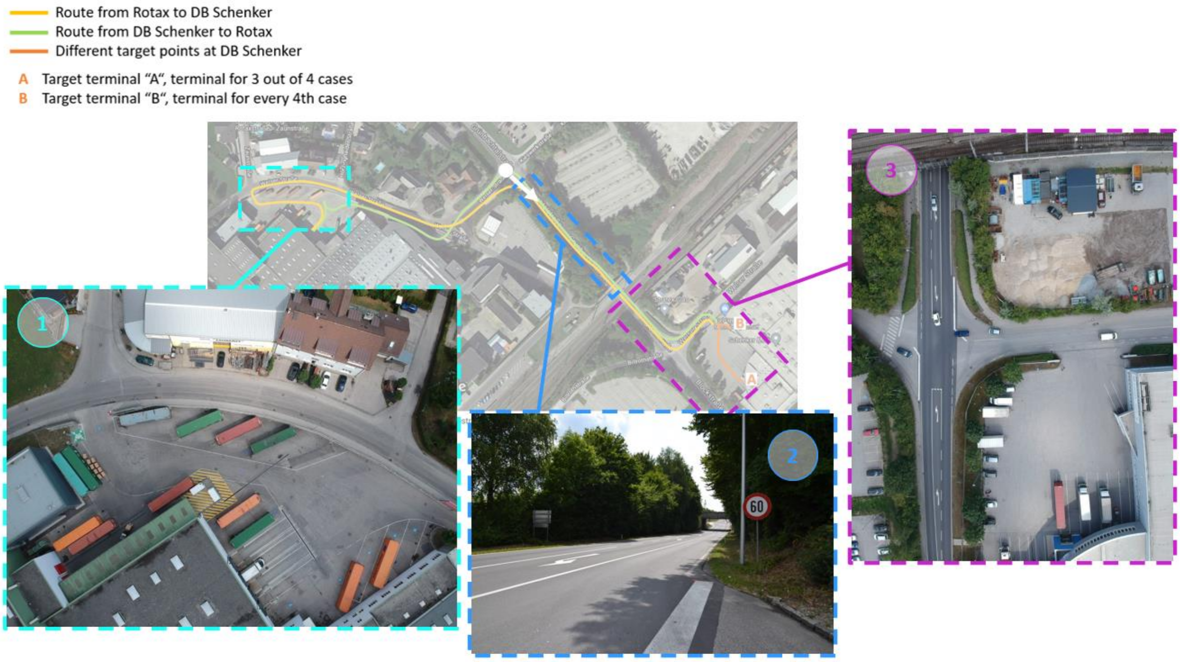

Figure 5: Hub-to-Hub - UC 2 site overview: (1) BRP Rotax factory, (2) Segment of the public route, (3) DB Schenker factory

Currently, a human driven truck is connecting BRP Rotax and DB Schenker. The truck is loaded with filled lattice boxes at the site of Rotax. At the logistic centre the lattice boxes are emptied and filled with spare parts that need to go back to the production site. This process is repeated 16 to 17 times per day, Mondays to Fridays, all year long.

As a target, the autonomous electrically driven vehicle should fully take over the task of the human controlled truck as described in the previous point.

4.2.3. Autonomous ground support equipment in airport

This use case aims at demonstrating an automated baggage tractor on airside in Avinor OSL Gardermoen airport (Norway) to improve the airport logistics flows.

– Use-Case Name: Autonomous ground support equipment in airport
– Use-Case ID: UC 3
– Type of site: Private.

The UC 3 demonstrations will be performed under 4 different phases: Phase 0 to Phase 3.

Phase 0 & Phase 1: Playground area
The pilot area for Phase 0 and Phase 1 is an area in the northern part of Oslo Gardermoen airport, with minimal interaction with operations. The operation of the automated vehicle will be limited to this area. During Phase 0, the autonomous vehicle will be tested without trolleys, while for Phase 1, the operations will be tested with trolleys.

Figure 6 hereafter presents an overview of the Phase 0 and Phase 1.

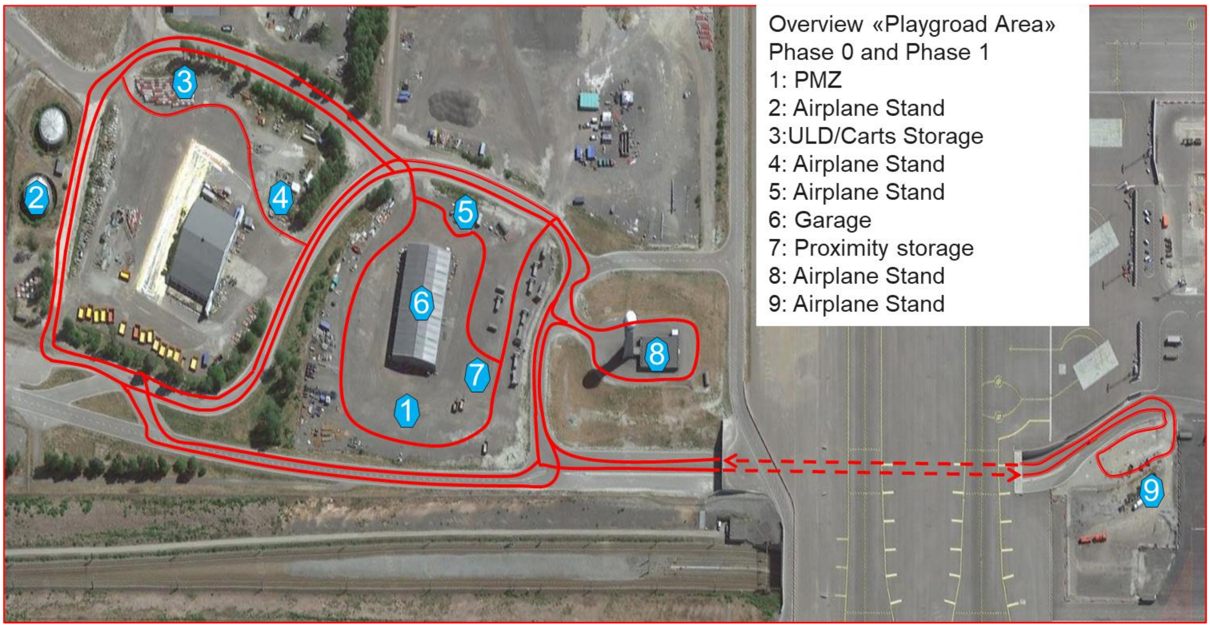

Figure 6: Airport - Phase 0 and Phase 1 overview

Phase 2: Extended mission
Phase 2 will focus on the deployment of the autonomous vehicle in a live environment, on a new route. The defined test area will be in the immediate vicinity of aircraft, buildings and other operational units.
Figure 7 hereafter presents an overview of the Phase 2 environment.

Phase 3: Full mission
Phase 3 will focus on the deployment of the autonomous vehicle on a complete trolleys transportation mission without on-board operator. The objective is to perform operations with remote supervision only from the Fleet Management System.

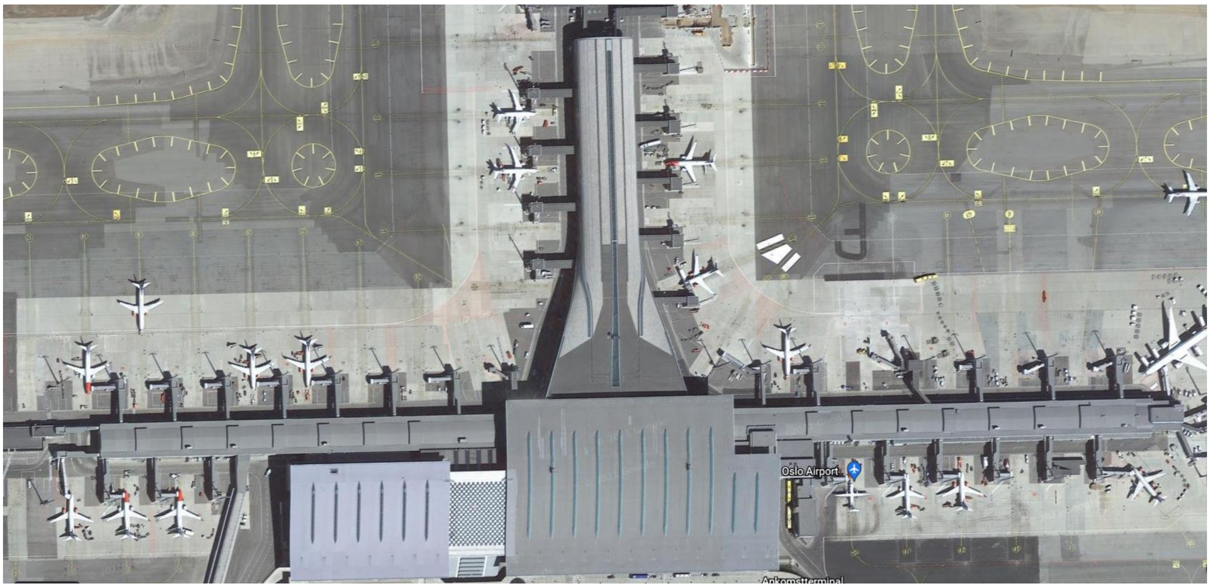

Figure 7: Airport - Phase 2 environment

4.2.4. Trailer transfer operations and automated ship loading in port

This use case will validate the developed AWARD technology on a busy roll-in/ roll-off terminal in Rotterdam (The Netherlands). The objective is to integrate automated trailer transfer with DFDS terminal systems and operate in a live environment with other vehicles and vulnerable road users.

- Use-Case Name: Trailer transfer operations and automated ship loading in port
- Use-Case ID: UC 4
- Type of site: Public and private

UC 4 will be performed under 3 different phases: Phase 1 to Phase 3. Figure 8 presents an overview of UC 4.

Phase 1: Terminal
Phase 1 will focus on trailers drop-off in an identified drop-off area inside the Terminal by a traditional driver. Then, the autonomous truck will collect the trailers and will move them to a storage area.

Phase 2: Smart gate
In Phase 2, the traditional driver will drop the trailers off outside the Terminal boundaries. The autonomous truck will then collect the trailers, drive along a public road which connects the parking area and the Terminal. A transition through a controlled gate will be necessary, to move the trailers to the storage area.

Phase 3: Boat loading
In Phase 3, the autonomous truck will collect the trailers from an identified storage area and will move the trailers onto a vessel.

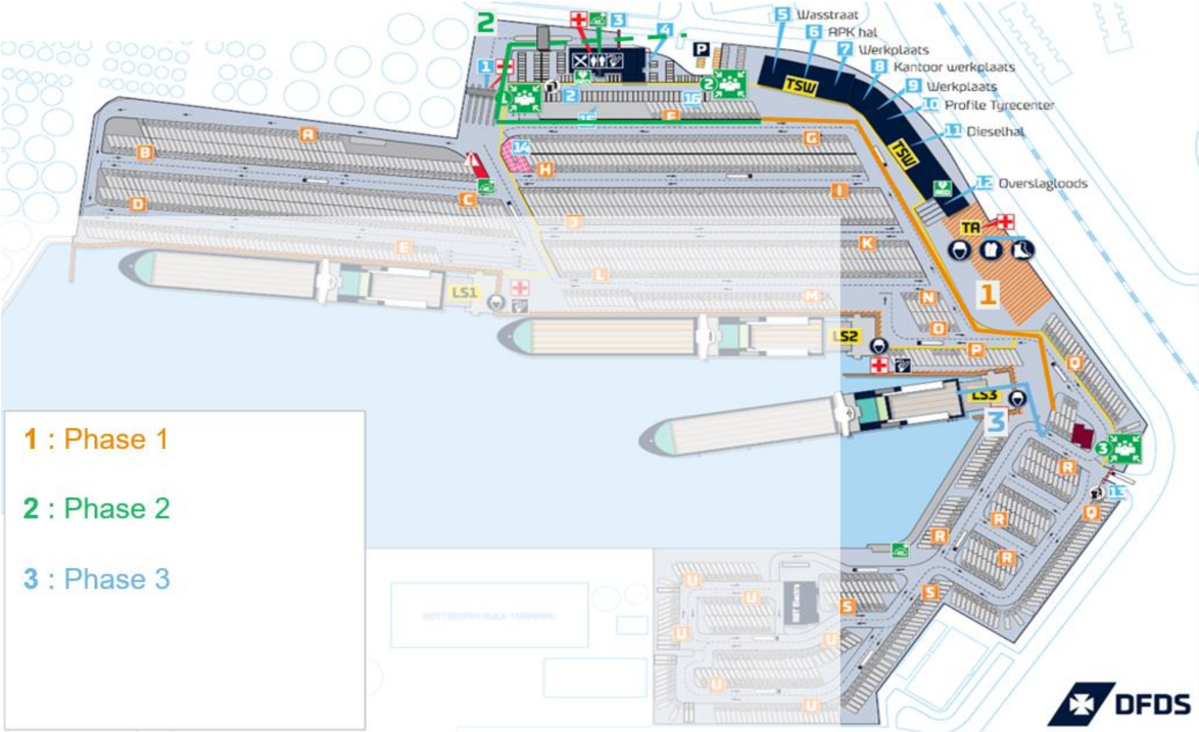

Figure 8: Port - UC 4 overview: (1) Phase 1 (orange), (2) Phase 2 (green), (3) Phase 3 (blue)

4.3. Use case innovation objectives

To automatize the logistics flow of the above use cases, the following innovation objectives shall be fulfilled:

Ambition 1: Design and development of a safe, low speed ADS for 24/7 availability.

Today, ADS architectures are suitable only for a limited ODD preventing from achieving 24/7 availability, especially due to adverse weather conditions. The AWARD ADS shall offer a unique set of sensors that enables 24/7 availability (night and day, good or bad weather conditions), within extended ODDs.

Ambition 2: Demonstration of ADS integrated in different heavy-duty vehicles in real-life logistics operations.

Today, Automated Ground Transport Systems for logistics operations are deployed over pilot projects that are not representative for real logistics operations. By addressing 24/7 availability, the fully automated HDV will be deployed over key pilot projects that are highly scalable and replicable over warehouses, factories, airports, and ports, in mixed traffic in restricted areas and on public roads.

Ambition 3: Validation of efficiency increase of fleets using trucks with ADS.

Today's Fleet Management Systems do not integrate all the required data to optimize logistics operations (e.g.: maintenance repair data, traffic management) and have overlapping functionalities with TOS or WMS. The new Fleet Management System will integrate data from vehicles, logistics systems and the road infrastructure, coordinating exchanges with different data providers to ensure economic viability of data-related business models, while providing high-reliable and secured tool that optimizes logistics flows and ensures safety for other road users.

4.4. Use case environments

Table 1 hereafter presents the generic description of the Use Cases environment according to a list of criteria which will be used in *T2.3 Definition of operational scenarios for the pilots* to specify the ODD, operational scenarios and conditions under which a given driving automation system or feature thereof is specifically designed to function. This includes, but is not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics.

Table 1: Basic elements of the Operational Design Domain (ODD)

Category	ODD group	ODD element	UC1	UC2	UC3	UC4
Physical Infrastructure	Roadway	Roadway Types/ Type of infrastructure element	Two-way roads, industrial buildings, slopes.	Unregulated crossing, driveway, side road, single-lane, rural, underpass, multi-lane, turn-only lane, compound.	Airport internal roads, tunnels, BHA (baggage handling areas), hangars.	Multiple routes cross the site with some limitations to flow.
		Roadway Surfaces / Ground characteristic	Concrete, asphalt, brick, gravel with small holes and bumps;	Concrete, asphalt, mixed, brick, grooves, drain cover.	Asphalt, light gravels around hangars.	Concrete, asphalt.
		Roadway Edges and Marking	Line markers, fences, shoulder grass, curbs.	Bordering wall, curb, line markers, shoulder gravel, shoulder grass, fence.	Bordering wall, curb, line markers.	Paint marked. Some bays are bounded by fencing and barriers. Some bays are bounded near to harbour edge.
		Roadway Geometry	Open area, straight road, intersections, turns, ramp(s)	Wide area, straight road, curve	Wide 2-ways roads (outside)	Wide 2-ways roads.
	Operating Area	Area types	Private	Private and public	Private	Private and public

Category	ODD group	ODD element	UC1	UC2	UC3	UC4
		Type of Site	Linde's Aschaffenburg production facility. Access controlled.	Rotax site is access controlled, DB Schenker site is usually publicly accessible	Private site (airport)	ISPS (International Ship and Port Facility Security Code) restricted site. Access controlled, open to registered traffic that meet regulations/requirements. No public thoroughfare. Multiple routes cross the site with some limitations to flow.
	Other		N/A	N/A	N/A	N/A
Operational constraints	Traffic	Minimum Speed Limit	N/A	15 km/h	N/A	15 km/h
		Maximum Speed Limit	30 km/h	60 km/h	30 km/h	30 km/h
		Traffic Density	Busy (forklifts, trucks, cars, pedestrians, etc.).	Busy during peak hours, less during low peak hours.	Busy during peak hours, less during low peak hours.	Very busy, lots of traffic 24/7.

Category	ODD group	ODD element	UC1	UC2	UC3	UC4
	Logistics	Process	Automatic loading/unloading and transportation.	Only transportation (no loading/unloading).	Transportation of airport dollies/baggage carts for point A to point B. No loading/unloading.	Trailer's collection and drop-off.
	Fleet Management System	Components	Currently, there is no FMS implemented. Cooperation between Dematic's E'tricc system and AWARD Consortium will be required.	Currently, there is no FMS implemented. The FMS components implemented within the project will be used.	Currently, there is no FMS implemented. The FMS components implemented within the project will be used.	The FMS components implemented within the project will be used.
		Data Services	N/A	Within the project, Digitrans will collect and provide weather data and road condition data.	N/A	N/A
Environmental Condition	Weather	Weather Conditions	Outdoors, German weather conditions. Winter conditions can be expected.	Outdoors, Austrian weather conditions.	Indoor/Outdoor Norwegian weather conditions.	Outdoors, Dutch weather conditions.
		Weather-induced Roadway Conditions	When there is heavy rain/snow then the essential road-markings are obscured. Snowy/Icy conditions can be expected.	When there is heavy rain/snow then the essential road-markings are obscured. Snowy/Icy conditions can be expected.	When there is heavy rain/snow then the essential road-markings are obscured. Snowy/Icy conditions can be expected.	When there is heavy rain/snow then the essential road-markings are obscured. Snowy/Icy conditions can be expected.

Category	ODD group	ODD element	UC1	UC2	UC3	UC4
		Visibility	Limited with fog, heavy rain, heavy snow, etc.	Limited with fog, heavy rain, heavy snow, etc.	Limited with fog, heavy rain, heavy snow, etc.	Limited with fog, heavy rain, heavy snow, etc.
	Connectivity	Network	4G.	4G.	4G. 5G testing.	4G. Wi-Fi coverage.
		Localization Quality	GNSS is available, quality will be verified during the project implementation. Possible additional anchor points shall be needed if relevant for the automated vehicle.	GNSS is available. More sophisticated localization support data (e.g High Definition-Maps) would need to be created if relevant for automated vehicle.	GNSS is available. Some open/empty and tunnel areas could be challenging and may require additional anchor points if relevant for the automated vehicle.	GNSS is available. Some open/empty areas could be challenging and may require additional anchor points if relevant for the automated vehicle.
Objects (dynamic)	Other road users	Vehicles	Forklift trucks, cars, vans, trucks, tugger trains.	At company premises: other trucks or transport means such as forklifts, passenger cars of employees, or visitors. On public road: any other vehicle type, e.g. conventional car, truck, semi-automated car, etc.	Every special airport vehicle could be encountered (baggage tugs, catering trucks, emergency vehicles...). Most challenging ones are: - Aircraft towing truck, as in some areas they can maneuver on the road.	Mostly articulated truck traffic, either attached to cabs or tractor units. High volume of movements. High volume of parked trailers in designated bays.

Category	ODD group	ODD element	UC1	UC2	UC3	UC4
					- Emergency vehicle, for which the AV needs to let the priority.	
		Cyclists	Yes	Yes	No	Some cyclists are present on the edges of the terminal operations. Cyclists are present on the public road section.
		Pedestrians	Yes	Yes	Yes	Yes
		Other (dynamic) objects	N/A	Public road characteristics: further vulnerable road users (scooter, skateboard, etc.). Company premise characteristics: gates, terminal.	Airplanes.	Port operations vehicles, reach-stackers.
Dynamic driving Tasks			Longitudinal (accelerating/braking) and lateral (steering) control should be supported by the automated forklift truck on the site.	Longitudinal (accelerating/braking) and lateral (steering) control should be supported by the automated truck on public	Longitudinal (accelerating/braking) and lateral (steering) control should be supported by the automated baggage truck on the site.	Longitudinal (accelerating/braking) and lateral (steering) control should be supported by the automated terminal tractor on the site.

Category	ODD group	ODD element	UC1	UC2	UC3	UC4
				roads and company premises.		
Events		Vehicles	Any of the vehicles can be expected at any place and time on the route. Diverse driving situations and events might arise with other vehicles.	Diverse driving situations and events might arise with other vehicles.	Airport traffic is similar to public road traffic. Diverse driving situations and events might arise with other vehicles.	Diverse driving situations and events might arise with other vehicles.
		Pedestrians	Pedestrians can occasionally be expected on the route. Diverse driving situations and events might arise with pedestrians.	Diverse driving situations and events might arise with pedestrians on the public roads.	Pedestrians are mostly gathered around airplane parking spaces but can also be found elsewhere at the airport.	Diverse driving situations and events might arise with pedestrians.
		Cyclists	Cyclists can occasionally be expected on the route. Diverse driving situations and events might arise with cyclists.	Diverse driving situations and events might arise with cyclists on the public roads.	Cyclists can rarely be expected on the route. Diverse driving situations and events might arise with cyclists.	Diverse driving situations and events might arise with cyclists on the public roads.

Category	ODD group	ODD element	UC1	UC2	UC3	UC4
		Emergency vehicles	N/A	Diverse driving situations and events might arise with emergency vehicles on the public roads.	Diverse driving situations and events might arise with emergency vehicles at the airport.	N/A
		School buses	N/A	Diverse driving situations and events might arise with school buses on the public roads/	N/A	N/A
Signs and Signals Events		Traffic signs	Vertical signs: ramp ahead, speed limit reminders, cross walks. Horizontal signs: directions, pedestrian crossing, etc.	Vertical signs: stop signs, speed limit signs, town signs, etc. Horizontal signs: directions, pedestrian crossing, etc.	Vertical signs: Signs are present but are smaller and have a different color than signs on public roads. Horizontal signs: directions, etc.	Vertical signs: stop signs, turning signs, etc. Horizontal signs: directions, etc.

Category	ODD group	ODD element	UC1	UC2	UC3	UC4
		Traffic signals	N/A	None within the initial situation. Might be expected for project.	No traffic signals as on public roads, but traffic is signaled with yellow rotating lights in low visibility situations. Yellow flashing lights also warn when gates go up and down.	N/A
		Vehicle signals	N/A	To-be-defined.	Standard vehicle signals in use by vehicles at the airport.	N/A

5. Value chains, stakeholders & users

This chapter presents the AWARD project value chains identified for the project at the AWARD technology development level, and at the innovative products level. Then the stakeholders and users are presented, together with the methodology used for their identification.

5.1. Overall description of AWARD value chain

5.1.1. AWARD technology development

The AWARD consortium is a strong partnership of leading European research centers (RTOs) as well as companies, associations, and certification bodies in the area of autonomous heavy-duty vehicles and logistics. The consortium is made of 29 partners coming from 11 European countries and Israel. These parties have extensive track-records in the field of autonomous heavy-duty vehicles and associated technologies including state of the art autonomous driving and fleet management systems.

To allow and cover all technical developments and economic conditions necessary for a successful work on the AWARD project, the consortium will strongly rely on complementary and key parties completing the project value chain (figure 9).

Figure 9: AWARD value chain

Continental, Navtech, Adasky, Foresight and EasyMile will be involved in the development and in the manufacturing of sensors for the AWARD ADS. They will also participate in the development and validation of this ADS, together with EasyMile, Ottopia and RTO (CEREMA, VTT, AIT, LCM, FHO) who will also provide infrastructure for validation and tests.

Kamag, Terberg, Dematic, SAS & TLD (Alvest group) are the truck manufacturers for the heavy-duty vehicles that will be deployed over the different logistics pilots. They will integrate these ADS into the vehicles with EasyMile, through the implementation of dedicated specific mechanical and electrical parts. These truck manufacturers all gather valuable experience on automated HDV for logistics.

Applied Autonomy will develop the fleet management and supervision system to optimize logistics operations through exhaustive data collection and processing, relying on its core of expertise, with DFDS, Ottopia and AIT which have also worked on that topic.

DFDS will also supervise the pilot's implementation and will lead logistics operations in ports. Avinor (airport), DFDS (port), Rotax and DB Schenker (warehouse and shuttle service) and Linde Material Handling (loading and unloading operations) will lead their related use cases. Digitrans, VTT, Cerema, EasyMile will provide proving grounds and CERTX will validate the AWARD solutions, as a certification body.

ENIDE will support the consortium for dissemination and exploitation strategy and opportunities. With IRU, CARA, BizUp, VTT, FRACS, ITS Norway and AustriaTech, ENIDE will also contribute to impact assessment of the pilot projects, the study of new business models and regulatory frameworks.

5.1.2. Value chains

Two value chains streams are identified through the AWARD technology development:

1. ADS development to be integrated into new vehicle platforms (hardware and software), *cf.* figure 10.

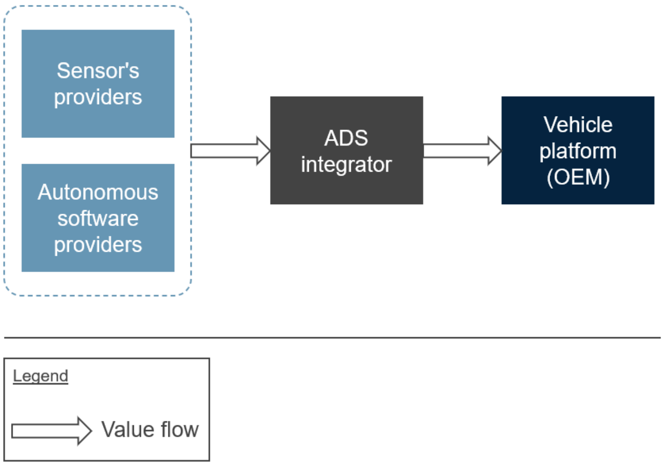

Figure 10: ADS value chain

2. Automated heavy-duty vehicle to be integrate into an AGTS (see section 6), cf. figure 11.

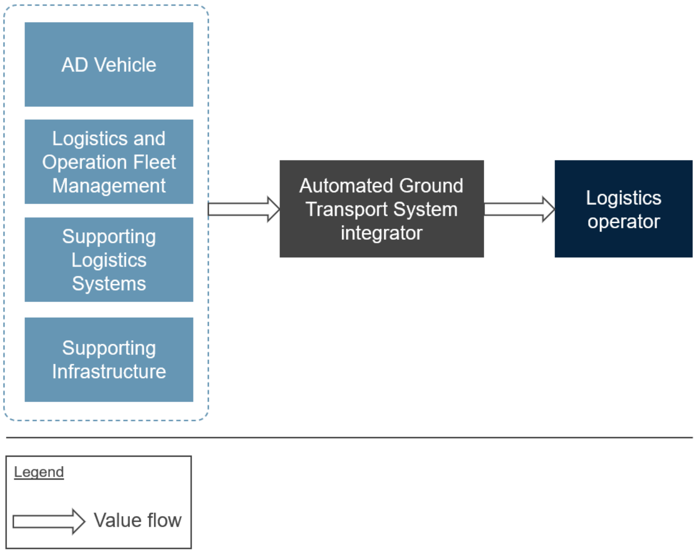

Figure 11: AGTS value chain

5.2. Overall description of users and stakeholders

The AWARD project adopts a comprehensive view on understanding users' and stakeholders' needs. These encompass three main categories:

- Direct process participants are all users and stakeholders who interact directly with the vehicle, either remotely or on site.
- Indirect process participants are all users and stakeholders who are part of the technical or logical operations of the organisation taking advantage of autonomous vehicles.
- And lastly, overall stakeholders which contains all users and stakeholders who are in some way, shape or form, related to the AWARD project.

The overall stakeholders are based on the Cooperative, Connected and Automated Mobility (CCAM)[9] categorisation in C-ITS Platform Phase I Chapter 12.4.1[10].

Figure 12 shows the dendrogram of the users and stakeholders.

[9] Cooperative, Connected and Automated Mobility (CCAM), https://ec.europa.eu/transport/themes/its/c-its_en, 2016

[10] Cooperative Connected and Automated Mobility (CCAM), C-ITS Platform Final Report, https://ec.europa.eu/transport/sites/transport/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf, 2016

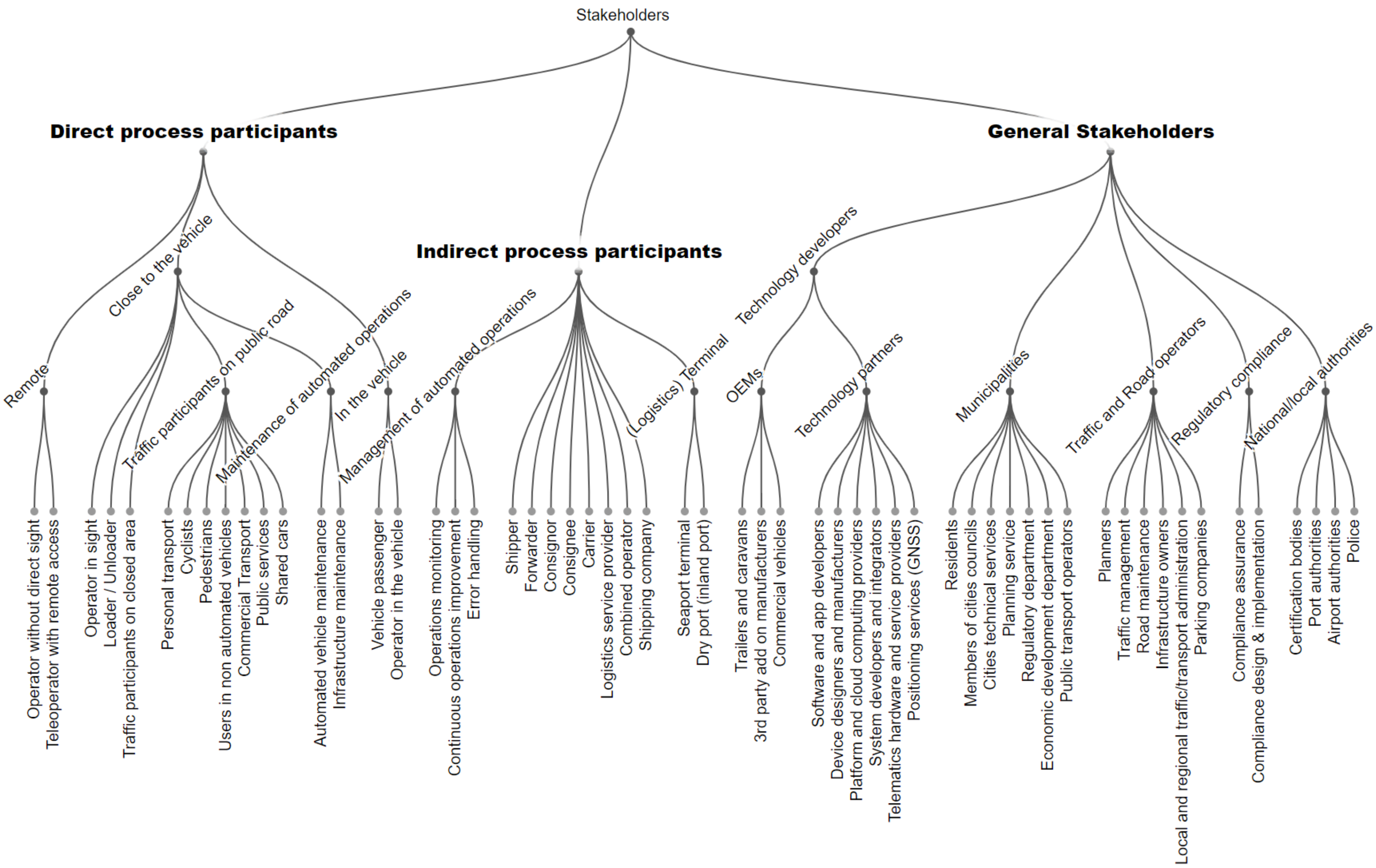

Figure 12: Stakeholder taxonomy for the Automated ground Goods Transportation System (AGTS)

Direct process participants interacting with the automated vehicle

Direct process participants can be remote, close to the vehicle, or in the vehicle:

- Remote:
  - Operator without direct sight of the vehicle but monitoring the vehicle via the Fleet Management System to control vehicle status and check for error situations *(Survey: Applied Autonomy)*
  - Teleoperator with remote access to the physical controls of the vehicle via hardware in a control center (steering wheel, pedals) *(Survey: Ottopia)*
- Close to the vehicle (*Survey: Use case leaders – Dematic, DigiTrans, Avinor and DFDS*):
  - Operator in sight of the vehicle with e.g. a remote control
  - Loader / Unloader
  - Traffic participants on public road (by CCAM) (Cooperative, connected and automated mobility (CCAM), 2016):
    - Personal transport
    - Cyclists
    - Pedestrians
    - Users in non-automated vehicles
    - Commercial Transport
    - Public services
    - Shared cars
  - Traffic participants on closed area (airport, port, etc.):
    - Depending on use case as Airport and Port have different vehicle types and personnel on the road
  - Maintenance of automated operations:
    - Automated vehicle maintenance
    - Maintenance of transport infrastructure for automated vehicles
- In the vehicle:
  - Vehicle passenger
  - Operator in the vehicle with steering wheel, joystick or other type of direct input

Indirect process participants (Technical / Logistical / Management), based on the exploratory project "Logistics and vehicle technology needs analysis"[11]:

Within the concrete use case situations, they can be:

- Management of automated operations:
  - Operations monitoring
  - Continuous operations improvement
  - Error handling
- Shipper
- Forwarder
- Consignor
- Consignee
- Carrier

[11] Atzmüller, B., Neubauer, M., Pell, A., Saleh, P., & Stieninger, M., DigiTrans: Bedarfsanalyse Logistik und Fahrzeugtechnologie - Deliverable 3, 2017

- Logistics service provider
- Combined operator
- (Logistics) Terminal
  - Seaport terminal
  - Dry port (inland port)
- Shipping company

General Stakeholders, roughly following the CCAM C-ITS Final Report 2016[12], can be:

- Technology developers:
  - OEMs
    - Trailers and caravans
    - 3rd party add-on manufacturers
    - Commercial vehicles
  - Technology partners
    - Software and app developers
    - Device designers and manufacturers
    - Platform and cloud computing providers
    - System developers and integrators
    - Telematics hardware and service providers
    - Positioning services (GNSS)
- Municipalities
  - Residents
  - Members of cities councils
  - Cities technical services: traffic, road maintenance, lighting, water, freight transport, etc.
  - Planning service
  - Regulatory department
  - Economic development department
- Traffic and road operators
  - Planners
  - Traffic management
  - Road maintenance
  - Infrastructure owners (tunnels, bridges)
  - Local and regional traffic/transport administration
  - Parking companies (i.e., National Car Parks)
- Regulatory compliance related to automated operations
  - Compliance assurance
  - Compliance design & implementation
- National/local authorities
  - Certification bodies

[12] Cooperative Connected and Automated Mobility (CCAM), C-ITS Platform Final Report, *https://ec.europa.eu/transport/sites/transport/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf*, 2016

– Port authorities
– Airport authorities
– Rescue services
– Police

The categorisation of users and stakeholders for each use case was applied and is available in Annex 1.

6. AWARD System of Systems

Within the AWARD project, a large variety of different systems can be identified, therefore it is necessary to introduce a couple of definitions by following the ISO15288. A system is defined as "*an integrated set of elements, subsystems or assemblies that accomplish a defined objective. These elements include products (hardware, software, firmware), processes, people, information, techniques, facilities, services and other support elements*" (INCOSE)[13]. The previously described use-cases indicate that a joint effort of different systems will be needed to accomplish the desired functionality. That constellation can be described as a "System of Systems" (SoS) which is defined as "*an SOI (System of Interest) whose elements are managerially and/or operationally independent systems. These interoperating and/or integrated collections of constituent systems usually produce results unachievable by the individual systems alone*" (INCOSE)[14].

6.1. System of Systems components

Derived from the AWARD project goals, the defined objective of the involved SOI can be described as "Realize the automated ground goods transport of goods in a defined area". This system will be further on named as "Automated Ground Goods Transport System (AGTS)" as presented in Figure 13.

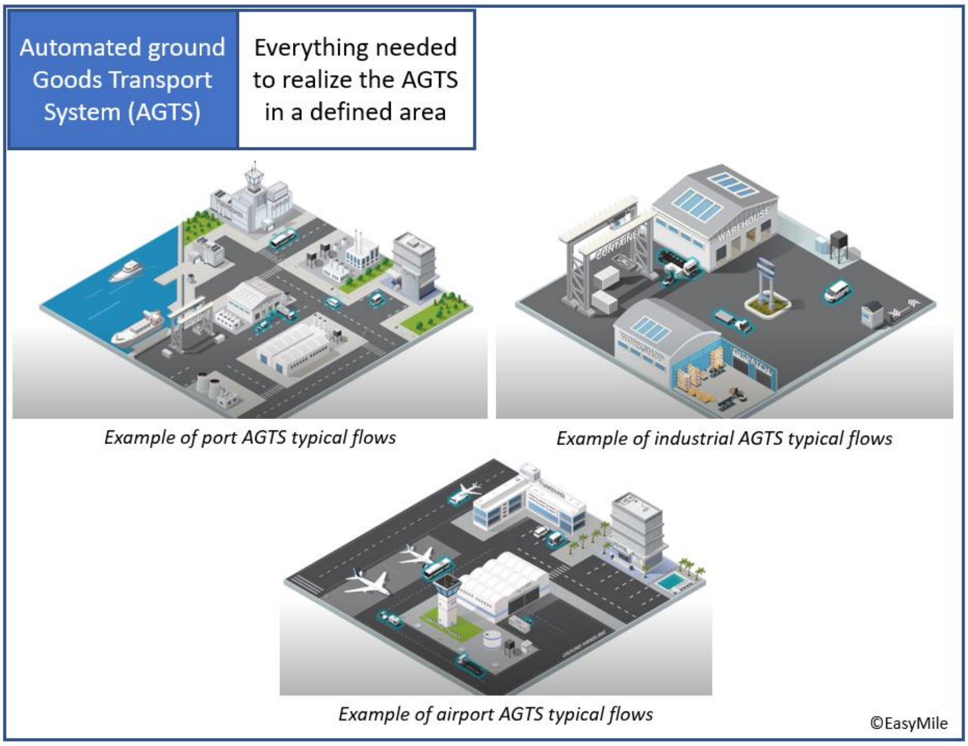

Figure 13: Example of AGTS where multiple flows are handled by autonomous industrial trucks

[13] International Council On Systems Engineering (INCOSE), Systems engineering handbook a guide for system life cycle processes and activities, *INCOSE-TP-2003-002-04*, 2015.
[14] International Council On Systems Engineering (INCOSE), Systems engineering handbook a guide for system life cycle processes and activities, *INCOSE-TP-2003-002-04*, 2015.

Observing the current state of technology and the main characteristics of this objective, it can be said that different elements will be involved – each with a significant amount of operational independence. As the single elements are not able to achieve the mentioned overall objective by themselves, we can define the AGTS as a System-of-Systems by following the previously introduced definition.

For this AGTS, several subsystems can be identified:

- A "**Logistic Operation & Fleet Management (LOFM)**" system will control the overall workflow and coordinate the activities of other subsystems.
- The physical process of moving goods from one point to another requires a vehicle to perform that task. As AWARD targets an automated goods transport, that vehicle can be defined as "**Autonomous Driving Vehicle (ADV)**".
- Several infrastructure elements "**Supporting Infrastructure (SI)**" will most likely be involved to realize the intended operations, e.g., barriers, stationary sensors etc.
- Beside the actual ADV, other logistic systems (e.g., forklifts, cranes, etc.) "**Supporting Logistic Systems (SLS)**" will be involved in the intended operations.

Figure 14 illustrates the constellation of the SoS.

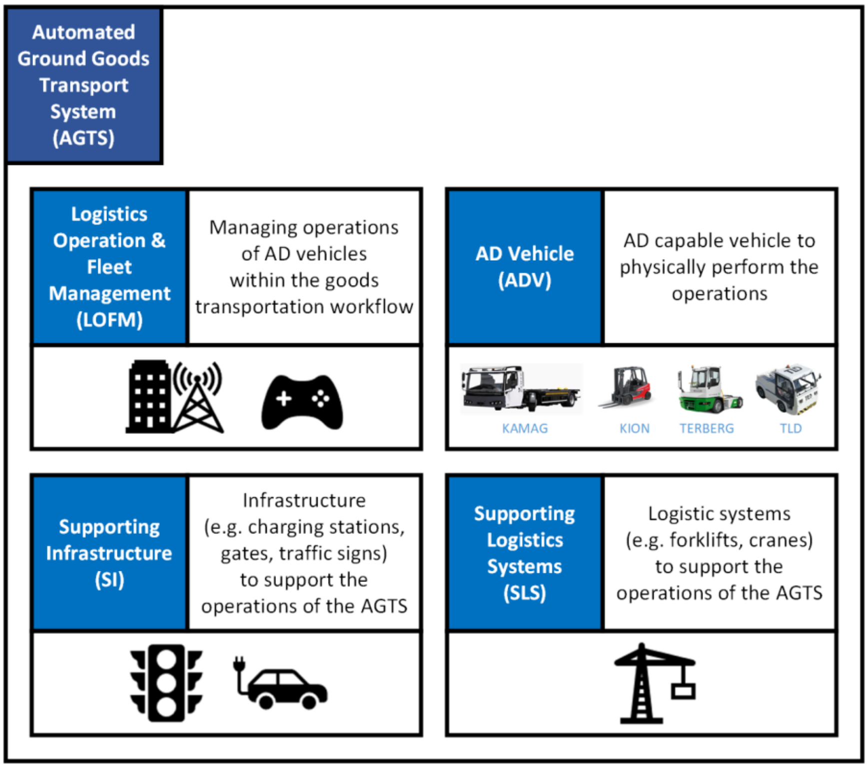

Figure 14: AGTS subsystems

Between the different subsystems the following interactions can be identified (figure 15). Relationships and flows of information are identified between each subsystem of the AGTS. These flows of information are necessary to enable the right level of subsystems interactions required for virtuous operations of the ADV in the operating environment.

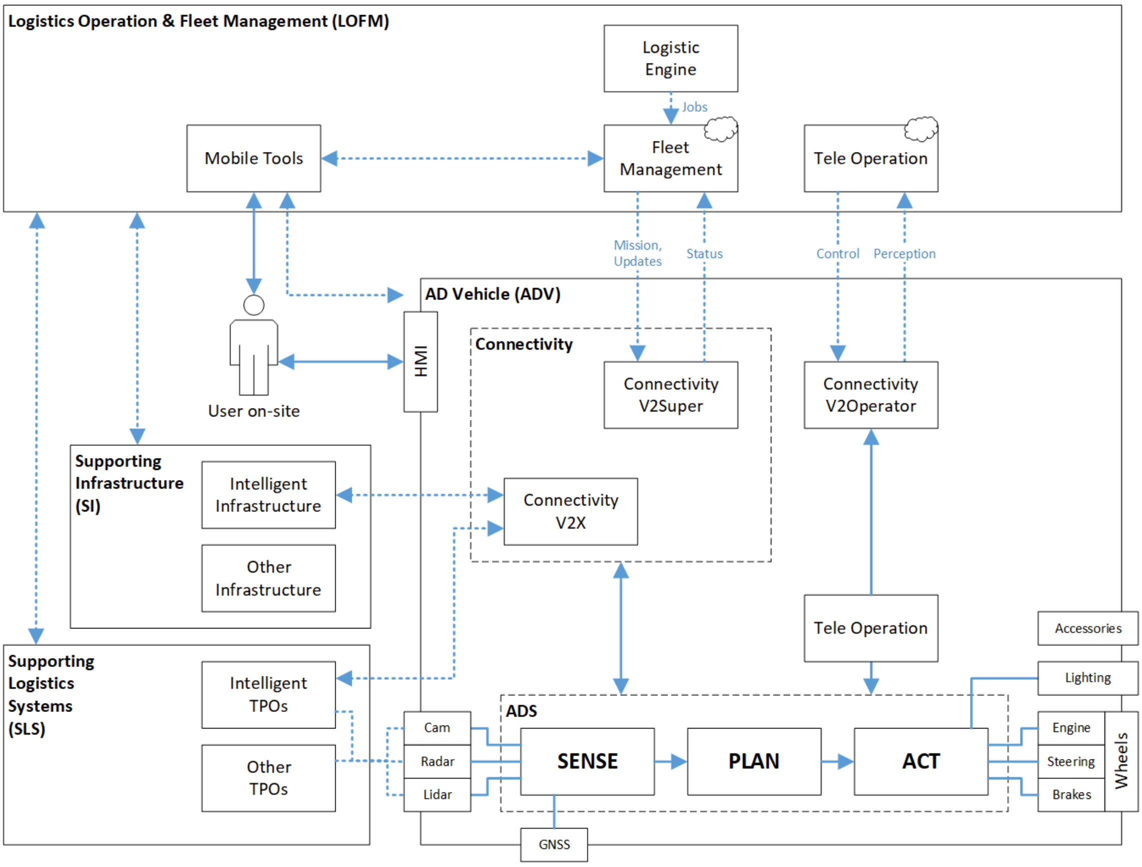

Figure 15: Subsystems interactions

6.2. Logistics Operation & Fleet Management (LOFM)

Within the LOFM, the following subsystems can be identified (figure 16).

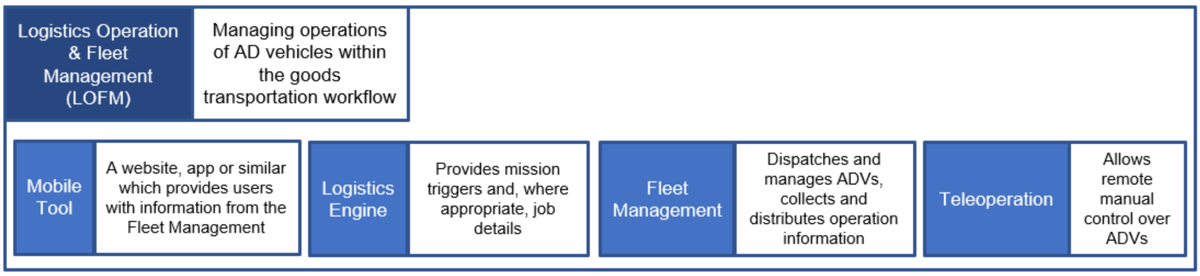

Figure 16: LOFM subsystems components

6.2.1. Fleet management

The Fleet Management System supports the management of a fleet of ADS-equipped vehicles deployed in driverless operations. This includes collecting transport orders from logistic systems, information from auxiliary systems (e.g., road sensors, cameras, etc.) and status from the fleet vehicles (breakdowns, data collection for curative and preventive maintenance, etc.), disseminating dispatch information to the fleet (e.g., trip routes and other order details, managing emergencies) and status information to vulnerable road users, and activating teleoperation when needed. The Fleet Management System may serve as the responsible agent vis-a-vis law enforcement, emergency responders and other authorities for vehicles.

Overall, the Fleet Management System will act as a control tower, gathering all information from the different subsystems to coordinate the operations and protect road users with a systemic approach (figure 17). It aggregates information to orchestrate smooth and efficient operations and provides an interface for operators to interact with.

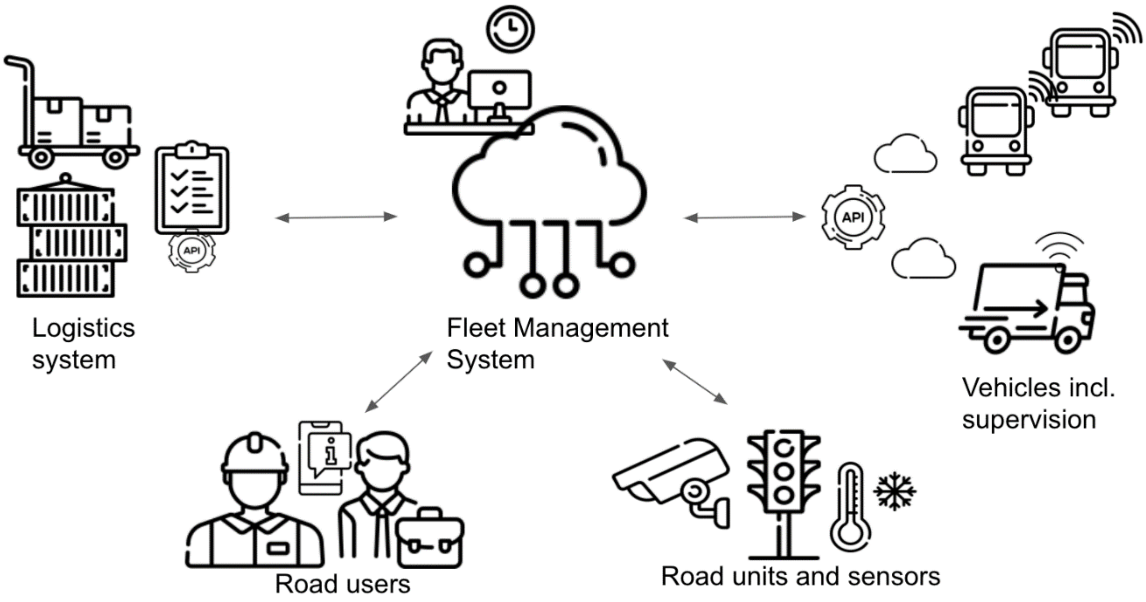

Figure 17: Fleet Management System subsystems constellation – arrows represent the data flow

6.2.2. Mobile tools

The mobile tools pass information to and from the Fleet Management System, fulfilling a number of different functions:

- Road users or traffic participants are provided with warnings regarding accidents that occurred on site or dangerous road conditions (ice, oil spills, etc.), thus increasing their safety. Additionally, road users can also report incidents or situations that require action, for example the yard management.
- On-site operators such as vehicle operators, maintenance personnel or loaders/unloaders obtain information about the state of the vehicle and its planned missions. They can also use the mobile tool to report back to the fleet management system when an operation or maintenance task has been completed, or to record any errors or unexpected events.
- For vehicles which are not directly connected to any system (due to lack of a suitable interface), the mobile tool acts as a way of registering these vehicles in the fleet management system, so that at least basic information such as their location is provided and thus taken into account when managing the fleet.

6.2.3. Mission trigger

Missions are triggered by different logistics engines in each use case. This reflects the fact that the use case sites are all rather diverse, such that the mission triggers fulfil different needs. Different types of job information are sent to the Fleet Management System, which then uses this as a trigger to define and start a mission, containing details on the vehicle to be used, a route, a timeframe, etc. Below is a high-level description of the different types of mission triggers:

1. Request by logistics system:
   A mission may be triggered by a logistics system defining a job, containing information such as nature of cargo, pick-up and destination locations, and contacting the Fleet Management System in order for this job to be converted into a full mission. The FMS may require confirmation from the logistics system before starting the mission.

2. Manual request:
   Where a logistics system may not cover the entirety of the operations or the possibility for manual input is desired, it is possible to use a human operator as the logistics engine and trigger a mission by addressing the FMS directly via a suitable interface, such as a website allowing to enter relevant data, or via a touch screen with predefined buttons.

3. Timetabled request:
   A mission can be triggered via a logistics engine in the form of a schedule, whereby missions are predefined by the FMS and are started at specified times. This mission trigger may for example be used in conjunction with manual requests.

4. Sensor-based trigger:
   In cases where the mission parameters can be predefined but the timing of the mission must be flexible, a sensor can trigger a mission. In this case, the sensor acts as the logistics engine and sends a signal to the FMS when it detects the fulfilment of certain conditions, which triggers the FMS to start the mission.

6.3. Supporting Logistics Systems (SLS)

SLS contains external subsystems which can have interactions with the ADV during the entire logistic operations. These interactions can be split into two categories:

- Active interaction: systems integrated to the ADV logistics operations for the good transportation / manoeuvre process (e.g., quay crane, gantry crane, straddle carrier, reach stacker, belt loader, container haulage train, etc.).
- Passive interaction: systems on the logistic site without interaction with the ADV's operation (e.g., other trucks, maintenance vehicles, sidewalk cleaning vehicles, etc.).

The external subsystem composing the SLS are called Traffic Participants and Obstacles (TPO). Two types of TPOs are denoted:

1. Intelligent TPOs: systems that can communicate using V2X technologies with the ADV (refer section 6.4.3.1).
2. Other TPOs: systems that are perceived with the ADS-Sense system of the ADV and managed as independent obstacles.

6.4. Autonomous Driving Vehicle (ADV)

Within the ADV, the following subsystems can be identified as detailed in figure 18.

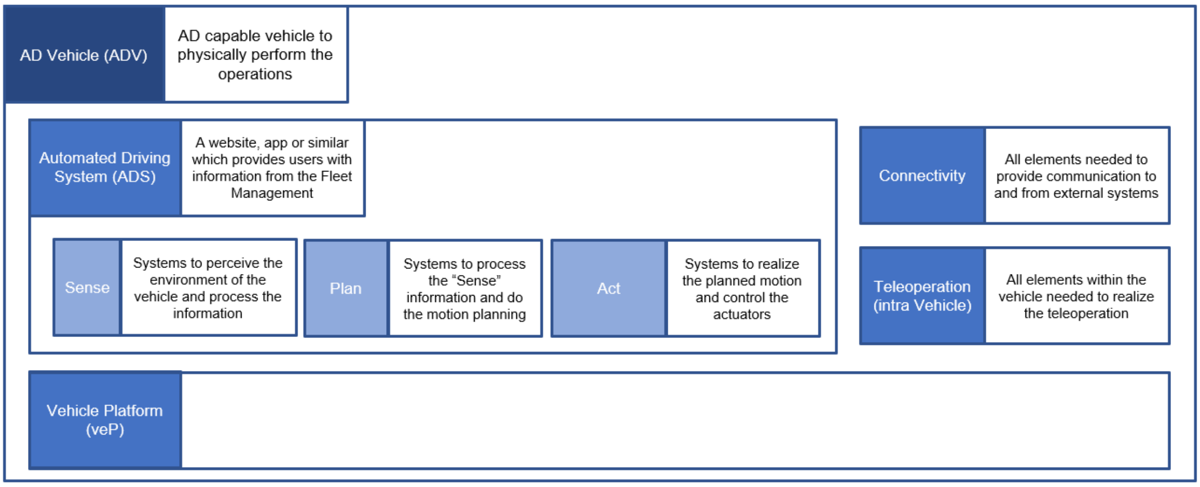

Figure 18: ADV subsystems components

6.4.1. ADS

The Automated Driving System (ADS) consists of all elements necessary to enable the Vehicle Platform (VeP) to be used within the AGTS. Within the ADS, 4 different subsystems can be identified.

ADS-Sense: Covers Detection (e.g. Camera, Radar and Lidar Technologies, etc.) and Perception (e.g. Camera, Radar, Lidar and Sensor-Fusion-Stack). Within those building blocks a comprehensive model of the ego-vehicle and the whole vehicle environment is created (figure 19).

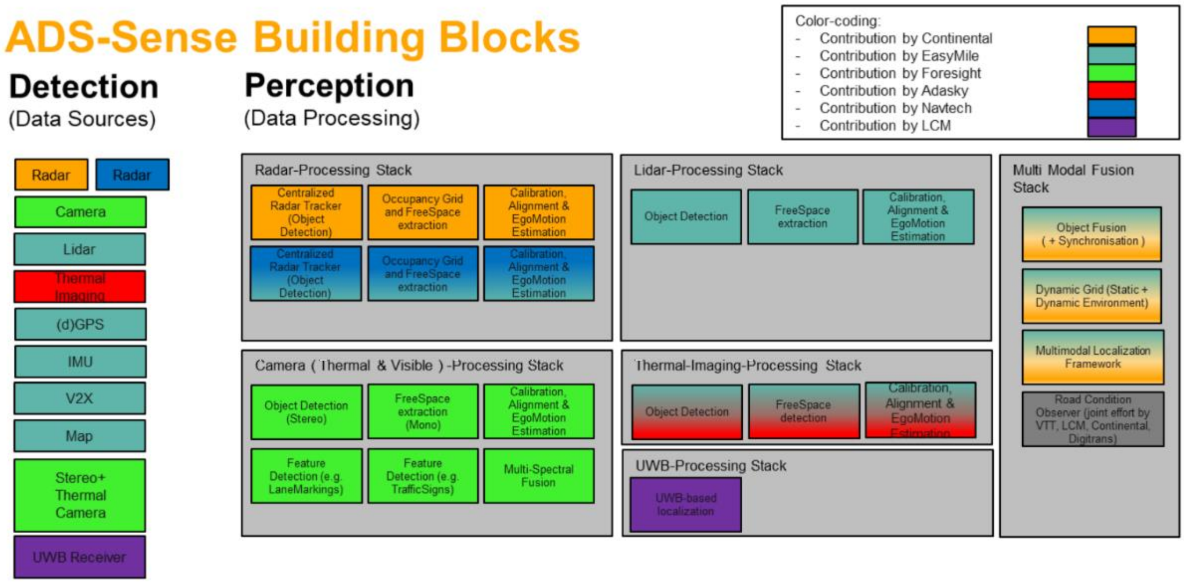

Figure 19: ADS Sense building blocks

The Perception building blocks will be used by:

- obstacle detection functions to determine adverse object positions and determine their relative speeds with respect to the ego ADV;

- localization functions which allows the ADV to estimate its ego position with respect to its current observation of the environment.

One of the AWARD project objectives is to develop an ADS-Sense subsystem robust to adverse weather conditions by relying on the fusion of heterogenous sensor modalities – camera (visible & thermal), radar, lidar.

ADS-Plan: This subsystem processes the input coming from ADS-Sense, fleet supervision system, infrastructure information, high-definition maps, and other constraints (speed limits, acceleration limits...) to plan all relevant vehicle actions – especially the dynamic driving task – and provides input for ADS Act.

ADS-Act: Realizes the planned motion planning by controlling the actuators (propulsion, steering and braking systems). This system also controls the vehicle accessories like lights, automated platform systems, horn, etc.

6.4.2. Vehicle platform

The ADV consists of the different platforms from the different suppliers physically performing the goods transport for each use case. Within AWARD the following platforms will be used according to the use case:

1. Kion: Counter-balanced forklift truck
2. Kamag: Swap body truck
3. TLD: Tow tractor for industry & airport
4. Terberg: Terminal tractor

All these platforms are embedding drive-by-wire steering, braking and powertrain systems to process orders sent by the ADS-Act system. The platforms also embed all sensors, ECUs, accessories, electric batteries required for the platform to be operational. Specific vehicle hardware systems for logistics operations can also be integrated depending on the vehicle type and target use case (e.g. Automatic fork system, electronic trailer hooking/unhooking system, etc.).

6.4.3. Connectivity

6.4.3.1. V2X (vehicle-to-everything)

The ADV is able to communicate with infrastructure elements using V2X technology. The ADV needs to be equipped with an On-Board Unit (OBU), a communication device suited to provide a V2X connectivity which interacts with infrastructure equipped with a dedicated Road Site Unit (RSU).

The 802.11p communication protocol is used and messages between RSU and OBU are exchanged using standardized data formats depending on the message type. As an example, in case of a connected traffic light, the traffic light phase and time to phase switch are broadcasted which are then used by the ADS-Plan subsystem to compute the optimal ADV speed. In this case a SPAT message type is used (Signal Phase And Timing message).

Vehicle-to-Infrastructure (V2I) communication can be used to enable the vehicle to cross intersections, handle automated infrastructure or other traffic situations regulated by traffic lights.
Vehicle to Vehicle (V2V) communication will not be addressed within this project.

6.4.3.2. Connectivity V2Super

The ADV must be connected to internet to communicate with the FMS (MQTT as a transport layer with a proprietary applicative protocol) and to get GNSS RTK (Real Time Kinematic) correction with improve the GNSS accuracy. This link is used to retrieve ADV telemetry at a 2 Hz frequency (speed, position...), send missions to the AV and retrieve the AV state (mission status, errors...). This is usually achieved by using the existing 3G/4G mobile network but could also be achieved using a WIFI network.

6.4.3.3. Teleoperation System

The ADS-Teleoperation subsystem contains all in-vehicle building blocks to allow humans to safely intervene, guide and even take over the vehicle when needed – remotely. For that purpose, the ADS-Teleoperation might interface with the other sub-systems of the ADS (e.g., ADS-Act for remote control of the dynamic driving task or ADS-Sense to get sensor feedback). The system includes an AI-based networking solution (connectivity V2Operator) that predicts the state of available cellular networks, using multiple modems to ensure a minimal latency and high data throughput. Other hardware components include video encoders that dynamically compress video streams from several cameras and a computer platform that runs the software. The ADS-TeleOperation system's multi-modem networking solution also serves as a reliable communication pipeline for data transmission to and from the ADS towards the teleoperation center.

6.5. Supporting Infrastructure (SI)

Supporting Infrastructure (SI) are located on the ADV's surrounded operating environment. SI can be facilities, gates, barriers, traffic lights, road signs, externally mounted cameras or sensors that will have interactions with the ADV.

Two types of SI are considered for AWARD application:
- Standard SI: the infrastructure is detected using the ADS-Sense sub-system.
- Intelligent SI: the infrastructure is detected using V2X technology as per described in section 6.4.3.1.

As an example, a traffic light can be a standard SI or an intelligent SI. As standard SI, the traffic light phase color can be detected by the ADS-Sense, whereas as intelligent SI, the connected traffic light can rely on the SPAT (Signal Phase and Timing) message to retrieve the phase color.

7. Conclusion

Deliverable D2.1 is a document reviewed and agreed by the AWARD Project General Assembly. It is meant to be used as base reference by the Consortium to set the studies and developments of the subsequent project work packages and deliverables.

The content of the deliverable provides a clear overview and common understanding of the four use cases, stakeholders, value chains and targeted users which are addressed by the AWARD project. Brainstorming and workshops sessions with Consortium members enabled to agree on a common understanding of the SoS and its components, defining the right terminologies and a global system architecture that will lay a solid ground base reference for the project objectives achievements.

The work carried out in T2.1 enabled to understand that autonomous technology integration into an existing system is complex. The autonomous vehicle is only one of the elements requiring automation. The full system needs to be upgraded so that the independent autonomous vehicle technology can be turned into a safe, reliable and optimized system, towards a large-scale integration.

Through the work performed for the D2.1 definition, WP2 secures the establishment of a clear project scope ensuring innovation and exploitable results in line with the users and stakeholders' needs and requirements. The present deliverable providing a high-level description of the project pillars, each of the sub-systems components which are mentioned in section 6 will be further detailed in the technical work packages:

- ADV in WP3 and WP4;
- LOFM in WP5;
- SI and SLS in WP4, WP5 and WP6.

Finally, this deliverable is a first step for the completion of the WP2 subtasks, where the performance and design requirements for the system architecture will be built. This work will be achieved starting from a deep analysis of the user and stakeholder requirements (T2.2), from which operational scenarios (T2.3) and functional requirements (T2.4) are derived. These lead to the safety analysis and requirements according to ISO 26262 and SOTIF ISO in WP4.

8. References

[1] ISO 26262-9:2018, Road vehicles — Functional safety — Part 9: Automotive Safety Integrity Level (ASIL)-oriented and safety-oriented analyses, 2018

[2] Ludwig Von Bertalanffy, General System Theory, *New York, George Braziller*, 1986

[3] [12] [13] International Council On Systems Engineering (INCOSE), Systems engineering handbook a guide for system life cycle processes and activities, *INCOSE-TP-2003-002-04*, 2015

[4] Maier M., Architecting principles for systems-of-systems, Systems Engineering, 1998

[5] [9] [11] Cooperative Connected and Automated Mobility (CCAM), C-ITS Platform Final Report, *https://ec.europa.eu/transport/sites/transport/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf*, 2016

[6] [10] Atzmüller, B., Neubauer, M., Pell, A., Saleh, P., & Stieninger, M., DigiTrans: Bedarfsanalyse Logistik und Fahrzeugtechnologie - Deliverable 3, 2017

[7] NHTSA, A Framework for Automated Driving Systems in Testable Cases and Scenarios, Washington, DC: US DOT, *National Highway Traffic Safety Administration*, 2018

[8] Cooperative, Connected and Automated Mobility (CCAM), *https://ec.europa.eu/transport/themes/its/c-its_en*, 2016

9. Annex

9.1. Annex 1: Users & stakeholders per UC

In this section the users and stakeholders are reviewed by the use case if they apply or not. Not all users and stakeholders are necessarily relevant for every use case. Therefore, some of these rows may be empty if they are not relevant for this use case.

9.1.1. UC 1

Direct process participants	Applies to Use Case
• Remote	
○ Operator via the fleet management system	Apply
○ Teleoperator via hardware in a control centre (steering wheel, pedals)	Do not apply
• Close to the vehicle	
○ Operator in sight of the vehicle	Apply
○ Loader / Unloader	Do not apply
○ Traffic participants on public road	Do not apply
▪ Personal transport	
▪ Cyclists	
▪ Pedestrians	
▪ Users in non automated vehicles	
▪ Commercial transport	
▪ Public services	
▪ Shared cars	
○ Traffic participants on closed area	Apply
▪ Personal transport	Apply
▪ Cyclists	Apply
▪ Pedestrians	Apply
▪ Users in non automated vehicles	Apply
▪ Commercial transport	Apply
▪ Public services	Do not apply
▪ Shared cars	Do not apply
○ Maintenance personnel of automated operations	
▪ Automated vehicle maintenance	Apply
▪ Maintenance of transport infrastructure for automated vehicles	Apply
• In the vehicle	
○ Passenger	Do not apply
○ Operator in the vehicle	Apply

Indirect Process participants	
• Management of automated operations	
○ Operations monitoring	Apply
○ Continuous operations improvement	Apply
○ Error handling	Apply
• Shipper	Linde
• Forwarder	Linde
• Consignee	Linde
• Carrier	Linde
• Terminal operator	Linde
• Logistics service provider	Linde
• Combined operator	Linde
• Logistics Terminal	Linde
• Shipping company	Linde
General stakeholders	
• OEMs	
○ Trailers and caravans	Do not apply
○ 3rd party add on manufacturers	Do not apply
○ Commercial vehicles	Do not apply
• Technology partners	
○ Software and app developers	Apply
○ Device designers and manufacturers	Apply
○ Platform and cloud computing providers	Apply
○ System developers and integrators	Apply
○ Telematics hardware and service providers	Apply
○ Positioning services (GNSS)	Apply
• Municipalities	Do not apply
○ Residents	
○ Cities technical services	
○ Planning service	
○ Members of cities councils	
○ Regulatory department	
○ Economic development department	
• Traffic / road operators	
○ Planners	Do not apply
○ Traffic management	Do not apply
○ Road maintenance	Apply

○ Infrastructure owners (tunnels, bridges)	Apply
• Regulatory compliance related to automated operations	
○ Compliance assurance	Apply
○ Compliance design & implementation	Apply
• National/local authorities	
○ Parking companies (i.e. Ncp)	Do not apply
○ National/local authorities	Do not apply
○ Certification bodies	Do not apply
○ Port authorities	Do not apply
○ Airport authorities	Do not apply
○ Rescue services	Do not apply
○ Police	Do not apply

9.1.2. UC 2

Direct process participants	**Applies to Use Case**
• Remote	Apply
○ Operator via the fleet management system	Apply
○ Teleoperator via hardware in a control centre (steering wheel, pedals)	Apply
• Close to the vehicle	
○ Operator in sight of the vehicle	Apply
○ Loader / Unloader	Do not apply
○ Traffic participants on public road	Apply
▪ Personal transport	Apply
▪ Cyclists	Apply
▪ Pedestrians	Apply
▪ Users in non automated vehicles	Apply
▪ Commercial transport	Apply
▪ Public services	Apply
▪ Shared cars	Apply
○ Traffic participants on closed area	Apply
○ Maintenance personnel of automated operations	Apply
▪ Automated vehicle maintenance	Apply
▪ Maintenance of transport infrastructure for automated vehicles	Apply
• In the vehicle	
○ Passenger	Do not apply
○ Operator in the vehicle	Apply

Indirect Process participants	
• Management of automated operations	Apply
○ Operations monitoring	Apply
○ Continuous operations improvement	Apply
○ Error handling	Apply
• Shipper	DB Schenker
• Forwarder	DB Schenker
• Consignee	BRP ROTAX
• Carrier	DB Schenker
• Terminal operator	
• Logistics service provider	DB Schenker
• Combined operator	
• Logistics Terminal	
• Shipping company	
General stakeholders	
• OEMs	
○ Trailers and caravans	Apply
○ 3rd party add on manufacturers	Apply
○ Commercial vehicles	Apply
• Technology partners	
○ Software and app developers	To be defined
○ Device designers and manufacturers	Apply
○ Platform and cloud computing providers	Apply
○ System developers and integrators	To be defined
○ Telematics hardware and service providers	Apply
○ Positioning services (GNSS)	Apply
• Municipalities	Apply
○ Residents	Apply
○ Cities technical services	
○ Planning service	
○ Members of cities councils	
○ Regulatory department	
○ Economic development department	
• Traffic / road operators	Apply
○ Planners	
○ Traffic management	
○ Road maintenance	
○ Infrastructure owners (tunnels, bridges)	

• Regulatory compliance related to automated operations	Apply
○ Compliance assurance	Apply
○ Compliance design & implementation	Apply
• National and regional authorities	Apply
○ Parking companies (i.e. Ncp)	Do not apply
○ National/local authorities	
○ Certification bodies	
○ Port authorities	Do not apply
○ Airport authorities	
○ Rescue services	
○ Police	

9.1.3. UC 3

Direct Process participants	**Applies to Use Case**
• Remote	
○ Operator via the fleet management system	To be defined
○ Teleoperator via hardware in a control centre (steering wheel, pedals)	Do not apply
• Close to the vehicle	
○ Operator in sight of the vehicle	Do not apply
○ Loader / Unloader	Apply
○ Traffic participants on public road	Do not apply
▪ Personal transport	
▪ Cyclists	
▪ Pedestrians	
▪ Users in non automated vehicles	
▪ Commercial transport	
▪ Public services	
▪ Shared cars	
○ Traffic participants on closed area	Apply
○ Maintenance personnel of automated operations	
▪ Automated vehicle maintenance	Apply
▪ Maintenance of transport infrastructure for automated vehicles	Apply
• In the vehicle	
○ Passenger	Apply
○ Operator in the vehicle	Apply
Indirect Process participants	
• Management of automated operations	

○ Operations monitoring	Apply
○ Continuous operations improvement	Apply
○ Error handling	Apply
• Shipper	
• Forwarder	Airport ground handling companies
• Consignee	Avinor/Smart Airport Systems
• Carrier	
• Terminal operator	Avinor
• Logistics terminal	
• Logistics service provider	Airport ground handling companies
• Combined operator	Airport ground handling companies
• Shipping company	
General stakeholders	
• OEMs	
○ Trailers and caravans	Apply
○ 3rd party add on manufacturers	To be defined
○ Commercial vehicles	Do not apply
• Technology partners	
○ Software and app developers	Apply
○ Device designers and manufacturers	Apply
○ Platform and cloud computing providers	Apply
○ System developers and integrators	Apply
○ Telematics hardware and service providers	Apply
○ Positioning services (GNSS)	Apply
• Municipalities	Do not apply
○ Residents	
○ Cities technical services	
○ Planning service	
○ Members of cities councils	
○ Regulatory department	
○ Economic development department	
• Traffic / road operators	Apply
○ Planners	
○ Traffic management	
○ Road maintenance	
○ Infrastructure owners (tunnels, bridges)	
• Regulatory compliance related to automated operations	
○ Compliance assurance	Apply

○ Compliance design & implementation	Apply
• National/local authorities	Apply
○ Parking companies (i.e. Ncp)	
○ National/local authorities	
○ Certification bodies	
○ Port authorities	
○ Airport authorities	
○ Rescue services	
○ Police	

9.1.4. UC 4

Direct Process Participants	Applies to Use Case
• Remote	
○ Operator via the fleet management system	Apply
○ Teleoperator via hardware in a control centre (steering wheel, pedals)	Do not Apply
• Close to the vehicle	Apply
○ Operator in sight of the vehicle	Do no apply
○ Maintenance teams	Apply
○ Loader / Unloader	Apply
○ Traffic participants on public road	Apply
▪ Personal transport	
▪ Cyclists	
▪ Pedestrians	
▪ Users in non automated vehicles	
▪ Commercial transport	
▪ Public services	
▪ Shared cars	
○ Traffic participants on closed area	Apply
○ Maintenance personnel of automated operations	Do not apply
▪ Automated vehicle maintenance	
▪ Maintenance of transport infrastructure for automated vehicles	
• In the vehicle	
○ Passenger	
○ Operator in the vehicle	Apply
Indirect Process participants	
• Management of automated operations	
○ Operations monitoring	Apply

○ Continuous operations improvement	Apply
○ Error handling	
• Shipper	DFDS
• Forwarder	No direct contact to forwarders
• Consignee	
• Carrier	
• Terminal operator	DFDS
• Logistics service provider	
• Combined operator	
• Logistics Terminal	DFDS Seaways
• Shipping company	DFDS A/S owner of vessels
General stakeholders	
• OEMs	Apply
○ Trailers and caravans	
○ 3rd party add on manufacturers	
○ Commercial vehicles	
• Technology partners	
○ Software and app developers	Apply
○ Device designers and manufacturers	Apply
○ Platform and cloud computing providers	To be defined
○ System developers and integrators	Apply
○ Telematics hardware and service providers	Apply
○ Positioning services (GNSS)	Apply
• Municipalities	Apply
○ Residents	Apply
○ Cities technical services	Apply
○ Planning service	
○ Members of cities councils	Apply
○ Regulatory department	Apply
○ Economic development department	Apply
• Traffic / road operators	Apply
○ Planners	
○ Traffic management	
○ Road maintenance	
○ Infrastructure owners (tunnels, bridges)	
• Regulatory compliance related to automated operations	Apply
○ Compliance assurance	
○ Compliance design & implementation	

• National/local authorities o Parking companies (i.e. Ncp) o National/local authorities o Certification bodies o Port authorities o Airport authorities o Rescue services o Police	Apply

9.2. Annex 2: Project Memorandum

Project ID

AWARD - All Weather Autonomous Real logistics operations and Demonstrations - is a 3-year Innovation Action performed by a Consortium of 29 Partners coordinated by EasyMile. Starting on the 1st of January 2021, the project has received funding from the European Union's Horizon 2020 research and innovation program under the Grant Agreement No. 101006817.

Project introduction

AWARD's objective is to bring disruptive changes in the logistic industry by scaling Autonomous Driving Vehicles (AD Vehicles) system and Logistics Operation & Fleet Management (LOFM) system for heavy-duty vehicles, targeting compliance with ISO 26262 and taking into consideration SOTIF recommendations. The AD Vehicles' Autonomous Driving System (ADS) will be based on multiple sensor modalities and an embedded teleoperation system to address 24/7 availability. The ADS will then be integrated into multiple vehicle types used in low-speed areas. Finally, these vehicles will be deployed, integrated and operated in a variety of real-life use cases to validate their value in the application and identify any limitations and functional level to address 24/7 availability. This challenge will be particularly tackled by extending the AD Vehicles performances under harsh weather conditions (rain, fog, snow) that are today limiting the Operation Design Domain (ODD), which describes the specific conditions under which a given AD Vehicle or feature is intended to operate. These are to be developed along with an adapted regulatory framework for autonomous logistics operations in warehouses, airports, and ports.

Use Cases description

- Use case 1: Autonomous loading & unloading forklift operations
  Demonstration of an autonomous counterbalanced forklift truck for logistics operations within factories, in Linde Aschaffenburg Material Handling (Germany).

- Use case 2: Hub-to-hub autonomous logistics
  Demonstration of an autonomous swap body truck between the Engine Factory of BRP-Rotax and the Logistic Hub of DB Schenker (Gunskirchen, Austria), which are connected via factory areas, public side roads, public main roads and public crossing areas.

- Use case 3: Autonomous ground support equipment in airport
  Demonstration of an autonomous baggage tractor on airside in Avinor OSL Gardermoen airport (Norway).

- Use case 4: Trailer transfer operations and automated ship loading in port
  Demonstration of an autonomous trailer on a busy roll-in/roll-off terminal in Rotterdam Port (The Netherlands).

AWARD value chain

AWARD's value chain is described in figure 20.

Figure 20: AWARD value chain

Stakeholders & Users

The AWARD project adopts a comprehensive view on understanding user and stakeholder needs. These encompass three main categories:

- Direct process participants are all users and stakeholders who interact directly with the vehicle, either remotely or on site.
- Indirect process participants are all users and stakeholders who are part of the technical or logical operations of the organisation taking advantage of autonomous vehicles.
- And lastly overall stakeholders which contains all users and stakeholders who are in some way, shape or form related to the AWARD project.

AWARD System of System

Derived from the AWARD project goals, the defined objective of the involved System of Interest can be described as “Realize the automated ground transport of goods in a defined area”. This system will be further on named as Automated ground Goods Transport System (AGTS). For this AGTS, several subsystems are identified (figure 21).

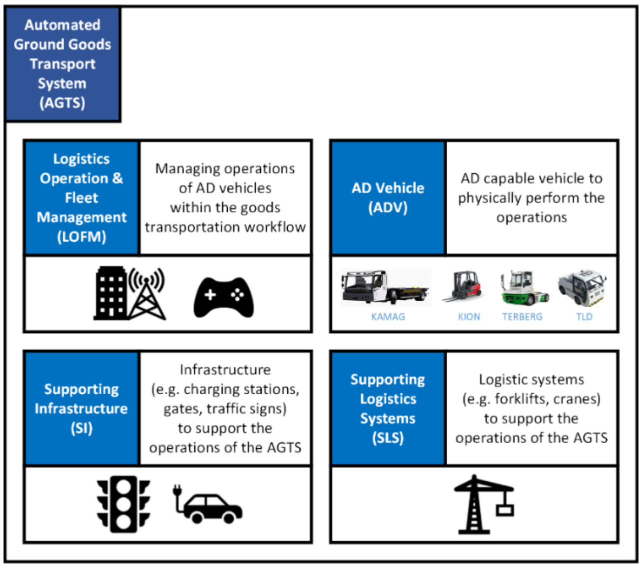

Figure 21: The AGTS and its subsystems