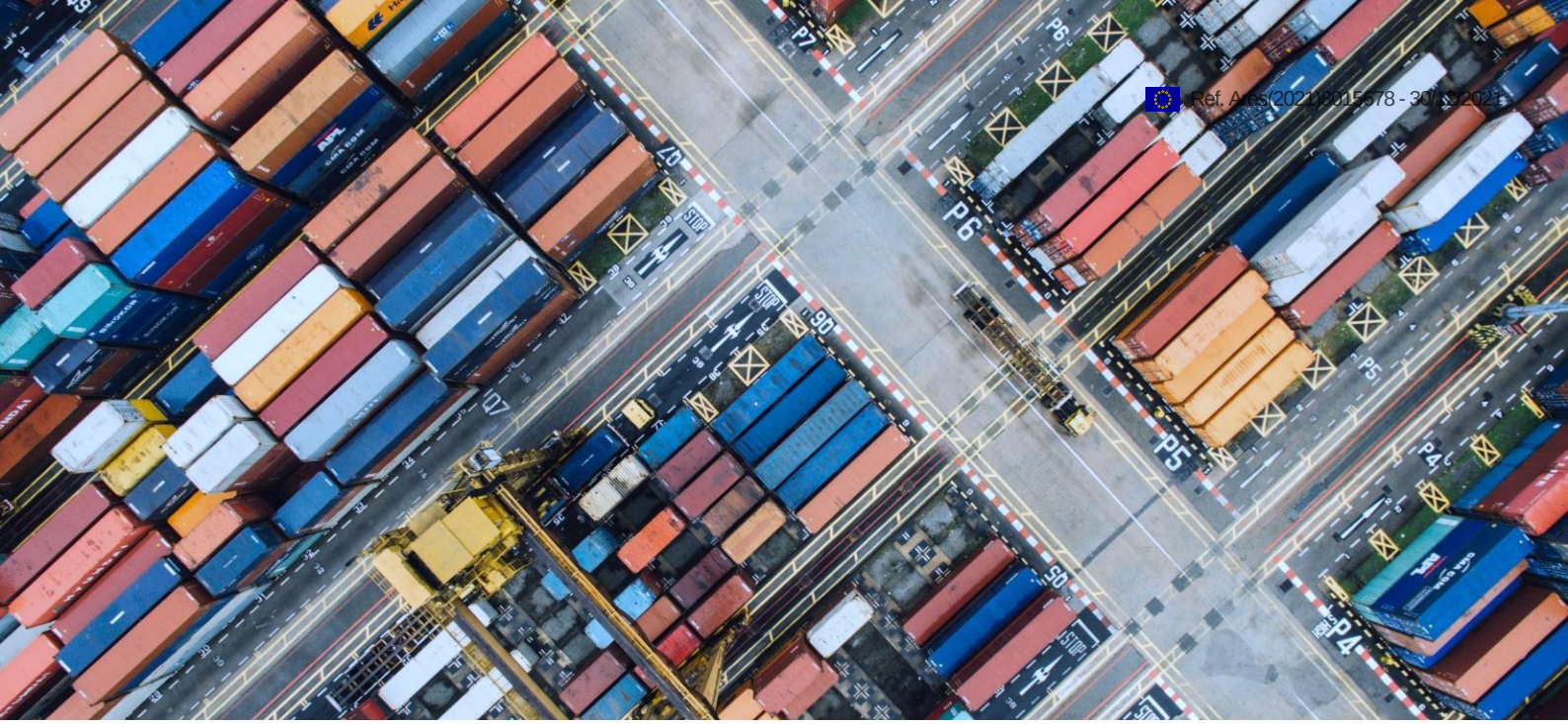

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AWARD
Scaling autonomous logistics

D8.1
Market opportunities, barriers and solutions

—

Lead: ENIDE

Due date: December 2021

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2.0	20/12/2021	Loha Hashimy	ENIDE	Sent for submission

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Table 1 Acronyms

ADS	Autonomous Driving System
AGC	Automated Guided Vehiclets
AGT	Automated Guided Transport
AGV	Automated Guided Vehicle
AHDV	Automated Heavy-Duty Vehicle
AV	Autonomous Vehicle
BSI	British Standards Institution
CAD	Connected and Automated Driving
CAV	Connected and Autonomous Vehicle
HDV	Heavy-Duty Vehicle
LiDAR	Light Detection and Ranging
LOFM	Logistic Operation & Fleet Management
MaaS	Mobility as a Service
ODD	Operational Design Area
OEM	Original Equipment Manufacturer
PAS	Publicly Available Specification
SAE	Society of Automotive Engineers
SAM	Serviceable Addressable Market
SOM	Serviceable Obtainable Market / Share of Market
T	Task
TAM	Total Addressable Market
WP	Work Package

1. Executive Summary

Benefits such as lower labor costs, higher productivity, and reduced risk of product damage while transferring items or raw materials within industries are fueling market expansion of automated vehicles in logistics. According to Gartner Inc, by 2023, there will be 745,705 autonomous-ready vehicles on the road, up from 137,129 in 2018[1]. Despite the increase in activities and the progress made in the area of the connected and automated vehicle, the idea of Autonomous Vehicles (AVs) driving around in everyday traffic within the near future is still faced with a lot of skepticism (Shanker, et al., 2013). However, logistics provides ideal working environments for autonomous vehicles, and it is believed that in near future AVs will be widely used within the clearly defined boundaries of a controlled environment such as ports, distribution centers, and production plants. Thus, it is important for logistics professionals to prepare for their arrival as the smooth adoption of the technology could allow for building a competitive advantage.

The AWARD project's goal is to develop a safe autonomous driving system that improves efficiency in adverse weather conditions, with a focus on four heavy-duty vehicle use cases like forklift (un)loading in warehouses and industrial plants, hub-to-hub shuttle service on open roads, automated baggage dispatching in airports, trailer transfer operations, and vessel loading in ports.

Task T8.1 will conduct a thorough examination of the technological, commercial, organizational, and social possibilities of connected and automated heavy-duty trucks in real-world logistics operations. Analyzing the limitations and drivers of automation in logistics enable us to reveal potential opportunities. T8.1 collects information from all of other WPs in order to better understand the AWARD solutions, conducts analyses, and gives comments and advice to the technical WPs in order to align market demands with project technology advancements.

A comprehensive desk research and literature review were conducted. Secondary data is collected to segment the market, understand market dynamics, and calculate market size. To give early insights into the industry's attractiveness, this market study is integrated with a preliminary competition analysis, followed by Porter's five forces analysis. We'll also investigate across the EU to see whether there are any similar programs or efforts in other European nations.

The analysis of market trends, drivers, barriers, and opportunities will serve as the foundation for the solution creation later in this project. Section 4 identifies the most relevant mega, macro and micro trends in automated heavy-duty vehicles, followed by a market segmentation analysis based on vehicle autonomy, vehicle type, sources, and applications.

An initial competitive landscape research was carried out, with a focus on the key players in outdoor logistics automation, primarily in Europe. In contrast to long-distance applications in public (e.g., platooning), solutions for logistics procedures within a private location/confined area are considered.

[1] https://www.gartner.com/en/newsroom/press-releases/2019-11-14-gartner-forecasts-more-than-740000-autonomous-ready-vehicles-to-be-added-to-global-market-in-2023

Then, for the four use cases in AWARD, we used Porter's Five Factors to identify and evaluate five competitive forces that influence the market and help establish an industry's weaknesses and strengths.

2. Introduction

Material handling in industrial contexts is a critical element of logistics systems. Since 1950s, Automated Guided Transport (AGT) systems and Automated Guided Vehicles (AGVs) have been utilized to optimize material flow and reduce personnel as a natural result of concepts for increasing productivity through improved work processes. This progress was fueled by the modernization of production as a result of management's increased reliance on technology, to the point where total automation was envisioned.

Recent technical breakthroughs in the development of Autonomous Vehicles (AVs) have been heralded as the next mobility and transportation revolution. Autonomous vehicles offer a lot of potential for an industry that is dealing with a manpower shortage and a desire for faster delivery times. Also, the growth of e-commerce and shorter delivery times have engendered the need to overcome limitations on driving hours and capital usage. Aside from economic considerations, one of the most significant advantages is unrivaled flexibility in terms of integration into an existing or evolving context. Extending these benefits of industrial vehicles through automation technology leads to higher reliability and lower operational costs. The introduction of AVs has the potential to radically transform the way mobility and transportation logistics are handled. Connected and Automated Vehicles (CAVs) can open new business opportunities for the logistics industry if utilized properly.

An AV should be able to acquire data about its surroundings, evaluate the data, utilize the interpretation to plan the best feasible AV actions, transform these plans into actionable commands, and execute the actions (Anderson, et al., 2014). To that end, the vehicle is equipped with several technologies and extensive backup systems that monitor the operation of the vehicle's various components.

According to (Shanker et al., 2013), there are two major methods to obtaining these capabilities. The first mainly relies on V2V and V2I communication technologies. The concept is that the infrastructure tells the vehicle what its environment looks like, and the vehicle adds its own Light Detection and Ranging (LiDAR) observations of its surroundings and compares this information with a map database to detect discrepancies as barriers to drive around. The advantage of this method is the relatively low cost of operations, while the disadvantages include a restricted capacity to react to rapid changes and the weight of needing to construct road infrastructure. The second approach does not rely on environmental input, but rather allows the vehicle to completely observe and analyze its surroundings. The disadvantages of this system include the increased vehicle cost due to the necessity for a suite of cameras, radars, and sensors, as well as the increased sensitivity to weather conditions. The benefit is the capacity to respond to changes in the environment more rapidly, as well as a larger degree of infrastructure independence. Though, the combination of both techniques would result in more safety and self-driving capabilities than each option alone.

2.1. Aim of AWARD

AWARD aims at developing and enabling to deploy a safe autonomous transportation system in a wide range of real-life use cases in a variety of different scenarios. This encompasses the development of an autonomous driving system (ADS) capable of handling adverse weather conditions such as heavy rain, snowfall, fog. The ADS solution will be based on multiple sensor modalities to address 24/7 availability. The ADS will then be integrated into multiple vehicle types used in low-speed, mostly in confined areas. Finally, these vehicles will be demonstrated in a variety of real-life use cases to validate their value in the application and identify any limitations. Logistics operations will be optimized thanks to a new fleet management system that will act as a control tower, gathering all information from subsystems (vehicles, road sensors, etc.) to coordinate the operations and protect vulnerable road users. This work should then enable commercial exploitation of the technology and policy recommendations for certifications processes.

2.2. Scope of T8.1 and relationship with other WPs

This task will deliver a comprehensive business focused analysis of all different deployment opportunities related to connected and automated heavy-duty vehicles in real logistics operations. Additionally, all potential technical, business, organisational, social, or other barriers will be investigated, identified and suitable solutions found. A broad consultation with key stakeholders shall be done, in close cooperation with WP2 (especially with T2.2), WP7 (Particularly T7.3 and T7.4) and WP9 (both regarding gathering necessary input, as well as regarding dissemination of the deliverables that will come as a result of this task´s efforts). The goal of consultation is to receive input on opportunities, barriers and solutions from stakeholders, through direct interviews, local workshops and an online survey
Some inputs of WP2 to T8.1 are:

- the use cases' specifications,
- the definition of AWARD system,
- identified key stakeholders, and end-users needs and requirements

Taking these inputs and combining them by identified key exploitable results from WP9, T8.1 preforms the market analysis of the target market for AWARD solutions. AWARD has three technical WPs, namely WP3, WP4 and WP5. The innovative system of system is developed in these WPs and used for the demonstrations in WP6. T8.1 gets inputs from all these WPs to better understand the solutions AWARD offers, perform analysis and provides feedback and inputs to the technical WPs in order to match the market needs with the technological developments of the project.

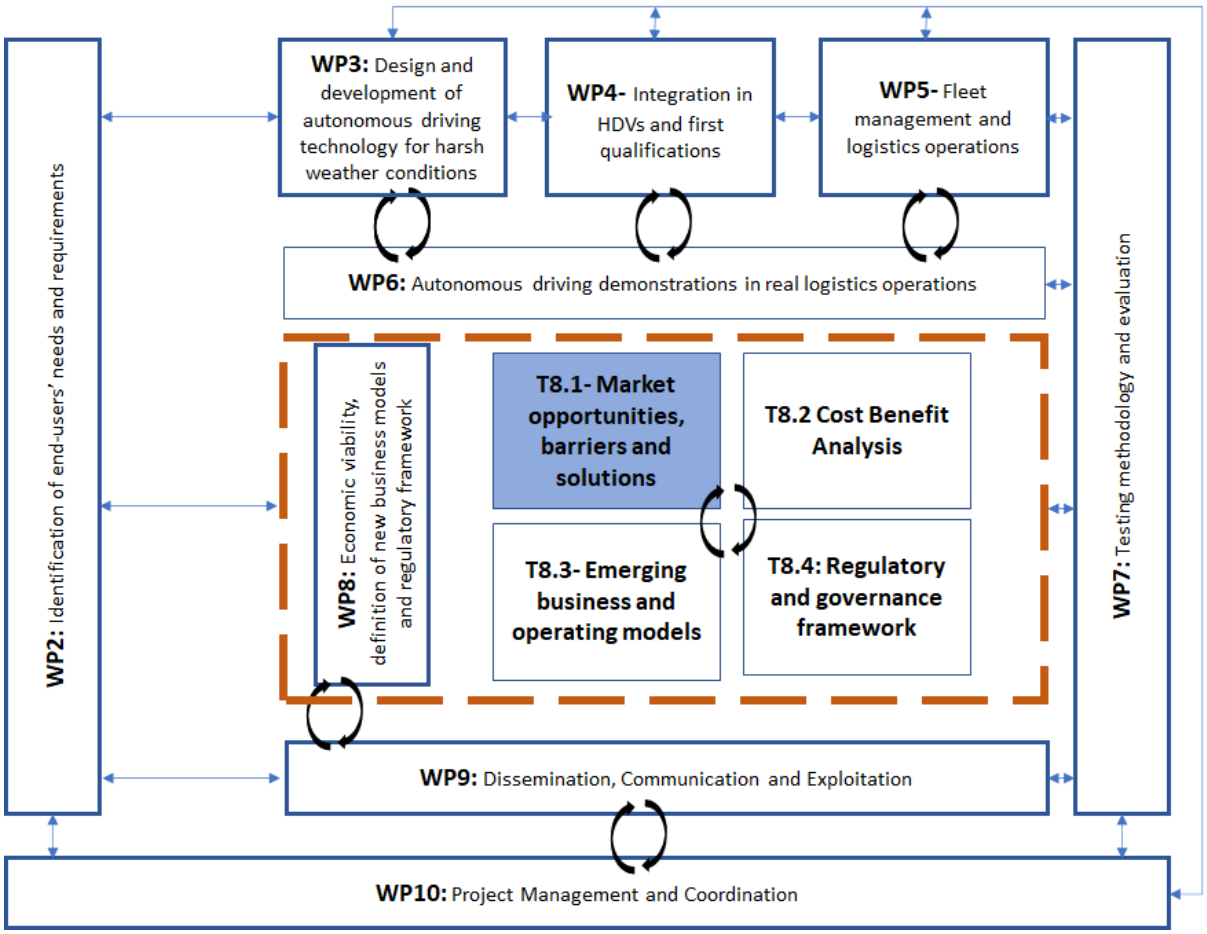

Figure 1: Task 8.1 relationship with other WPs

The results of T8.1 will be used as inputs for the other tasks in WP8 and will also contribute to WP7 mainly the impact assessment of the project results. Furthermore, WP8 and WP9 are closely related as market and competitive analysis performed in T8.1 are considered as inputs for the exploitation of results.

2.3. Intended Audience

This is a public report, thus; apart from internal use by consortium partners (the relationship of this task and other WPs has explained above) external stakeholders including policy-makers, researchers, private companies, the general public, and many others working on mobility and logistics can use the analysis performed in this report. Also, some inputs will be received from these stakeholders to better understand the market.

2.4. Structure

The remainder of this report is structured as follows:

- Chapter 3 explains the methodology used
- Chapter 4 contains the market analysis of connected and automated heavy-duty vehicles in real logistics operations
- Chapter 5 presents the initial market analysis of logistics operation and fleet management system

- Chapter 6 presents the initial competitive analysis results including information on key market players, existing products and their features.
- In Chapter 7, we have performed a Porter's five forces analysis for the four use cases of AWARD
- Chapter 8 concludes and summaries the initial findings and provides some insights on the next steps.

3. Methodology

There are different approaches to conduct market research. But as any other research process, it starts with preparation and setting objectives followed by determining the research approach, data collection, analysis and reporting.

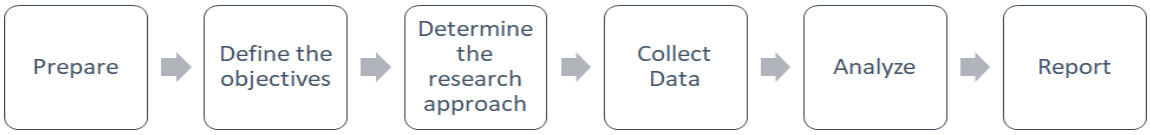

Figure 2: Market research approach

In the preparation phase, the project objective, identified problem and the proposed solution are revised to better understand the project and the market it targets. Two target markets are identified to be studied, the market for autonomous vehicles in logistics with a specific focus on the AWARD use cases and the market for logistics operations fleer management. The objective of the study is to identify the most pertinent aspects of the market and provide insights regarding the market dynamics, size, and competitors. These insights can be used to effectuate better the business decisions at consortium level as well as help partners with their individual exploitation plans at partner level. Then, the research and analysis method are defined to obtain the necessary qualitative and quantitative data. In AWARD, both secondary and primary data is collected to get enough information about the market. Since the nature of this task is exploratory, qualitative analysis is used to get as much information as possible with predefined constraints. The collected data is then analyzed and is reported in D8.1 and D8.5.

Aligned with this methodology, T8.1 uses an interactive approach to study the market opportunities, barriers, and solutions. As the first step, an intensive desk research and literature review is conducted to investigate the autonomous vehicles in logistics market. Secondary data is compiled to segment the market, understand the market dynamics and define the market size. This market analysis is combined with an initial competitive analysis followed by Porter's five forces analysis that will provide early insights into the attractiveness of the industry. An internal workshop and a survey are organized to get initial insights on drivers, barriers and opportunities. The survey is sent to external advisory board members as well. An initial analysis is performed based on these inputs and are reported in this deliverable.

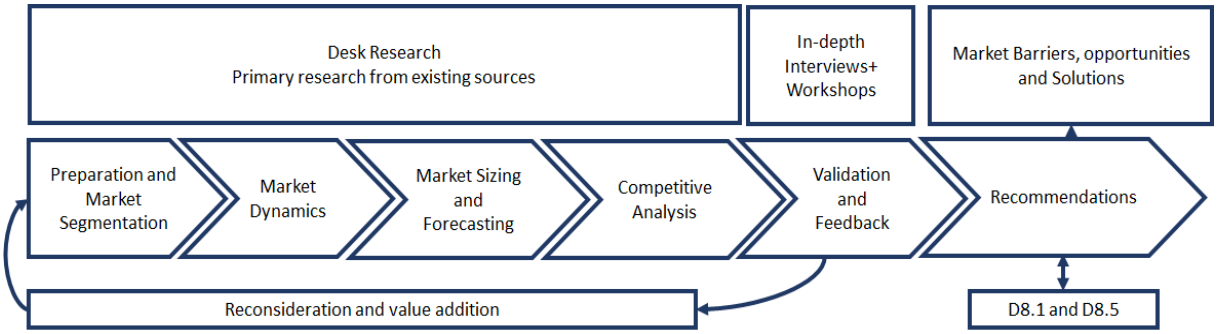

Figure 3: Task 8.1 methodology for market barriers, opportunities and solution analysis

Further, in the second year of the project, some in-depth interviews will be conducted with key opinion leaders to gather inputs on barriers and opportunities to connected and automated heavy-duty vehicles in real logistics operations. Also, some workshops will be organized with both internal and external stakeholders to discuss and align the market barriers and opportunities with solutions. The primary data gathered from these interviews and workshops will help us validate our research findings and provides us with first-hand data on market dynamics and size for both automated vehicles in logistics and logistics operation fleet management.

The task is ongoing and is performed during the lifetime of the project. The initial analysis reported in this deliverable will be updated and communicated with partners, specifically solution providers to ensure the competitiveness of the project outcomes.

4. Autonomous Vehicles in Logistics

4.1. Automation in logistics - market Segmentation

The market of automation in logistics can be segmented in different ways. In AWARD, we have segmented the market based on automation level, vehicle type, geography, and application as described in the sub-sections below.

4.1.1. Market segmentation by level of vehicle autonomy

Automation in general and in road freight transportation has evolved during the last years into different automation levels related to the capabilities of the vehicles and the need of drivers to control the vehicle. According to the Society of Automotive Engineers (SAE) There are five levels of automation:

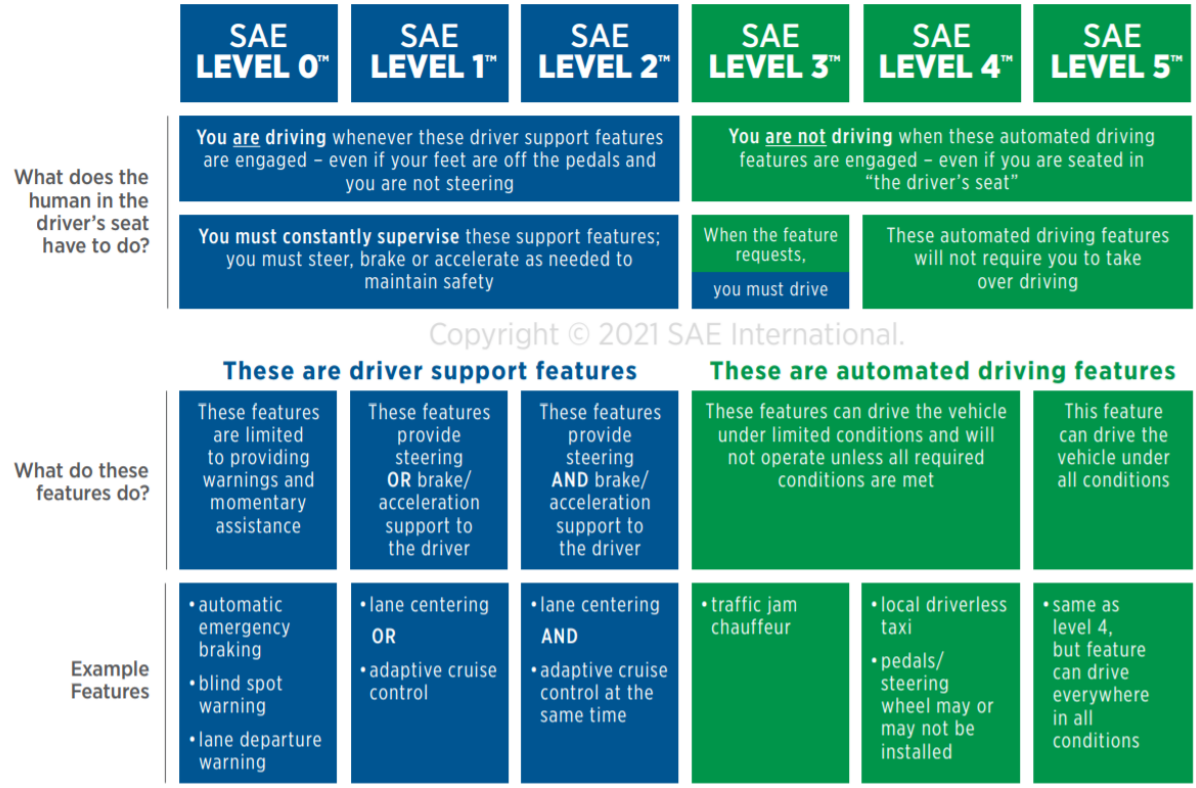

Figure 4: Different levels of automation (Source: SEA[2])

Level 0: No Driving Automation. The driver is completely responsible for controlling the vehicle, performing tasks like steering, braking, accelerating or slowing down. Level 0 vehicles can have safety features such as backup cameras, blind spot warnings and collision warnings. Even automatic emergency braking, which applies aggressive braking in the event of an imminent collision, is classified as Level 0 because it does not act over a sustained period.

Level 1: Driver Assistance. At this level, the automated systems start to take control of the vehicle in specific situations, but do not fully take over. An example of Level 1 automation is adaptive cruise control, which controls acceleration and braking, typically in highway driving. Depending on the functionality, drivers are able to take their feet off the pedals.

Level 2: Partial Automation. At this level, the vehicle can perform more complex functions that pair steering (lateral control) with acceleration and braking (longitudinal control), thanks to a greater awareness of its surroundings.

Level 3: Conditional Automation. At Level 3, drivers can disengage from the act of driving, but only in specific situations. Conditions could be limited to certain vehicle speeds, road types and weather conditions. But because drivers can apply their focus to some other task — such as looking at a phone or newspaper — this is generally considered the initial entry point into autonomous driving. Nevertheless, the driver is expected to take over when the system requests it. For example, features such as traffic jam pilot mean that drivers can sit back while the system handles it all — acceleration, steering and braking. In stop-and-go traffic, the

[2] For the full definition of Society of Automotive Engineers levels see: https://www.sae.org/standards/content/j3016_202104/. Level 4 includes vehicles either with a driver (e.g. motorway autopilot) or without a driver (e.g. shuttles on dedicated trips).

vehicle sends an alert to the driver to regain control when the vehicle gets through the traffic jam and vehicle speed increases. The vehicle must also monitor the driver's state to ensure that the driver resumes control, and be able to come to a safe stop if the driver does not.

Level 4: High Automation. At this level, the autonomous driving system of the vehicle is completely capable of monitoring the driving environment and performing all driving operations for normal routes and circumstances established within its Operational Design Area (ODD). If the vehicle detects an environmental situation that necessitates human intervention, such as heavy snow, it may notify the driver that it has reached its operating limitations. If the driver does not reply, the vehicle will be automatically locked.

Level 5: Full Automation. Vehicles with Level 5 autonomy are completely self-contained. There is no need for a driver. In fact, Level 5 vehicles may lack a steering wheel and gas/brake pedals. Level 5 vehicles may include "smart cabins," allowing passengers to send voice commands to select a destination or set cabin settings such as temperature or media selection.

According to SEA, levels 0-2 are already in the market and the fully industrialized rollout and market uptake of levels 3-5 will happen during 2020-2030. A similar prediction can be found at the ERTRAC CCAM Roadmap. Looking at the agenda 2030, low-speed automated vehicles covering full traffic complexity for transport of goods in use cases similar to AWARD, restricted areas, are expected to be highly available by 2040 and are the first in order to receive high market uptake. Confined zones are expected to expand and combine into complete urban autonomous shuttles and deliveries.

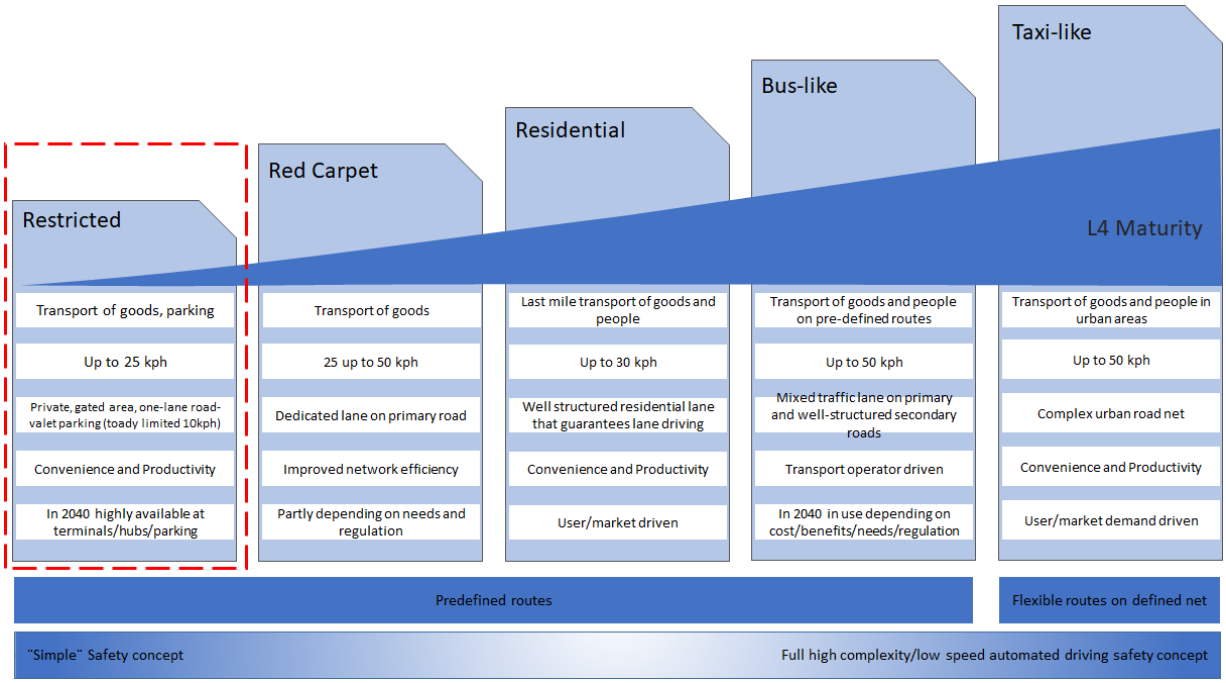

Figure 5: Outlook on low-speed automation [3]

3 https://www.ertrac.org/uploads/documentsearch/id75/Draft%20ERTRAC%20CCAM%20Roadmap%20V9%2030-09-2021.pdf

Level 4 automation is foreseen to be driven by business use-cases for logistics and is expected to have high penetration. The key to penetration is affordability and by 2030, the costs of manufacturing automated vehicles are expected to decrease. Thus, further pushes the market uptake.

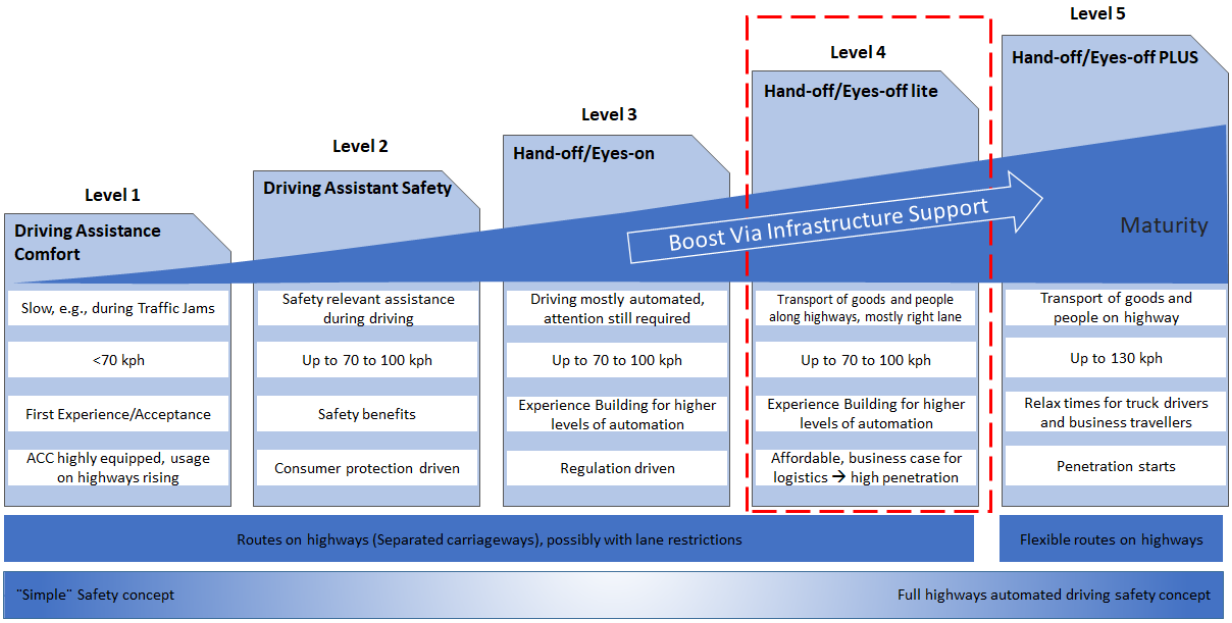

Figure 6: Outlook on highway automation [4]

Furthermore, AWARD's use-cases are highly aligned with the ERTRAC CAD Roadmap 2019. During the lifespan of the project, highly automated freight transport vehicles in confined areas as port, airport, forklift and hub-to-hub will be tested. Highly automated unmanned trucks without driver cabins will operate in designated extended transport corridors that comprise both indoor and outdoor areas in the hub-to-hub use case. This use case provides us with a clear picture of the needs, safety requirements and will enable us to evaluate the state of art as well as define the future roadmap for highly automated vehicles on open roads.

4 https://www.ertrac.org/uploads/documentsearch/id75/Draft%20ERTRAC%20CCAM%20Roadmap%20V9%2030-09-2021.pdf **** 3 & 4 are the same ref ***

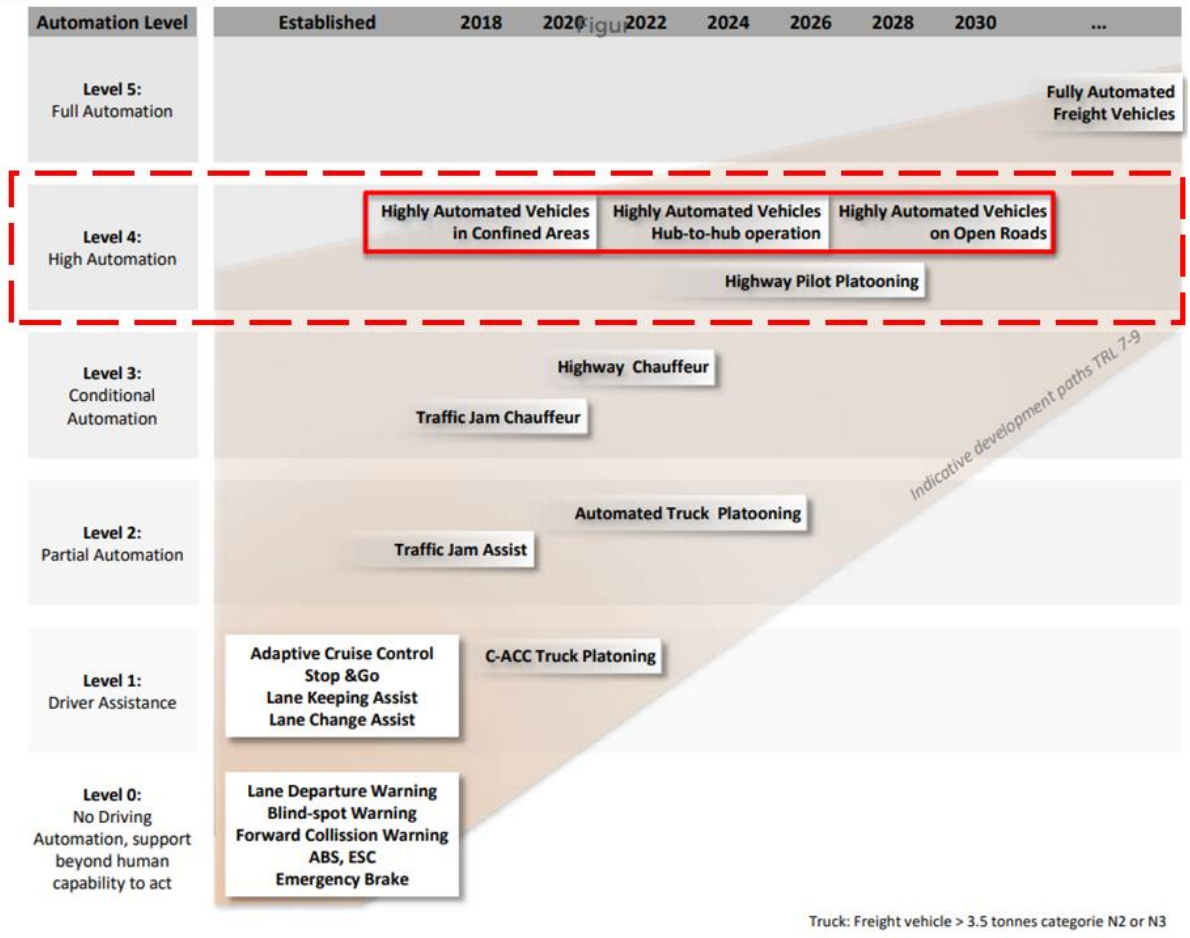

Figure 7: The Automated Driving development path for freight vehicles [5]

4.1.2. Market segmentation by vehicle type

The market can be segmented into road passenger and road freight commercial vehicles based on vehicle type. Road passenger vehicles are used to transport passengers while road frieght commercial vehicles are used for carriage of goods. The size distinction between the two types of vehicles is significant. Road freight commercial vehicles are the focus of AWARD. Based on the gross vehicle weight, road freight commercial vehicles are classified into eight classes (GVW). The number of classes and weight ranges for each class are shown in table 3 (ACT Research, 2021)[6]. Light Duty, Light Medium, Medium, and Heavy-Duty trucks are some of the most common classifications. These classes are a subset of industry-specific truck classifications.

Table 2: Vehicle classes and weight ranges for each class

Weight Class	Light duty				Light Medium Duty	Medium Duty		Heavy-Duty
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
From (lbs)	--	6,001	10,001	14,001	16,001	19,501	26,001	33,001
To (lbs)	6,000	10,000	14,000	16,000	19,500	26,000	33,000	--

[5] https://www.ertrac.org/uploads/documentsearch/id57/ERTRAC-CAD-Roadmap-2019.pdf
[6] https://www.actresearch.net/types-of-commercial-vehicles/

Class 1-3 are most of the time also considered as non-commercial vehicles, LDVs or vans, thus are not in the scope of AWARD. Medium duty and heavy-duty vehicles are the market segments that AWARD focuses on.
AGVs, on the other hand, come in a variety of shapes and sizes. Different forms of AGVs include automated guided vehiclets (AGC), tow tractors, forklifts, unit load handlers, large load vehicleriers, mobile picking robots, and so on. We employ an automated forklift offered by KION at AWARD covering this type of industrial vehicles as well.
In the forklift vehicle category, the visible E-CB (electric counterbalance) forklifts market in EMEA is expected to reach around 120.000 vehicles in terms of annual sales by 2021. Linde MH, Still, Jungheinrich, Toyota, Hyster, and Crown are among Europe's largest OEMs. In 2026, it is expected that 5% of the 120.000 E-trucks would be automated.
According to Gartner Inc., while autonomous-driving-capable vehicle sales are expected to expand quickly, net additions of autonomous commercial vehicles remain modest in absolute terms when compared to passenger autonomous vehicle sales. In 2020, the passenger category was predicted to have 325,682 AV sales, while the commercial segment had just 10,590 (Table 4). Though, it is expected that due to regulatory hurdles, the number of commercial AVs manufactured and sold in the coming 3-5 years will be higher.

Table 3: Autonomous ready vehicles-net addition

Use Case	2018	2019	2020	2021	2022	2023
Commercial	2,407	7,250	10,590	16,958	26,099	37,361
Passenger	134,722	325,682	380,072	491,664	612,486	708,344
Total	137,129	332,932	390,662	508,622	638,585	745,705

4.1.3. Market segmentation by geography

4.1.3.1. By continent

Most of the global regions are today looking at possible applications of automated vehicles, being for mobility and/or logistics purposes. The competitive edge of one region over another depends on different factors, including the preparedness of the region in terms of regulatory environment, the infrastructure in place, or the adequate R&D of OEMs and other industry players. Counting multiple large vehicle manufacturers with premium offering and suppliers of complex vehicle components, Europe, North America and Japan have taken an early start for the development of automated vehicles.
The European Union intensified the funding of collaborative research in the field of connected and automated vehicles. Already in the Horizon 2020 Program, a call on “Automated Road Transport” provided over 300Mn€ of funding. The research funding continues now in the framework of the program Horizon Europe for 2021-2027.[7] One of the main challenges for the European Union compared to the other regions around the globe will be to come out with a

[7] https://www.ertrac.org/uploads/documentsearch/id75/Draft%20ERTRAC%20CCAM%20Roadmap%20V9%2030-09-2021.pdf

harmonized regulatory framework, enabling manufacturers to test autonomous vehicles along the European roads. Solving this issue will lead to a better market penetration.

Considered as late starters, China is also now pushing to accelerate the development of automated vehicles in their region. In Asia, China can count on the push from the central government. On February 2020, eleven central level governmental departments jointly issued a Strategy for Innovation and Development of Intelligent Vehicles.

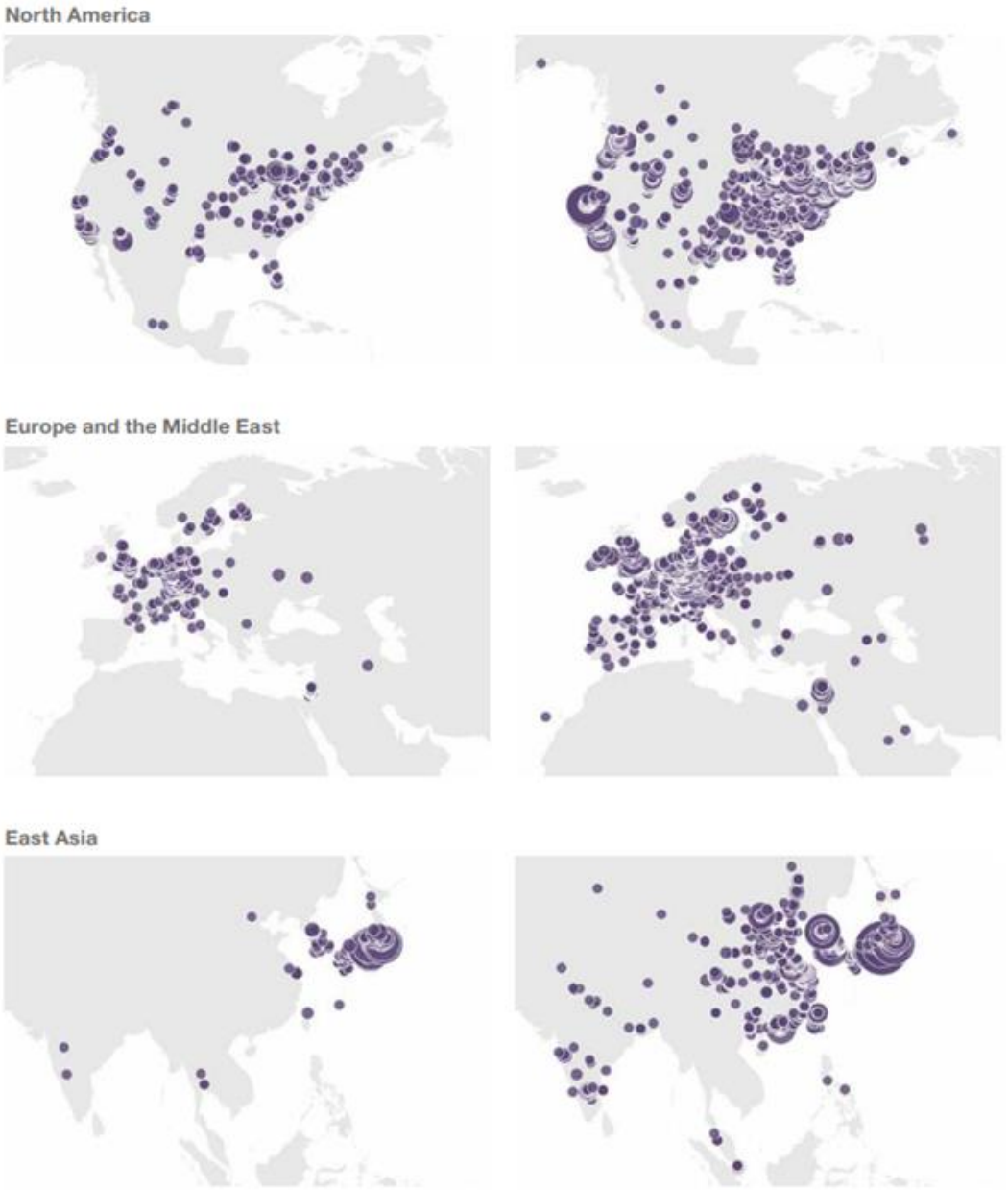

Figure 8: Geographical distribution of AV-related patents in selected regions, pre-(left) and post-2005 (right) [8]

[8] https://www.wipo.int/edocs/pubdocs/en/wipo_pub_944_2019-chapter3.pdf

4.1.3.2. Example of advanced countries in AHDVs in Real Logistics Operations

As of 2018, the consulting firm KPMG is publishing an annual index assessing the level of readiness of 30 countries for autonomous vehicles. In the 2020 report[9], KPMG identifies Singapore, Netherlands, and Norway as the top 3 of the most advanced countries. The index compiles measures around four pillars to assess the countries: policy and legislation, technology and innovation, infrastructure, and consumer acceptance. The city-state of Singapore is particularly advanced in terms of policy environment and testing sites for automated buses. Singapore also witnesses a very high level of consumer acceptance.
The Netherlands is an interesting example of advanced country in automated heavy-duty vehicles in real logistics operations. The European country issued the "Experimenteerwet zelfrijdende auto" (law governing the experimental use of self-driving vehicles) to facilitate tests of driverless vehicles on public roads. The RDW (Dutch Vehicle Authority) has then the option of issuing exemptions for self-driving vehicles. Dutch roads have for example been witnessing the test of truck platooning operations in 2019. The country also extended its use of smart road furniture with 60 new areas of the countries equipped in 2019 with traffic lights sending their status wirelessly to AVs. The Netherlands is also leading the infrastructure pillar thanks to the quality or its roads, under the assumption that AVs work better on high-quality roads, with poor roads limiting a country's adoption.

4.1.4. Market segmentation by application

Autonomous Transport systems can be classified into indoor automated transport systems and outdoor automated transport systems[10]. Indoor connected and automated system have been used in logistics for a long time now. The term Automated Guided Vehicles is often used in the industry to describe any vehicle that does not require a human operator to drive. Outdoor automated transport systems can further be divided into outdoor HDVs in public roads and outdoor HDVs in confined areas. Connected and Automated Vehicles (CAV) in both indoor and outdoor environments in logistics can be considered a type of AGVs. The focus of AWARD is mainly on the outdoor automated transport and logistics systems. The four main applications and use cases in AWARD are forklift, hub to hub, port and airport. Our focus will be on these four use-cases, which are the main applications of AVs in logistics. Figure 10 shows AWARD use-cases matrix including 5 key dimensions: geographic areas, roadway types, traffic conditions, weather conditions, incidents (based on ITF report, Managing the Transition to Driverless Road Freight Transport).

[9] https://assets.kpmg/content/dam/kpmg/es/pdf/2020/07/2020_KPMG_Autonomous_Vehicles_Readiness_Index.pdf

[10] https://www.researchgate.net/publication/303481045_Autonomous_Vehicles_and_Autonomous_Driving_in_Freight_Transport

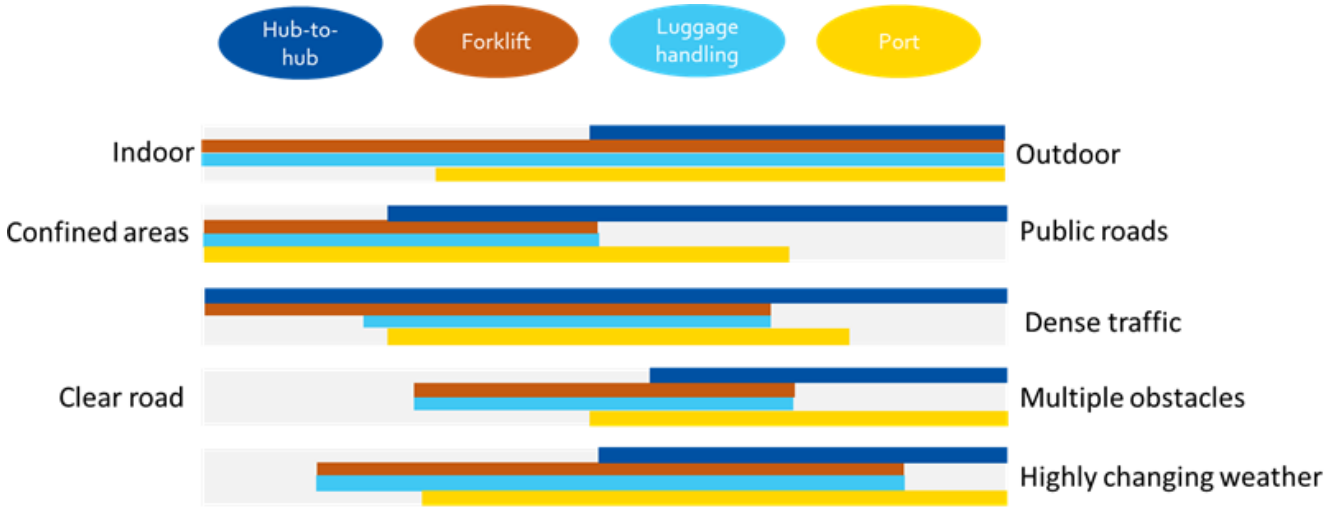

Figure 9: AWARD use-cases matrix - 5 key dimensions

AWARD focuses on four specific use cases that are also considered as the most important and probable field of application for AHDV in the close future: hub-2-hub, which involves both public and confined outdoor areas, forklift for indoor and outdoor confined areas, port and airport trucks for outdoor confined areas.
AWARD will have a great impact on accelerating the deployment of innovative connected and automated freight transport solutions in Europe because AWARD's core strategy is to focus on 4 worldwide market segments for which the safety driver can be safely removed in the short to medium term. This means that these 4 market segments are the most promising markets for enabling a large-scale deployment of automated freight solutions at short and medium terms. Demonstrations of fully available automated HDV performing 24/7 real logistics operations of duration from 20 to 36 months long in 3 European countries will demonstrate the operational efficiency, the economic and societal added values as well as the full safety of the AWARD automated logistics operations without safety driver in both indoor and outdoor systems including public and confined areas. The selection of the use cases is key to test different scenarios: hub-2-hub, which involves both public and confined outdoor areas, forklift for indoor and outdoor confined areas, port and airport trucks for outdoor confined areas. At the end of such demonstrations, it is expected that the concerned Port / Airport / industrial end-users will keep operating such solutions on a day-to-day basis. The AWARD project will thus be an essential commercial springboard to penetrate the huge 4 targeted markets of airport, port, warehouse and hub-to-hub logistics.

4.1.4.1. AWARD use case 1: Forklift

Forklift use case or Autonomous truck loading with autonomous forklift, will be deployed to address technological challenges related to logistics operations within factories, in Linde Aschaffenburg Material Handling (Germany). There will be 2 demonstrators within the UC 1:

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

4.1.4.2. AWARD use case 2: Hub-to-hub

Hub-to-hub or Shuttle service from warehouse/production site to logistics hubs, aims at demonstrating autonomous heavy-duty vehicles working on an extended ODD 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.
The overall goal is highly automated, continuous, hub-to-hub freight transportation between the engine production factory of BRP Rotax and the logistics center of DB Schenker in Gunskirchen (Upper Austria). The two sites are connected via public side roads, public crossing areas and a public main road.

4.1.4.3. AWARD use case 3: Luggage handling

Luggage handling use case or Automated baggage tractor on airside in Avinor OSL Gardermoen airport, aims at demonstrating autonomous heavy-duty vehicles working on an extended ODD with the demonstration of an automated baggage tractor on airside in Avinor OSL Gardermoen airport (Norway).
The UC 3 will be performed under 4 different phases: Phase 0, Phase 1, Phase 2 and Phase 3.
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.
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.
The Phase 3 will focus on the deployment of the autonomous vehicle on a full mission, whose objective is to perform operations with remote supervision only from the Fleet Management System.

4.1.4.4. AWARD use case 4: Port

Port use case or trailer transfer operations and automated ship loading in Rotterdam port, will validate 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
The UC 4 will be performed under 3 different phases: Phase 1, Phase 2 and Phase 3.
The 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 another parking area ready for loading the ship.
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.
In Phase 3, the autonomous truck will collect the trailers from an identified storage area and will move the trailers onto a vessel.

4.1.4.5. Other use cases

First-mile, middle-mile, and last-mile are three different types of use cases for road goods shipping. While AWARD focuses on first-mile delivery, autonomous trucks can be used for middle and last-mile deliveries as well. Long-haul transport is one of the most common applications for autonomous trucks. Plus, a pioneer in self-driving truck technology, has collaborated with SF Express to develop China's first commercial freight pilot project.[11] The findings of the trial reveal that Plus' AV trucks successfully traveled over 100,000 kilometers on two independent long-haul routes without a single safety incident while saving 20% on fuel costs. According to Bloomberg, Amazon is buying 1,000 AV truck systems from them, with a $200 million option to buy a 20% stake in the company.[12]
Kodiak has revealed that their self-driving AV trucks are now conducting commercial deliveries with the assistance of a safety driver.[13] Kodiak and Gatik are among many companies that have been concentrating on middle-mile highway routes since the last two years. TuSimple also recently revealed that its self-driving trucks transported fresh watermelons for 951 kilometers in just 14 hours, a task that would normally take 24 hours.[14]In line haul transportation, truck convoys or platooning is another application of ADHV. Some EU funded projects as ENSEMBLE focused on this use case. Truck platooning provides gains in traffic safety, fuel economy, and logistical efficiency, according to the findings of the project's demonstrations.
Automated trucks and AGVs have wide areas of applications. However, it's important to remember that using AHDV in general, but mainly in public raises a variety of challenges, which are addressed in the following section.

Conclusion

It can be observed from the analysis above, that levels 1-3 of AVs already exist in the market. Business use-cases for logistics are believed to drive Level 4 of automation. Passenger AVs can have a much higher penetration rate, though commercial AVs are getting higher attraction from the market as logistics industry provides the conditions for testing and validating such vehicles and laying down the bases for mass production and adoption. To sustain Europe's competitiveness, the European Union increased financing for joint research in the field of connected and autonomous vehicles. Based on a KPMG report, the Netherlands and Norway are among the top 3 of the most advanced countries in AVs. The introduction of AVs has the potential to dramatically transform the way mobility and transportation logistics are handled. While four use cases are tested in AWARD, the AVs produced and tested in the project can be used for other applications outside the scope of the project and thus broadening the market and usage of the technologies developed in the project.

[11] https://plus.ai/press-release/SF-Express-Selects-Self-Driving-Truck-Company-Plus-for-China-First-Commercial-Freight-Pilot-Using-Supervised-Autonomous-Trucks.html
[12] https://www.bloomberg.com/news/articles/2021-06-21/amazon-is-in-talks-to-buy-stake-in-ai-truck-driving-startup-plus?sref=LspfQlRv
[13] https://www.prnewswire.com/news-releases/self-driving-truck-startup-kodiak-robotics-expands-into-texas-and-begins-first-freight-deliveries-300897021.html
[14] https://www.cnbc.com/2021/05/19/tusimple-self-driving-trucks-saved-10-hours-on-24-hour-run.html

4.2. Market Dynamics

Market dynamics are the elements that influence product supply and demand in a market. In this part, we examine the market's trends, drivers, challenges, and opportunities.

4.2.1. Market trends

With regard to market trends, we did a preliminary analysis focusing on two main sources: (1) the DHL Logistics Trend Radar (5th Edition) and (2) the Trendmanagement expert database.

4.2.1.1. DHL Logistics Trend Radar

The DHL Logistics Trend Radar is based on over 13,000 DHL customers, partners, and employees who visit the DHL Innovation Centers every year, providing DHL experts with invaluable feedback to develop the DHL Logistics Trend Radar. The following figure shows one result focusing on 'Auto-Mobility'-related trends clustered in low, medium and high impact areas. A further classification within this figure is done by dividing trends into social & business trends as well as technology trends. In total, the DHL Logistics Trend Radar contains 29 key trends.

The most important social & business trends are:

- Supergrid Logistics
- Next-Generation Security
- Sustainable Logistics
- Logistics Marketplaces
- Future of Work
- Omnichannel Logistics

The most important technology trends identified are:

- Self-Driving Vehicles
- Artificial Intelligence
- Robotics & Automation
- Internet of Things
- Cloud & APIs
- Big Data Analytics

Figure 10: Auto-Mobility-related trends bases on the DHL Logistics Trend Radar

4.2.1.2. AWARD-related trends (Trendmanager)

Based on the Trendmanager tool (www.trendmanager.com) a trend analysis was performed. The online tool Trendmanager helps companies and project as AWARD to identify and systematically monitor the trends that are relevant for them. An interactive trend radar shows the most important trends in relation to each other. Currently 50 mega-trends, 352 macro-trends and 38052 microtrends are part of the Trendmanager tool.

The following selection on megatrends and related macro-trends is focused on logistics and automated driving topics and the trend selection was done by the project partner University of Applied Sciences Upper Austria. The trend descriptions are directly cited out of the licensed trend management tool.

Megatrends

1) Intelligent Infrastructure

Extensive technological measures are needed to overcome the challenges facing infrastructure; for example, mobility and energy supply. Advanced network technology is essential for a functioning City OS operating a smart city.
Advanced network tech is required for a functioning smart infrastructure. It includes technologies such as 5G, NFC and laser, but also energy transmission. Smart cities make use of information and communications technologies along with sensor networks to control the flow of goods, people and traffic as well as energy consumption and infrastructure utilisation.

A wide variety of mobility solutions come under the heading of Connected Mobility. People can make use of various services seamlessly. Autonomous systems are self-driving vehicles and other autonomous systems for land and air.
Energy supply, too, relies on smart infrastructure. Smart grids control the generation, consumption and storage of energy. A reliable and resilient energy system and uninterrupted access to energy are integral to modern life. The energy transition is making energy storage systems one of the greatest infrastructural challenges. Green IT is supporting energy conservation by means of suitable technologies as well as the optimisation of energy consumption and use of resources in the production, operation and recycling of technological devices.

Related Macro-Trend **Autonomous Systems:**

Description:

Autonomous vehicles that operate on land, water and in the air will fundamentally change our understanding of mobility. With the aid of sensors, such as radars, LiDAR and camera systems, vehicles can scan their environment with more accuracy than human drivers. Autonomous robots deliver goods, explore bodies of water and pick up rubbish.

Traffic management using algorithms: Traffic will fundamentally change when vehicles can communicate with one another, and artificial intelligence manages the flow of traffic. Systems that facilitate accident-free and legally safe driving already exist. Algorithms continuously calculate possible routes in transit with the aim of finding a route that is guaranteed not to cause damage. In the process, they predict other drivers' legal maneuvers in fractions of a second.

Acceptance by society: However, for the technology to make a breakthrough, it requires acceptance by society. Many people do not like relinquishing control. Plus, other drivers have to be convinced -the artificial intelligence will decide according to their moral code if, for example, an accident cannot be avoided. This code varies from region to region.

Drivers:

- **Environmental Impacts**: Heavier traffic causes substantial environmental impacts. Vehicles sit there unused for most of the day. Self-driving vehicles with environmentally friendly drives could be an alternative to vehicle ownership, especially in built-up areas. Passenger vehicles can be ordered via platforms.

- **Safety**: Human error causes accidents with health and sometimes fatal consequences. Autonomous vehicles minimise the risk. There are also economic benefits to greater road safety.

- **Human Reclamation**: In many places, urban planning is geared toward the private motor vehicle. Many people are now calling for more space for pedestrians and

cyclists with a view to improving quality of life and reclaiming the streets. In the countryside, vehicle services could make vehicle ownership redundant.

Challenges & Opportunities:

- **Transportation & Mobility Challenge**: Technical progress and society's acceptance of autonomous systems have not come far enough yet. Many people have concerns about trusting a machine with their safety.
- **Transportation & Mobility Opportunity**: Autonomous vehicles reach their destination faster and safer. Considerable cost savings can be made due to the lack of a human operator. Vehicle makers become all-in-one providers.
- **Energy & Environment Challenge**: The development of autonomous electric vehicles is only a stepping stone because the manufacture of batteries and electricity generation also have adverse impacts on the environment.
- **Energy & Environment Opportunity**: Free-flowing traffic with environmentally friendly fleets reduces pollutant emissions. At the same time, the vehicles could serve as energy reservoirs.

2) Industry & Logistics 4.0

Industry 4.0 is the name of a megatrend for the comprehensive digitalisation of industrial production in order to better equip it for the future. The term goes back to the German government's research union and a project of the same name in the government's high-tech strategy; it also refers to a research platform. Industrial production is to be dovetailed with modern information and communication technology. The technical basis for this is intelligent and digitally networked systems. With their help, largely self-organised production should become possible: People, machines, plants, logistics and products communicate and cooperate directly with each other in Industry 4.0. Networking should make it possible to optimise not just one production step, but an entire value chain. The network should also include all phases of the product's life cycle - from the idea of a product through development, production, use and maintenance to recycling.
Logistics 4.0 describes the fourth industrial revolution, referring to the cross-sectional function of logistics in operational service provision. A variation of the term can be found in the English-language translation, since in the English-speaking world the term Smart Factory or Smart Manufacturing is more commonly used as a synonym. The term 4.0 is integrated into the rapidly developing world of digitalisation and represents the successor to the three previous industrial revolutions.

Related Macro-Trend **Truck Platooning:**

Truck Platooning: With truck platooning, two or more vehicles drive safely behind each other at short intervals. Driving as a networked truck convoy (platoon) contributes to reducing CO2 emissions and increasing road safety.
Electronically linked truck convoys open up new opportunities for more economical and efficient driving in road freight transport: slipstream driving enables fuel savings of up to 10% for the entire platoon. CO2 emissions are also reduced accordingly.

At the same time, the connection of the vehicles via the electronic drawbar can increase road safety in road freight transport. This is because the control systems of the following vehicles react reliably and faster than any human being to the driving manoeuvres of the lead vehicle.

Related Macro-Trend **Digital Twin**:

The concept of the digital twin pursues the approach of mirroring products, objects, systems and processes on a digital level. For this purpose, the forces acting on the component, such as temperature, pressure, tension, vibration and friction, are recorded, transmitted and processed in real time using sensors. The permanent comparison of the real component and the digital copy results in an increasingly realistic simulation of reality. With the support of machine learning, component failure can be precisely predicted; the maintenance and servicing intervals can then be adjusted as needed. In addition, the collected data is used to detect production errors at an early stage and to further optimise systems and machines.

3) Sustainability

The concept of sustainability now has an influence on a wide variety of global debates. The entire economy, power generation, production, agriculture and consumer goods sectors are scrutinized for their degree of sustainability.
Consumer decisions are now best made from an ethical perspective. Products and retailers who have signed up to such standards are proving highly popular among consumers.
Sustainable work is being vehicleried out at the supposed end of the product life cycle too: the circular economy is the term now used to describe the reuse of unused objects and waste. It will help to relieve the problem of disposal, at least partly. Ideally, no waste at all will be produced in private households thanks to the zero-waste concept.
Industry is also increasingly investing in ecologically safe production processes. Conserving resources and reducing emissions are now a priority. The “harvesting” of ambient heat and kinetic energy could, in future, create small amounts of energy to power small devices.
Food will also be produced while sparing our resources in order to guarantee sustainable and comprehensive supplies. Decentralized vertical farming concepts and a smart form of agriculture are already making a contribution to this.

Related Macro-Trend **Jobs 4.0**:

Taking a look at the current reporting on the subject of trucks and professional drivers, the same headlines again and again. It is about autonomous driving, digitalisation, gigaliners and the future of truck drivers. But what is behind all these expressions and how do they influence the future of truck drivers and the logistics industry?

4) Information Communication Technology

Big Data, Artificial Intelligence and Co. now also enable a hyper-personalised approach by analysing customer data on the net - with all the open questions and concerns regarding privacy, data protection and cybersecurity surrounding digital identities. Digital disruption has

become a buzzword and new technologies and digital innovators from other industries are turning the world of commerce upside down.

Related Macro-Trend **Cooperative Systems:**

Definition of a harmonised approach for the development and evaluation of cooperative systems, including the assessment of strategies for their deployment.

On-board driver assistance coupled with two-way communication between vehicles, with and between road infrastructure can help drivers better control their vehicle and hence have positive effects in terms of safety and traffic efficiency. Vehicles can also function as sensors reporting weather and road conditions including incidents, to be used for high-quality information services.

Enabling precisely this sort of interaction, this is where so-called "cooperative systems" come into play. The ITS Action Plan looks to further consolidate R&D results and to promote coordinated deployment.

5) Logistics

Logistics is an interdisciplinary science as well as a branch of industry or an operational function in organizations that deal with the planning, control, optimization and execution of flows of goods, information and people. Particularly in the automotive and space and air vehicle manufacturing industries, logisticians are increasingly taking over outsourced production stages of the pre-integration of assemblies (exhaust, axles, seats, wiring harnesses, loading devices, tanks). A special feature is usually the delivery to the production line not only just-in-time, but also just-in-sequence for flexible production.

Related Macro-Trend **Hyper Connected Logistics Systems**

Hyperconnected Logistics Systems investigates human logistics technology systems and aims at the (further) development of methods and tools for designing these systems. The focus is on the integrative consideration of the topics 'Digital Supply Chain, 'Traffic Telematics (ITS) and 'Automated Driving.

Related Macro-Trend **Warehouse robots**

Robots in the warehouse - these are automatic systems and special software for the control and handling of goods. However, digitalisation and the advent of Industry 4.0 have led to major advances in robotics and automation, which can be seen in every link of the supply chain. Robotisation of the warehouse is based on the following premises: Load units must be standardised, regardless of whether it is a pallet, a box or any other type of container.

Related Macro-Trend **Smart Container**

Containers are the most effective way to transport materials through a manufacturing environment and will be the key to achieving Smart Materials — a core tenet of the IoT initiative for manufacturing, Industry 4.0. With self-directed containers that provide real-time location visibility, you'll never lose another container or be short of crucial material lineside again. Smart Container module works together with its Pick, Replenishment and Work Instructions modules for a complete material flow management solution.

With regard to market trends, we did a preliminary analysis focusing on two main sources: (1) the DHL Logistics Trend Radar (5th Edition) and (2) the Trendmanagement expert database. Both trend analysis tools provided similar aspects. To sum it up also with regard to the AWARD project, self-driving vehicles combined with intelligent infrastructure and big data as well as sustainable logistics seem to be core trends.

4.2.2. Market drivers

We have compiled primary and secondary data to find the drivers and enablers of automated heavy-duty vehicles in logistic. A workshop was conducted in November 2021 with the the participation of some consortium partners representing different stakeholder groups such as manufacturers, research institutes, consultancy firms, technology providers, associations, end users like representative of ports, airports and industrial companies to discuss drivers, barrier and opportunities to AHDVs in logistics. It consisted of two parts; a survey using polls to measure the sentiments of participants about the market and a team work to collect more detailed opinions. Mentimeter and Metroretro platforms were used for the first and second accordingly.
The results of the workshop were combined with the secondary data collected through desktop research of academic publications and online resources to reach a comprehensive conclusion about the most influential drivers toward automated HDVs in logistics.
The drivers have been classified into five categories: technical, social, economic, environmental, and legal as it can be seen in Figure … and detailed in the following subsections.

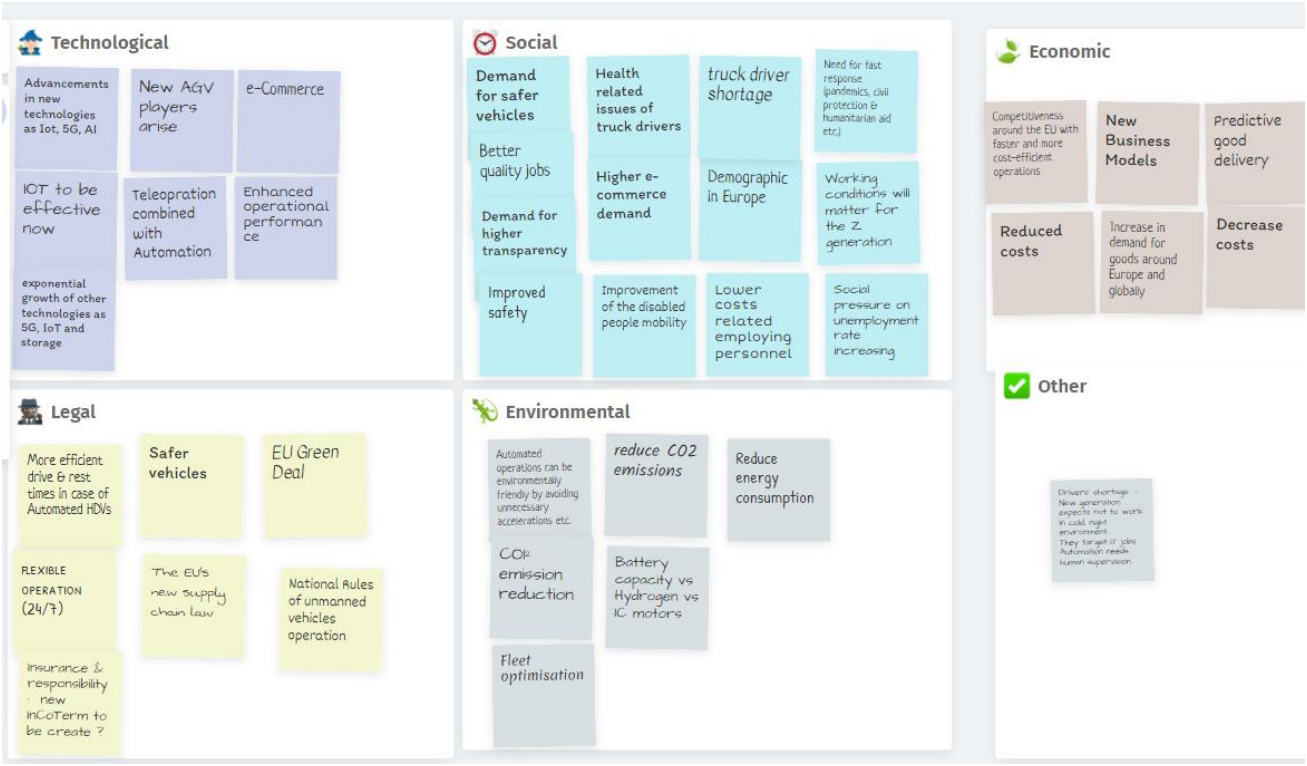

Figure 11: A screenshot of the group work on the drivers of HDVs automation in logistics

4.2.2.1. Technological drivers

The technology underlying self-driving vehicles is advancing at a rapid rate. Self-driving vehicles navigate using artificial intelligence (AI), which requires a huge amount of data, IoT and sensors to collect the data, high speed connection and network to communicate with other devices, affordable storage and so on. The exponential growth in these disruptive technologies will further drive innovation and advancements in AHDV for logistics. In answer to the question, "Which technological developments enable automation in real logistics?" participants ranked AI, machine and computer vision, geo-localization, big data and advancements in radars as the five most relevant technological drivers for autonomous vehicles in logistics.

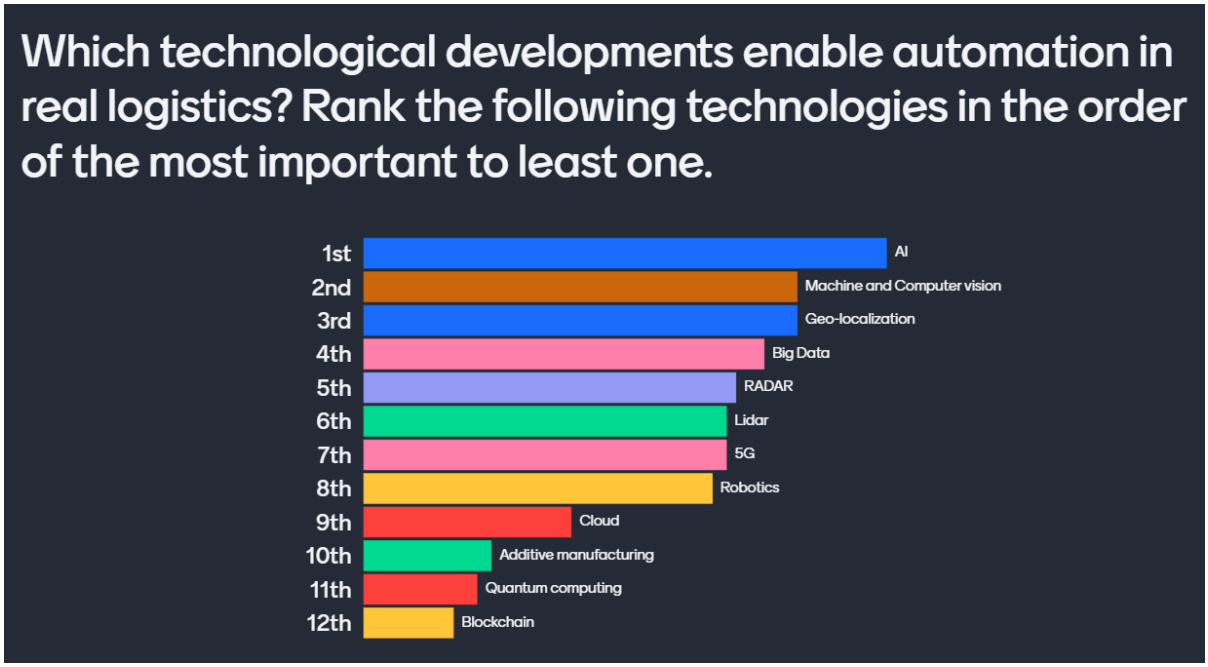

Figure 12: important technological enablers of automation in real logistics

The rise in new AGV players, technological advancements that make e-commerce more efficient and increase the demand for online shopping, enhanced operational performance and the combination of teleoperation with automation are considered as other drivers that are directly or indirectly related to the advancements in technologies that ultimately drives automation of HDVs in logistics.

A self-driving vehicle on the road should use sensors to detect objects and ADAS software and AI algorithms to respond swiftly and correctly. The core of a smart vehicle is artificial intelligence. However, there are still skepticisms regarding the usage of AI. End users are still apprehensive of AI-based judgments, especially when it comes to critical tasks like steering a vehicle. Thus, the fast pace of technological advancements might soon enable autonomous vehicles to drive on confined and public areas, but acceptance is crucial for mass adoption.

4.2.2.2. Economic incentive

The operational expenditures of the trucking business in the United States have climbed 18 percent since 2010, according to the American Transportation Research Institute (ATRI)[15]. This shift is attributable to a general increased trend in permille prices across a variety of locations. Between 2010 and 2018, the cost of Truck/Trailer Payments (a statistic for the per-mile cost of road haulage) climbed by 44 percent, from $0.184 per mile ($0.30 per kilometer) to $0.265 per mile ($0.43 per kilometer). The situation is not different in Europe. According to experts from Transport Intelligence (TI) and Upply, average rates in European road transport climbed by 3.2 percent year over year in Q1 2021. The average rate climbed by 0.4 percent over the previous quarter.[16] Increasing costs are creating more potential for disruption; freight companies and major transport operators will look for innovative ways to increase efficiencies

[15] https://aktrucks.org/wp-content/uploads/2020/01/doc01315520200106124920.pdf
[16] https://trans.info/en/european-road-transport-rates-rise-further-see-where-it-has-been-more-severe-250003

and save costs. Apart from costs per mile, financial losses due to human errors as truck crashes are also high – when they happen, fleet owners have to not only pay for vehicle repairs but also loss of consignment, as well as driver downtime and depreciation in a vehicle's value.

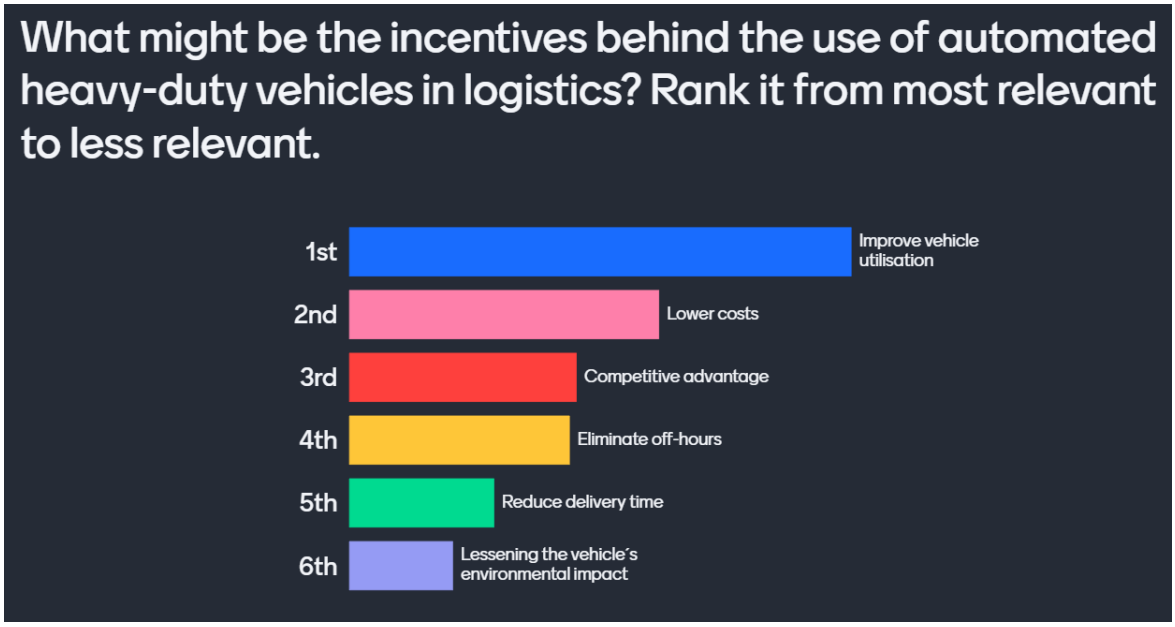

Figure 13: incentives behind the use of automated heavy-duty vehicles in logistics

In response to the question "What might be the incentive behind the use of automated heavy-duty vehicles in logistics?", participants ranked improved vehicle utilization, lower costs, elimination of off-hours and reduced delivery time as the most relevant drivers of AHDVs by logistic companies. It is obvious that economic incentives are most of the time the main drivers of innovation in private firms. The rise in competition around the EU with faster and more cost-efficient operations pushes the companies to innovate in order to gain competitive advantage.

4.2.2.3. Social drivers

Two major social drivers of AHDVs are: e-commerce growth, EU demographic changes and shortage of truck drivers, and the increase demand for safer and healthier conditions for drivers and society.

E-commerce growth: Customers' expectations for fast shipment and delivery throughout the world will rise as their shopping patterns move toward online purchases. According to the 2021 European E-commerce report, prominent webshops in the EU-27 had a 13 percent rise in online traffic in 2020 compared to 2019. Web traffic increased by 8% in the first six months of 2021 compared to the same period in 2020, and by 18% compared to the same period in pre-COVID 2019. Furthermore, the number of shipping alternatives provided by webshops has rapidly expanded over the last decade, notably in Europe. Aside from home delivery, 61 percent of EU-27 e-stores now give the option of picking up an online purchase at their

store(s)/outlet(s), and 56 percent of e-stores also offer the option of delivering goods to logistics service provider pick-up sites.[17]
China and the US, the two main e-commerce market shareholders also noticed a high increase in e-commerce demand. China is the world's fastest-growing and largest e-commerce market, with roughly 854 million internet users and a volume of 1.94 trillion USD of e-commerce in 2019. This is a 27 percent growth year over year and a fourth of China's overall retail sales volume.[18]

Changing demographics and shortage of truck drivers: Aging population, increase in retirements, elimination of obligatory military services that forced people to learn driving HDVs might be some reasons for shortage of truck drivers in the EU. Some other reasons are industry wage concerns, poor working conditions, and health issues for instance have left the UK with the shortage almost 100,000 HGV drivers and the EU-27 with a shortage of 400,000 drivers. The sector has seen a shortage of fresh workers, with the position being viewed as an unappealing option. The epidemic has strained the supply system, since the pool of truck drivers has shrunk and demand for transportation has increased, mainly due to increase in e-commerce as explained before. According to a report published by World Economic Form in march 2021 on autonomous trucks, there are a number of different factors causing the trucking industry to suffer a shortage of drivers as detailed in Figure below.

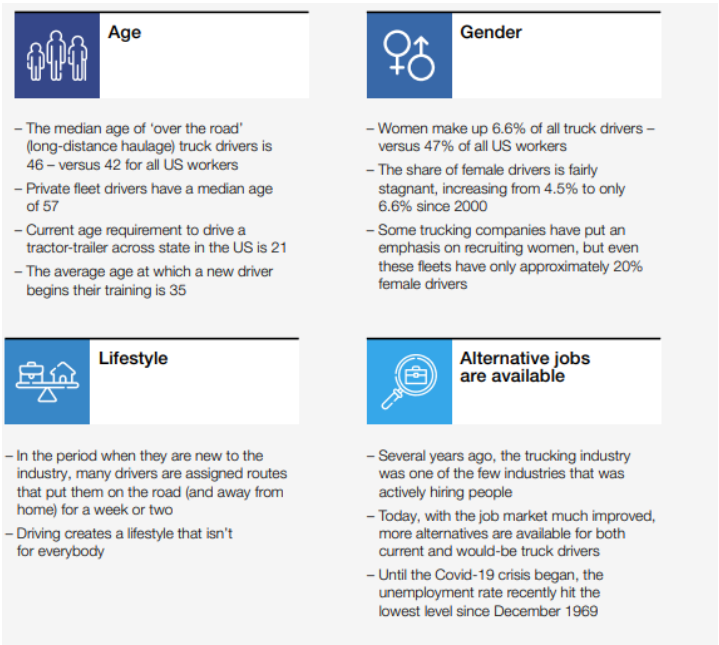

Figure 14: Main factors of trucking industry driver shortage

Aligned with the finding from the literature, the workshop participants highlighted demand for higher safety, truck driver health issues, the importance of working condition for Z generation, demographic changes and the shortage of truck drivers, need for timely response to the natural disasters like pandemic, humanitarian aid, civil protection, and the demand for higher equality and diversity as increasing the positions for disabled people and women as some social drivers of AHDVs.

[17] https://ecommerce-europe.eu/wp-content/uploads/2021/09/2021-European-E-commerce-Report-LIGHT-VERSION.pdf
[18] https://www.sinorbis.com/china-e-commerce

4.2.2.4. Legal and political drivers

While regulation is more a barrier rather than a driver to connected and automated vehicles, the EU policy makers and auto industry push for a fast and successful deployment of these technologies across Europe. Participants of the workshop believe that initiatives as EU-Green Deal, the EU´s new supply chain law, and the demand for safer vehicles can drive innovation in logistics and enable advancements in AHDVs. Moreover, higher pressure on the working conditions of the drivers by the EU authorities and the concerns about the resting time, health issues, and improved safety of drivers forces companies to provide more facilities and comfort to drivers by adopting new technologies.
As discussed in the next sub-section, the EU's policy focuses on reducing vehiclebon emissions in transportation. For example, the European Commission's 2018 plan aims to set the stage for a transition to 'net-zero' greenhouse gas emissions across the EU by 2050. It emphasizes the necessity of converting to low-vehiclebon modes and zero-emission vehicles, emphasizes the essential role of electrification and renewable energy sources, and pushes for operational efficiency gains in the transportation sector. By establishing enforceable norms, EU law directly targets the environmental and health implications of transportation. These include emission restrictions for automobiles, vans, trucks, and buses, as well as noise maps and noise management action plans for significant transportation facilities such as airports. These regulations foster a more sustainable and green moods of transportation and logistics. As such, companies are forced to innovate and utilize new technologies.

4.2.2.5. Environmental drivers

In the EU, transportation accounts for one-third of total final energy use. Oil provides the majority of this energy. As a result, transportation accounts for a significant portion of the EU's greenhouse gas emissions and is a significant contributor to climate change. Transport, particularly in cities, continues to be a substantial source of air pollution. Particulate matter (PM) and nitrogen dioxide (NO_2) are air pollutants that impair human health and the environment. Logistic and transport accounts for a high percentage of these pollutants generation and thus endangering the human health and environment. In the EU, approximately 27.3% of greenhouse gas emissions are produced by light and heavy-duty vehicle.

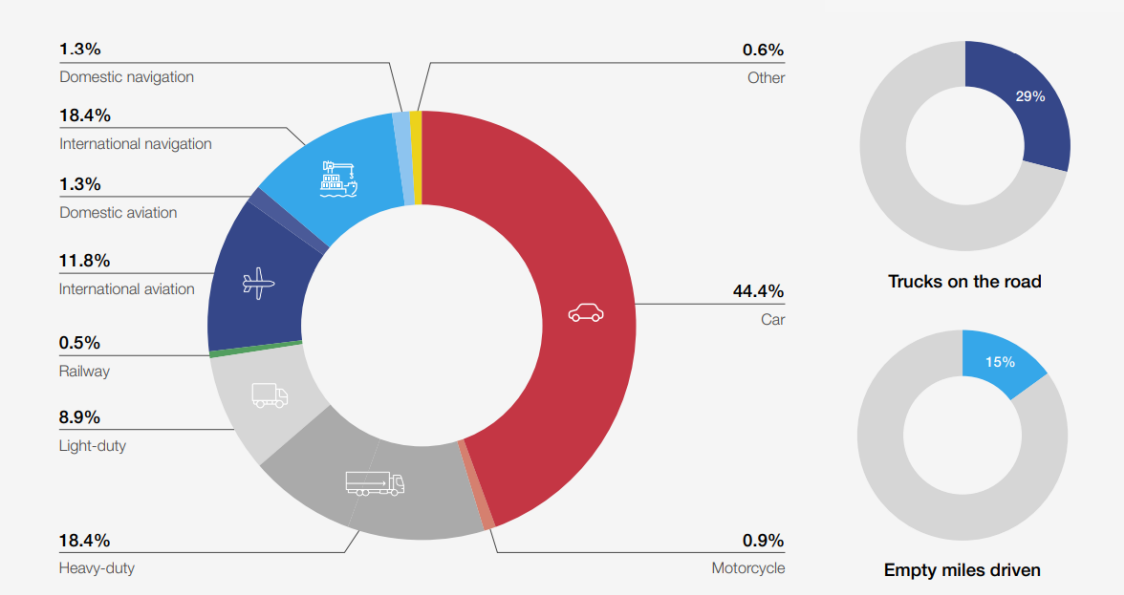

Figure 15: share of GHGs in EU transport sector[19]

Moreover, according to the European Environment Agency, the logistics industry produces 25% of CO2 emissions in Spain, a statistic that appears to be rising over time as the number of small and major retailers engage in e-commerce.[20]

Changing our fleet of vehicles to a more ecologically friendly fleet is one approach for reducing the environmental effect of logistics and transportation. Electric vehicles are the finest alternative today for not sacrificing efficiency while moving our goods while also raising awareness of environmental conservation. Furthermore, we may help the environment by using software that allows us to optimize our routes and mark the automation and elimination of manual operations as a priority. As such, environmental concerns drive companies to use technologies to tackle issues related to CO2 and green gas emissions.

In summary, high competition, in addition to low vehicle utilization rates, regulations, rising fuel prices, and a growing driver svehiclecity, are hindering the trucking sector from satisfying the increased demand brought on by the e-commerce boom. As a result, both traditional sector players and newcomers are looking to automated technology for new answers. Automation would help trucking operators to manage a variety of everyday difficulties more easily by boosting fleet utilization and driver capabilities, as well as enhancing fuel savings.

4.2.3. Barriers

Automated HDV operations in logistics can create new opportunities for the society, trade and transport operators by bringing goods to the customers more efficiently and at a lower cost. However, as a result of each new technology, a few barriers were identified. In order to make the transition to automated vehicles in logistics, safety, cyber-security and other issues will have to be discussed during the course of the project.

It's important to note that a few barriers identified are expected to become opportunities as technology get more mature and users' acceptance improves. Such a barrier is safety where

[19] https://www.weforum.org/whitepapers/autonomous-trucks-an-opportunity-to-make-road-freight-safer-cleaner-and-more-efficient

[20] https://www.bytemaster.es/en/articulo/como-impacta-el-medio-ambiente-en-el-sector-logistico/

the majority of partners expect automation to become an opportunity instead of a barrier in the next 10 years.
Additionally, the literature indicates that a few barriers to automation exist such as the following ones:

- **Technological barriers**: Technology is not still mature for automation to become available in non-protected environments, especially when infrastructure is not suitable (Roland Berger, 2016)
- **Security** (McKinsey&Company, 2016a)
- **Infrastructure** (Roland Berger, 2016)
- **Regulatory and legislation:** In the EU, the Treaty of Rome requires that a driver is responsible at all times for a vehicle on public roads, which creates uncertainties regarding the usage of AVs that effectively hinder their adoption (van Dijke & van Schijndel, 2012). Though, the usage of AVs in logistics is subject to fewer laws and regulations as the vehicle is used in a confined area most of the time.
  Also, lack of criteria for verifying whether a system is safe enough to be licensed. The British Standards Institution (BSI) has issued a Publicly Available Specification (PAS), "Assuring Safety of Automated Vehicle Trials and Testing," PAS 1881, to aid in the promotion of safe public trials and development testing of automated vehicles such as driverless vehicles.
    - **Liability:** It is not clear who is to be held accountable in the event of an accident. Generally, it is expected that liability will shift away from drivers to manufacturers as automation advances. However, before vehicles with automation Level 4 become common, many vehicles will be controlled in part by both the human driver and the automation system. Though, it is argued that the liability issue would be less severe when transporting goods rather than people.
- **Ethics and social:** It is sometimes stated that the judgments made by AVs in cases where an accident is unavoidable may be challenged in court. There is a discussion over how to deal with the ethical concerns of developing AVs because there is no clear answer (Gerdes & Thornton, 2015).

Currently, the employment of AVs in a regulated and private outdoor setting is more appropriate since there is considerably less ambiguity, fewer restrictions apply, the liability problem is not as complex, and an efficiency-driven business rationale applies.
The AWARD partners consisting of OEMs, research institutes, associations etc. ranked the following predefined barriers in order of importance as presented in Figure 3. Safety concerns is the most important barrier according to the 16 partners participating at the workshop, followed by high manufacturing costs, lack of digital infrastructure and restructuring of employment (new skills required etc.). The least important barriers included data privacy and market uptake. It was noted that the market is quite ready to adopt automated HDVs in logistics.

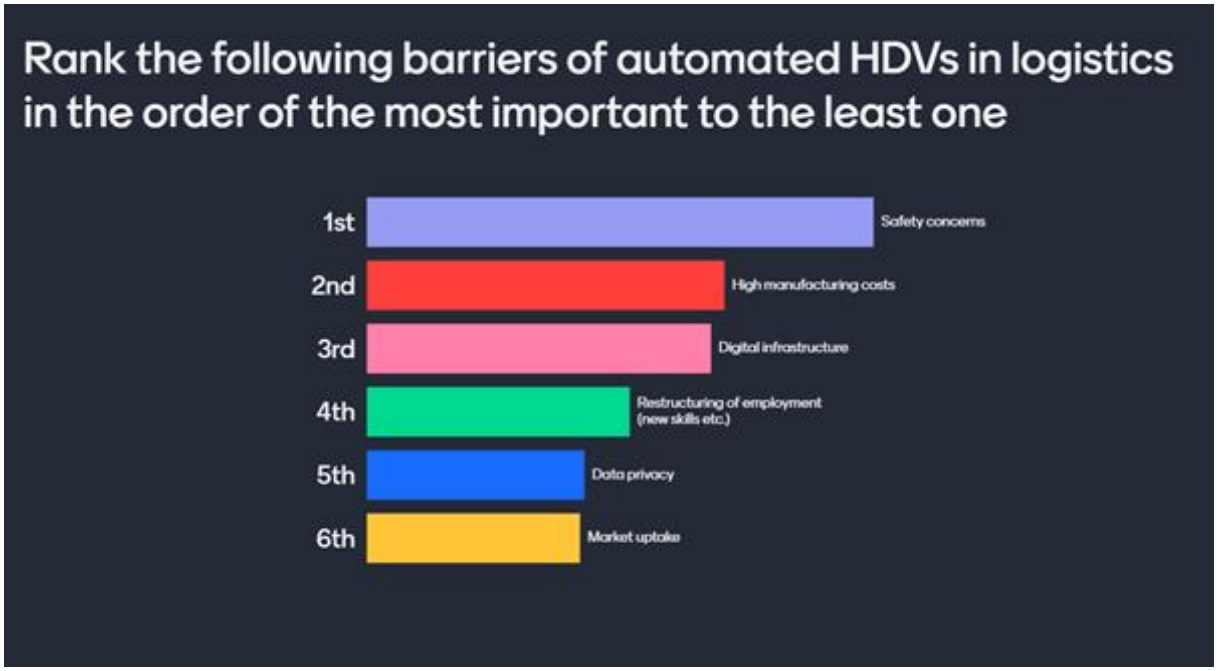

Figure 16: Barriers of automated HDVs in logistics, importance ranking by AWARD partners

The AWARD partners identified the barriers of automation in logistics using an online survey tool. Those included safety, costs, infrastructure, user acceptance, legal, technical etc. as in Figure 12.

Figure 17: Barriers identified by the AWARD partners

4.2.4. Opportunities

The opportunities of automation in logistics are well known from both research and industry sides.

The main opportunities of automated HDVs in logistics include "*decreasing transport costs, higher safety, efficient use of resources, tackling the lack of drivers and an overall more efficient*

service performance" (Neuweiler, L., & Riedel, P. V., 2017). A more customer-focused supply chain avoiding bottlenecks such as driver rest time and human caused accidents can increase efficiency and add value to the logistics industry.
Roland Berger, 2016 indicates a few opportunities from the automation of HDVs in logistics:

- Increased safety: Automation will eliminate human-related mistakes and accidents.
- Decreased transportation costs: More economic transport assignments and less costs for the transport operators and the consumers
- Decreased fuel consumption: Optimal driving behavior which can result to less fuel consumption due to high accelerations and decelerations
- Improved truck utilization: The truck can be driven for more hours while the driver has a maximum driving time and needs to rest
- Better road utilization
- Better driver utilization

DHL, 2014 includes Environment & Emission as an opportunity from automation of HDVs.

The AWARD partners ranked the potential cost reduction – efficiency gains as the most important opportunity from automation. Restructuring of employment and road safety followed.

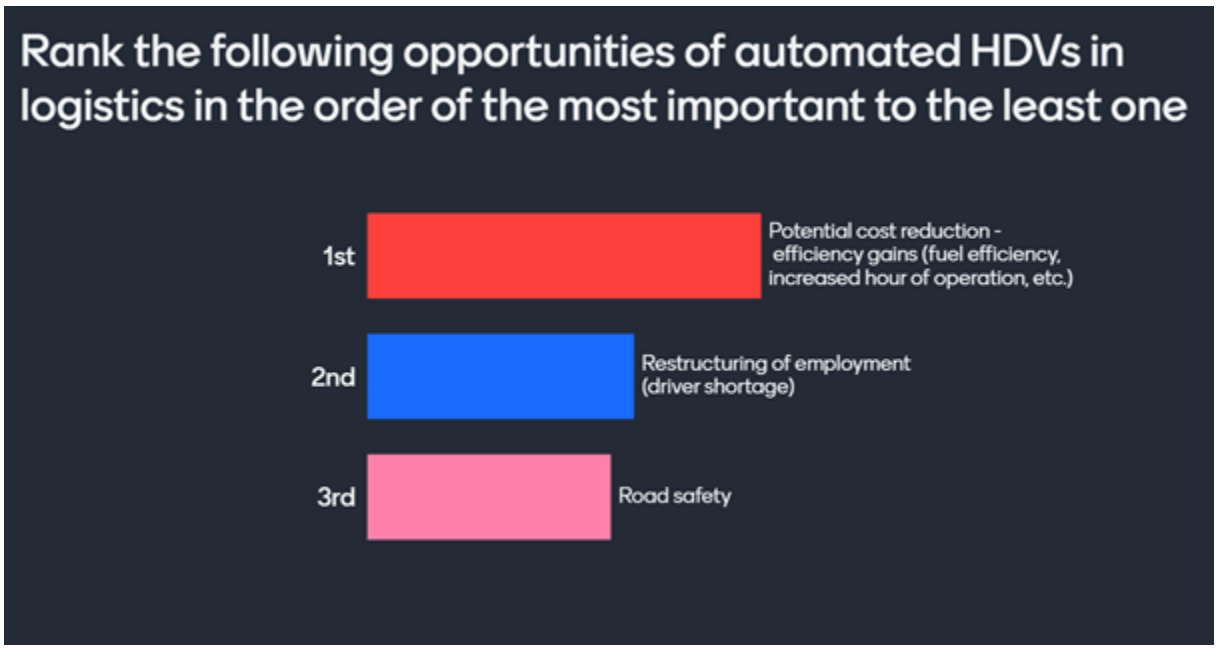

Figure 18: Opportunities of automated HDVs in logistics - ranking by importance - AWARD partners

In Figure 15 and Figure 16, the AWARD partners were asked to reply on the timeline of safety and employment structuring to be opportunities instead of barriers. In both cases, the majority of the respondents indicated that in 10 years, technology will make it possible for automated HDVs to become safer than the current ones and that automation can benefit operators on the employment issues such as driver shortage.

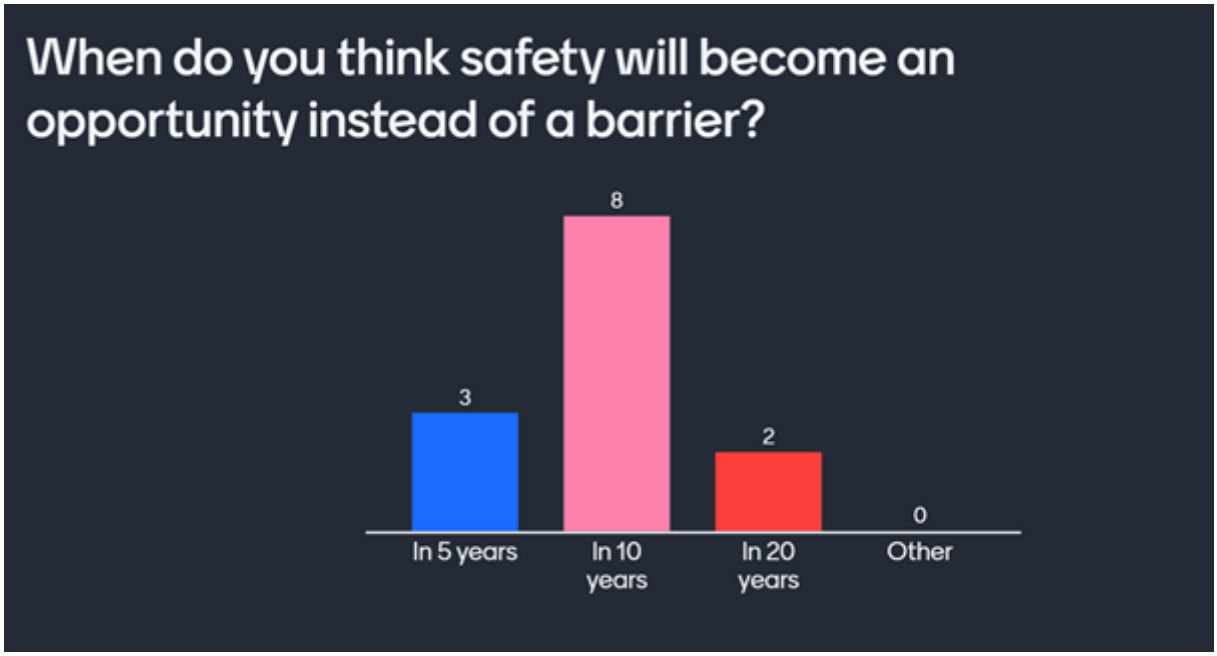

Figure 19: Safety - transition from a barrier to an opportunity

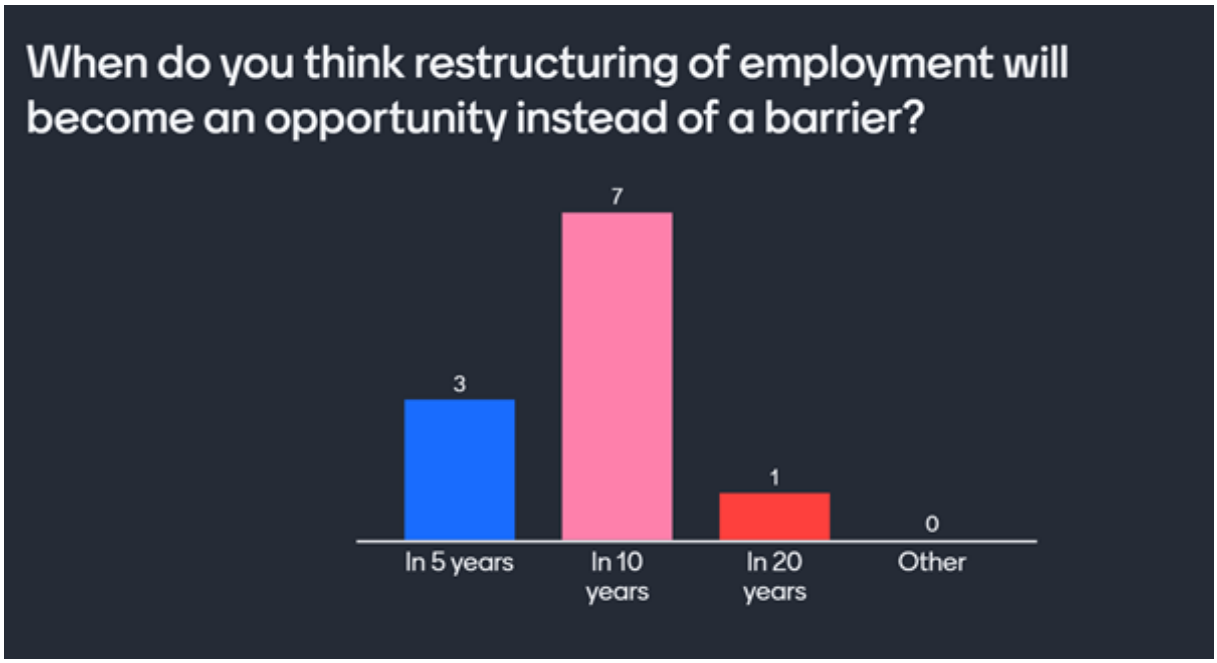

Figure 20: Restructuring of employment - transition from a barrier to an opportunity

4.3. Market size and forecasts

Only limited publications exist to date on the economic developments of the vehicle automation technologies and their impact on the different segments of the logistics industry. To perform a first market sizing exercise, the main source considered to assess the projected market value, being at global or regional levels, is adapted from a market study ordered by the UK Centre for Connected and Autonomous Vehicles. This market forecast was produced recently, taking into account the latest trends observed, as the relatively slower rollout of connected and automated vehicles than anticipated still a few years ago. Additionally, the hypothesis taken to build up this market forecast are aligned with the projected evolution of

the segmentation of the market by level of vehicle autonomy presented in the previous section (4.1.1.).

4.3.1. Global

As we discussed in the previous section (4.1.2. Market segmentation by vehicle type), the market can be segmented into passenger and commercial vehicles based on vehicle type. When we talk about autonomous vehicles, another layer of the market should be added and is composed by the technologies that enable autonomy. If we consider the first major method to achieve AV actions discussed in the introduction, namely the method that relies on both V2V and V2I communications technologies, on-vehicle components are sustained by technologies or areas that support AVs implementation (i.e., parking sensors, reversing cameras included in the infrastructure). However, the technologies that are not fitted in AVs are not integrated in our market sizing at this stage, and only intra-vehicles technologies are included in the scope of this section.

The UK Centre for Connected and Autonomous Vehicles ordered a report produced over the February 2019-February 2020 period, with the objective to identify the potential of the development of the AVs [21].

The global market for AVs (Level 3 or above) and Connected and Autonomous Vehicles (CAVs) technologies should reach about €741bn in 2035, taking into account a rapid technology development and a moderate global CAV update (15% of total annual global vehicle sales and 9% of total HGVs sales in 2035). The market uptake will accelerate exponentially from 2030 onwards. However, the global sales should not exceed €19bn in 2025 and 139bn in 2030.

The CAVs technologies (on-vehicle components) are expected to contribute about 15% of the global CAV market.

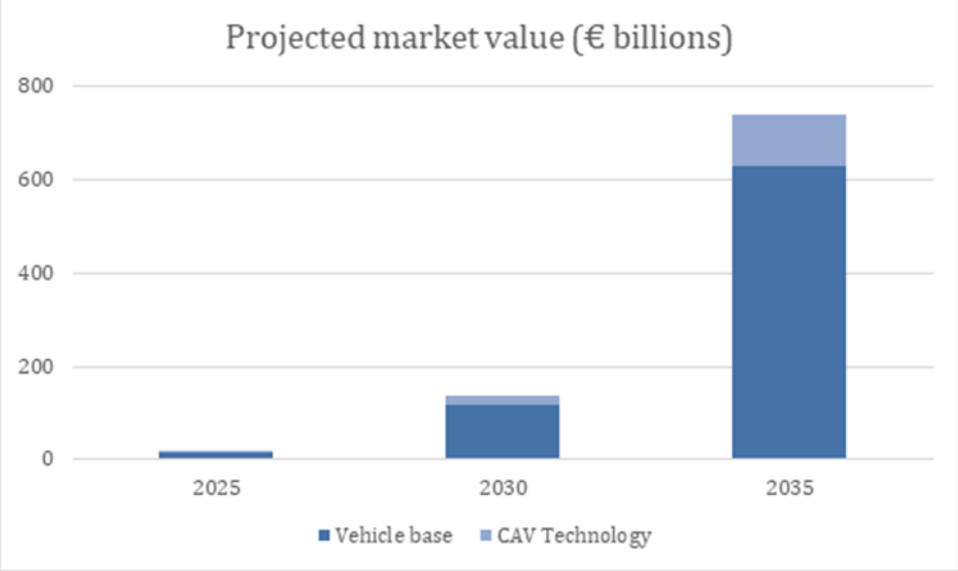

Figure 21: The projected market value for CAV

21 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/919260/connected-places-catapult-market-forecast-for-connected-and-autonomous-vehicles.pdf

Of course, these numbers on the global market size are subject to many uncertainties, including the uptake rates across different markets, or the evolution of the costs of the different technologies. In this sense, estimates presented here are quite conservative compared to other analysis in which the global CAV market could reach over USD 550bn by 2026[22] (about €491bn). This more conservative view also reflects a slower CAV penetration in certain regions, and especially in Asia-Pacific, where a certain lag for the adoption of the Level 3 and Level 4 is still expected in the existing literature.

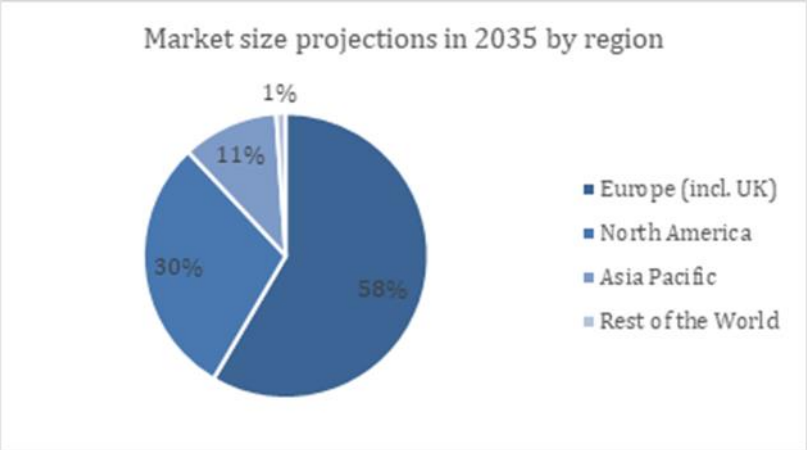

Figure 22: Global vehicle sales segmentation[23]

In 2035, commercial freight vehicles (vans and HGVs) should take a limited share of the total CAV market. According to the assumptions from the UK Centre for Connected and Autonomous Vehicles analysis, vans will correspond to the second largest vehicle sector, corresponding to about 20% of all CAVs sold in 2035, while the HGVs share should not exceed 3.1%.

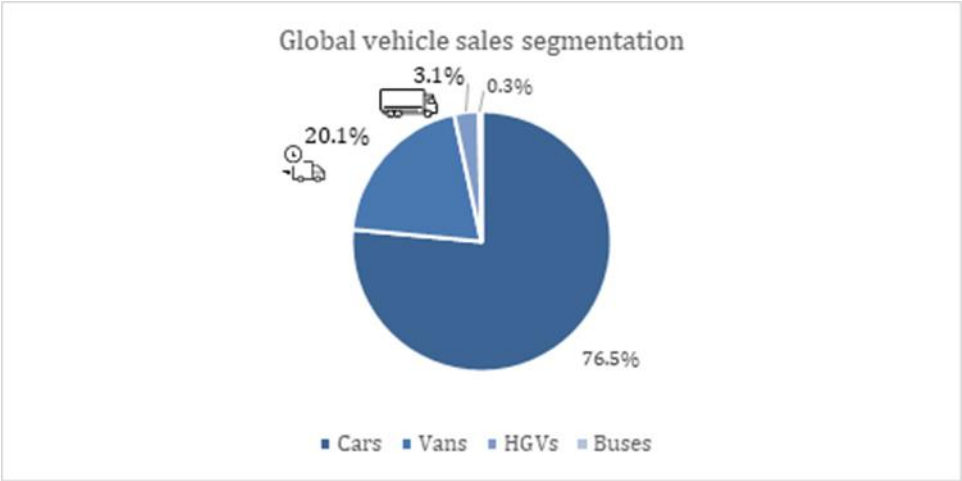

Figure 23: Global vehicle sales segmentation[24]

[22] Allied Market Research (2018) - https://www.alliedmarketresearch.com/autonomous-vehicle-market
[23] Allied Market Research (2018) - https://www.alliedmarketresearch.com/autonomous-vehicle-market
[24] Allied Market Research (2018) - https://www.alliedmarketresearch.com/autonomous-vehicle-market

4.3.2. Europe

As highlighted in the previous section, Europe is expected to be leading in terms of adoption of CAVs (base vehicles and attached technology). The predicted trend for Europe is ahead of the global average in terms of market uptake, and in this sense, the European CAV market (including UK) could represent up to 58% of the global market in 2035. The factors explaining this prominent position are mainly linked with the presence of multiple large vehicle manufacturers with a premium offering and suppliers of additional vehicle components, but also a relatively early emergence of testing and regulatory landscape.
This enthusiastic vision of a European continent leading the market for automated vehicles could be reverted quickly, and especially if we consider the addressable market included in AWARD, which is quite limited compared to the global market. Connected and automated heavy-duty vehicles in real logistics operations are, as we have seen previously, a limited portion of the total automated vehicles expected to be sold in the coming years. Rapid evolution in the readiness of the market in the different regions, especially in terms of regulatory environment and capacities to run large-scale tests, could reshuffle the existing expectation of an AV market led by the European continent.

4.3.3. TAM, SAM, SOM

The projected market value presented in the previous sections provides with an overall idea of the Total Addressable Market for automated vehicles. The Serviceable Addressable Market (SAM) is limited by AWARD's four use-cases: (1) hub-to-hub, involving vehicles used forfirst-mile delivery, (2) port and (3) airport trucks, and (4) forklifts operating both in indoor and outdoor confined area. Additionally, the serviceable addressable market for this project primarily targets the European market.

Port:
Europe is one of the densest port regions worldwide with over 1 200 commercial seaports operating along about 70 000 kilometers of coasts (including UK).
The Netherlands is the leading maritime country in Europe by gross weight of seaborne freight handled in all ports , while the city of Rotterdam is leading the ranking of the main seaports in Europe. Antwerp, Hamburg, Piraeus, Valencia, Algeciras, Bremerhaven, Barcelona, Gioia Tauro, and Le Havre completed the top 10 in 2019.

In 2020, according to Eurostat data, around 3.3 billion tons of goods transited through European ports (EU27), a volume decreasing by 7.3% from the pre-pandemic data. An estimated 250 million containers are handled per year. The yearly European market for Yard truck (AWARD addressable market) is 1 300 vehicles (i.e., 17% of world yard tractor market).

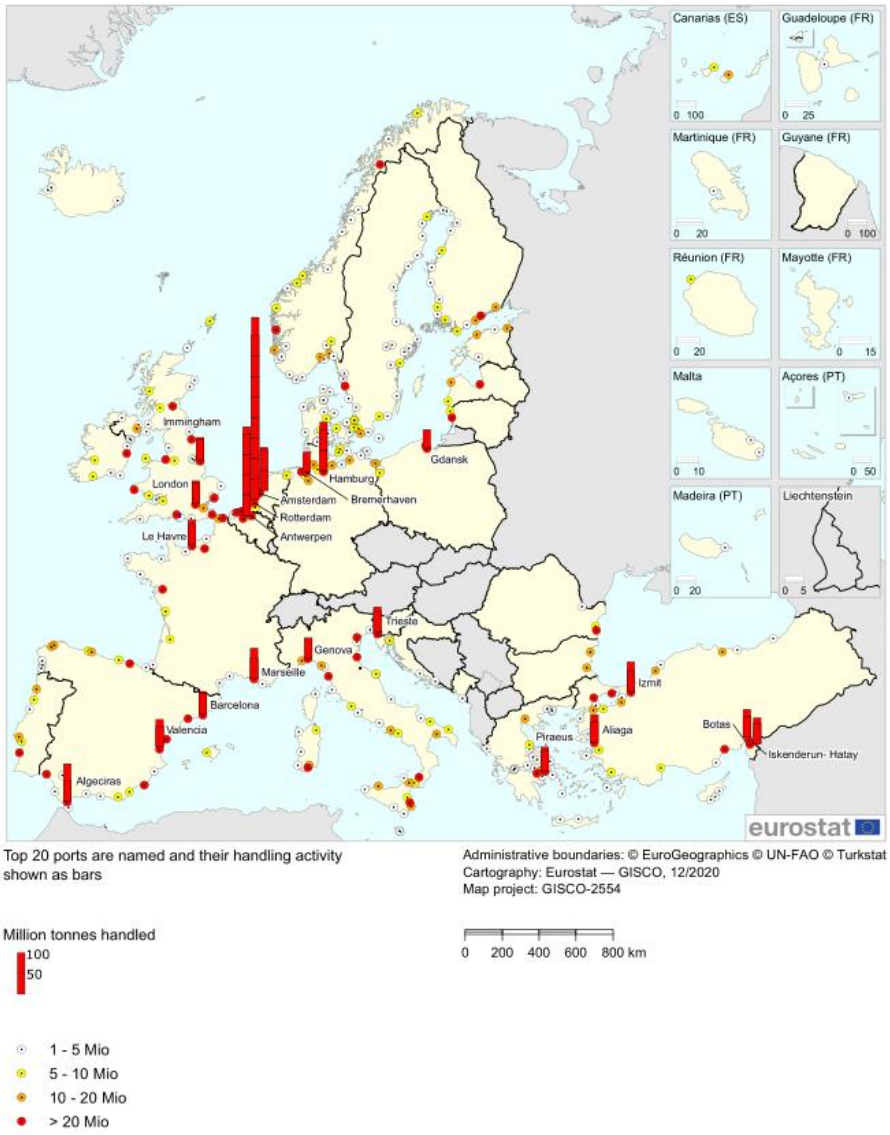

Figure 24: Main vehiclego ports by gross weight of freight handled, 2019

Airport:

AWARD use case focus on the demonstration of an autonomous baggage tractor transporting goods in indoor and outdoor environments. Our serviceable market therefore encompasses transport of both cargo and mail loaded in aircrafts, and luggage.

If we look at pre-pandemic data, 1 034 million people travelled by air in the European Union in 2019, and about 13.7 million tons of freight and mail were loaded and unloaded this same year according to Eurostat data.

Paris Charles de Gaulle became the main European airport for freight and mail. This airport also recorded the highest number of air passengers in 2019. Amsterdam Schiphol and Frankfurt-am-Main complete the top 3, both in terms of passenger transported and freight and mail handled.

The European Union (EU27) counted 298 airports carrying at least 15 000 passengers annually.

Table 4: Number of airports by number of passengers caried, Eurostat 2019

> 10 million	5 to 10 million	1 to 5 million	500 000 to 1 million	100 000 to 500 000	15 000 to 100 000

Hub-to-hub:

Real-logistics operations encompass many different elements, one of them being the transportation of completed goods from a factory to a distribution center or warehouse. These operations can be defined as "first mile delivery". For retailers, first mile delivery operations are the transportation of manufactured goods from a supplier's warehouse to the retailer's distribution center.

In the past decades, production, distribution and logistics operations in Europe happened in a quite dense trading area condensing most of the activities, the so-called "Blue Banana". This logistics corridor, stretching from Benelux to northern Italy, is now being complemented by several additional corridors due to a combination of different factors: enlargement of the European Union, new infrastructure available, growing manufacturing belt running from Poland to Turkey, among others. Consequently, we now observe a wider distribution of logistics facilities and transportation networks. The international consultancy firm Cushman & Wakefield anticipates eight future distribution corridors until 2030[25] in Europe. Along these corridors, existing or emerging logistics hubs concentrates logistics operations.

Figure 25: Emerging logistics hubs within the main distribution corridors in Europe (Source: Cushman & Wakefield)

[25] The Changing Face of Distribution, the Shape of Things to come, Cushman & Wakefield, 2019

These logistics hubs can be considered as a first high-level proxy to determine the serviceable addressable market for our hub-to-hub use case. Additional data should be collected in the coming months to refine our analysis and provide a more detailed picture.

Forklift:
The worldwide market for forklift vehicles (>3.5t) is estimated at 900 000 vehicles per year, among which Europe counts for about 35%. KION currently delivers roughly 30% of such a market.
Related to the forklift vehicle category, the visible E-CB (electric counterbalance) forklifts market in EMEA for 2021 is forecasted to be approximately 120 000 vehicles in terms of annual sales. The biggest OEMs in Europe include Linde MH, Still, Jungheinrich, Toyota, Hyster and Crown. Out of the 120 000 E-trucks, it is estimated that 5% will be automated in 2026.

5. Competitive landscape

The focus in this Competitive Analysis section is on the main actors of outdoor logistics automation, mainly in Europe. Solutions for logistics processes within a private site are taken into consideration, as opposed to long-haul applications (e.g., platooning). The scope of the solutions analyzed may be able to operate indoor, however only indoor applications (e.g. AGV, AMR etc.) are not considered in this study.
The analysis primarily focuses on European key players. Some interesting companies providing solutions from North America and Asia will be mentioned, however they may not be deeply investigated at this stage.

A market share approach has been considered and ultimately disregarded. Indeed, the outdoor automation market for logistics applications is at its very early development phase and head-to-head competition is very limited. Such analysis could have been performed on the main Vehicle OEMs listed in section 7.1 and their existing manned solution, however, this would have not given much information regarding their outdoor automation solutions market share.
The ultimate intention is to compare the AWARD autonomous solution with the available solution on the market. From a technology standpoint, there is a high level of expectations regarding the overall performances of the AWARD autonomous solution, especially under adverse weather conditions. However, those performances are yet to be characterized. The timeline for this deliverable, happening early in the project, does not allow such comparison. Nevertheless, it is foreseen to be addressed in a much deeper way in deliverable D8.5.

Due to the new nature of the outdoor automation market, public information is fairly limited. The information gathered and used for this analysis are mainly relying on public information from the companies' websites and few dedicated project communications.

5.1. Heavy Duty Vehicle OEMs

For the analysis of the OEMs, relevant manufacturers were collected within the consortium for the respective AWARD use cases. All OEMs are producing or at least develop heavy duty vehicles for outdoor logistics automation and are located in Europe. For a uniform representation of these OEMs, they are presented in ID vehicleds, which contain the essential information.

Table 5: Heavy Duty Vehicle OEMs

KION GROUP	***PRODUCT***	***FACTS***
Company description: *Founding year: 2006* *Nb employees: 36,200* *Turnover: € 8.3 Billion (KION Group, 2020)* *Group members: Linde MH, Still u. Dematic*	*Heavy Duty material handling equipment* • *Payload: Up to 3T* • *Drive system: diesel and electric* 	*Past AGVs projects:* • *Wall-E & R2D2 at Bay Bell Aluminium 2018* *Partnerships:* • *Fraunhofer LoadRunner (2021)*

ek·robotics	***PRODUCT***	***FACTS***
Company description: *Founding year: 2006* *Nb employees: 200* *Turnover: € 27.8 Million (ek robotics, 2019)*	*Heavy Duty material handling equipment* • *Payload: Up to 20T* • *Drive system: diesel and electric* 	*Past AGVs projects:* • *Outdoor AGV for Tricor in Bad Wörishofen (2014)* • *Cutom Mover for JTI, Trier (2018)* •

KAMAG	***PRODUCT***	***FACTS***
Company description: *Founding year: 1969* *Nb employees: 300* *Turnover: € 190 Million (TII Group, 2020)* *Parent organization:*	*Heavy Duty Logistics vehicles.* • *Payload: Up to 17T* • *Drive system: diesel and electric*	*Past AGVs projects:* • *Demonstration at CeMAT (2018)* *Other funded projects:* • *SAFE20* • *SAFE3LY* *Partnerships:*

TII Group		• *Automation PoC with DB Schenker (2018)* • *Teleoperation PoC with Fernride (2021)*

KONECRANES	***PRODUCT***	***FACTS***
Company description: *Founding year: 1994* *Nb employees: 16,900* *Turnover: € 3.2 Billion (Konecranes Group, 2020)*	*Heavy Duty container port equipment* • *Payload: 70t* • *Drive system: diesel and electric* 	*Past AGVs projects:* • *AGVs Long Beach Container Terminal (2020)* *Other funded projects:* • *GAMA* • *PRODUCTIVE 4.0* • *OPTIMUM* *Partnerships:* • *Automated Terminal Tractor with Terberg (2018)* • *FRESH wit HHLA (2019)*

KALMAR	***PRODUCT***	***FACTS***
Company description: *Founding year: 1997* *Nb employees: 5.500* *Turnover: € 1.5 Billion (Kalmar, 2020)* *Parent Organization: Vehiclegotec*	*Heavy Duty yard logistics & container port equipment* • *Payload: up to 70t* • *Drive system: diesel and electric* 	*Past AGVs projects:* • *PSA Singapore (2015)* • *Kalmar Fastcharge (2018)* *Partnerships:* • *Terminal Automation with Nokia (2021)* • *Stategic Cooperation with Sichuan Port & Shipping Group (2021)*

E/NRIDE	***PRODUCT***	***FACTS***
Company description: *Founding year: 2016* *Nb employees: appx. 100* *Turnover: appx. € 10 Million (annual)*	*Heavy Duty Logistics vehicles* • *Payload: up to 16t* • *Drive system: electric*	*Past AGVs projects:* • *DB Schenker (2018)* • *Lidl, Coca Cola, Michelin (2019)* • *Oatly (2020)* *Other funded projects:* • *Tripple F (19 – 21)*

Funding: appx. $ 150 Million		*Partnerships:* • *5G with Ericsson & Telia (2018)* • *Innovation Partnership with Port of Helsingborg (2019)*

STÄUBLI WFT	***PRODUCT***	***FACTS***
Company description: *Founding year: 2018* *Nb employees: appx. 90* *Turnover: appx. € 8,4 Million (Stäubli – WFT,2019)* *Parent organization: Stäubli*	*Heavy duty logistics & special vehicles* • *Payload: up to 500t* • *Drive system: electric* 	*Partnerships:* • *Automation partnership with BMW (2018)*

TERBERG SPECIAL VEHICLES	***PRODUCT***	***FACTS***
Company description: *Founding year: 1869* *Nb employees: appx. 260* *Turnover: € 216,7 Million (Terberg, 2019)* *Parent organization: Royal Terberg Group*	*Heavy duty logistics & special vehicles* • *Payload: up to 36T* • *Drive system: diesel, electric & hydrogen* 	*Past AGVs projects:* • *Terberg launches AutoTUG on TOC Europe Conference (2017)* *Other funded projects:* • *Living Lab Zeeland (2019 – 2023)* *Partnerships:* • *Automated Terminal Tractor with KONECRANES (2018)* • *Autonomous Tractor with ZF (2019)* • *Unmanned Truck with ASI, Phantom Auto and FANUC (2020)* • *Teleoperation with with Fernride (2021)*

GAUSSIN Be Faster... Safer & Cleaner	***PRODUCT***	***FACTS***
Company description: *Founding year: 1880* *Nb employees: appx. 310*	*Heavy duty logistics & special vehicles* • *Payload: up to 65T* • *Drive system: electric & hydrogen*	*Past AGVs projects:* • *Tuas Megaport project Singapore (2019)* *Partnerships:*

Turnover: € 40,3 Million (GAUSSIN, ,2020) *Parent organization: GAUSSIN Group*		• *Long term partnership with ST Engineering Land System (2019)* • *Airport logistics with SIEMENS (2019)*

	PRODUCT	***FACTS***
Company description: *Founding year: 2016 (VDL Automated Vehicles)* *Nb employees: 15,464 (VDL Group)* *Turnover: € 4.7 Billion (VDL Group, ,2020)* *Parent organization: VDL Group*	*Heavy duty public transport & special vehicles* • *Payload: up to 70T* • *Drive system: electric & diesel* 	*Past AGVs projects:* • *Automated Yard TractorKatoen Natie Singapore Pte. Ltd (2017)* • *Heavy Duty AGVs for BASF (2017)* *80 AGVs Singapore Port (2019)* •

	PRODUCT	***FACTS***
Company description: *Founding year: 1928 (Volvo Trucks)* *Nb employees: 96,194 (Volvo Group)* *Turnover: € 20,6 Billion (Volvo Trucks, ,2020)* *Parent organization: Volvo Group*	*Heavy duty vehicles (Trucks)* • *Payload: up to 36T* • *Drive system: electric & diesel* 	*Past AGVs projects:* • *Bronnoy Kalk AS in Norway (2018)* • *DFDS Göteborg (2019)* *Partnerships:* • *AI platform for autonomous trucks with NVIDIA (2019)* • *Autonomous transport solutions with Aurora (2021)*

	PRODUCT	***FACTS***
Company description: *Founding year: 1961* *Nb employees: 97 (France)*	*Heavy duty vehicles (Trucks)* • *Towing capacity: up to 30T* • *Drive system: electric*	*Past AGVs projects:* • *Toulouse-Blagnac Airport (2019)* • *GEODIS logistics company (2021)*

Turnover: € 70 Million (Charlatte, Annual) *Parent organization: FAYAT Group*		*Partnerships:* • *Autonomous tractor for industrial sites and airports with NAVYA (2018)*

	PRODUCT	***FACTS***
Company description: *Founding year: 1987* *Nb employees: 1900 (TLD Group)* *Turnover: € 700 Million (Alvest Group, 2019)* *Parent organization: Alvest Group*	*Heavy duty vehicles (Trucks)* • *Towing capacity: up to 25T* • *Drive system: electric* 	*Past AGVs projects:* • *Japan Airlines (2019)* • *Shiphol Airport (2021)* • *PSA Sochaux (2021)* *Partnerships:* • *Autonomous tractor for industrial sites and airports with EasyMile (2017)*

5.2. Outdoor ADS providers for Logistics applications

Amongst the current ADS providers, this analysis is focusing on the ones developing technologies for outdoor automation. The solutions may be suitable for indoor operation; however, we limit the study to the ones enabling outdoor operations.

A list of criteria has been chosen with the intention to map some of the key ADS players currently on the market. The mapping is very difficult to provide in an informed and unbiased way as the amount of public information available is extremely limited.

5.2.1. Criteria

The criteria used for mapping are explained hereafter.

Retrofit vs. Integrated approach

ADS providers could be classified into two main groups, regarding how they install their automation on a vehicle. They can either work with an existing vehicle and upgrade it to fit all the necessary components for automation (retrofit approach) or work with a vehicle OEM so the OEM integrates all the necessary component on its production line (integrated approach).

OEM Partners

For the ADS providers part of the integrated approach (cf. previous paragraph), we provide the – public – list of vehicle OEM partners they are working with, for logistics applications.

Safety approach
This criterion relates especially to the ISO 3691-4:2020 – Driverless industrial trucks, and how the ADS providers intend to get their technology compliant with its requirements. It eventually comes down to the ability to CE mark the automated vehicles.

Autonomous navigation technology
We distinguish here two main categories:

- Guided navigation: inherited from the AGVs, the navigation mainly relies on a guidance system such as a magnetic tape, QR code or transponders for instance.
- Free navigation: coming from the latest autonomous technology development, the navigation relies on the fusion of different modalities (LiDAR s, GNSS etc.) to localize the vehicle on a map.

Funding profile
Providing insights on company's strategies and development stages.

Operations footprint
From global to local, market footprint of past and ongoing projects.

It would be very interesting to be able to compare each ADS provider technology in regard to adverse weather conditions (e.g., performance under rain, snow, fog etc.). However, such data is not publicly available and could only be biasedly assumed based on the sensors used on the vehicles operated. Therefore, we decided to exclude this criterion from this analysis, but we hope to provide some insights at the end of the project to compare the AWARD solution with the competitive technology.

5.2.2. Mapping

The study here considers 4 main European companies having operations of autonomous outdoor logistics solutions, described briefly hereafter.

AI Drivers is a British company located in London with subsidiaries in Singapore, Shanghai (China) and Chennai (India). The company was founded in 2018 and is composed of about 60 employees.

EasyMile is a French company located in Toulouse with subsidiaries in Berlin (Germany), Denver (Colorado, USA), Singapore and Adelaide (Australia). The company was founded in 2014 and is composed of about 250 employees.

Götting is a German company located in Lehrte, founded in 1965 and automating vehicles through their FOX department since 2000.The company is composed of about 70 employees.

Navya is a French company located in Lyon with subsidiaries in Paris (France), Saline (Michigan, USA) and Singapore. The company has been founded in 2014 and is composed of about 180 employees.

There are many other ADS providers worldwide, at different stages of commercialization. For instance, Sensible4 is a Finish company that based its autonomous technology on tackling extreme weather conditions (especially Scandinavian winter), but do not apply it on logistics vehicles or applications today. In North America, both ASI Robotics and Outrider have a proven track record of autonomous yard operations. In Asia, Uisee has applied its autonomous technology on a tow-tractor in demonstration at Hong-Kong airport.

Table 6: Main European companies with autonomous outdoor logistics solutions

Company	Retrofit vs. Integrated	OEM Partners	Safety approach	Autonomous navigation technology	Funding	Footprint
aidrivers	Retrofit		Unknown	Free (Lidar SLAM)	Private equity	Global, port industry focus
easymile	Integrated	TLD, KAMAG, Terberg, Kion	Inhouse hardware and software developments	Free (Lidar SLAM)	Private equity	Global
GÖTTING	Retrofit		Safety sensors based	Guided (transponders)	Family owned	Germany centered & EU
navya	Integrated	Charlatte	Safety sensors based	Free (Lidar SLAM)	Public & private equity	Global

6. Porter's Five Forces Analysis

This section provides basic information on Michael Porter's Five Forces to set the scene for further AWARD-respective strategic analysis. To help the reader to get familiar with Michael Porter's ideas, we start with the original text published in the Harvard Business Review in 1979.

"*The essence of strategy formulation is coping with competition. Yet it is easy to view competition too narrowly and too pessimistically. While one sometimes hears executives complaining to the contrary, intense competition in an industry is neither coincidence nor bad luck.*

Moreover, in the fight for market share, competition is not manifested only in the other players. Rather, competition in an industry is rooted in its underlying economics, and competitive forces exist that go well beyond the established combatants in a particular industry. Customers, suppliers, potential entrants, and substitute products are all competitors that may be more or less prominent or active depending on the industry.

The state of competition in an industry depends on five basic forces, which are diagrammed in the Exhibit. The collective strength of these forces determines the ultimate profit potential of an industry. It ranges from intense in industries like tires, metal cans, and steel, where no company earns spectacular returns on investment, toward mild in industries like oil field services and equipment, soft drinks, and toiletries, where there is room for quite high returns."

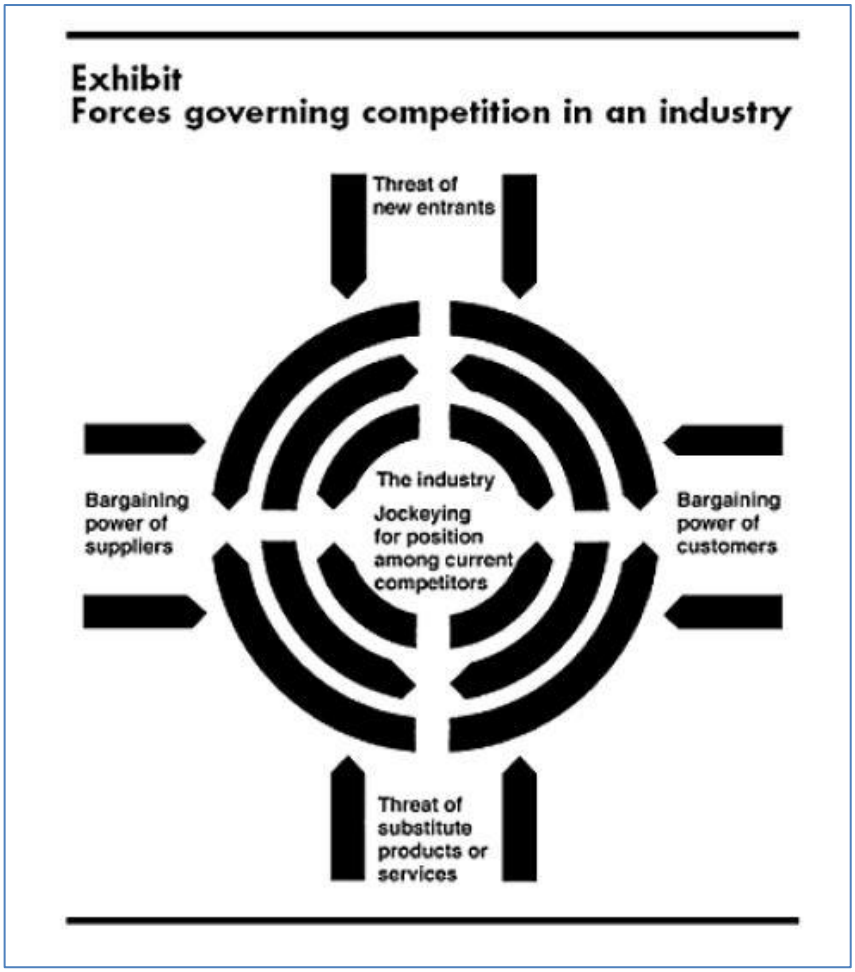

Figure 26: Porter's Five Forces (1979)

Following the original input from Michael Porter we could conclude that Porter's Five Forces is a business analysis model helping to explain why various industries are able to sustain different levels of profitability. Before analyzing the AWARD-related use cases and business areas we want to provide you with a short definition of the five forces itself (Harvard Business School, Institute for Strategy & Competitiveness):

a. Threat of substitute products or services
b. Bargaining power of supplier
c. Bargaining power of buyers
d. Threat of new entrants
e. Rivalry among existing competitors

Threat of substitute products or services

A substitute is another product or service that meets the same underlying need that the industry's product meets in a different way. Videoconferencing is a substitute for travel. Email is a substitute for express mail. The threat of a substitute is high if it offers an attractive price-performance trade-off versus the industry's product, especially if the buyer's cost of switching to the substitute is low.

Bargaining power of supplier

Companies in every industry purchase various inputs from suppliers, which account for differing proportions of cost. Powerful suppliers can use their negotiating leverage to charge higher prices or demand more favorable terms from industry competitors, which lowers industry profitability. If there are only one or two suppliers of an essential input product, for example, or if switching suppliers is expensive or time consuming, a supplier group wields more power.

Bargaining power of buyers

Powerful customers can use their clout to force prices down or demand more service at existing prices, thus capturing more value for themselves. Buyer power is highest when buyers are large relative to the competitors serving them, products are undifferentiated and represent a significant cost for the buyer, and there are few switching costs to shifting business from one competitor to another. They can play rivals against each other – especially if an industry's products are undifferentiated, it's inexpensive to switch loyalties, and price trumps quality. There may be multiple buyer segments in a given industry with different levels of power.

Threat of new entrants

The threat of new entrants into an industry can force current players to keep prices down and spend more to retain customers. Actually, entry brings new capacity and pressure on prices and costs. The threat of entry, therefore, puts a cap on the profit potential of an industry. This threat depends on the size of a series of barriers to entry, including economies of scale, to the cost of building brand awareness, to accessing distribution channels, to government restrictions. The threat of entry also depends on the capabilities of the likely potential entrants. If there are well established companies in the industry operating in other geographic regions, for example, the threat of entry rises.

Rivalry among existing competitors

If rivalry is intense, it drives down prices or dissipates profits by raising the cost of competing. Companies compete away the value they create. Rivalry tends to be especially fierce if:

- Competitors are numerous or are roughly equal in size and market position
- Industry growth is slow
- There are high fixed costs, which create incentives for price cutting
- Exit barriers are high
- Rivals are highly committed to the business
- Firms have differing goals, diverse approaches to competing, or lack familiarity with one another

The following figures provide a very first Porter's 5-forces-analysis for the AWARD use case, which needs to be updated at the end of the project.

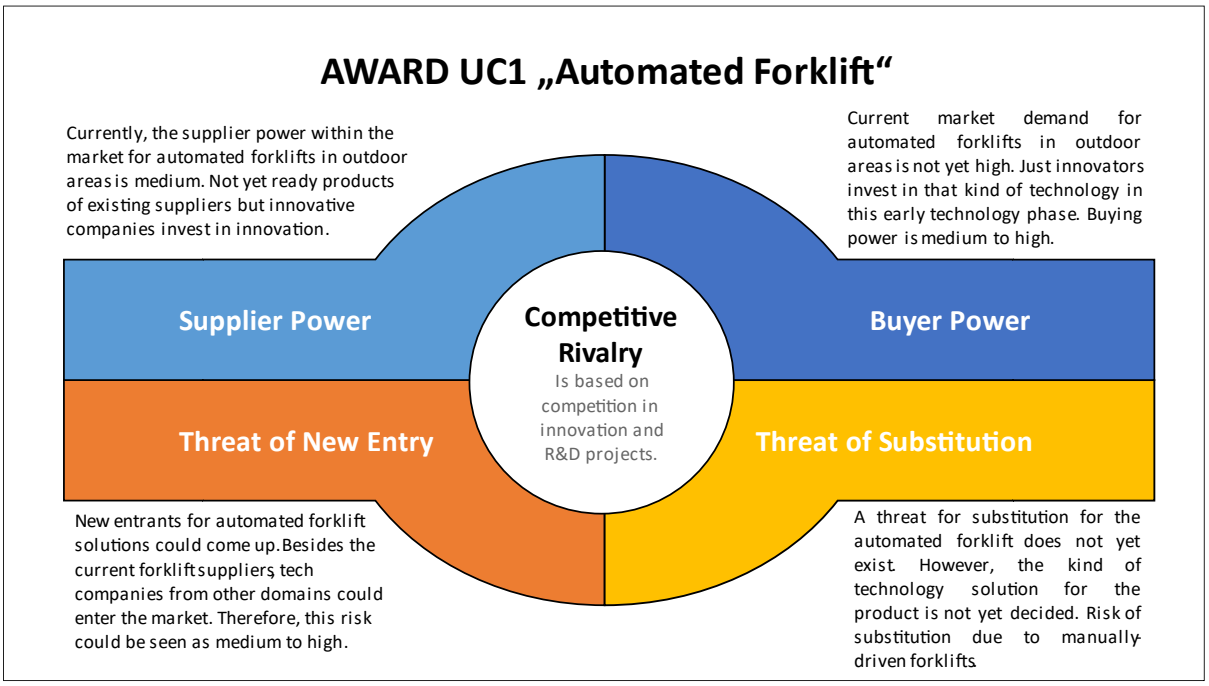

Figure 27: Initial Porter's Five Forces analysis for the AWARD UC1 "Automated Forklift"

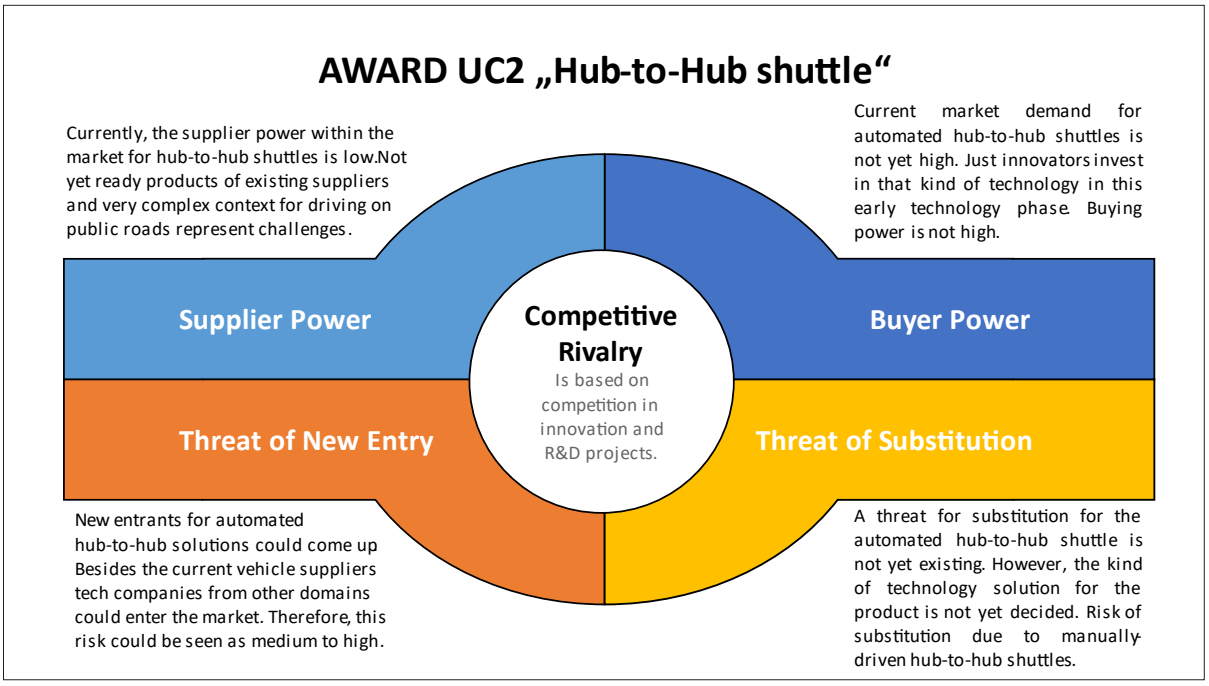

Figure 28: Initial Porter's Five Forces analysis for the AWARD UC2 "Hub-to-Hub shuttle"

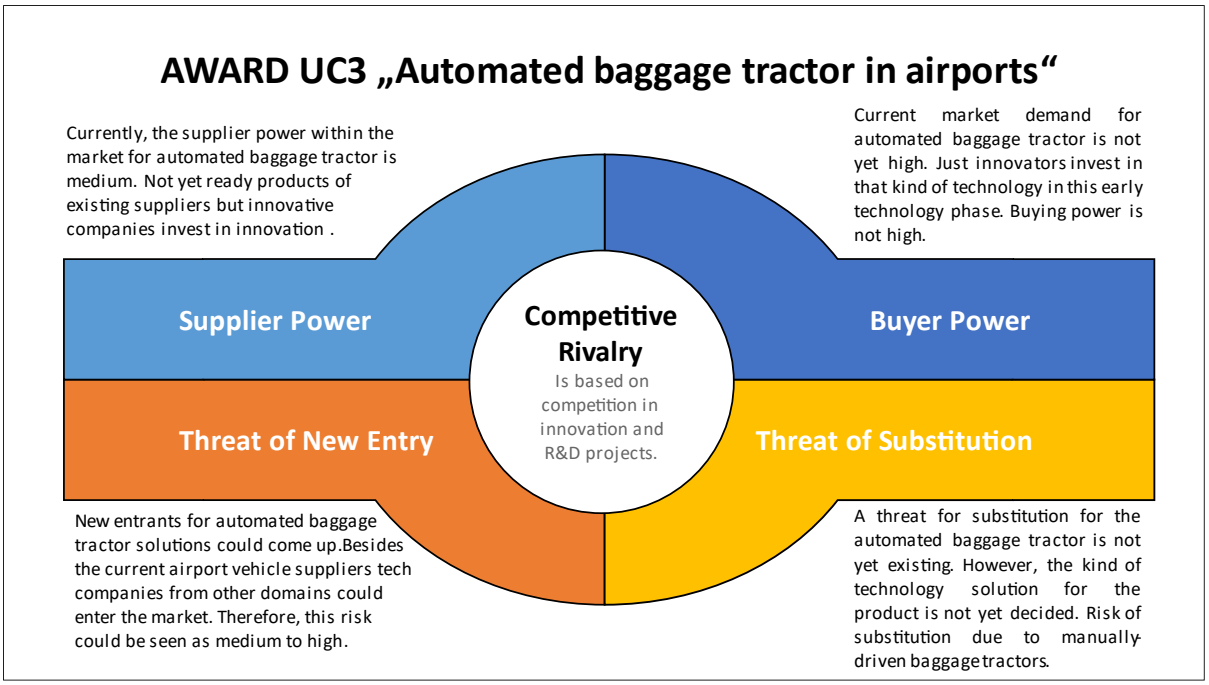

Figure 29: Initial Porter's Five Forces analysis for the AWARD UC3 "Automated baggage tractor in airports"

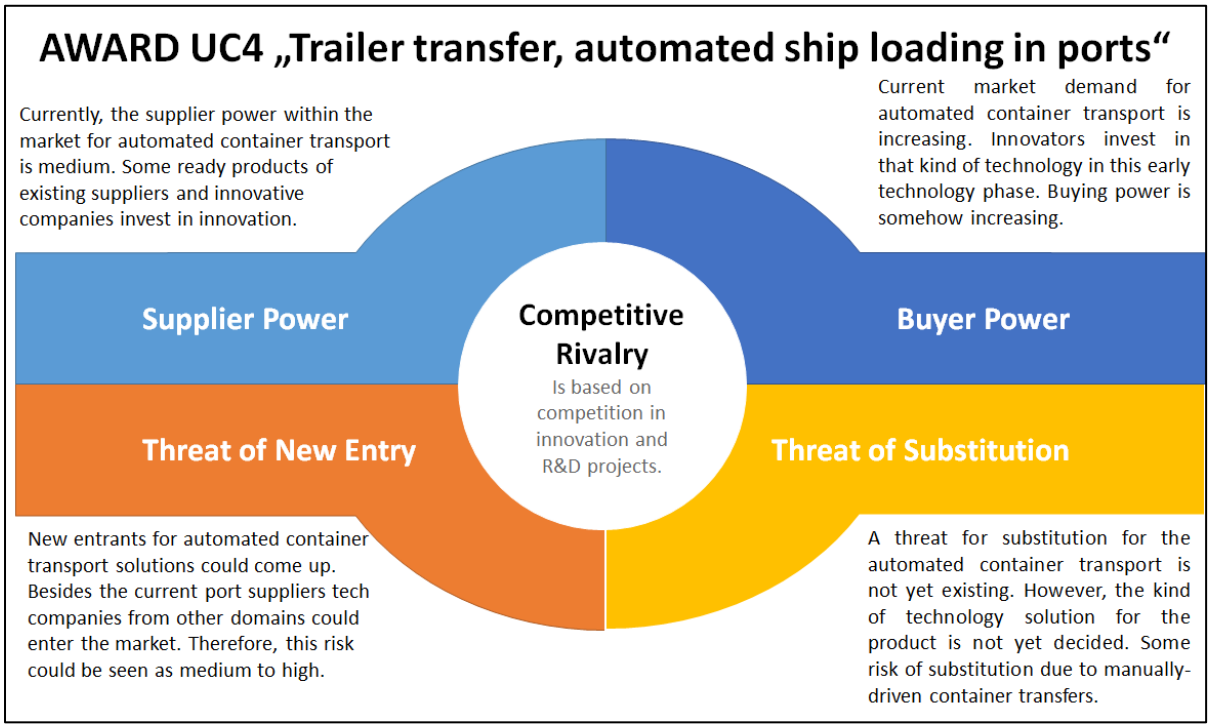

Figure 30: Initial Porter's Five Forces analysis for the AWARD UC4 "Trailer transfer, automated ship loading in ports"

In the market analysis context, an initial competitive landscape analysis was performed based on the Porter's Five Forces (1979). Based on the four AWARD use cases, the main outcome for the five forces (Supplier Power, Buyer Power, Threat of New Entry, Threat of Substitution and Competitive Rivalry) is the following. Low supplier power due to not yet ready products, low buyer power due to limited demand of just the innovators in the market, medium to high risk of new market entrants due to a lot of possible new technology players, low risk of substitution based on the limited number of available products and finally the competitive rivalry is based on a competition between high innovative companies and R&D projects.

7. Conclusions and next steps

This preliminary research has assessed market features and possible competitive offers for AHDV and fleet management system, using the general approach of Market Analysis in AWARD. This is a living document that will be updated over time. Despite the fact that the market for connected and automated vehicle solutions is increasing in Europe, this preliminary investigation has shown that there are still significant challenges to overcome in order to achieve widespread acceptance. As Connected and Automated Mobility proves to be a great chance to make our transportation systems safer, greener, more efficient, and user-friendly, these barriers are gradually being lifted.

The market is segmented based on level of autonomy, vehicle type, geography, and applications. According to SEA and ERTRAC, the fully industrialized deployment and commercial adoption of levels 3-5 will take place between 2020 and 2030. According to Agenda 2030, low-speed autonomous vehicles handling complete traffic complexity for goods delivery in use cases similar to AWARD, limited regions, are predicted to be widely accessible by 2040 and to be the first to acquire widespread market adoption. Confined zones are projected to grow and merge into fully autonomous urban buses and deliveries.

Market drivers are divided into five groups, Technical, social, economic, environmental, and legal. The five most important technical drivers for autonomous operations in logistics are AI, machine and computer vision, geo-localization, big data, and radar advances. Increasing prices raise the risk of disruption; freight businesses and big transportation operators will seek out new and inventive methods to improve efficiencies and save money. Furthermore, financial losses resulting from human errors like as truck wrecks are considerable. Regulations, rising fuel prices and their negative impact on the environment, as well as a growing driver shortage, are preventing the trucking industry from meeting the increased demand brought on by the e-commerce boom. As a result, both established players and newbies alike are turning to automated technology for solutions. Automation would make it easier for trucking companies to deal with a range of problems on a daily basis by increasing fleet utilization and driver capabilities while also lowering fuel costs.

Automation comes together with many opportunities of economic, societal, environmental nature, improving trade efficiency and benefiting transport operators and consumers. Issues, such as driver shortage can be addressed through the adoption of automated HDVs in logistics. However, as a result of each new technology, barriers were also identified during the course of this task both through literature review and inputs from the partners' workshop organised in the framework of Task 8.1. In order to make the transition to automated vehicles in logistics, safety, cyber-security and other issues such as technological, security, infrastructure, legislative etc. will have to be discussed during the course of the project and beyond. Task 8.1 will continue identifying new barriers and opportunities that might result from the pilot tests and will address them with some final recommendations as an output of the report D8.5.

Limited research exists on the potential market size of the autonomous vehicles on the logistics industry. Still, data available forecast an exponential increase of the market,

especially following the full deployment and commercial adoption of levels 3-5. According to the middle scenario of a study conducted by the UK Centre for Connected and Autonomous Vehicles, the global market for AVs and CAVs technologies should reach about €741bn in 2035. However, commercial freight vehicles (vans and HGVs) should still take a limited share of the total CAV market. Europe is expected to be one of the leading markets, thanks to the pre-existence of a relatively dense network of vehicle manufacturers with a premium offering and suppliers of vehicle components, in addition to a fairly advanced testing and regulatory landscape. AWARD Serviceable Addressable Market (SAM) is bounded by the four use-cases. With one of the densest port regions worldwide, the yearly European market for yard truck (AWARD addressable market for the port use-case) is estimated to be about 1 300 vehicles. The continent also counts 40 airports handling more than 10 million passengers annually. The effect on the number of vehicles that constitutes the addressable market for this use-case needs to be further assessed. Additional research will also help us refine the total addressable market for the huh-to-hub use-case. Regarding the market for automated forklifts, the visible E-CB (electric counterbalance) forklifts market in EMEA for 2021 is forecasted to be approximately 120 000 vehicles in terms of annual sales.

The early development phase of the automated logistics processes within private site constrained the competitive analysis among few actors. Additionally, the timeframe in which the study is conducted is prior to experiments, hence the comparison will be limited to specific aspects (not including all weather conditions) and four actors: AI Drivers, Easymile, Götting and Navya. The latter presents similarities with Easymile on the retrofit approach as opposed to the two others prioritizing integrated systems. On one side, Navya, Easymile and AI Drivers share common autonomous navigation technologies (with Lidar SLAM) as well as funding approach (private for all three and a complementary public part for Navya) and footprint (global for all three and a port and industry focus in addition for AI Drivers). On the other side Götting is more in favor of guided autonomous navigation technology, a famiily owned funding and Germany and EU centered footprint. Götting shares the same safety sensor-based approach than Navya where Easymile focuses its safety approach on inhouse hardware and software developments. AI Drivers safety approach remains unknown. The outdoor autonomous vehicle market is new, and the Fleet Management System market for autonomous application even newer. Due to its early development in today’s automated logistics operations, fleet management systems do not present a sufficient technological readiness today to be included in the competitive analysis, it is assumed that the first trends will appear in 3 to 5 years.

The preliminary study of market trends using two key sources: (1) the DHL Logistics Trend Radar (5th Edition) and (2) the Trendmanagement expert database show that self-driving vehicles, in combination with intelligent infrastructure and big data, as well as sustainable logistics, appear to be critical developments.
A preliminary competitive landscape analysis based on Porter's Five Forces was undertaken as part of the market study. The major consequences for the five forces (Supplier Power, Buyer Power, Threat of New Entry, Threat of Substitution, and Competitive Rivalry) are low buyer power due to limited demand from only the market's innovators, medium to high risk of new market entrants due to a large number of potential new technology players, low risk of

substitution due to a limited number of available products, and competitive rivalry based on a competition between high innovative firms.

As previously stated, this is a preliminary market assessment, and further research will be conducted in the following months. As a result, the following are some future steps:
Next steps:

- Updating the report with new stats and content
- Doing market analysis for the fleet management system
- 4.1.2 -> More data on the vehicle types except for vans and HDVs – same for the market size
- PESTEL Analysis
- Benchmarking of AWARD solution with the existing solutions in the market
- Collect more primary data through workshops/interviews
- SWOT analysis

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