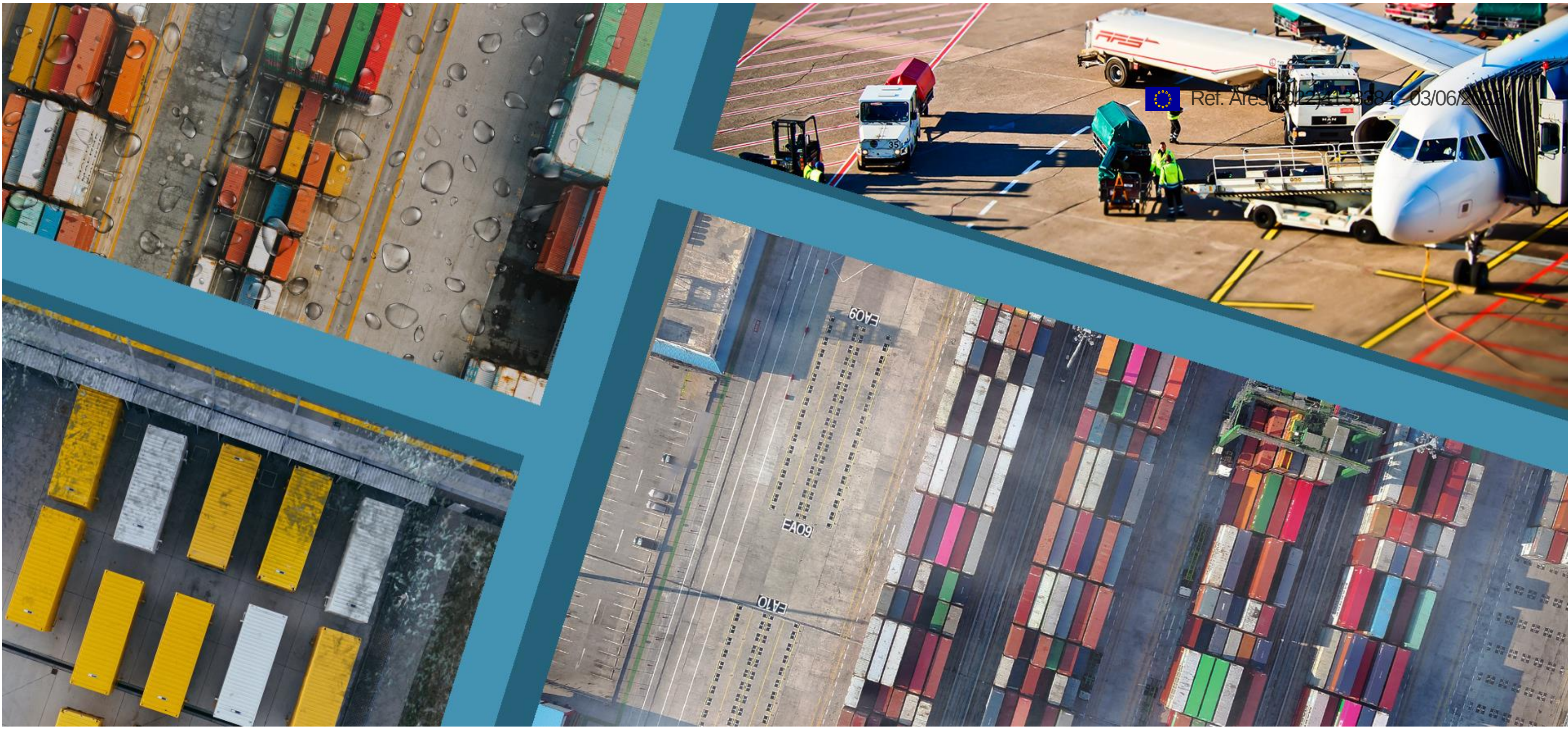

AWARD

Scaling autonomous logistics

D2.2
User and Stakeholder Requirements

—

Lead: AIT

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LEGAL DISCLAIMER

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List of Acronyms

ADS	Automated Driving System
AGV	Automated Guided Vehicle
AGTS	Automated Ground Goods Transportation System
ATS	Automated Transport Systems
AV	Automated Vehicle
D	Deliverable
FMS	Fleet Management System
HDV	Heavy-Duty Vehicles
N/A	Not Applicable
LOFM	Logistic Operation & Fleet Management
OEM	Original Equipment Manufacturer
ODD	Operational Design Domain
OS	Operational Scenario
SI	Supporting Infrastructure
SLS	Supporting Logistics System
SOI	System of Interest
SoS	System of Systems
SOTIF	Safety Of The Intended Functionality
T	Task
UC	Use Case
WP	Work Package

Glossary

Fleet Management System	A Fleet Management System supports the management of a fleet of ADS-equipped vehicles deployed in driverless operation. This includes collecting transport orders from logistic systems, information from auxiliary systems (e.g. road sensors, cameras, etc.) and status from the fleet vehicles (breakdowns, data collection for curative and preventive maintenance. etc.), disseminating dispatch information to the fleet (e.g. trip routes and other order details, managing emergencies) and status information to vulnerable road users, and activating teleoperation when needed. The Fleet Management System may serve as the responsible agent vis-a-vis law enforcement, emergency responders and other authorities for vehicles.
Operational Scenario	Different ways in which one, vehicle or user, interacts with autonomous guided vehicles. E.g. AGV is driving if X amount to dock, AGV is waiting for loader, etc.
System of Systems	A "System of Systems" (SoS) is a SOI whose elements are managerially and/or operationally independent systems. These interoperating and/or integrated collections of constituent systems usually produce results unachievable by the individual systems alone. Because an SoS is itself a system, the systems engineer may choose whether to address it as either a system or as an SoS, depending on which perspective is better suited to a particular problem[1]. The following characteristics can be useful when deciding if a particular SOI can better be understood as an SoS[2]: • Operational independence of constituent systems • Managerial independence of constituent systems • Geographical distribution • Emergent behavior • Evolutionary development processes

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

[2] Maier, M. W. (1998). Architecting principles for systems-of-systems. *Systems Engineering: The Journal of the International Council on Systems Engineering*, *1*(4), 267-284.

1. Executive Summary

Deliverable 2.2 presents a systematic analysis of user and stakeholder requirements for comprehensive automated ground goods transportation system (AGTS) technology, which is developed within the project AWARD. The goal of this project is to pave the way for the roll-out of driverless transportation, whatever the weather conditions are. It will deploy safe and efficient connected and automated heavy-duty vehicles in real-life logistics operations. The results delivered by this report comprise an acceptance and expectations analysis and an aggregated list of 26 user and stakeholder requirements, covering aspects like vehicle fleet operation, reliability, job and workforce, conditions, business modelling, as well as ethical aspects.

In addition to this overall summary and aggregation of expectations and requirements, the report provides a detailed analysis of specific characteristics and preconditions of the four AWARD use cases that must be considered. In particular, the current and planned future operational workflows are specified, which serve as a central cornerstone both for the use case analysis and for the technical and demonstration workpackages. Furthermore, the specific expectations and requirements for a large number of different user and stakeholder groups are presented. For the group of 'direct process participants' (persons who will get in touch with or are affected by automated logistics vehicles), a detailed workflow specification is provided, requirements from recent research and practice are summarized, and remaining challenges are outlined. For the 'indirect process participants' (being involved in the logistics processes, but not directly interacting with a vehicle), the main motivations are summarized. Furthermore, beyond a concrete logistics process, the requirements for the group of general stakeholders of future AGTS are analyzed, including technology developers (OEMs and their supply partners), authorities and regulation bodies, as well as municipalities and traffic operators.

The methodology to achieve the results consisted of a mixed methods procedure. The work was embedded into an acceptance and expectations framework that was used to structure the identified opportunities and concerns. Data was gathered from more than 200 representatives of all the above stakeholder groups. Following a mixed-methods approach, using different data sources, including a state-of-the-art literature analysis, a survey, interviews embedded in the stakeholders' context, use case site visits, and an international stakeholder workshop. Insights and statements related to the user requirements have been integrated in a database of more than 1000 entries and consolidated, to derive a set of 26 user and stakeholder requirements.

The document concludes with a formal linkage of the user and stakeholder requirements to the functional requirements defined in Task 2.4, in order to guide the further technical development in the project. Furthermore, business-related activities are recommended that should be focused on in the further course of the project, in order to address barriers and to foster exploitation of project results. The results reconfirm the necessity of a human-centered development process in the further course of the project, and they provide detailed specifications of the workflows and design requirements for the future workplace of human AGTS operators.

2. Introduction

The increasing level of automated technology is transforming many parts of economy and society, and some of the most promising advances are made in the transport and workplace domains[3]. The logistics domain has been affected by this trend since a long time, and already now many specialized areas operate with automated loading or warehouse management technology[4]. A wide introduction of automated vehicles may be achieved sooner in freight transport and logistics than in passenger transport, because environments are more controllable and thus viable for the operation of automated and connected vehicles within different parts of supply chains (e.g. warehouses, factories, ports, airports and other logistics hubs). Fewer vulnerable road users, low driving speeds and a well-defined layout of logistics yards are typical and useful characteristics of such areas. Furthermore, automated commercial vehicles aim at increasing freight transport capacity through 24/7 driverless operation.

Acceptance is widely recognized as a major requirement for a successful and responsible introduction of automated ground transport system (AGTS) by various stakeholders[5]. First approaches towards a systematic investigation of requirements have been undertaken, and test fields and innovation laboratories have been set up that specialize on automated road transport logistics use cases, their further development and certification[6]. However, a comprehensive and systematic level of understanding the requirements for automated vehicle operation in specific logistics value chains and stakeholder constellations has not fully been achieved. The European research and development project AWARD aims to close this gap. The project gathers 29 leading institutions who develop and deploy safe and efficient connected and automated heavy-duty vehicles in real-life logistics operations. The requirements for such novel systems are explored within a range of real-world applications and with different types of purpose-built vehicles and fleet management system prototypes. The gained knowledge shall help to validate solutions for example in terms of functional safety, availability, efficiency, scalability, or cost-benefits for hub operators or fleets.

Document scope

The present report documents a systematic analysis of the requirements from stakeholders and users of AGTS systems, which has been performed within the requirements definition phase of the project AWARD (Task 2.2). As Figure 1 shows, the main scope and terms have been defined in the preceding scoping task (Task 2.1), mainly including a stakeholder taxonomy (see a description below), the definition of the AGTS system of systems, and the use cases and its

[3] Baldauf, M. Fröhlich, P., Sadeghian, S., Palanque, P., Roto, V., Ju, W., Baillie ,L. and Tscheligi, M.. (2021). Automation Experience at the Workplace. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems* (pp. 1-6).

[4] van Meldert, B. and de Boeck, L. (2016). Introducing autonomous vehicles in logistics: a review from a broad perspective. *FEB Research Report KBI_1618.*

[5] Bottalico, A. (2021). The Logistics Labor Market in the Context of Digitalization: Trends, Issues and Perspectives. In *Digital Supply Chains and the Human Factor* (pp. 111-124). Springer, Cham.

[6] Fröhlich, P., Schwieger, K., Nitsche, P., Reinthaler, M., Gruber, M., Tscheligi, M., Nöst, M., Neubauer, M., Pell, A.: (2017). Defining HMI and UX Test Environments for Automated Logistics"; Proc. *Mobile HCI 2017 Workshop: Mobile Interaction With and In Autonomous Vehicles*

constituting operational scenarios (see below). The expectations and requirements from users and stakeholders directly feed into the definition of functional requirements (Task 2.4), as well as to several important subsequent activities of the project, most importantly the user-centered design of the human-machine interface for fleet management and tele-operation (Task 5.3), the definition of evaluation criteria and methodology (WP7), as well as business modeling (WP8) and exploitation (WP9).

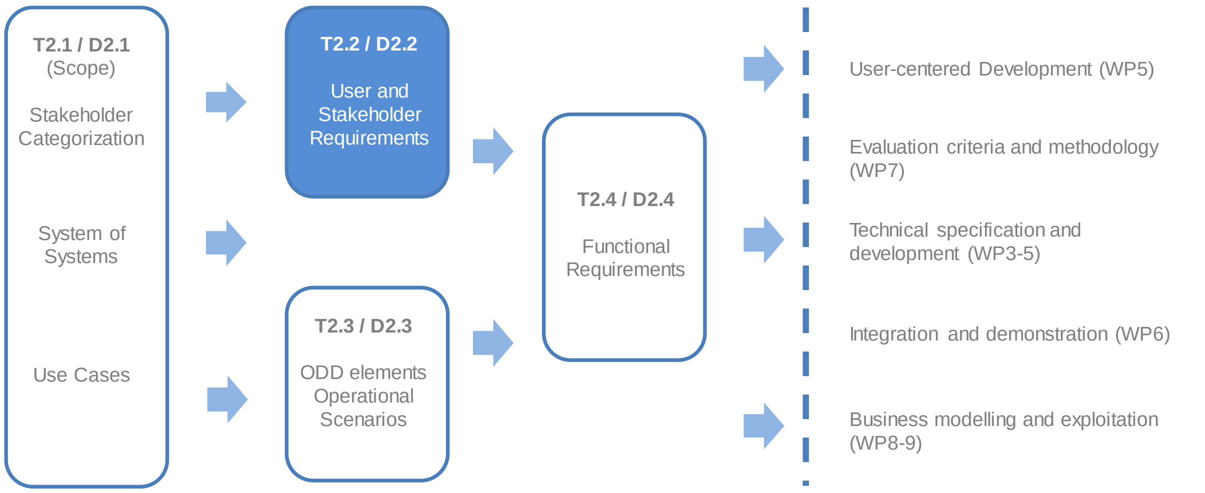


Figure 1: Overview of the relationship of the user and stakeholder requirements task and deliverable (T2.2 and D2.2) within the overall requirements workpackage (WP2), and their contribution to subsequent activities in other workpackages

Use Case Scope and Associated Stakeholder Groups

As Figure 1 highlights, a key output from Task 2.1 is a taxonomy of users and stakeholders of future AGTS. It provides a reference frame that helps to categorize involved AGTS stakeholders of the dynamically developing ecosystem, value chains and work role models, in order to enable a common ground for communication.

The taxonomy is divided into three main categories. **Direct process participants** are those persons who get in touch with or are affected by automated vehicles. This includes staff remotely managing the vehicles, persons close to the vehicle working in a logistics hub or production site, as well as other road users on public roads. For human–machine interaction (HCI), this group is the most relevant one, as it is related to direct contact of human operators and technology. However, for a more holistic discussion of requirements for logistics processes, also **indirect process participants** are relevant, which go beyond those who directly are in remote or on-site contact with an automated vehicle. Then, beyond a concrete logistics process, there is the group of **general stakeholders**, who should have an overarching interest in the topic, either economic, social or research interest in (the future use of) AGTS.

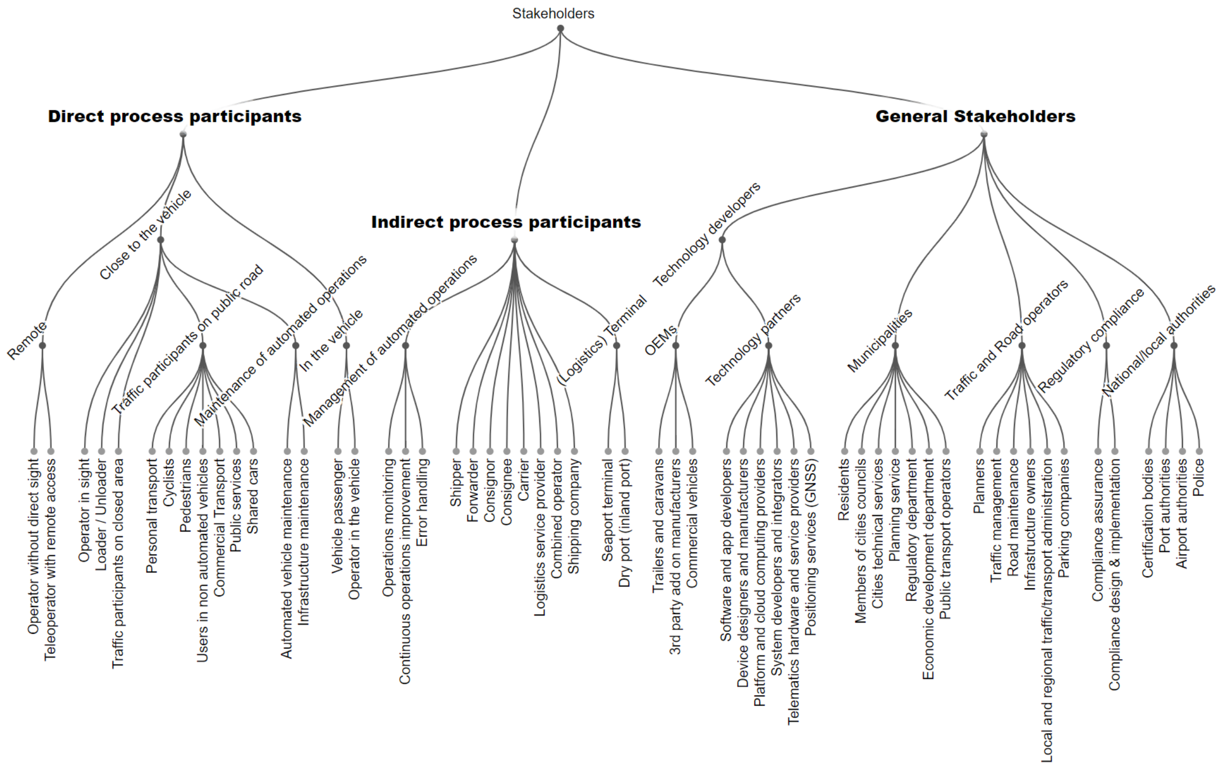
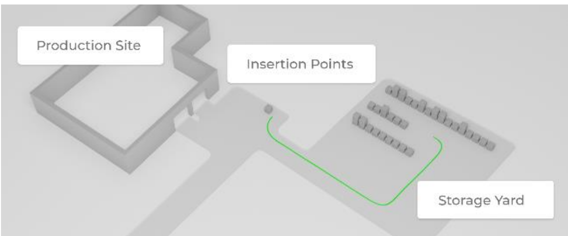
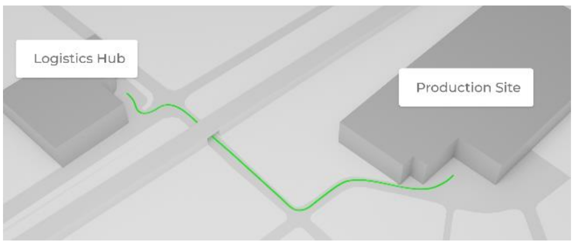


Figure 2: Stakeholder taxonomy for the automated ground goods transportation system (AGTS)

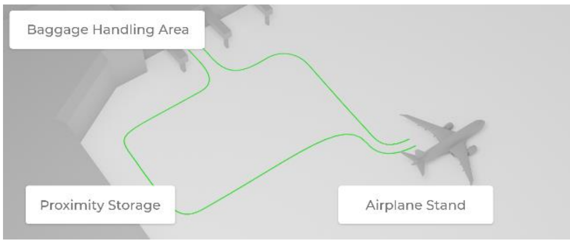
The use cases address vehicle tasks in different settings, from operational area to public roadways as well as with different automated vehicles and users. The AWARD project aims at demonstrating the automated vehicles working in all weather conditions and addressing challenges related to the deployment of these vehicles in real logistics operations through several strategic use cases that meet market needs, from the factory to logistics hubs. Below, the general scope of the use cases and related tests planned within the AWARD project are shown (see section 6.2 for a more specific description of the operational workflows involved therein).



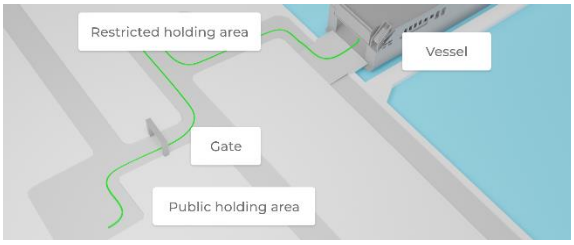
Use Case 1: "Loading and transport with an automated forklift"
This use case focuses on the highly automated movement of lattice boxes with forklifts indoors and outdoors.



Use Case 2: "Hub-to-hub shuttle service from warehouse/production site to logistics hubs"
This use case focuses on the highly automated transport of lattice boxes between two hubs including public roads and restricted areas.



Use Case 3: "Automated baggage tractor on an airport"
This use case focuses on highly-automated airside baggage transport operations. Airside baggage transport operations include indoor as well as outdoor operations, e.g. in hangars, tunnels, and service roads.



Use Case 4: "Trailer transfer operations and automated ship loading in a port"
Trailer movements in ports are a vital element of logistics operations in ports. This use case involves the automation of trailer movements in ports.

Goals and structure of the document
The goals for the user and stakeholder requirements specification addressed in this document are as follows:

1. Identify factors that are relevant for broad acceptance of AGTS
2. Specify the requirements from users and stakeholders, based on the above analysis
3. Investigate contextual specifics from the perspective of each use case and stakeholder group
4. Propose approaches to address the requirements.

The document is structured as follows: After a description of the methodology applied to meet the above goals (section 0), a summary of the acceptance and expectations towards future AGTS is provided in section 0, thereby addressing the first goal of the document. To meet the second goal, the specified requirements are presented in section 0. Then, sections 0 and 0 provide specific needs and conditions for each use case and stakeholder group. The document concludes with recommendations on how the requirements shall be addressed in the further course of the project.

3. Methodology

This section outlines the methodological approach for the user and stakeholder requirements analysis, in order to address the goals specified above. Figure 3 provides an overview of the procedure. In order to identify factors that are relevant for a broad acceptance towards AGTS, a dedicated framework was created that could cover and structure all relevant usage areas and user groups. Based on this acceptance and expectations framework, a set of questions was set up that could be used for each form of inquiry applied within the requirements gathering process. Then, data was gathered, following a mixed-methods approach, consisting of state-of-the-art literature analysis, a survey, interviews embedded in the stakeholders' context, use case site visits, and an international stakeholder workshop. To illustrate the approach, a video[7] demo has been created to document the chosen approach. Insights from the gathered data were integrated into a central repository, and expectations and requirements were consolidated. In order to come up with innovative approaches towards meeting the requirements, workshops and iterative meetings were conducted within and outside the consortium.

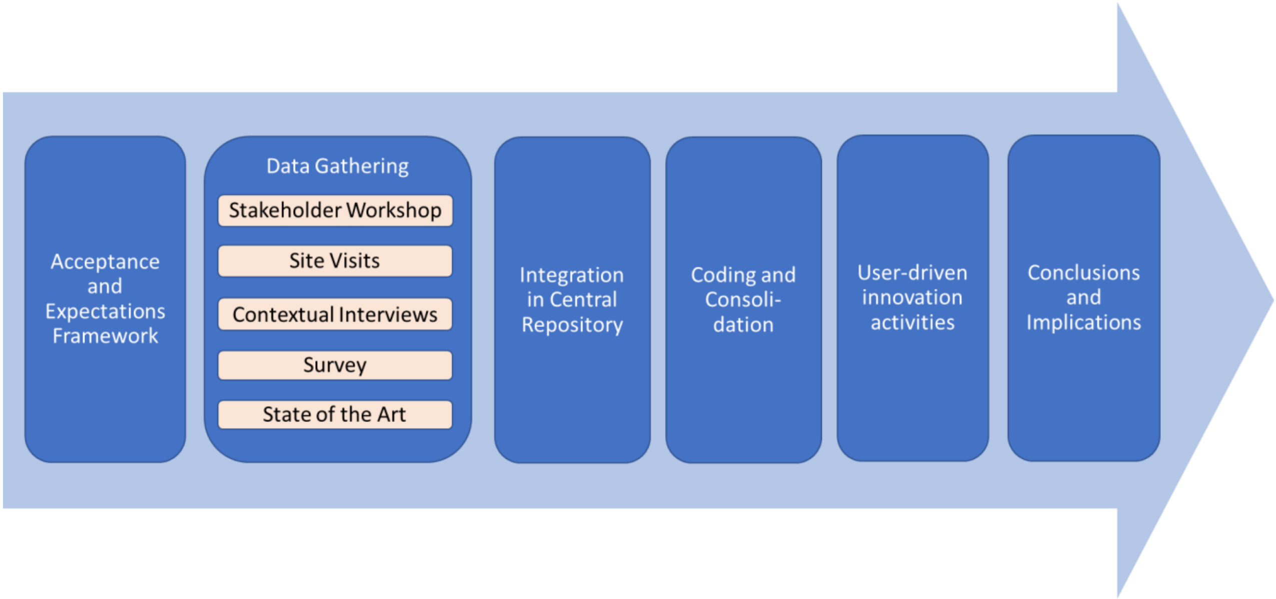


Figure 3: Overview of Procedure

Acceptance and Expectations Framework

In order to structure the data capturing activities and the derivation of requirements insights is depicted in Figure 4, an automated road transport logistics acceptance model (ARTLAMI has been developed (see background, characteristics and validation of this model in Annex 7). This model includes factors that have been shown to be relevant for similar application sectors, namely usefulness, ease of use (or ease of operation), supporting conditions, acceptance by others, trustworthiness (Safety/Security/Reliability). Furthermore, the relationship between these

[7] Video on the AWARD user requirements gathering methodology, published at the AutomotiveUI 2021 conference (see also Rosic, J., Hammer, F., Gafert, M., Fröhlich, P. (2021). Acceptance is in the Eye of the Stakeholder. *Adjunct Proceedings of Automotive UI 2021*.) Video viewable here.

factors and their relation to the general support (or acceptance) of future automated ground transportation systems have been modeled.

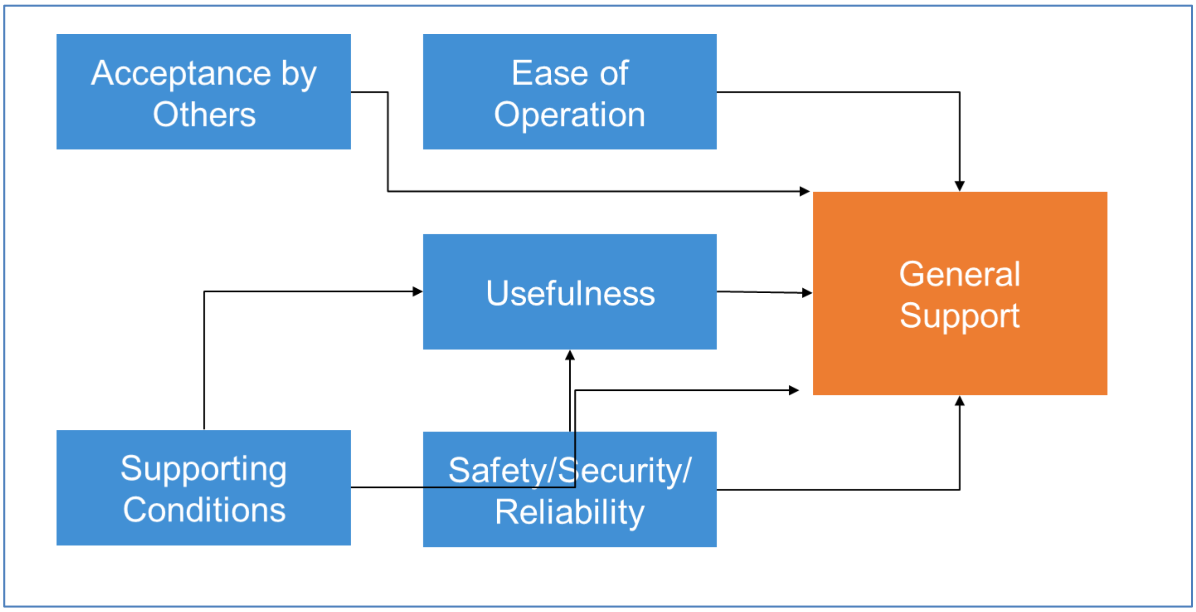


Figure 4: The Automated road transport logistics Acceptance Model (ARTLAM) developed for the Requirements Analysis

Data Gathering
To capture the data necessary for gaining insights, a mixed-methods approach was used to enable the modelling of expectations factors across different stakeholder groups, as well as for deep insights into the workplace requirements of future AGTS systems. All empirical data gathering activities were conducted in compliance with the General Data Protection Regulation (GDPR), following the AWARD ethics procedures (D1.1).

State of the Art Knowledge: Already available knowledge both about expectations and about the requirements was identified. A literature search was carried out, which covered different fields, including mobility sciences (automated transport and logistics), technology acceptance, and human factors. Furthermore, strategic documents (e.g. the ERTRAC roadmap) related projects and activities were investigated, most importantly from the ALICE repository, but also from different national projects (see Annex 6 for more details).

Survey: In order to capture expectations and needs for the different application fields and groups of actors, and in order to model acceptance factors, a survey study with respondents from different European countries was conducted. In addition to each of the acceptance scales, subjects were required to provide textual comments to justify their statements and to provide further detailed comments. The resulting data was then subject to further qualitative analysis. A more detailed description can be found in Annex 3.

Interviews: To receive more specific insights, especially on the requirements from the perspective of specific users and experts, 1-hour interviews were conducted. These followed the same procedure as the survey, and data was captured with a similar form as the survey, in order to facilitate a consistent data structure. Please see Annex 3 for further details.

International Workshop: Building on the gained results, tailored participatory workshops were conducted that enabled the different groups to comment on preliminary requirements, to mitigate contradicting opinions, and to propose first ideas towards alternative solutions. A more detailed description can be found in the Annex 4.

Site visits: At each of the four use case sites, visits have been organized that maximized attendance in times of COVID-caused travel restrictions, but that still provided a realistic experience of the contextual opportunities and challenges. This was realized by a mixture of a workshop format and walk through the respective site, which could be attended physically and virtually (through a teleconferencing tool). A more detailed description can be found in Annex 5.

Figure 5 provides an overview of the participants from survey, interviews and workshops (N=203), whose data were further analyzed. This number does not contain the participants of the discussions and presentations during the site visits (135 participants), as they were purely project-internal participants and their input was not collected along the acceptance survey questions – nevertheless, all relevant mentions were considered for the analysis.

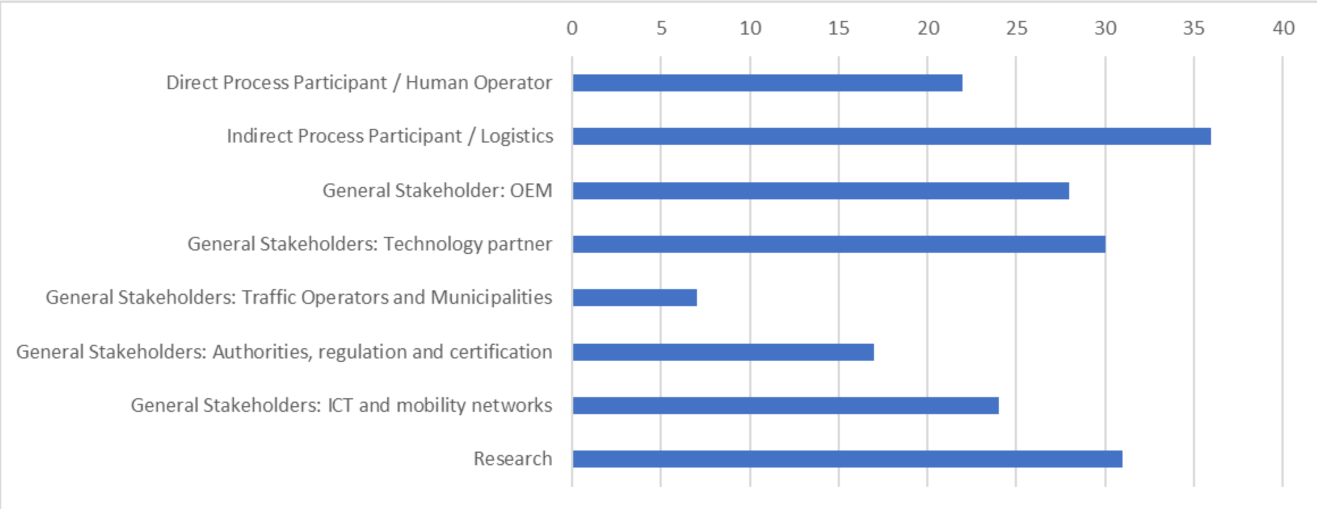


Figure 5: Sum of participants representing different stakeholders in the empirical data gathering activities (survey, interviews and workshops)

Integration of gathered results into a central repository

From all of the above results gathered throughout the previously described heterogeneous different sources, observations, opinions, and mentions were extracted and documented in an integrated online repository that is interweaved with the stakeholder categories, the use cases and operational scenarios, as well as the functional requirements. This repository gained from this user and stakeholder aggregation process includes 1040 entries.

Coding and consolidation

All entries were then coded with regard to the respective acceptance factor, a content category tag, the respective use case, the involved stakeholders, the type of entry (observation, requirement, expectation or condition), the type of evidence (insight from empirical inquiry, from scientific literature, established practice) and name of evidence (e.g., number of interview). Furthermore, in case the entry was a clear requirement, it was qualified with regard to its importance (must-have, nice-to-have). These entries were then consolidated with regard to different approaches, depending on the type of targeted result. In order to gain an understanding of the influence of the acceptance factors from the above-described ARTLAM model, descriptive statistics as well as correlations and regression analysis were accomplished. For each of the acceptance factors, this was complemented by a qualitative content analysis of expectations towards the described scenarios of automated road transport logistics (see the resulting summary in section 0).

Furthermore, the entries within the data repository containing user and stakeholder requirements were consolidated by carrying out two aggregations for its interpretation. During a first analysis, sixty-five different topics were identified, which resulted in a first classification of the data (first aggregation). Once the first classification was made, the topics were grouped into 26 classes, which were transformed into requirements (second aggregation). These are presented in section 0.

User-driven innovation activities
A further detailed qualitative content analysis of the coded results was then conducted, in order to understand the specific conditions from the perspective of each use cases and stakeholder groups. The empirical insights were complemented by previous scientific work and research projects. Based on these insights and further iterative discussions with end-users and experts, a workflow and tasks analyses for each use case and stakeholder group were conducted, to enable a common understanding and clear guidance in the subsequent phases. The results of this analysis are provided in sections 0 (use case specific) and 0 (stakeholder-specific).

In order to discuss challenges and alternative solutions related to the design of novel automated vehicle solutions in the work context, two international workshops have been co-organized with Human-Computer Interaction experts. The first workshop ("Automation Experience at the Workplace") was held in conjunction with CHI 2021 in May 2021, the leading conference in the field of Human–Computer Interaction[8]. In this workshop, the data gathering methodology was presented, and methodological aspects on capturing acceptance from future operators of AGTS were discussed. The second workshop "AutoWork – Future of Work and Well-Being with Automated Vehicles" was held in conjunction with the Automotive UI 2021 conference[9], which is the leading conference on Human–Computer Interaction for vehicles, and which has increasingly featured automated driving and teleoperation as a prominent topic. Here, preliminary findings related to the needs of a LOFM operator were discussed alternative solutions for AGTS fleet management were discussed.

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[8] Baldauf, M. Fröhlich, P., Sadeghian, S., Palanque, P., Roto, V., Ju, W., Baillie ,L. and Tscheligi, M.. (2021). Automation Experience at the Workplace. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems* (pp. 1-6).

[9] Fröhlich, P. Schartmüller, C., Wintersberger, P., Riener, A., Kun, A., Brewster, S. Shaer, O., Baldauf, M. (2021b). AutoWork 2021: Workshop on the Future of Work and Well-Being with Automated Vehicles. *13th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (AutomotiveUI ´21 Adjunct)", ACM, New York, NY, USA, 2021, 4 S.

Derivation of Conclusions

The results were then interpreted such that they can be readily used by the subsequent activities. First, in order to support functional development, the consolidated and aggregated requirements were qualified with regard to whether they relate to any of the functional requirements that are documented in D2.4. Second, conclusions for further business modeling were drawn. Third, approaches for the further development of the fleet management user interface were developed, based on the gathered user requirements. Furthermore, mainly based on the use case specific workflow models, implications for the integration and demonstration were derived. Furthermore, refinements of the evaluation procedure are proposed.

4. Acceptance and Expectations

In this section, the main findings regarding acceptance and expectations are summarized across all stakeholder groups and use cases (please refer to sections 0 and 0 for a differentiated analysis). As shown in Figure 6, overall expectations concerning the different acceptance factors were positive with averages of 4 or higher (with 1=low expectations and 5=high expectations) for usefulness, safety, security and supporting conditions and above 3.5 for reliability and stakeholder acceptance. The lowest expectations were expressed regarding ease of operation, showing that this is currently an area of greater uncertainty and reflecting to low correlations with general support which was also expressed strongly.

Figure 6: Mean rating score for the acceptance factors (see the Likert scale descriptions and responses in more detail in the following subsections).

4.1. Usefulness

As Figure 7 shows, the overall expected usefulness of the different use cases among the survey participants was very high. Among the main characterizing factors seen to contribute to the system's improvement in efficiency were **the availability and flexibility of the operations** expected to **run 24/7**. This would include work at night and **unrestricted operating hours** not dependent on situations related to human employment (i.e. holidays or sick leave). Automation was also seen to **enhance the speed of the processes** with less room for failure and error also contributing to **on-time delivery**. Flexibility would be achieved because automated vehicles can be more easily **assigned ad-hoc** to other tasks than humans which can be expected to **increase the total amount of goods being transported** over large distances. In terms of time and **cost-effectiveness**, optimization of the process would contribute to **competitiveness** (cutting down the time for management of the units that need to be transported, processing speed, smooth running of the operations). Increased **customer satisfaction** due to faster transport and cost reduction (energy, time) resulting in **lower prices** for the same services were expected.

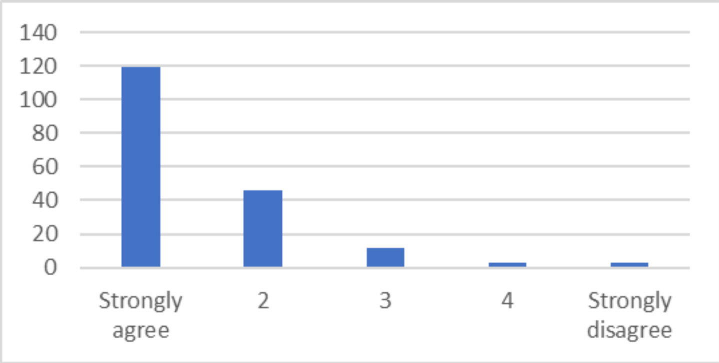

Figure 7: Histogram of rating categories indicating to which degree participants agreed to the statement regarding the respectively selected use case "Automated transport logistics systems will be useful"

Apart from **human error minimization**, change of **working conditions** towards new and/or office jobs were expected and adjustments regarding the combination of **teleoperation and automated driving**. Automation was expected also to trigger an **impact on employment** such as **the loss of jobs in the transport and logistics sector**. However, solving the issue of the **labor shortage** was seen as a positive outcome – less challenging and monotonous jobs would be replaced and the manpower could be used in other activities while re-training would be provided for **new job profiles**. Nevertheless, fear of losing jobs and lack of **employee acceptance** of the automation process was expected as well. Even though machines were perceived as **making fewer errors than humans** or at least not allowing for human errors, the automation process and **vehicles were still expected to be error-prone**. In case of errors, participants considered that it would be much harder for the machine to adapt compared to a human, and certain operations would still need to be performed by humans.

For the automated vehicle itself, apart from its 24/7 availability and time flexibility where its **availability at short notice** would increase the capacities, requirements were mostly concerned with the possibility of **the manual mode** of the vehicle in case the automated mode would be disabled. The communication and the **information exchange about the vehicle's position** would be necessary, as well as **the ability to operate in all-weather conditions** such as cold, fog or snow. In terms of technical availability, this was mainly related to the **sensor technology** of the vehicle (e.g. recognition and detection of loading areas). Another challenge related to vehicles could be **traffic safety** regulations for driving on public roads without the driver – seen as a barrier for the pilot and operational mode. Additionally, questions that were put forward were concerns regarding the time for an automated truck to **become as efficient as a normal truck** and if the automated system could be **as fast as experienced workers**.

Positive expectations	Concerns
• 24/7 productivity, availability and flexibility • Optimization of the process, decrease of operational costs and cost effectiveness • Human error minimization • Change of working conditions towards new and/or office jobs • Solving the issue of the labor shortage • Enhanced speed of the processes (and delivery) with less room for failure and error • The ability to operate in all weather conditions • Increasing transport efficiency • Reducing emissions • Improving road safety • Interest and fascination with automated driving	• Trigger potential impacts on employment • Technology readiness (sensors) • Interactions with other road users and mixed traffic • High requirements on data analysis and organizational control • Data security and data ownership issues • legal and operational issues regarding approval and technical controls • Driving conditions without a safety driver in both public and closed roads; manual mode availability • Policy changes (internal/politics) • Implementation time and cost vs investment returns • Usefulness – safety tradeoff

Table 1: Summary of positive expectations and concerns regarding usefulness

4.2. Ease of Operation

In contrast to usefulness, **expectations for ease of operation** were more reserved with participants on average expressing neither a predominantly positive nor a negative attitude (Figure 8). For an automated system to be easy to use, it would mainly need to satisfy requirements related to **the system's design and reliability,** where **human-computer interaction** and **human oversight** and **interventions** were most often mentioned. Also, the **flexibility of operations** and **24/7 operation** without additional cost were common mentioned needs. Remote operations with real-time tracking were expected to increase ease of operatino due to fewer constraints.

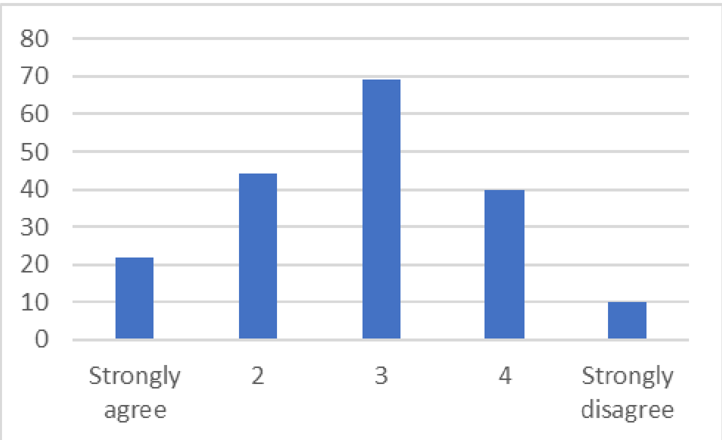

Figure 8: Histogram of rating categories indicating to which degree participants agreed to the following statement: "It will be ease to operate the automated logistics system in the use case [selected use case]"

Expectations related to the human-machine interface, on a more general level, related to **an intuitive UI and a straightforward GUI** needed for easy operations of the system. Also, the automated system should be **consistently integrated** with the current systems (e.g. enterprise resource planning systems) and provide **easy communication** between the parts of the AGTS including people interacting with the system.

For the operations to be carried out efficiently according to the responses, certain aspects related to **reducing the complexity** of operations would need to be satisfied. For example, this included the **simplification of the automation task** and the **harmonization of operations**, avoiding overloading the task due to parallel systems (manual and automated). Furthermore, **data evaluation and error analysis** would need to be improved, and there should be a focus on the **systematic and repetitive type of operation** (i.e. vehicle performs on the same route, in order to increase predictability and feasibility of training). It was suggested that the complexity of operations would have to be sorted out even before introducing automated transport (e.g. loading and unloading one vessel at a time, while a vehicle is moving backwards and forwards between yard and ship).

More concretely and often depending on a specific use case, the reported requirements included having a mobile **notification system** about the vehicle status for the personnel and other types of **indicators of the system** state (e.g. a color indicator). Furthermore, **real-time tracking** and **integration of AV system state information** in the overall logistics management system would support intervening more effectively. The wish was also expressed that physical investigation of the AV should be enabled, e.g. that a human operator could go to the location and check a non-functional vehicle on site).

Training for the handling of automated systems was recognized as necessary in the responses for all involved to avoid mistakes. With increasing scope of the system and vehicle deployment, operators would familiarize themselves with the new workflows, and therefore the expectation was that it should be simple to use it. **Human intervention** and **training for supervision** of operations were considered to significantly contribute to the easy use of the system and to be especially important in situations that could pose problems with AV as well as **unforeseen and rare difficulties** that would need a lot of human oversight. Some of these situations included **a safety driver on board** needed for feasibility or having an AV **safety operator** that may help to resolve mixed traffic and blocking when it appears. Conditions that interfered with the mapped-out path of AV were also seen to benefit from physical intervention **involving a fleet manager for better operations. On-site/physical intervention** would be preferred to handling the AV remotely (even after physical inspection). Additionally, there should be **a reliable form of communication** in case something unexpected happens (and this communication should go to the foreman).

For the AV vehicle itself, a **simple and fast maintenance** would be needed, with a minimum amount of training and to have an **easy access to AV** (in terms of diagnosing, status reports, configure, repair, update, change parts). To inspect problems with AV physically (apart from remotely) it would be helpful for the system to indicate whether the issue was caused internally (e.g. system failure) or externally (e.g. animal running in the area). Relying on previous experience, it was reported by some stakeholders that remote control or inspection as handling of the problem through cameras isn't always as helpful as direct physical interaction to solve the issue. **All-weather scenario-based verification** would be needed for the AV and operations (such as rain and wind as well as snow and ice conditions), and in case the AV doesn't operate only in a closely regulated environment that simplifies the automation task, **additional traffic management** to facilitate driving into fast-moving lanes was mentioned as a requirement.

Additionally, some expected that automated vehicles would be **accessible to everybody in the future** which will, in turn, **would require highly educated people** for the operation. Also, the automation process was expected to bring **changes to the business model** in terms of companies only buying the transportation service, rather than the vehicles. Higher ease of operation was expected with an external service provider, and lower ease of operation was expected if the company itself would need to provide everything. Among the conditions influencing the operation of the automated system would be its dependence on the particular **proof of concept** and the pilot, focused use case with a manageable application area, flexibility to adapt company premises, and the application area.

Positive expectations	Concerns
• Less accidents due to human error • Remote operations with less constraints • As the scope of the system increases – less dependency on human involvement • Deployment process quick and easy/low maintenance • Cost efficient, flexible, innovative logistics and business models • Improved data evaluation and error management • Standardization/well defined operational domain/less bureaucracy • Technology and experience already in place • Easy training due to predictability (i.e. route of the vehicle)	• Human oversight and training for supervision of operations • Handling complex UIs and the complexity of operations (also before automation) • Trained and skilled workers for the operations • Integration and compatibility with other processes/users/systems • Public roads operations • All weather scenario based verification • Flexibility, maintenance, failures, manual interventions • Reliable form of communication (between AV, operating system, site of operations)

Table 2: Summary of positive expectations and concerns regarding ease of operation

4.3. Supporting Conditions

Participants **overall showed positive expectations towards supporting conditions**, but they were not as strongly expressed as with some other factors, revealing some uncertainty in this regard (see Figure 9). Apart from the technological requirements that may support automation and related logistics, other often mentioned conditions were training. This includes time to **train new technicians** and form teams, (basic) training for specialized **IT features related to AV**, **training of fleet managers** and people that communicate and interact with AVs such as personnel **involved with the vehicle directly** to gain full trust in the vehicle and know-how to handle it, as well as already trained staff that would need only additional information for the optimized process. For example, trained personnel would engage in solving problems on-site and report back to the fleet manager who has an overseeing role (remote).

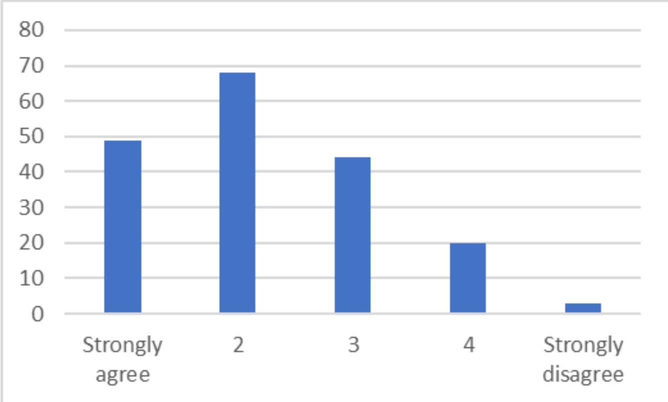

Figure 9: Histogram of rating categories indicating to which degree participants agreed to the following statement "Good supporting conditions can be expected for the use case [selected use case]. Examples for supporting conditions: Training, job profile adjustments, internal communication, supporting infrastructure, policy changes, etc."

Supporting conditions related to technology that were most often mentioned as a concern were **the sensor technology readiness**. However, for a transition phase**, operators in the vehicle could mitigate shortcomings of immature technology** to some extent. In case of the AV breakdown, **an emergency system** would be needed so that the infrastructure or mapping out of the paths for other AVs is not affected. In the case when remote monitoring/teleoperation would not be possible, enabling other **flexible setups** for safe operations was proposed (e.g. an operator outside but near the vehicle at least as an interim step). Other mentioned conditions included **intelligent traffic lights**, **sensors that inform the vehicle about critical situations or other road users** approaching and assets like **HD maps and defined routes**. For the operations not involving the vehicle in sight, **control software** would need to be available, in order to assign the tasks to the vehicle from a control room (e.g. if no YMS/ERP systems are available in a port in UC4).

As it would be possible to **monitor** the equipment and the operations **remotely, fast reaction** was expected but **the need for manual intervention** was also foreseen. Some differences could be expected between **controlled environments** (such as factories) where supporting conditions were considered good or better than **public spaces**. Furthermore, if the open road segment received additional traffic lights, this would be good support from the authorities. Aspects concerned with communication included **internal communication** about the state of the system (such as having color indicators about AVs through the interface) as well as enabling **remote communication with AV** and the participants (or passengers if applicable). In situations where communication currently depends on radio communication devices, there would be a possibility of miscommunication (i.e. because everybody would talk too much, or because instructions may not be clear) the automated process would need to regulate such internal communication.

Logistics and production processes were expected to run smoothly with fewer accidents. There were also positive expectations in relation to **an easier and fully reliable operative system** and **technical support**. In more general terms, as more people realize the omnipresence of automation, the willingness of companies to **invest in the technologies** was expected to help them make progress. Additionally, monitoring operations at different levels and stakeholders, especially **safely implementing the automated transport** part would be needed for all involved stakeholders to trust in its smooth operation.

Furthermore, questions were posed related to **digitalization strategy** and about increasing data mining and digitalization rather than automated system (e.g. end-to-end road transport). Other considerations were about investing in **a good dedicated supporting team** which would be **locally based support** readily available in case of issues and which also performs constant monitoring - considered more desirable than remote support teams (i.e. in other countries).

Among the reported concerns in relation to supporting conditions, **the infrastructure** and **slow policy changes** could be the aspects blocking acceptance as well as **resistance from drivers** and **traffic conditions**. Extension of infrastructures and enabling additional ones for the road and company sites will be needed to support the process. As the biggest challenge for automated vehicles would likely be **interacting with VRUs**, the design of infrastructures was seen to participate in effectively creating a supporting condition for such interactions. Furthermore, **a tradeoff between the costs of vehicle technology and infrastructure** also would need to be considered and **price schemes** to make the **service affordable.** A **positive financial impact** was expected once the AGV is deployed and operators get used to it – if deployment concerns are successfully managed. **Testing in real operation** could be challenging and considering that typically only a few use cases are tested, the concern was that the **solutions might not be well generalizable**. Some noted that if the benefits of the automation process are not **easily presented and understood**, this could negatively affect the supporting conditions. **The lack of experience** with new technologies was observed to sometimes lead to **very high requirements,** even if they are not actually required for the use case.

Positive expectations	Concerns
• Innovative solutions/smooth operations • Low cost (less or no personnel, vehicles, 24/7 operations) • Safer, less accidents and more easy and reliable operative system • Recognition of automation as driving progress • Remote monitoring that provides fast interventions • Strong partners who are leaders and experts in the domain and already developed AGV projects • Readiness of the technology • Logistics and production processes can run more smoothly • (Better) Regulation of internal communication with automated process • Automated driving system is modular and configurable	• Sensors and technology readiness • Training: interaction with the vehicle, specialized IT features, technicians, fleet managers... • Interacting with VRUs • Overview of operations and communication • Supporting infrastructure • Transparence and clear communication about the benefits • New area of expertise • (Legal) Regulations that slow down the implementation/Politics/Policy changes/Additional expenditures on training • Investing in dedicated and readily available local support team • Price schemes to make the service affordable • Intelligent communication about the state of the system • Trust (in the process/in innovation/automated system) • Lack of experience with new technologies can lead to high expectations

Table 3: Summary of positive expectations and concerns regarding supporting conditions

4.4. Trustworthiness

Expectations regarding trustworthiness were **overall positive, but they differed notably** between the aspects subfactors safety, security and reliability (see Figure 10). **Safety** was regarded more positive than security and reliability, because automated driving systems were expected to be released only if they have passed high safety-related benchmarks, and if they can operate in well-defined and standardized conditions. In relation to safety, the most commonly described expectations were concerned with **minimization of accidents or errors** in the automated processes as well as different aspects of AV interactions with process participants and other traffic. The prevailing belief was that **reducing human involvement** would result in more safety. However, **risks posed by the AV due to the novelty** of technology, complexity and implementation process also were necessary to be considered.

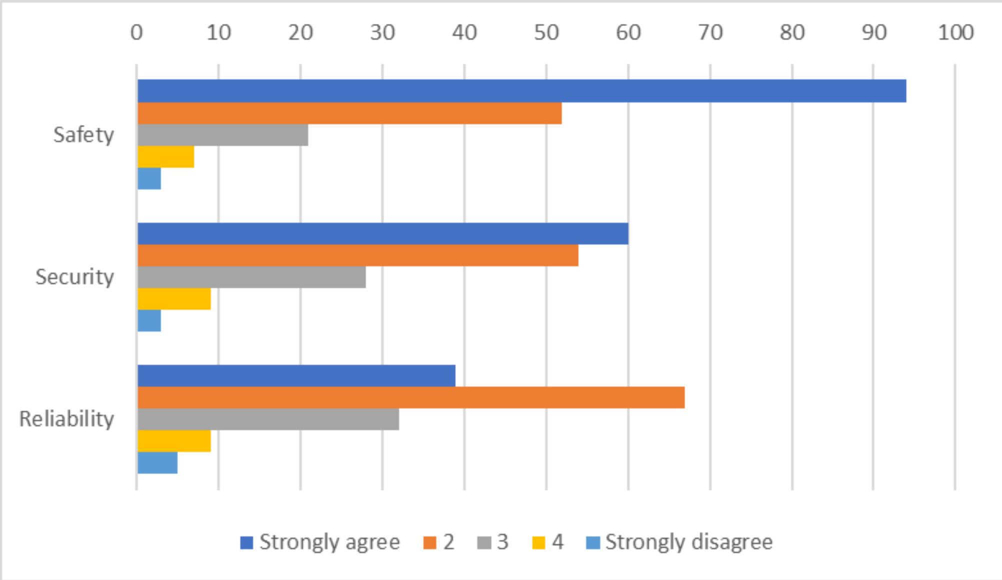

Figure 10: Histogram of rating categories indicating to which degree participants agreed to the following statement regarding the respectively selected use case: "The system will have a high level of safety." (Safety); "The system will be secure" (Security); "The system will be reliable" (Reliability)

AVs were generally seen as **more predictable and therefore safer**, yet some questions remained about **ensuring the safety of traffic interactions** as well as road safety. With their **low speed and sensor technology,** AV operations were expected to be safe, as they would be embedded in **highly controlled situations**. However, there were concerns regarding **sensing uncertainties and malfunctions**., which could occur due to **bad weather conditions that would affect sensors** or circumstances that involve **uncertain and unpredictable behavior** of either people or other vehicles. Therefore, the AV stopping in time and in a safe way for other road users and **allowing for manual operation** would be needed. Special attention would need to be paid to **AV to adapt to its route and environment** in avoiding obstacles. **Risk of collisions** in maneuvers such as airplane turnarounds or complicated road intersections such as roundabouts also needs careful consideration.

Security aspects were mostly reported to relate to **the threat of cyber-attacks** and **data ownership** and were regarded as fundamental affecting all parts of digital logistics systems. Apart from **regulations, legal frameworks and compliance** that need to be met for the projects to be realized, security mechanisms would need to be deeply **integrated into the development and testing procedures**. Relevant questions that were brought up concerned **security maintenance**, checking and testing the system against attacks and ensuring high-security features through **the design of the system to handle risks**. It was considered that as systems get automated, more security issues could emerge due to unknown risks of new technologies or potentially due to still immature IT security of automated vehicles. Depending on a use case, sometimes the risk could be related to **human presence on the site** of operations that could range from searching and control for illegal immigration, to theft, vandalism or even terrorist acts.

Reliability was mostly perceived as dependent on **the maturity of technology** and **the system's ability to handle unexpected situations, weather conditions, breakdowns of equipment, complex traffic and interaction with humans**. It was expected that reliability would improve with **extensive testing** even though it might not be plausible to cover all possible scenarios with testing before the final deployment. Increasing computational power, improving sensor's reliability and providing constant data backup would help solve issues related to technical standardization that in turn would affect the **flexibility of the system**.

Human oversight, intervention and decision making were considered Indispensable for unexpected or critical situations, especially when they depend on risk-taking. The reliability of AVs would closely be related to **critical situations posed by weather conditions,** yet the expectation was that **the vehicle would not be able to improvise like a human driver** to solve challenges. Apart from detailed planning between all points of action and participants in the process due to the complexity of the automated logistics system to fulfil reliability expectations**, switching to non-automated operations** was seen as a viable option in specific situations. Since reliability is also dependent on the costs, **carrying out cost-efficiency analysis** would be needed to assess the tradeoff between cost, redundancy and reliability.

Positive expectations	**Concerns**
• Reduction of human error/accidents • Well defined operations/vehicle paths • Resilient and robust systems (by design) • Testing beforehand contributes to better running of the system • More secure than manned systems • More secure in confined areas • Higher reliability due to less downtime • 24/7 operations and constant level of performance •	• Weather/unexpected events/system failure • Other road users interactions • Sensor sensitivity/Flexibility of operational mode (manual option) • Cyberattacks/data security • External factors/entries/human inference • Tradeoff between cost and reliability/investment

Table 4: Summary of positive expectations and concerns regarding trustworthiness

4.5. Acceptance by Other Stakeholders

When participants were asked about whether automated road transport systems would be accepted by other stakeholders, **responses were only moderately positive** (see Figure 11), and their statements were mixed. Aspects expected to have positive relations with acceptance by others were the **reduction of incidents, cost-effectiveness, positive environmental influence, the potential of innovation** and **curiosity around automation**.

Companies' need for novel technology was expected to eventually contribute to acceptance and successful introduction of automation. Automated Guided Vehicles (AGV) were considered to already be **well known in the industry** and because Automated Driving Systems (ADS) with higher autonomy levels and more flexibility were perceived as new and exciting, **positive curiosity** about them may lead to **an easier transition to automation**. Over time, with other **road users getting used to ADS**, use cases involving shuttle services were expected to become popular. Representing **innovation and futuristic processes**, **increase of comfort**, and improving the **environmental impact** with less noise and fuel consumption, automation was expected to be perceived as a positive change that is innovative and good for the company. Acceptance was expected to increase over time as systems evolve, bringing a positive image towards automation and electric drive technologies.

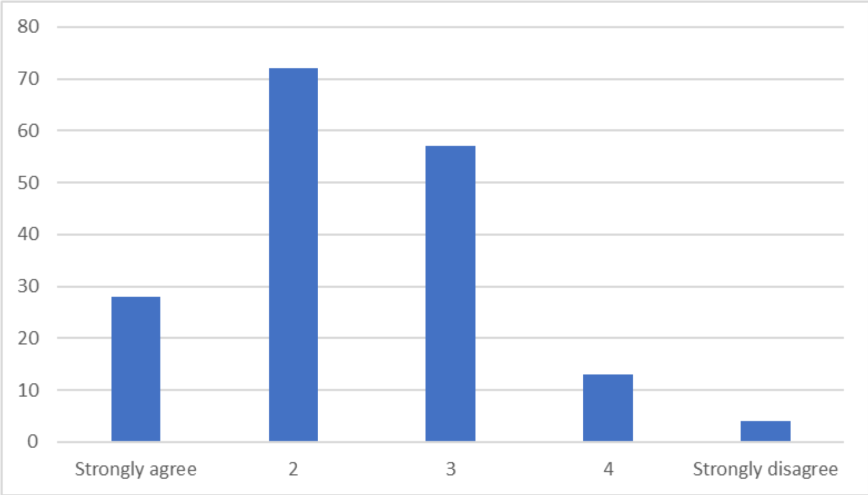

Figure 11: Histogram of rating categories indicating to which degree participants agreed to the following statement "Other affected stakeholders will accept automated logistics systems in the use case [selected use case]"

Companies, as well as end-consumers, could be satisfied with automation due to the expected time and **cost-effectiveness, reliability, and reduction of damage and error**, which can also increase reputation. Some statements suggest that the process of automation is regarded positive if it is not driven by technology alone but seen as **an integral part of a holistic logistics operation**. **Lowering the level of effort** with automation is considered beneficial for logistics operators although the question about **the reliability** of the automated system and its **integration into existing logistics** may pose some doubt.

The most common concern regarding acceptance by others was **the threat to employment** that would reduce low skilled jobs and the underlying developments perceived as machines substituting workers/people. Respondents also state that the role of unions will also have an impact on acceptance. Furthermore, when it comes to the regulatory process, **considerations of stakeholders and the traffic, as well as neighborhoods** close to the site and automated vehicle operations, would need to be taken into account to achieve wide stakeholder adoption. **Bureaucracy and ownership** of the machines and generally **ethical and legal challenges** were also mentioned as important issues to be addressed.

Another major factor deemed to rapidly decrease acceptance is the occurrence of **accidents,** especially when **vulnerable road users** are affected. Acceptance was expected to come with time as **a stepwise process** also for interactions with people not used to automation. Introducing a new stage in the ongoing process **may disrupt operations** and affect acceptance if the expectations are not met. At the first stage, it can be the case that people are **hesitant when innovation is deployed** and might face it with distrust. This can be related to **the lack of knowledge** that can **create uncertainty** and **skepticism about innovation**. In this context, acceptance would depend on **the training and education of people to feel safe** if not necessarily changing skeptical attitudes.

Positive expectations	Concerns
• Positive effect on environment - noise and pollution • Familiarity with AGV • Perception of change as holistic and integrative not driven solely by technology (isolated processes) • Acceptance both by partners and competition due to benefits • Applicability beyond use cases • Companies and customers satisfaction due to time efficiency • Innovation and future oriented demonstrations/comfort/positive image/reputation • Expected acceptance (of the vehicle and technology) due to needs and getting used to the situation • Openness to change/replacement of manual processes	• Seen as a threat to employment/low skilled jobs/union issues • Acceptance dependent on training and education to overcome resistance • Changes need time/stepwise process • Safety aspects affect acceptance (vulnerable participants/accidents) • Reliability of the logistics and integration/software • Expectations and inexperience with automation/hesitation at first stages of deployment • More difficult for direct or indirect vehicle interaction (than general stakeholders) • Technical, ethical and legal challenges • Unnecessary bureaucracy in the current state of regulations • Operational difficulties

Table 5: Summary of positive expectations and concerns regarding acceptance by other stakeholders

5. Specification of User and Stakeholder Requirements

Table 6 shows the consolidation of the user and stakeholder requirements into a list of 26 elements, following the methodology outlined in section 0. The column "Aggregated User Requirements" contains the stated requirements. "Topic" and "ID" columns contain the subject of the requirement and its identifier for easy reference. Finally, the use case column specifies, for each requirement, which are the use cases to which it is applicable.

Topic	ID	Aggregated User Requirement	Use-case
Personnel	R1	Highly qualified personnel shall be available to support/solve problems related to the automated system.	1,2,3,4
	R2	Working unions help shall be required for acceptance of the automation process.	1,2,3,4
	R3	For the acceptance of the automation process, there shall be clear information about the impact on working conditions (employment, qualification, tasks, etc.) as well as new job opportunities.	1,2,3,4
	R4	Training for personnel directly/indirectly involved shall be carried out.	1,2,3,4
External conditions	R5	The vehicles shall be able to operate in public/private areas interacting with other traffic/road users.	2
	R6	AGTS operation shall be adapted to different weather conditions.	1,2,3,4
	R7	The vehicles shall guarantee at all times the safety of all the people around it.	1,2,3,4
	R8	The behavior of the vehicles shall be adjusted according to the road conditions: area (public or private), surface (pavement, concrete), relief (slope, flat), and geometry (curve, line).	1,2,3,4
	R9	For the implementation of the AGTS, the opinions / suggestions / requirements of the people who will interact with the vehicles on public roads shall be considered.	2
	R10	The vehicles shall be able to interact with the available digital/physical infrastructure.	1,2,3,4
Vehicle Fleet Operation	R11	The vehicles shall be eco-friendly (low noise, low CO2/GHG emissions).	1,2,3,4
	R12	The vehicles shall be equipped with an emergency system, to be stopped and/or intervened by an in-site driver.	1,2,3,4
	R13	A recurring physical inspection of the vehicles shall be done.	1,2,3,4
	R14	The vehicles shall inform the control system (LOFM) about its movements (actions, positioning, longitudinal and lateral motion, etc.) and status (sensors, tires, fuel/energy, etc.).	1,2,3,4
	R15	The user interface shall be easy to use.	1,2,3,4
	R16	The vehicles shall allow remote intervention / control at any time.	1,2,3,4
Reliability	R17	The AGTS shall be able to define a detailed route before starting operations, as well as modify it in real-time if	1,2,3,4

Topic	ID	Aggregated User Requirement	Use-case
		necessary (for example, under the presence of an obstacle/accident).	
	R18	The AGTS shall be robust to face external attacks (e.g., cyber-attacks), as well as prevent misuse by internal unqualified personnel.	1,2,3,4
	R19	The AGTS shall be reliable and fault tolerant.	1,2,3,4
	R20	A delay time shall be considered for the implementation of the AGTS to achieve the desired performance.	1,2,3,4
	R21	The AGTS shall be integrated with existing systems avoiding any interference.	1,2,3,4
Business model	R22	The AGTS shall be standardized to simplify its implementation in logistics use cases.	1,2,3,4
	R23	Automation shall result in higher profitability, coming from higher productivity (24/7 operability), higher transport capacities, and optimization of movements/time (and therefore, reduction in fuel/energy consumption).	1,2,3,4
	R24	Tasks around the vehicles shall be automated.	1,2,3,4
Ethical and legal scope	R25	A regulatory change shall be made to consider the presence of automated vehicles.	1,2,3,4
	R26	Ethical and social implications shall be studied.	1,2,3,4

Table 6: User/Stakeholder requirements.

Table 7 is added to Annex 1 to illustrate the aggregation process from where these requirements were defined. This table shows topics obtained from the first aggregation, as well as their clustering into the requirements defined at the second aggregation. A last column indicates the users/stakeholders from whom this requirement comes from, for process traceability purpose.

6. Use Case Specific Considerations

Naturally, the operational conditions form an important requirement for the development of automated transport. The four AWARD use cases introduced in section 2 have been chosen such that they leverage high added value when realized.

Figure 12 shows that the acceptance and expectations scores are mostly similar among the use cases. This indicates that there is an overall coherence among most of the assessed factors. The strongest difference is in the ease of operation, which most strongly depends on the exact definition of operational conditions. In order to shed more light on this aspect, section 6.1 provides an overview of the most challenging aspects to be tackled in each of the use cases, based on the analysis of the gathered inquiry data. Section 6.2 then provides a detailed overview of the operational processes that the automated vehicles will be embedded in.

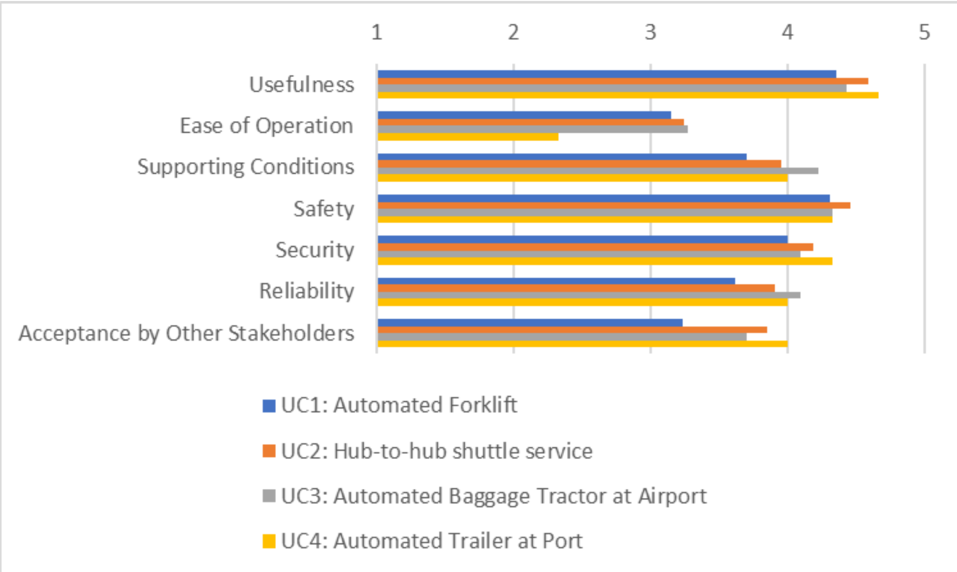

Figure 12: Mean rating scores for the acceptance dimensions, differentiated by the four AWARD use cases

6.1. Comparison of use-case specific characteristics

The defined use cases have specific challenges and requirements in common that need to be addressed – these are outlined throughout this document. In the following, we show some specific challenges that, according to the users and stakeholders interviewed during the requirements analysis, make each of the specific use cases stand out and that make them especially interesting to analyze and evaluate.

Particular characteristics of Use Case 1: "Loading and transport with automated forklift"

One of the most important aspects of this use case is that it includes the **automated handling of the load**, which includes the identification of the box and its carriage. This means that two forms of automation need to be combined: the "taxiing" throughout the yard and the loading process. One should highlight that both these activities are considerable complex in the given conditions on site: for movements throughout the yard, there is a **high density and dynamics of unregulated movements** of other manually driven forklifts, goods stored at the side of the way and

pedestrians, and the load to be handled may not always be at the same place. On top of this, there needs to be **a unified view for logistics personnel** onto the technologically separated processes of automated driving and loading.
Furthermore, similarly to the airport scenario, on the UC1 site there are **strict safety rules**, imposed by the regulations imposed on the production site. To aggravate this, the use case site is strongly **restricted with regard to layout** design and separation of the vehicle from other traffic.
A further functionality foreseen in this use case is **automated battery charging**, which would increase efficiency of operations, but which needs to be defined specifically at a later stage in the project.

Particular characteristics of Use Case 2: "Hub-to-hub shuttle service from warehouse/production site to logistics hubs"

The major differentiation of the use case "Hub-to-hub transport" from the others is that it prominently includes driving in the **public traffic infrastructure**. One of the implications is that **teleoperation** is most needed here, while in the other use cases operators would be available on site to take over supervision and manual control, in case of limited functioning of driving automation. The development of a suitable solution for **takeover and handling of teleoperation control by logistics personnel** is therefore necessary. In combination with this, a specific **vehicle-infrastructure communication** is necessary, which, for example, necessitates the control of traffic lights. Here, especially **legal regulation and certification** aspects will need to be clarified, in order to allow operation.
Also, due to the involvement in public road infrastructure, a **safety driver** is in a transition phase, and thus safe operation conditions need to be enabled also for this type of human operator.
From an economic perspective, similarly to the current condition where a subcontractor handles the hub-to-hub transport, the automated version may be on a **transport as a service** model.

Particular characteristics of UC3: "Automated baggage tractor on an airport"

Airports are regarded as environments with remarkably good supporting conditions, as they are **highly regulated** and strongly **oriented towards ensuring safety**. These conditions support automated processing, which are also dependent on **standardized conditions**. In combination with this, supporting infrastructures such as **training facilities are already in place** and the handling of regulations can mostly be taken over by the airports themselves. The downside is that many **safety regulations are already in place that all need to be adhered to**, before the vehicle can start operating. The airport is a diffuse system with many actors around. **Keeping people and machines separate from each other** will be a challenge for the design of the layout.
Respondents also noted that the airport is traditionally **very open towards technological innovations**, and thus automated transport will not be challenged by the workforce, and also comparably few concerns about job losses may be expected. Furthermore, due to the high level of automation of subsequent baggage handling, a **centralized management of the overall process** is possible, but on the other hand, the **efficient and reliable integration** with these processes is necessary.

Particular characteristics of UC4: "Trailer transfer operations and automated ship loading in a port"

One of the main mentioned opportunities for automated handling in this use case is the **reduction of the number of external actors** from the inner parts of the port. In order to achieve this, a number of serious challenges has been mentioned particularly for this use case (see also the lower score for ease of operation). One of them is the need to quickly unload on a **tight time schedule**, as a vessel needs to be unloaded and loaded upon its arrival within a certain predefined and inflexible time span. In this regard, much **precision** is needed for the positioning of the trailers at the dock or within the vessel. Furthermore, there is an inherent need for **supplemental tasks to be performed by humans**, such as the winding of the legs of the trailer to attach it to the truck, or the handling of customs. The **internal communication** modalities would also need to be changed, as they currently are based on voice radio. In addition, a challenge is also seen in the necessary **additional investments in further automation** (e.g. automated loading, docking, communications and positioning technology, as well as surveillance related to available parking spaces), in order to achieve the needed degree of automation to achieve profitability. With the port, there will also arguably be more **concerns by the workforce**, as replacements of low-skilled jobs may be more likely than in the other investigated use cases.

6.2. Use-case specific operational process conditions

In order to drive the development of operational use cases and requirements definition, the step-by-step operational workflows at the status quo ("AS-IS") are described, and the planned process for the automated solution ("TO-BE") are depicted.

The flow chart compromises the following elements:

- Circle → Start / Stop of the process.
- Rounded rectangles → Process.
- Rectangle → Predefined process which is described in a vertical container named "Process: <name of process>".
- Vertical container containing one of the stakeholders depicted in Figure 2.
- Lines with arrows → Link from one process to the next.
- Dotted lines → Links between predefined processes and their definition
- Speech bubble → Additional information

The flow chart has multiple color-coded elements to help distinguish different interactions and concepts:

- Blue → Human operator is interacting with the FMS and an HMI is required. This could be either a mobile application, an information wall panel, auditory information, etc. How these interactions will be enabled will be part of subsequent work packages.
- Orange → The AV is driving somewhere in an automated mode without human intervention.
- White → Processes which are irrelevant to the automated system or manual processes like unloading a truck with a forklift, taking a break, or connecting vehicle components.

UC1: Loading and transport with automated forklift

The status-quo operational scenario consists of five parts all executed by the direct process participant of a forklift driver shown in Figure 13. At the moment, most employees at this use case site are using forklifts to drive around the area. While handling other tasks, they check the pickup area on which production site employees drop boxes of which shall be brought to the storage yard while passing it. When the forklift driver sees a box, they pick up the box with their forklift and drive to the storage yard. The driver needs to choose one of multiple yards depending on the utilization state of said yard. Currently, there is no assisting system to help with this choice. Once a yard and a position has been selected by the driver the box is placed at the identified position. After the box has been placed the driver continues with their other tasks not related to the storage yard and another employee will intermittently check the pickup area.

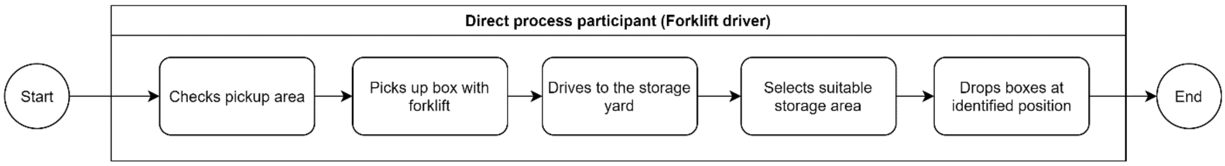

Figure 13: Status-quo of the operational process for UC1 Forklift (As-Is)

In contrast to the other use cases, no human interaction is required in the planned operational scenario of use case 1 shown in Figure 14. Instead of a human checking for boxes at the pickup area (insertion points), a light barrier detects the presence of a box and notifies the FMS which checks if a forklift is online and if the storage yards have enough space. When all checks return a positive result, the FMS issues a forklift from the parking area to the insertion points where it automatically picks up the box, drives to the storage yard at a viable position issued by the FMS, stacks the box and drives back to its parking space on completion.

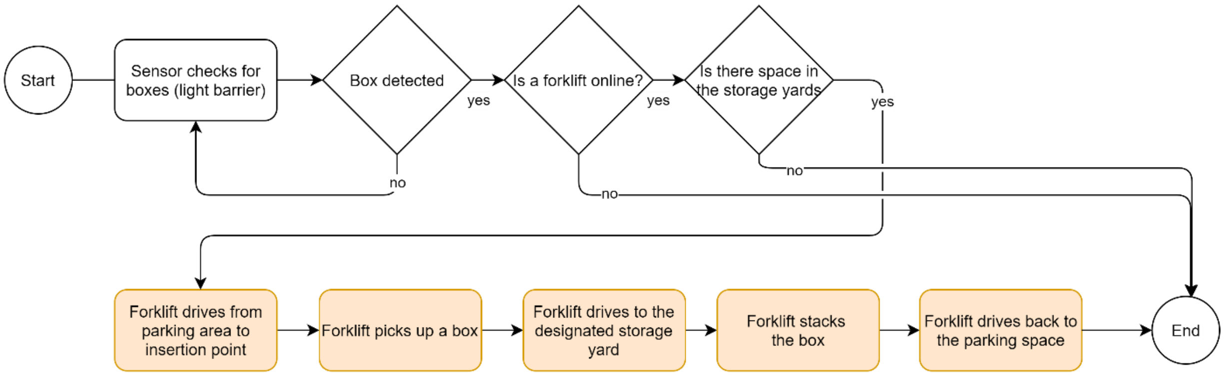

Figure 14: Planned operational process with the automated vehicle for UC1 Forklift (To-Be)

UC2: "Hub-to-hub shuttle service from warehouse/production site to logistics hubs"

The status-quo operational process of the Hub-to-Hub use case is solely managed and executed by the truck driver. When the truck (shuttle) is not needed or at night the truck is parked at the ramp of the logistics hub. Once a transport is required, the truck driver loads necessary items at the logistics hub onto the truck and starts driving at a predefined time to the production site. The driver positions the truck at the loading ramp, gets out of the truck and manually unloads the items with an electric lifting cart. Once unloaded, other items are loaded which shall be brought to the logistics hub. As soon as the unloading / loading process is finished, the truck driver drives back to the logistics hub and arrives typically 20 minutes past the full hour. If another transport is required, the driver may need to take a break before they unload the truck and start the cycle anew. This cycle is repeated every hour starting from 6am until 6pm in two shifts.

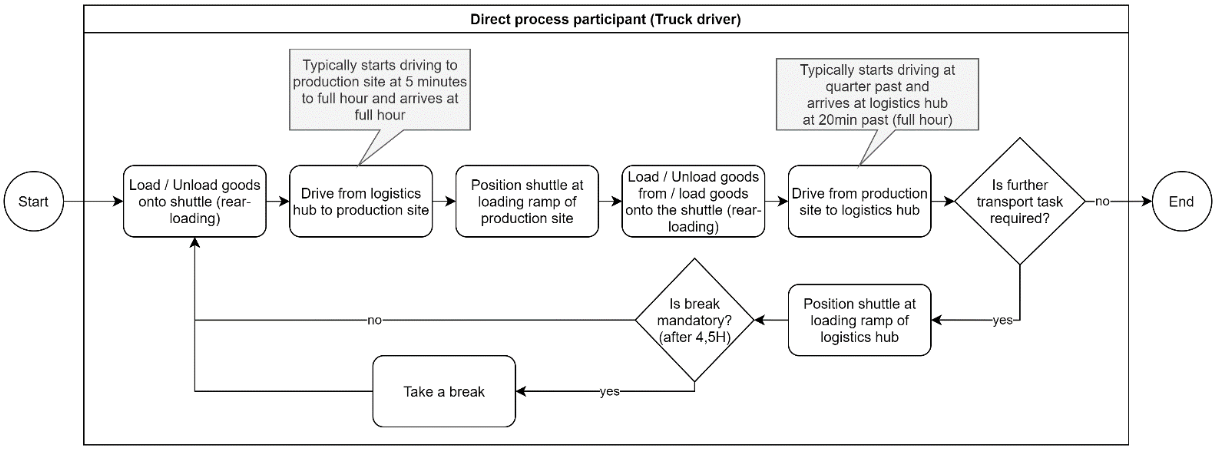

Figure 15: Status-quo of the operational process for UC2 Hub-to-Hub (As-Is)

The planned operational process introduces an automated vehicle which drives between logistics hub and production site (marked orange). The (un-)loading process needs to be handled manually by a direct process participant at the logistics hub and the production site. Once a delivery is required, the direct process participants (loaders) are informed by the FMS to load or unload the truck if required. This will be handled by mobile push notifications or informational wall panels. Although the As-Is process is timed hourly and the To-Be process will copy the timing in the first phases, push notifications enable a non-timed transport that may be used in the future. On completion, the loaders need to inform the FMS that the vehicle can start driving which is again handled by a dedicated button at the ramp or a mobile application. The FMS starts the truck, which drives in an automated mode to the production site, where another loader is informed by the FMS to (un)load the truck. The truck drives back once the FMS is informed by the loader that the (un-)loading process is completed. At the logistics hub, the truck can either park when not needed or the cycle is continued by informing the loader via the FMS.

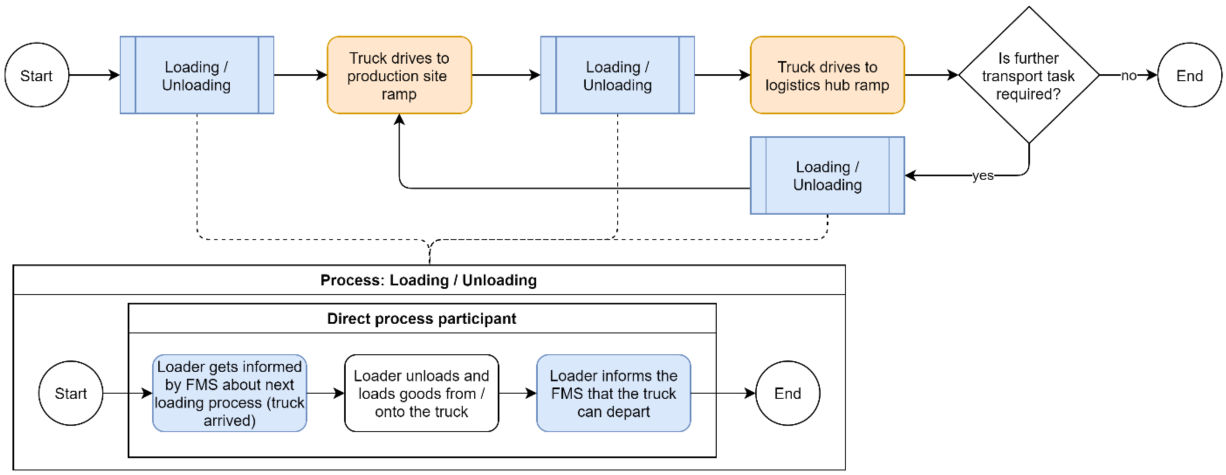

Figure 16: Planned operational process with the automated vehicle for UC2 Hub-to-Hub (To-Be)

Use Case 3: "Automated baggage tractor on an airport"

The status-quo operational scenario of the Airport use case consists of one or multiple ground and baggage handlers. These are human operators who service the aircraft, gate and baggage handling area. The flow chart describes the process of moving luggage from the gate's baggage handling area to the aircraft. The process of moving luggage from the aircraft to the baggage handling area is the same as shown in Figure 17 but the stations are reversed. When luggage should be moved from the baggage handling area to the aircraft, first trolleys are needed onto which the luggage can be loaded. The trolleys are pulled by a baggage tractor, which is driven by a handler from the proximity storage (special storage / parking area for equipment needed in proximity to the airplane) to the baggage handling area. To position the trolleys correctly they are unhooked from the baggage tractor. The luggage is now loaded onto the trolley by another handler. The baggage tractor can either choose to wait or drive to another destination in the meantime. All of this is coordinated via handheld transceivers. Once the luggage is loaded, the trolleys are hooked back to the tractor and driven to the designated airplane where they are unhooked so that the trolleys can be positioned better. Once the luggage is unloaded by a handler, the trolleys are hooked onto the tractor and driven back to the proximity storage.

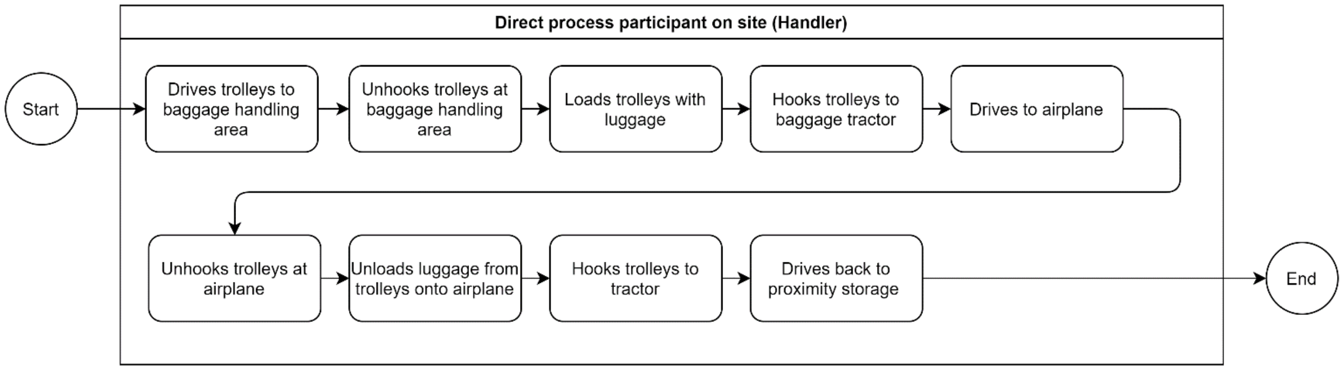

Figure 17: Status-quo of the operational process for UC3 Airport (As-Is)

The complex interactions between the handlers described above need to be translated into interactions the FMS can understand. The switch from handheld transceivers to mobile applications will most likely be a necessity. The process of unhooking and hooking the trolleys back to the baggage tractor will still be a manual process in AWARD, although there are plans to automate these actions in the future. As a result, a handler needs to be informed every time the FMS requires trolleys to be (un-)hooked and every time the handler completes the step of (un-)hooking (marked blue). These two processes are shown in Figure 18 as predefined processes "Process: Baggage tractor arriving / unhooking" and "Process: Calling baggage tractor / hooking" which are both handled by nearby handlers. In the case of "Process: Calling baggage tractor / hooking" the handler might need to call for a trolley if no trolley is present. However, as the FMS should schedule these tasks in advance, this will only be the case if the handler finishes the given task sooner than expected. Apart from these two predefined processes, the flow stays the same.

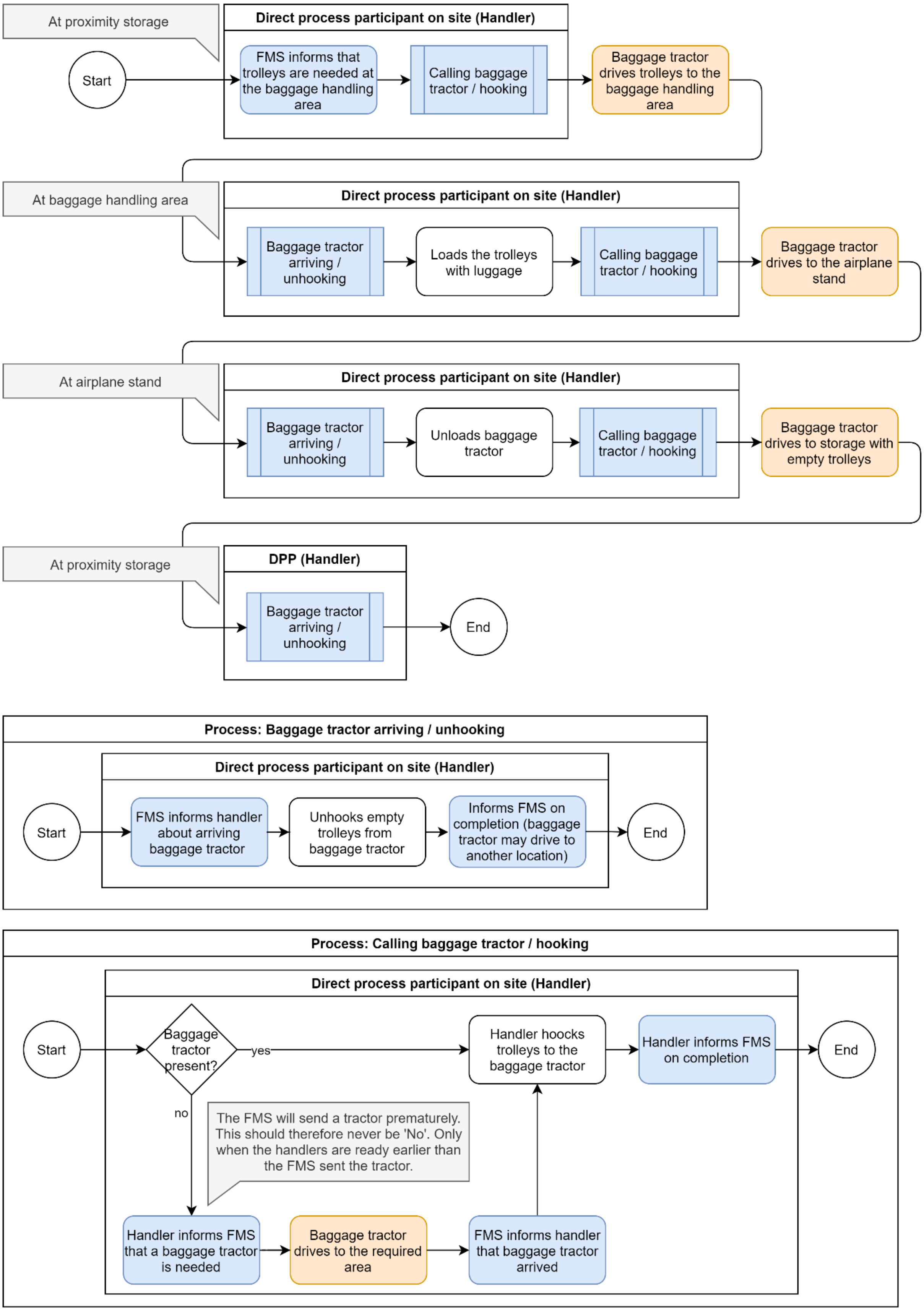

Figure 18: Planned operational process with the automated vehicle for UC3 Airport (To-Be)

Use Case 4: "Trailer transfer operations and automated boat loading in a port"

The current operational scenario seen at the port consist of two major players which are shown in Figure 19; the external truck driver and the internal truck driver. Both trucks are driven manually by a respective driver. First, the external truck driver delivers a trailer to the public parking area which is in close proximity to, but not part of the port itself. The external truck driver parks the trailer, uncouples all cables and hoses and informs the logistics management of the port (not related to the FMS which is used in to To-Be description) that a trailer has been delivered. On reception of the message, the logistics management system informs the internal truck driver that a trailer is waiting for pickup. An available driver either picks a truck or drives directly via the gate to the public parking area where the driver couples the truck to the trailer and drives it via the gate into the closed area of the port. Depending on the task given by the logistics management system, the driver either delivers the trailer to a numbered parking lot on a vessel or on site. The cycle of picking up other trailers from the public parking area may continue if necessary. Otherwise, the driver parks the truck in the controlled parking area.

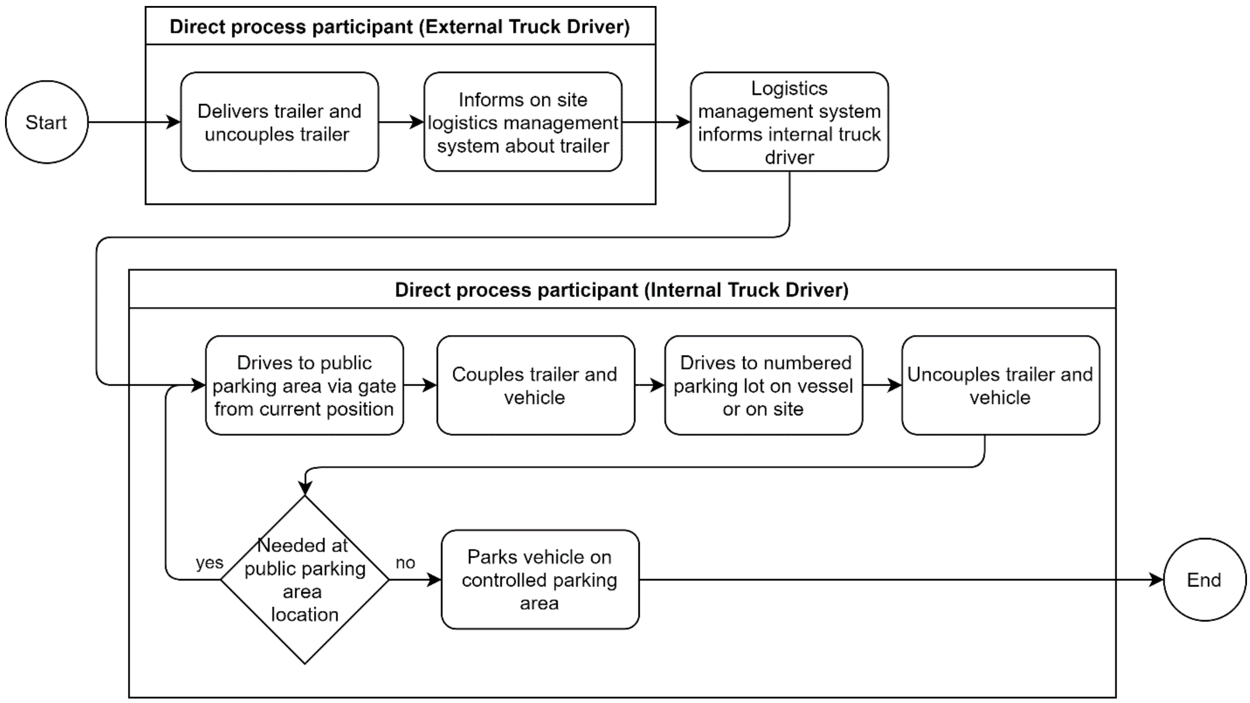

Figure 19: Status-quo of the operational process for UC4 Port (As-Is)

The To-Be operational scenario at the port, depicted in Figure 20, introduces the FMS and an automated vehicle which replaces the internal truck driver. The first step of placing a trailer at the public parking area is unchanged. However, instead of the logistics management system informing the internal truck driver, data is exchanged with the FMS which schedules an available automated vehicle to drive from its current position, which is either at the controlled parking area or at a numbered parking lot, to the public parking area where it should pick up the trailer. While driving to the public parking area the AV needs to pass a gate which is opened by the FMS in a timely manner. However, in reality the FMS does not communicate with the gate directly. It sends a request to the logistics management system which then opens the gate for the FMS. Once the AV arrives at the trailer the coupling process starts. This step needs to be handled manually by an employee on site who is informed by the FMS. This coupling employee is required to plug in all necessary cables and hoses. After completing the task, the employee needs to inform the FMS that it is safe for the AV to start driving. With the data provided by the logistics management system, the FMS knows the location to which the trailer shall be brought. This can either be a numbered parking lot on the vessel or on site. Once the AV reaches its destination, a coupling employee is again informed that the trailer needs to be uncoupled from the AV. Once the employee informs the FMS that the vehicle is uncoupled and it is safe to start driving, it will either continue the cycle and drive back to the public parking area or park at the controlled parking area and wait for another task.

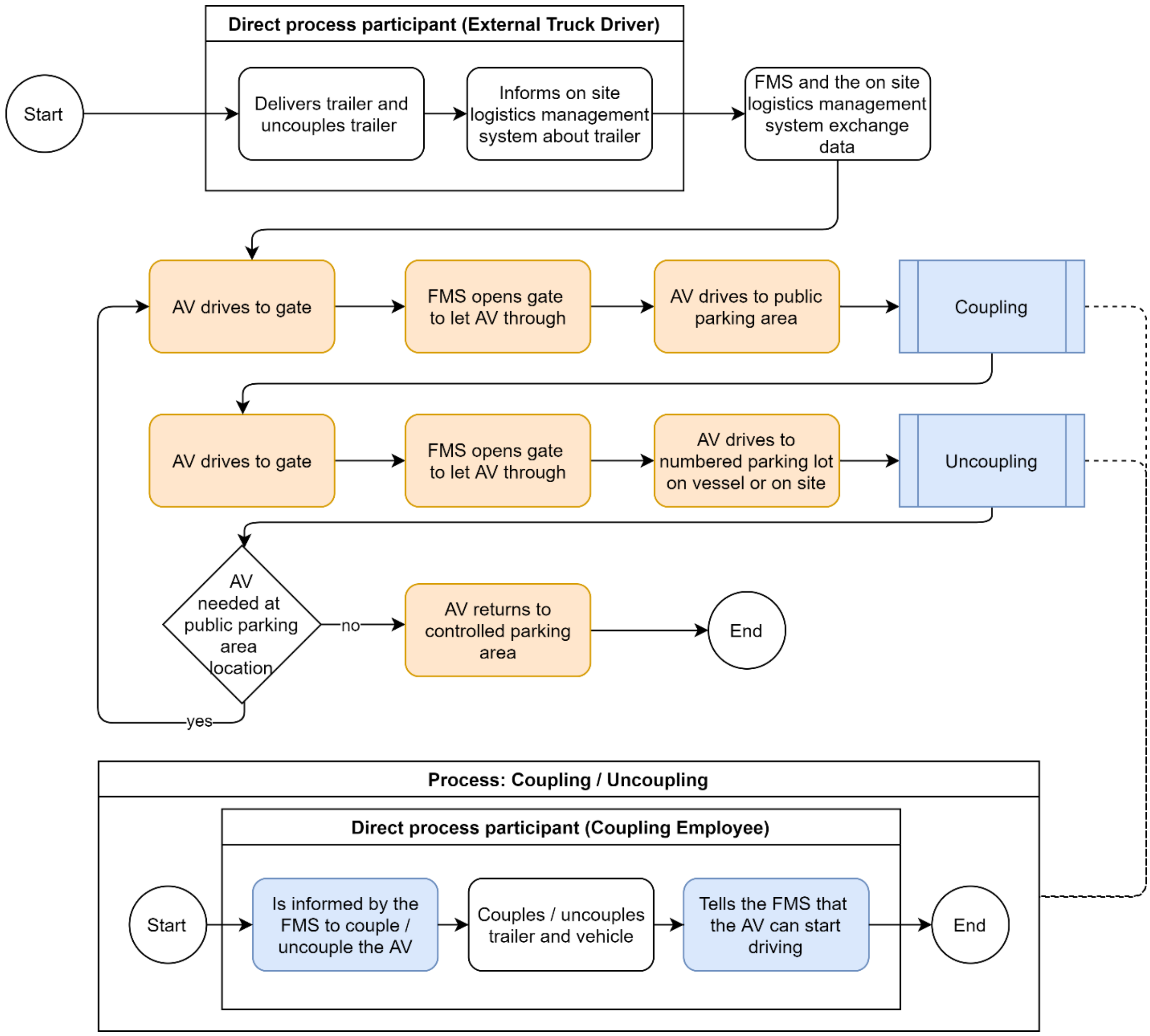

Figure 20: Planned operational process with the automated vehicle for UC4 Port (To-Be). The process definition "FMS opens gate" is a shorter form of the technical correct definition "FMS communicates with the local logistics management system which opens the gate"

7. Stakeholder-Specific Considerations

An important goal of the AWARD user and stakeholder analysis was to identify the specific requirements for the different relevant groups of stakeholders introduced in D2.1. These consist of direct process participants (i.e. human directly interacting, in vicinity of or being confronted with the automated vehicles), indirect process participants (who are involved in the logistics process but not necessarily directly with the vehicle), and general stakeholders (who are more in general interested in the topic). Figure 21 provides an overview of the expectations of the different stakeholders towards automated road transport logistics. Most of the stakeholder groups rather consistently follow the general pattern among the acceptance factors already presented in section 0: usefulness is seen most positive, and the supporting conditions are often regarded with less concern than the ease of operation. As regards the trustworthiness factors, safety is seen as more positive than security and reliability.

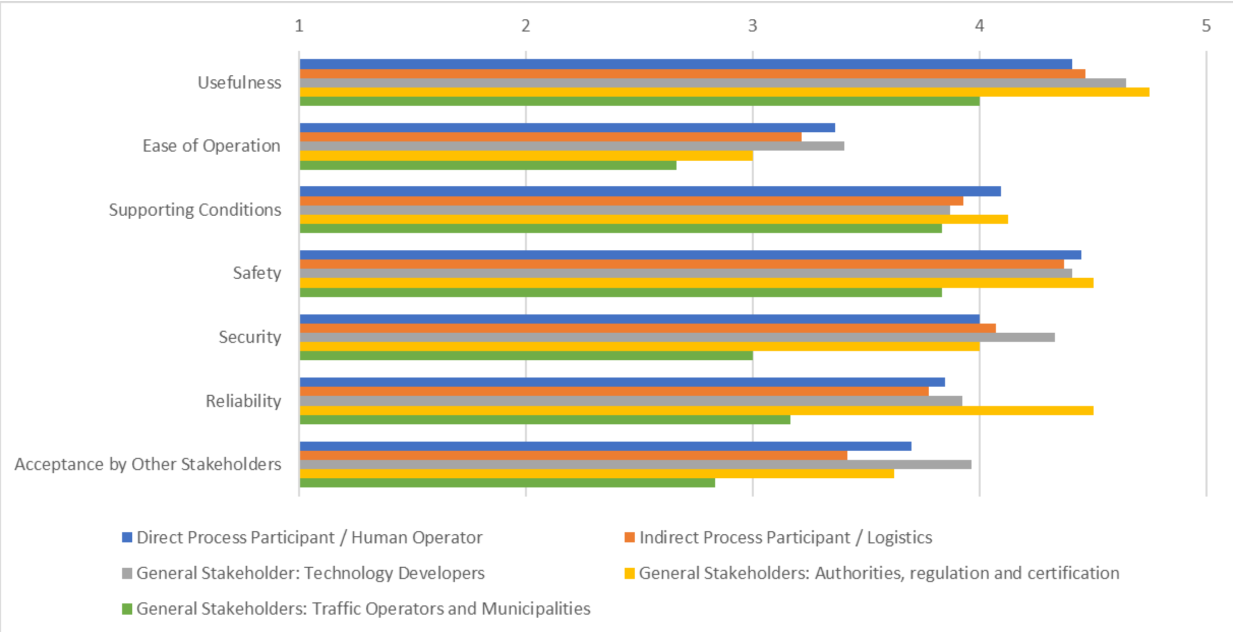

Figure 21: Mean scores for the acceptance and expectations factors related to the stakeholder groups 'Direct Process Participant / Human Operator'; 'Indirect Process Participants / Logistics', and 'General Stakeholders' (OEM; Technology partner; Authorities, regulation and certification; Traffic Operators and Municipalities'). A mean rating score of 1 indicates very low expectations and a mean rating score of 5 indicates very high expectations

Interestingly, direct process participants (the involved humans who will directly interact with the vehicle) and the indirect process participants (dealing with general logistics processes) had comparatively average to positive attitudes towards the considered use cases. It appears that municipalities and traffic operators see automated driving as more critical as the other groups, especially regarding usefulness, ease of operation and acceptance by other stakeholders.

7.1. General Stakeholders

7.1.1. Technology Developers

As highlighted in D2.1 and summarized in Figure 22, the value chain for the AGTS to be developed in the AWARD project comprises a large number of actors and stakeholder groups, most of them “technology developers” (i.e., OEMs or their technology partners). This includes the development and the manufacturing of sensors, which are then integrated in the ADS. Original Equipment Manufacturers (OEM) integrate these ADS in the vehicles and deploy them at logistics sites. The development of a fleet management supervision system of these automated vehicles then is another important part in the value chain, as it helps optimizing logistics operations at the end users’ industrial site. Further steps along the value chain towards end-consumers are not focused in the project. For those, the introduction of an AGTS does not have a visible impact, and therefore, changes with the introduction and penetration of an AGTS may be less significant. As long as the service quality is guaranteed, the wider population does not know or care about the logistic supply chain behind the products that are delivered to them (compare also [10]).

Figure 22: AWARD value chain for technology development (see further information in D2.1)

OEMs and their technology partners have a genuine interest in the successful deployment of AGTS services and products, and they have gathered expert knowledge in achieving this goal. Therefore, capturing their needs and expectations was an important component in the AWARD stakeholder requirements elicitation process. As Figure 23 shows, the most prominent topics mentioned in the survey, interview and workshop were business model/profitability and operation workflow, followed by public acceptance, accident/error management, flexibility, workforce and job aspects, intervention by humans, legislation and training.

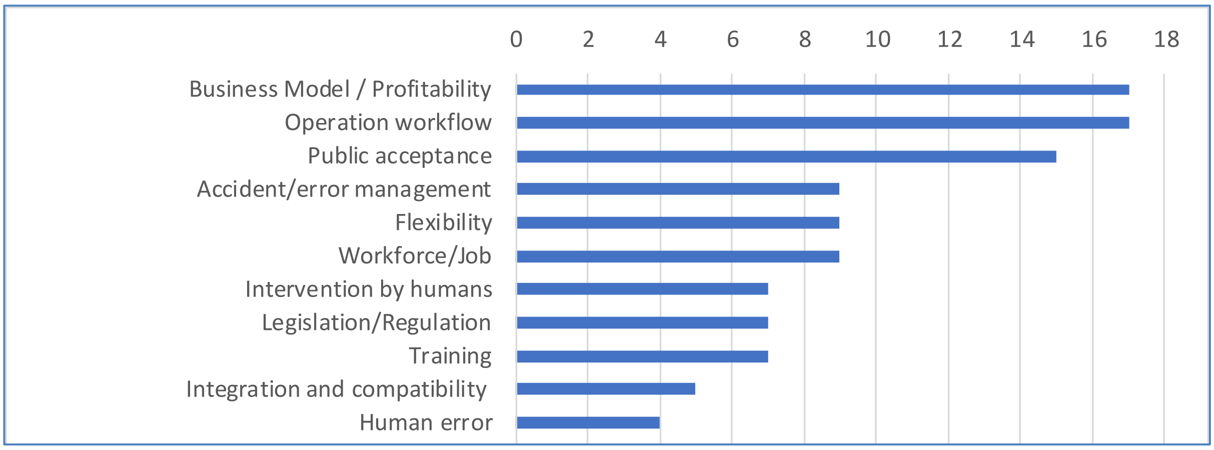

Figure 23: Most of often mentioned content categories of statements and number of mentions for the group of OEMs and Technology partners

Statements by technology developers tagged as *operation workflow* were often expressing the requirement for **repetitive routes and tasks,** and **predefined transport orders** were highlighted, in order to provide easy operations and maintenance. For the system to adapt, the operations also

[10] Hu, B. Z., de Papazikou, R. B. E., Boghani, E., Filtness, H. C., & A & Roussou, J. (2019). LEVITATE Societal Level Impacts of Connected and Automated Vehicles. Deliverable D7. 1 of the H2020 project LEVITATE: Defining the future of freight transport.

should allow for **a short learning curve with minimal downtime**. Safety was regarded as an important factor to consider for implementing new operations workflows, and consequently processes would need to be monitored at different levels of stakeholders' especially automated transport.

Some differences in expectations were observed regarding **restricted areas and public spaces.** There was less concern for the flow of operations that would be employed in restricted areas than in public ones, but the overall integration with other **processes and interactions with human involvement** would need to be considered with special attention. Interacting with the infrastructure further increases the **complexity of the system** as well as **irregularities in operations** and this would need to be considered for designing automated systems. Unknown external situations can be expected to pose challenges for remote operations and **the oversight role of AV safety operators** still needs to be precisely defined.

In order to ensure *public acceptance* of automation, **clear and transparent communication** among people and organizations was seen to have major consequences in the process. If the benefits of the process are not easily presented and understood this may lower the acceptance. To ensure a positive image towards automation, it would need to be seen as **an integral part of a holistic logistics operation** and not a change that is driven by technology alone. **Demonstrations of the automation processes** showing that the system is safe, secure and reliable would further contribute to acceptance. To gain the trust of the general public and other road users, they would need to be believable safer and **vehicles should always obey the traffic rules. Mistrust in automated systems** and **fear of losing jobs** would also affect the acceptance, as well as too high expectations concerning the automation processes.

Accident/error management was mostly reported in relation to interactions between AV and people or other vehicles and traffic, where **the concern was that AV could cause damage.** It was expected that technical measures should assure safety when dealing with AV and for emergency situations a proper plan for handling should be prepared. In order to avoid possible accidents, the necessary **testing and experience** for the deployment of the system should be in place.

To achieve *flexibility*, adaptation and versatile solutions of the system would need to be realized. Here the respondents referred to the possibility of AV **making detours**, coping with **weather conditions** and enabling **flexible setups** for safety operators. An automated driving system was generally considered to be modular and configurable and under good conditions, the expectation was that it would be easy to optimize its performance. However, the more customizable the system becomes (special problems), the more **complex** it will be to handle. Compared to the vehicles with drivers, the **operational flexibility** of the automated system was seen as reduced, and reliability may be impaired if there are disruptions in the infrastructure.

In relation to the category w*orkforce/job* impact, an increase in **skilled workforce** and **removal of certain tasks and jobs** was expected to happen, where, for example, remote operators can expect a more comfortable working environment and mobile working. According to this group, **drivers** would be most likely to experience job loss, yet many expected that there would be an opportunity to move to more **advanced positions** (with possibly better payment), e.g. control tower

operations. It was generally agreed that managing the transition and setting up accompanying change processes would be very important.
For the situations with safety and reliability goals, *intervention by humans* would be most needed. Whether an automated system can **fully replace** manual tasks, or to what extent and under which conditions needs to be considered. Also, the question is was how easily an automated system could **adapt to a changing environment** and situations that currently depend on typically **human decision-making** that involves risk-taking. For these reasons, some driving situations were expected to be denied or delayed with an automated vehicle, due to safety concerns. Good **access control** to the vehicle through information flow and interfaces as well as **physically** will be needed for error handling and rare unexpected difficulties.

Legislation and regulation aspects that were mentioned are expected to provide policies for driving on **public roads** and for **supporting infrastructures**. The potential for safe driving can also increase with the goals set by OEMs while the rigidity to change the **traffic rules** and infrastructure, too slow and too stringent legal requirements may delay and unfavorably impact the economical and road safety aspects. *Training* and supervision for all operators was regarded necessary, in order to form a **new type of expertise**.

How *integration and compatibility* of the new system will be handled was expected to depend on the **standardization** of processes and communication. It was regarded important to define **simple operations** for commitment and acceptance by workers. Also, aspects related to different classes of vehicles, 5G technology, and ODD limitations were stated as necessary elements of successful system integration.

7.1.2. Authorities and regulatory compliance

Figure 24 summarizes the responses of those persons who adhered to national and local authorities and who were responsible for regulatory compliance. On the topic of l*egislation/regulation* for transitions to automation, one of the recognized challenges was that regulators try to apply existing regulations to a **new paradigm**. This was deemed to be as a major factor for slowing down the process of putting new regulations in place. For the operations to succeed at all, **safety and compliance** to the respective benchmarks and regulations were considered as an absolute necessity. Furthermore, stakeholders reported that regulation for driving on public roads would not only be needed for pure technology testing, but it should also serve a concrete **business case** (noting that regulations have so far mostly focused on the former). For **fully automated driving** (without a safety driver), a new set of requirements was expected in relation to **new legislation** (i.e. UNECE regulation).

From the point of view of safety management of an automated vehicle, a level of requirement at least equal to that already in place for conventional road vehicles could be expected. The issue of **liability** and ensuring **contractual arrangements** was stated as important. Also, non-driving related questions should be clarified, such as the definition of responsibilities for handling supplemental **loading and unloading** operations. To this end, also procedures on how address **criminal acts** in situations where no vehicle driver or operator is present or reachable. Depending on the use case and site of operations, policy changes could be expected to rely more on local authorization (e.g. airport) as well as security analysis for the equipment deployed for the AV and testing.

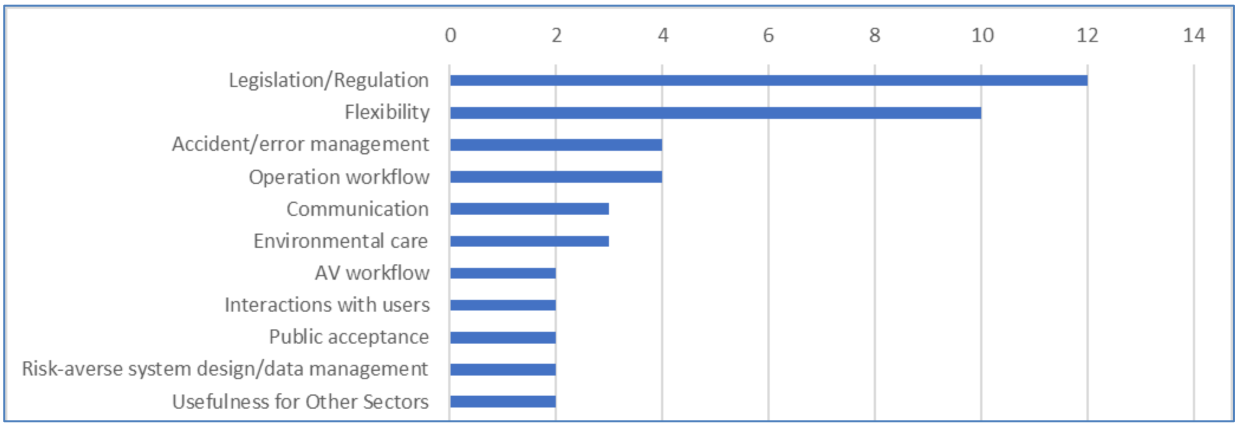

Figure 24: Most of often mentioned content categories of statements and number of mentions for the general stakeholder group 'authorities and regulatory compliance'

Concerning *accident/error management*, the safety issues usually stated by the stakeholders concern the handling of emergency situations, traffic priorities, possible collisions and damages that would affect people and traffic. Among these types of concerns was the possibility of AVs making damage to equipment, vehicles or personnel and for these reasons, everybody involved must comply with regulations. These regulations included complying with the entry and circulation instructions related to the ZEC (Controlled Evolution Zone) or the PSC (Collision Safety Perimeter). In the cases such as airports where damage to aircraft is very expensive and if sufficient **separation distance** and **protection zones** around the aircraft are not respected by AV, this could be of high risk and lead to interferences and blasts. Therefore, the AV must take into account other activities on the site of operations in order not to be a vector of accident which may include blocking certain areas or **trajectories** for automated vehicles.

Other vehicles and traffic participants were also mentioned as a safety issue for AV operations, and especially if public roads are used for the operation it would be difficult to identify an exhaustive list of hazards. According to the participants, **monitoring and incident-response** would have to be more robust to cope with such issues. **Safety-by-design** was deemed very important, including risk assessments with customers, concerns about localization and vehicle leaving route path or intersection handling. Security issues would also need to be taken into account regarding terrorism, and especially loading and unloading was seen as a critical point for trafficking or smuggling.

The mentioned c*ommunication* aspects were stated in terms of enabling an integrated but separated **combination of teleoperation and fleet management.** Also, the equipment of AVs equipped by communication means compatible with the existing system and the other involved participants were regarded necessary. Some examples were given to show that there are already some **good external interfaces** available to enable communication among vehicles at the production sites (e.g. sound and laser communication).

Among other aspects that have been mentioned by proponents of this stakeholder group were also *AV workflow, public acceptance,* and *usefulness for other sectors.* The expectations related to AVs in operation concerned the detection of **priority vehicles** and the response to their motion to ensure room for them to pass or to stop if necessary. The AV should be able to **detect a shock** (suffered or caused) and report it (with time stamp and qualification). With regard to public perception, raising too high expectations ("autonomous shuttle") might hinder the process.

In terms of *usefulness for other sectors*, some discussions revolved around the empowerment of logistics vehicles to enable the implementation of **service management** and not just merchandise management. This management would benefit not only the transporter, but also the customers, the freight forwarders, the shippers and, in general, all the actors involved. Mentioned services included the return of goods, sending another package by the end customer, or sending back external packaging so that it can be reused, as well as adaptation/modification of the delivery time to customers according to their availability. Furthermore, the designed processes, regulations and technology should not only be useable for the specific logistics use cases, but also bring benefits for other sectors, such as delivery, or individual/public transport. Also, the processes and products should be highly standardized, such that they can be unified internationally.

7.1.3. Operators and Municipalities

While in the use cases selected for the AWARD project, city administrations and urban systems are only indirectly involved, related needs have to be thoroughly considered, as these are expected to be an important factor for the success of market introduction. As shown in Figure 25, *public acceptance* is the category that most concern to these groups. Logistics experts from city administrations pointed out that, for acceptance **conflicts with other road users** should be avoided. Representatives from local authorities believed that automation of logistics, in **open areas**, must take into account potential interactions with other users: pedestrians, two-wheelers, moving or parked vehicles, priority vehicles, etc. Moreover, they added that the incorporation of automated vehicles in a public environment must take into account the traffic from existing services, such as **public transport and garbage trucks**.

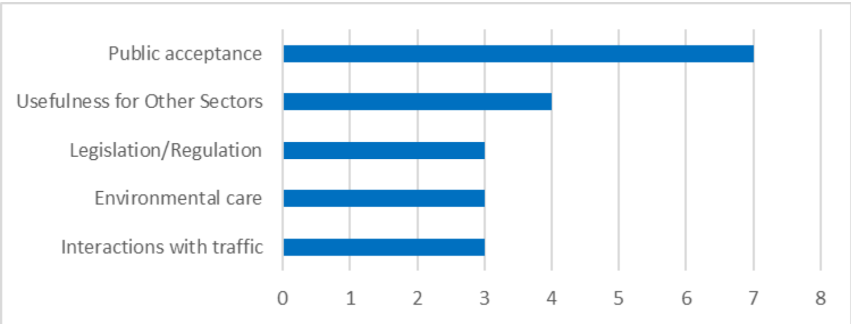

Figure 25: Most of often mentioned content categories of statements and number of mentions for the group of operators and municipalities

For managers of closed sites, ADS should take into account all potential interactions, especially with **other site users**: planes, loaders, other operators, etc. The interviewees also highlighted the importance of zero accidents during the **acceptance phase**. It was mentioned that the presence of a single accident could rapidly decrease the level of acceptance, especially if vulnerable users are involved. Also, there is concern regarding the possible impact on activities already established, especially if the vehicle goes through public roads. As example, one of the interviewees mentioned that the use of automated vehicles for logistics should take into account the reception of tourists, and not constitute an obstacle.

Concerning u*sefulness for other sectors*, there were great expectations coming from this stakeholder group about the use of automated vehicles to promote the growth of **local economies** (through e-commerce for example), as well as the improvement of **public services** (mail service, public transport, maintenance and cleaning services, etc.). One of the organizations believed that the implementation of automated vehicles in logistics should make it possible to bring a financial advantage for local producers; the latter do not systematically invoice, for reasons of competitiveness, the drop-off trips they make with their own vehicles. In addition, it was also mentioned that autonomy in logistics should allow to carry out repetitive short circuits, such as serving school canteens from a central kitchen, or serving hospitals or other establishments from a central laundry. About this, one organization expressed the difficulty of currently finding drivers to carry out logistical transport over short distances in urban areas. It is expected that the presence of automated vehicles can provide a solution to this problem.

Other categories with less presence are l*egislation and regulation*, e*nvironmental care*, and *Interactions with traffic*. On the first one, it was mentioned that the presence of automated vehicles must take into account all legal and regulatory aspects, both **national** (traffic regulations, environmental code, etc.) and **local** (signage, low emission areas, limited traffic areas, etc.). Moreover, an adaptation of insurance regulations is a point that has been regularly mentioned by participants. *Interactions with traffic* interviewees expressed their concern about the behavior that automated vehicles will have in the presence of **other road users**. The greatest concern was **vulnerable users** (pedestrians and two-wheelers), where potential risks in situations with priority vehicles (ambulances, patrols, vehicles firefighters, etc.) were highlighted.

Concerning ***environmental care***, local users expressed that the reduction of **CO2 emissions** as well as environmental **noise** is a primary issue. It was argued that automated logistics should be able to optimize and reduce the number of trips made by vehicles, as well as the number of delivery vehicles in circulation, which will surely result in a benefit for the environment. Although the issue of environmental pollution was comparatively rarely mentioned by the other stakeholder groups, the it should be regarded as a determining factor for the societal acceptance of automated vehicles. Jing et al.[11] place environmental friendliness as one of the six most mentioned factors in scientific studies related to the implementation of automated vehicles).

Even in case of the applications to the transportation of goods, the impact on the environment can be considerable. To give an example, urban freight transport in Paris contributes 73% to nitrogen oxide (NOx) emissions and 42% to fine particle emissions [12]. These high values are mainly related to the motorization of logistics transport vehicles (still mainly diesel, despite the progressive adaptation of vehicles to environmental constraints), to the driving styles of their drivers, and to the multitude of small trips inherent in urban logistics in congested space.

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[11] Jing, P., Xu, G., Chen, Y., Shi, Y., & Zhan, F. (2020). The determinants behind the acceptance of autonomous vehicles: A systematic review. *Sustainability, 12*(5), 1719.

[12] City of Paris (2019). Les chiffres des déplacements à Paris en 2019. https://www.paris.fr/pages/les-chiffres-des-deplacements-a-paris-en-2019-16899#:~:text=Baisse%20du%20nombre%20de%20deux,berges%20de%20Seine%20rive%20droite.

In this regard, expectations within the scientific literature are considerably high. It is envisaged that AVs will reduce greenhouse gas emissions and improve fuel economy, which reflects that AVs are more environmentally friendly than non-automated vehicles [13]. Nevertheless, some scholars point out that care must be taken with the recurrent presence of situations where AVs drive in degraded modes (i.e., drive at low speeds due to the presence of faults / being out of ODDs), which could affect the fulfillment of these expectations [14]. Since high-level AVs have not been widely used, it is hard to predict whether they will be more environmentally friendly than conventional cars in the future. However, this attribute is still valued by individuals with a high degree of environmental awareness.

7.2. Indirect Process Participants

The analysis of statements by the indirect process participants who will be directly involved in the logistics processes revealed that most of the statements concerned job and workforce-related aspects, as well as business model and profitability (see Figure 26). Topics related to *workforce/jobs* revolved around **replacing the driving task** by automation, as means to free workers from monotonous operations and to enable them to perform more demanding tasks. Less manual input and operations were also viewed as a means to reduce stress. The complexity of work was expected to decrease, as well as the number of work-related accidents. On the one hand, people were excited about the new technology that would bring increased efficiency and flexibility and economic benefits due to 24/7 operation. On the other hand, questions were raised how this would impact jobs and people potentially **becoming redundant.** There were also concerns about a **need for qualification and new training requirements**. Still, it was expected that the implementation of AVs should enable the development of **new skills and professions** and the creation of new jobs with ad hoc training. This transformation of existing professions was believed to lead to the creation of new skills focused on customer service and management.

In terms of *business model-profitability*, an automated transport system was expected to be successful from an operational and practical point of view and useful for logistics operations. For logistics to improve performance, an often mentioned opportunity was to carry out **additional rounds per day**, in order to overcome limitations like traffic disruptions, administrative formalities or activity time limitations linked to the labor code. With a better **choice of routes**, optimization of the **driving style**, movements over wider time slots, or even the **simultaneous management** of administrative formalities, it should be possible to carry out several other rotations daily.

[13] Piao, J., McDonald, M., Hounsell, N., Graindorge, M., Graindorge, T., & Malhene, N. (2016). Public views towards implementation of automated vehicles in urban areas. *Transportation research procedia, 14*, 2168-2177.

[14] Spieser, K., Treleaven, K., Zhang, R., Frazzoli, E., Morton, D., & Pavone, M. (2014). Toward a systematic approach to the design and evaluation of automated mobility-on-demand systems: A case study in Singapore. In *Road vehicle automation* (pp. 229-245). Springer, Cham.

Some other aspects of profitability concerned financial advantage for **local producers** in terms of reducing costs concerned with the first kilometer service. It was also mentioned that the return on investment should be under three years.

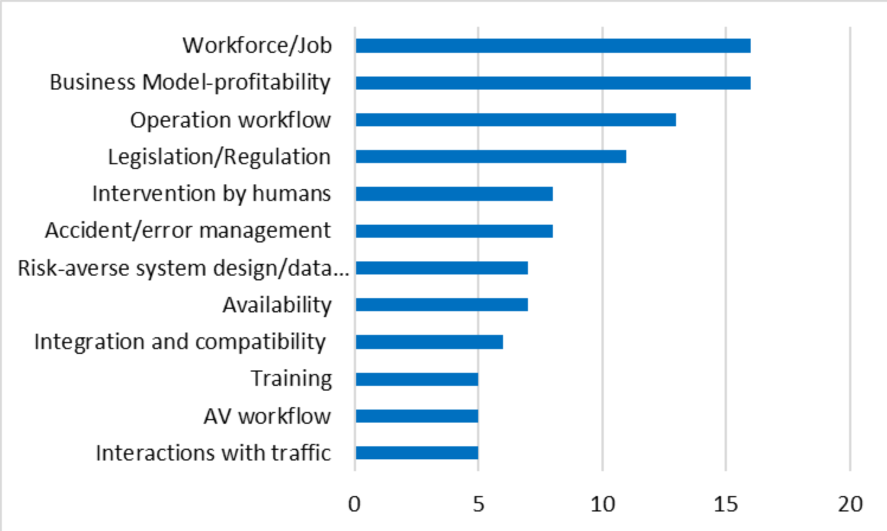

Figure 26: Most of often mentioned content categories of statements and number of mentions for the group of (future) indirect process participants

Concerning o*peration workflow*, more general expectations were related to **standardization** which includes carrying out the operations fast, improved planning and safety of people and equipment, dealing with **complex tasks** and **operating conditions** including **training** of the personnel. Depending on a specific stakeholder and use case, other aspects that would need attention in the automation process were concerned with **non-driving tasks** such as loading and unloading, where roles and responsibilities would need to be defined and customized. Even though the actual AV workflow requirements were not detailed within this stakeholder category, some of the major aspects related to AVs were **safety, handling the complexity, and ensuring security** in terms of unauthorized handling of the vehicles and data management. In addition, **breakdowns** in the system due to technical failure or maintenance posed a concern due to downtimes.

Legislation and regulation aspects were reported mostly in connection with high safety and security requirements related to vehicle handling or infrastructures. To ensure this, **strict legal framework** and **compliance conditions** would need to be met to avoid risking the failure of the process. The requirement for the vehicle would be that it should not be used or controlled by someone external or not qualified. In addition, the vehicle should have the authorization to drive on the public road in **manual mode**. The question of **ownership** in relation to machines, site of operations and automated systems were considered important, as well as regulation of mixed traffic participants and clearly defined roles for **surveying** the automated drive and associated responsibilities (e.g. in the case of extended work roles for a foreman in a factory or logistics site).

Apart from the safety measures, some other conditions were stated where i*ntervention by humans* would be needed, such as failure or reduced **reliability of the sensors** due to the harsh weather. Further, there should be the possibility to **monitor and teleoperate** the shuttle ride by the foreman and maneuver the vehicle remotely in case of critical situations when there is no safety driver on board. Also, it was reported that the vehicle must have a **manual mode.** In more concrete terms, regarding a*ccident/error management*, a focus was put on ensuring the **safety of people involved by technical features for avoiding collisions** but also that there should not be the risk of damage to the infrastructure.

There were also remarks related to *risk-averse system design/data management.* For example, risks related to cyber security were raised by stakeholders, as well as concerns about both **external factors and the system's design** that might interfere with the success of the automation, yet, the appropriate response to cyberattacks or humans trying to interfere with the system needs to be considered. For reasons of **hacker attacks, data theft or deliberate manipulation,** high levels of security against unauthorized tampering would need to be in place. Reliable and dependable IT was regarded as a means to prevent the increase in the costs associated with a system's failure.

The usefulness of automated vehicle applications was generally considered to depend on a*vailability* due to enabling automated **24/7 operation**. Nevertheless, weather conditions were mentioned as a challenge for achieving such availability. More specific aspects in this regard were concerned with different **automated driving tasks on a public road** that should be made possible (e.g., a roundabout, traffic light, etc.). As delays can be critical for the transport mission where the production line depends on it, issues such as the charging process should not reduce the availability of the vehicle. Furthermore, transport of goods by automated vehicle were expected to be easier for the **first kilometer rather** than for the last kilometer.

7.3. Direct process participants

Humans in direct contact with automated vehicles include AGTS operators with or without direct sight of the vehicle, and traffic participants affected by the automated vehicle. As Figure 27 shows, the most statements by the sub-group of direct process participants responding to our surveys and interviews were related to the category *operation workflow*, that is, the detailed planning between all points of operations and participants taking into account the **complexity of the automated logistics** system. To this end, automated operations would need to consider also **supplementary processes** to AV driving such as concurrent tasks: loading and unloading, the opening of building doors, filling in the number and reference number of transport units, information about the discharging status, location and availability of units, processing at the gates, customs status and customs clearance. Human operators at the logistics hub want to be sure that such processes are handled at least as efficiently as with current conventional vehicles (where these supplemental activities are typically handled by their drivers). Depending on the use case, some processes were reported to not yet have a **clear automation plan** (e.g., connecting and disconnecting trailer units in the port), and **human intervention** was deemed necessary in the foreseeable future. The workflow was thought to also require changes concerned with training, job profile adjustments, internal communication, supporting infrastructure, policy changes, and possible local support teams with better availability.

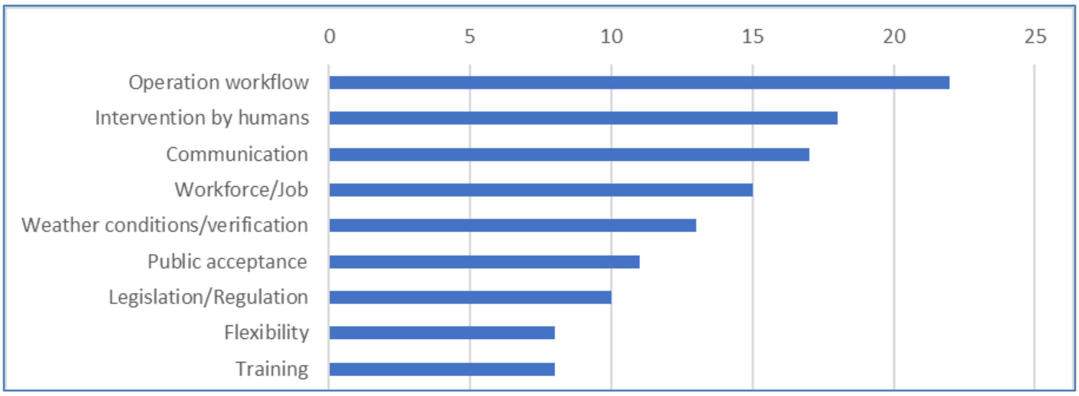

Figure 27: Most of often mentioned content categories of statements and number of mentions for the group of future direct process participants (operators, loaders)

There was also the prominent wish by direct process participants to be able to monitor and to **intervene with the vehicle** at any point in time. Participants often explicitly wished for the possibility to take over **manual control** at any time needed. The most common aspect related to this need of intervention was to inspect the vehicle in case of occurring problems. To do so efficiently, it seemed not only important to control the vehicle remotely, but also to enable **physical access** to the vehicle, either by oneself or by a remote person.

Compared to the other groups, the human operators (especially the fleet managers) provided notably many comments on the c*ommunication* of the vehicle. These were mainly concerned with communication between AV and the operating system that will provide information about **transport units** and any possible **technical failures**. Such situations include the **breakdown** of a system in which **sensors** that prevent communication with other units or mapping of the AV system could cause harm to others. To handle these breakdowns, **indicators of the state of the system** even if simple as color coding would be needed as well as the availability of **assigning mission to the vehicle** with control software/app. In any unexpected situations, there should be reliable communication for the **chain of commands**, clear internal communication and **reporting to the foreman.**

The topic of *workforce/job,* as in other groups, usually revolved around the concern for job losses and managing transition to new positions. However, it is not solely seen as a reduction of the workforce but also as an opportunity for higher quality and better paid job positions. These changes mainly concern **drivers' positions** and it wasn't expected for all of them to transition to new office jobs. This is why the **role of unions** in the process was expected to affect decision making in terms of finding the solutions and good agreements (i.e. will they move to the pension or become redundancy which would cost more). It was also speculated that for some workers the new job demands won't be attractive to, such as working in the office and behind the screen.

Weather conditions/verification was considered to have consequences on the **actual employment of the automated system.** It was noted that extreme weather situations might require **switching to non-automated operations. Human involvement** would be needed in situations where sensor performance may be affected by the weather (i.e. locating and connecting units) or constraints such as slippery roads, frozen components but also high sea waves that affect lashing in the ports.

The perspectives towards p*ublic acceptance* were either related to positive effects of automation representing the **future and progress** for companies or **skeptical attitudes** due to traffic safety and involved people. Some respondents pointed out that people and especially their employees would be interested in or even fascinated by automated vehicles. This could then contribute to the **willingness to attend extra training** or **adapt to a changed job profile**. Additionally, these attitudes could make **policy changes** within companies easier while policy changes and related political decisionmaking were expected to take time. Apart from expected greater transport **safety** and less noise **pollution**, **customer satisfaction** was meant to increase because of time saving on tasks and faster workflows. Public concerns about traffic safety were considered to slow down the transition process, regardless of whether it concerns **familiarization with AVs** or their ability of AV handling **unexpected situations** with **other traffic participants**. Also, due to safety concerns, the vehicle's **driving speed** could be reduced and thereby limit the overall performance of the logistics process, which would in turn have a negative impact on acceptance.

Legislation and regulation were expected to affect operations and aspects of safety and security, especially when it comes to **people's access on the operations sites,** especially **for external parties/workers**. Strict **legal frameworks and compliance conditions** were expected to ensure high safety and security. A number of issues regarding safety standards and responsibilities would need to be considered in relation to automated vehicles, **driver's license for automated vehicles**, **software and personnel**, checks regarding the trustworthiness, testing as well as **health and environmental** aspects. *Training* was seen as an inevitable part of the transition and it was recommended to offer this early in the process. It was regarded important that **personnel directly involved with the vehicle** receive training for **specialized IT features** related to AV.

7.3.1. Evolving Work Roles

As also reported in section 0, a main concern throughout stakeholders about the **impact of AGTS on employment**. Indeed, previous studies show that job relevance is a highly debated topic, for example with regard to truck driving [15] [16] [17] and logistics work[18]. On the one hand, the introduction of driverless trucks is considered as an opportunity for companies to compensate the shortage of drivers, in a work sector with comparably little attractiveness characterized by modest payment [19], there are indeed concerns that a considerable number of jobs may be

[15] Gittleman, M., & Monaco, K. (2020). Truck-Driving Jobs: Are They Headed for Rapid Elimination? *ILR Review*, *73*(1), 3–24.

[16] Ford, M. (2015). Rise of the Robots: Technology and the Threat of a Jobless Future. New York: Basic Books. ———. 2016. Driverless trucks: Economic tsunami may swallow one of most common US jobs. Guardian, February 16. Accessed at https://www.theguardian.com/technology/2017/ feb/16/self-driving-trucks-automation-jobs-trucking-industry (May 15, 2017).

[17] Pogue, D. (2017). When the robots take over, will there still be jobs left for us. CBS News, April 9. Accessed at http://www.cbsnews.com/news/when-the-robots-take-over-will-therebe-jobs-left-for-us/ (May 15, 2017).

[18] Bottalico, A. (2021). The Logistics Labor Market in the Context of Digitalization: Trends, Issues and Perspectives. *Digital Supply Chains and the Human Factor* (pp. 111-124). Springer, Cham.

[19] Hu, B. Z., de Papazikou, R. B. E., Boghani, E., Filtness, H. C., & A & Roussou, J. (2019). LEVITATE Societal Level Impacts of Connected and Automated Vehicles. Deliverable D7. 1 of the H2020 project LEVITATE: Defining the future of freight transport.

replaced [20] [21]. However, when analyzing comments from the truck driver community, there is much skepticism about the actual feasibility of widespread automation, due to practical and organizational factors like cost structures, supplemental work tasks, infrastructure investments, and policy changes[22]. Gittleman et al.[23] point out that instead of job losses the work profiles will change: "drivers" will take over non-driving tasks which are still at high demand, while pure trucking tasks are more prone to be automated. In sum, understanding the actual impact of transport automation on the job market is still a matter of research, as it is dependent on many factors and needs to be analyzed with differentiated scenarios.

Trends such as digitalization, automation and Industry 4.0, also transform the work roles in the intralogistics sector. Cimini et al. [24] introduce the paradigm of the "Logistics Operator 4.0", who is highly skilled and is supported by various advanced technologies, such as smart supervisory control of increasingly automated functions as well as by task assistance and augmentation. However, at the current stage most innovations are focusing on automating single vehicles, which leaves uncertainty about where, how, and how often fleet managers should be enabled to configure, monitor, or intervene with automated vehicles. When integrating such automated vehicle fleets, it is likely that also here the automation paradox can be observed: the less humans are involved in automated processes, the more crucial is their involvement in the planning, refinement and intervention [25]. Another aspect that is specific to the logistics sector, is the highly specialized and multifaceted appearance and behavior of vehicles and machinery used for a large variety of mobility and goods handling tasks, ranging from long-haul transport to small distances between hubs and intralogistics operations. Here, also other automated tasks such as loading and unloading and warehouse robotics are extending and interfacing with transportation tasks.

The paradigm of the Logistics Operator 4.0 introduced by Cimini et al.[26] conceptualize the work role profiles implied by increased automation and the required supervisory control of increasingly automated functions as well as novel human-computer interaction (HCI) features for task assistance and augmentation. While the importance of these functions is not put into question, their exact implementation still tends to be ascribed a lower priority and realized in an arbitrary manner. The key question so far remains unanswered: Who will be the operator(s) for future Logistics Operation & Fleet Management (LOFM) systems, and what is required to support

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[20] Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation?. *Technological forecasting and social change*, *114*, 254-280.

[21] Viscelli, S. (2020). Will Robotic Trucks Be "Sweatshops on Wheels?". *Issues in Science and Technology, 37*(1), 79-88.

[22] Orii, L., Tosca, D., Kun, A. L., & Shaer, O. (2021, May). Perceptions on the Future of Automation in r/Truckers. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems* (pp. 1-6).

[23] Gittleman, M., & Monaco, K. (2020). Truck-Driving Jobs: Are They Headed for Rapid Elimination? *ILR Review*, *73*(1), 3–24.

[24] Cimini, C., Lagorio, A., Romero, D., Cavalieri, S., and Stahre, J. (2020). Smart Logistics and The Logistics Operator 4.0. *IFAC-PapersOnLine 53*(2), pp.10615–10620.

[25] Bottalico, A. (2021). The Logistics Labor Market in the Context of Digitalization: Trends, Issues and Perspectives. In *Digital Supply Chains and the Human Factor* (pp. 111-124). Springer, Cham.

[26] Cimini, C., Lagorio, A., Romero, D., Cavalieri, S., and Stahre, J. (2020). Smart Logistics and The Logistics Operator 4.0. *IFAC-PapersOnLine 53*(2), pp.10615–10620.

operation? These aspects are of main research interest in the AWARD project and thus are considered in more detail in the following section.

7.3.2. The Human Logistics Operation & Fleet Management Operator

As noted above, apart from the overall Logistics Operator 4.0 paradigm by Cimini et al. [27], general role and task definitions are not yet available which could be used as a framework to describe the emerging work conditions around automated logistic fleet interactions. A comprehensive and extensible task and workflow analysis would thus be necessary as a first step. As shown in Figure 28 (top), interfaces that support these tasks should transparently map these tasks and related key performance indicators (KPIs).

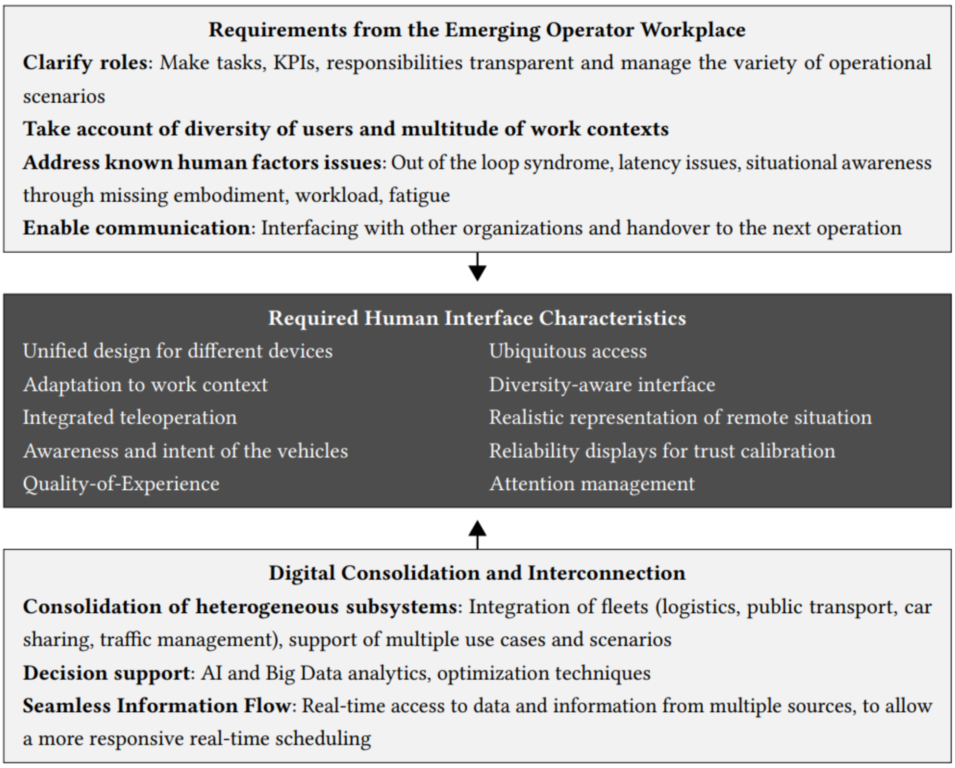

Figure 28: The tension of the human interface characteristics between the emerging operator workplace environment and the underlying digital consolidation and interconnection [28] .

Furthermore, there are known human factors requirements from remote operation of automated passenger vehicles[29] that have to be considered also for the automated fleet logistics domain. This includes reduced situational awareness, such as the 'out-of-the-loop syndrome', which should be avoided, and more time should be allowed for the take-over from automated to manual mode in case of remote operation. Designers also need to be aware of other limitations for

[27] Cimini, C., Lagorio, A., Romero, D., Cavalieri, S., and Stahre, J. (2020). Smart Logistics and The Logistics Operator 4.0. *IFAC-PapersOnLine 53*(2), pp.10615–10620.

[28] Gafert, M., Fröhlich, P, Ritzinger, U. and Baldauf, M. (2021). Challenges for Future Automated Logistics Fleet Interactions. Proc. *CHI Workshop on Automation Experience at the Workplace*. CEUR Workshop Proceedings, Vol-2905 (2021), ISSN: 1613-0073; Paper-Nr. 7, 6 S.

[29] Mutzenich, C., Durant, S., Helman, S., & Dalton, P. (2021). Updating our understanding of situation awareness in relation to remote operators of autonomous vehicles. *Cognitive research: principles and implications, 6*(1), 1-17.

situational awareness, important latencies (caused by network or processing capacity limits) or a missing feeling of embodiment of the controlled system (due to missing sensory information). Furthermore, there should be a balance between cognitive load, fatigue and alertness.

Figure 29 illustrates a generic **task flow of fleet management interventions**. Typically, an operator performs a logistics task not related to automated fleet operations (starting point of the cycle, at left side of the image). In case of an event in which the automated vehicle is likely to require an operator to refocus her/his attention, a takeover request is issued by the system. The system then has to provide the operator with an overall briefing of the situation (i.e. about the overall position of the system, the problem that occurred, and potentially recommended further actions). When the operator has then achieved situational awareness and decides to intervene by a teleoperation, he/she will be prepared for teleoperation. Once situation awareness has been received to the required operational level (e.g. having oriented from an ego-perspective, knowing where to drive, recognize the surrounding traffic, other road users and obstacles). Then, the operator performs the remote driving activity, navigates and, if necessary, communicates with other process participants. After the teleoperation phase, the human operator then should be prepared for the non-driving related task and the handover should be realized.

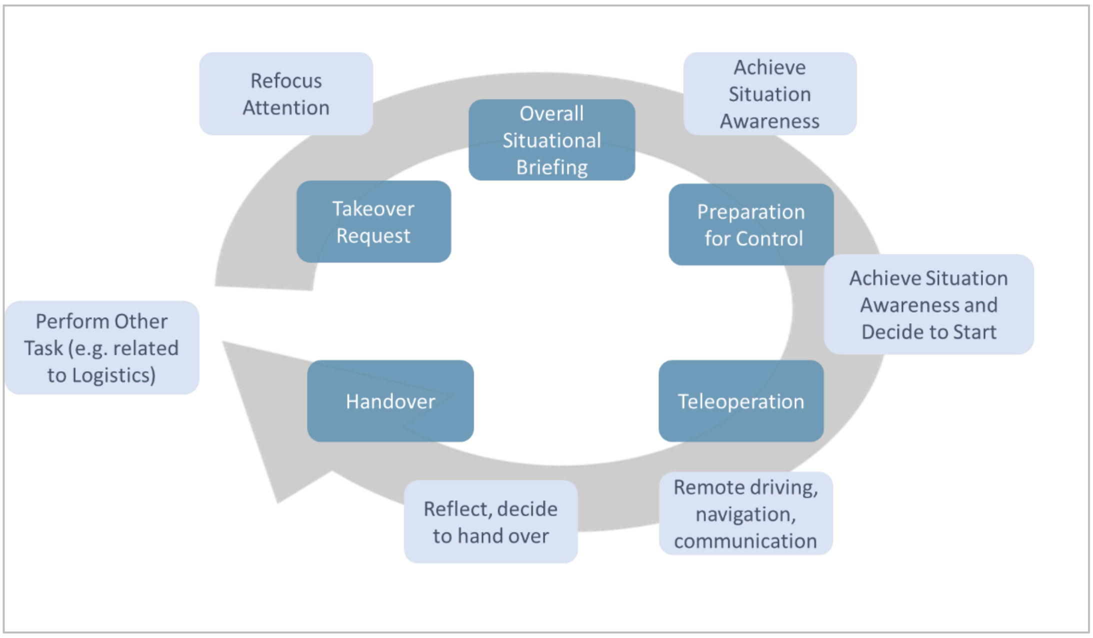

Figure 29: Phases of Automated Fleet Management and Teleoperation Interventions (Outer light boxes: human task; inner dark boxes: system task)

Figure 30 shows the task analysis of the human operator of the fleet management and teleoperation system in more detail. While the vehicle is driving or being used by direct process participants (loading, unloading), the fleet manager can use the FMS as a dashboard. There are two possible reasons the fleet manager might want or need to interact with the system. The first is a regular check which may include the KPIs, vehicle positions, protocols, statistics, and other parameters. The second reason is an interruption by the FMS which calls for the fleet managers input. This interruption needs to be forwarded to the fleet manager either on the dashboard as a popup, a mobile push notification or other HMIs. Regardless of the HMI type, the fleet manager must manage the interruption. The second step for both is checking the FMS for problems. If no problems occurred, which is most likely in the case of regular checks, the fleet manager can start her/his regular monitoring activity. Otherwise, if a problem occurred, which is the case if the FMS called for the fleet manager, he/she needs to analyze the problem and choose one of three processes. If the problem can be handled by the fleet manager directly, he/she can control the erroneous part directly from the FMS. This may include updating the mission, controlling the vehicles (no remote driving) or managing traffic lights.

The second possible interaction, if remote control is not enough, is remote driving. Remote driving or teleoperation requires an educated teleoperator who first needs to be briefed by the system on which vehicle to take over, where to drive, etc.. Once the teleoperator is ready to take over the vehicle, he/she is able to drive the vehicle remotely with either a steering wheel and pedals, a controller or another method of input which will be evaluated later. On completion of the given task, the teleoperator needs to hand over the control back to the automated system which then can continue to drive the vehicle. If neither remote control nor remote driving are feasible to resolve the problem, the fleet manager needs to contact a direct process participant on site who either goes to the vehicle to recover it if it cannot be reactivated, or manually handle the problem and hand over the control once finished. For the specific phase of teleoperation, Graf and Hussmann[30] have provided a compendium of user interface requirements, which however has so far not been empirically validated (see Figure 31). It is planned to build on this collection of requirements and further validate it.

[30] Graf, G., & Hussmann, H. (2020, September). User Requirements for Remote Teleoperation-based Interfaces. In *12th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (pp. 85-88).

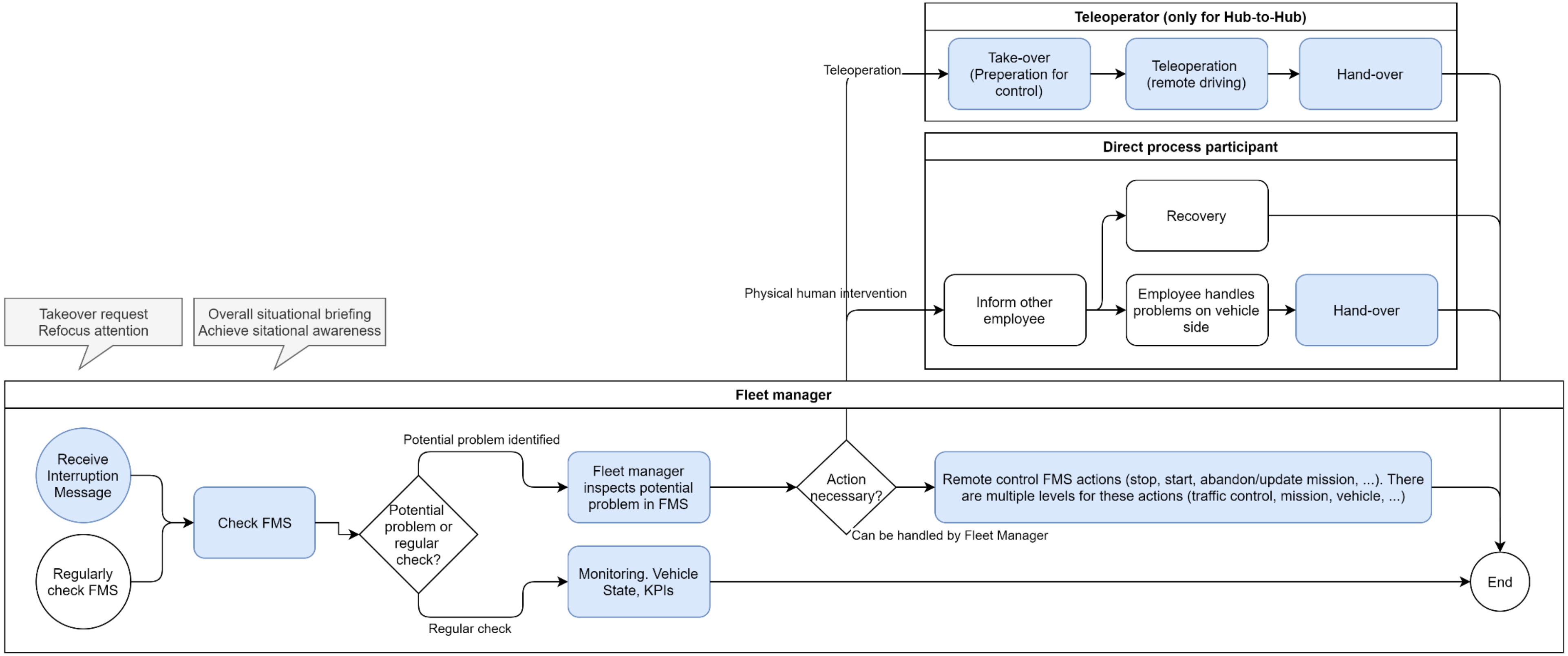

Figure 30: AGTS Operator Task analysis for the four use cases. Blue boxes indicate human activities/sub-tasks, which involve the FMS interface. Yellow boxes indicate unrelated activities/sub-tasks. White boxes represent all activities/sub-tasks that are defined by another instance not related to the FMS/automated driving.

Vehicle Position
- 360° Remote View
- Vehicle Heading
- Steering Wheel Orientation
- Wheels Orientation
- Vehicle Location
- Vehicle Speed

Vehicle Status
- Battery Charge Level
- Light State On/Off
- Overall vehicle damage

Vehicle Issues
- Motor Damage
- Tire Pressure
- Light Damage
- Other Damage

Object, Obstacle
- Obstacle Location
- Distance to obstacle
- Object characteristics
  - Object Material
  - Object Size

Weather Conditions
- Current Weather
- Predicted Weather
- Impact of weather

Vehicle Characteristics
- Vehicle Size
  - Length
  - Width
  - Height
- Vehicle Weight
  - Load/Unload
  - Type of Cargo

Vehicle Operations
- Projected other road user trajectory
- Projected control actions
- Potential for collision
- Projected vehicle position w/ communication latency
- Projected vehicle stop position w/ communication latency
- Projected distance from/to the target/obstacle

Communication State
- Bandwidth Available
- Bandwidth Requirements
- Bandwidth from/to the vehicle
- Signal strength (current / future trend)
- Mobile Carrier

Terrain Features
- Landmarks/barriers
- Clutter
- Uneven terrain
- Debris

On-Board Sensor
- Camera Status
  - State on/off
  - Orientation
  - Zoom Level
- Other sensor status
  - State on/off
  - Functionality
- Detections reliability
  - Sensor detection reliability
  - Numbers of sensors detecting target
  - Type of sensors detecting target
  - Past detections result

Task Objectives
- Time constraints
- Tasks to complete
- Task priority
- Status of tasks/progress
- Impact on plan
- Projected time to task completion
- Projected next or near future task
- Projected time to task completion
- Projected need to shed tasks

Environmental Information
- Vehicle to Infrastructure (V2X)
- Traffic Rules
- Vehicles assigned to area
- Location of other vehicle

Figure 31: Required Features for Remote Teleoperation-Based Interfaces (from Graf and Hussmann[31])

7.3.3. Other Traffic Participants affected by AGTS

As highlighted above, the safe and reliable interaction with other traffic participants is an important requirement. From the perspective of other traffic participants affected by automated vehicles (cyclists, pedestrians, or riders of motorized vehicles), most research has been conducted related to public roads. Many insights may be transferable to the interaction of automated vehicles with traffic participants in restricted areas such as logistics yards and production sites – however a scientific validation so far is missing. A recent large-scale survey study by the H2020 project BRAVE[32] indicates that acceptance of and trust in automated vehicles is varying between users of public road infrastructures: two-wheelers have higher preferences towards automated vehicles than car drivers and pedestrians.

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[31] Graf, G., & Hussmann, H. (2020, September). User Requirements for Remote Teleoperation-based Interfaces. In *12th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (pp. 85-88).

[32] Schrauth, B., Maier, S., Kraetsch, C., & Funk, W. (2020). D2. 3 Report on the findings of the population survey. Deliverable D2.3 of the EU-funded project BRAVE.

According to that report, there appear to be differences across different demographic factors, such as age (younger more positive than older), and gender (males more positive than females). Furthermore, according to the authors, the most often mentioned positive expectations towards automated vehicles are sufficient distances to other road users, better emergency braking reaction times, a stricter adherence to traffic rules, and more predictable driving. The main concerns identified by the authors of the report relate to the trustworthiness aspects, especially regarding the vehicle's reliability during a system handover, as well as possibly compromised security by hacker attacks. Pedestrians and car drivers are reported to be often more concerned than cyclists and powered two-wheel -riders, and females expressed concerns more strongly than males.

With regard to handling the issue of safety and reliability of interaction with other road users in production environments (such as in the AWARD forklift use case), the European machinery directive [33] provides relevant guidance and requirements. In general, a 3-step method shall be applied: (1) to inherently design for safety and therefore avoid potential problems and hazards (e.g., placement of operators such that they have vision into all relevant parts of danger areas, or predicting the intentions and further movements of other road users [34]; (2) to install technical protective measures (e.g. fleet management and teleoperation systems to compensate the lack of direct visibility), and (3) to provide information to exposed persons, in the form of warnings, signs and information on the machinery (applying to "residual risks" that cannot be reduced by safe design and technical protection measures).

With regard to this latter requirement of information and warnings, external HMIs (eHMIs) are a common approach to communicate towards other traffic participant and thereby to build and maintain trust [35]). To this respect, common industry standards for production and logistics machinery should be regarded, most importantly standard EN 61310-1 [36] (giving specifications for visual and acoustic signals), the user-centered design and the EN 894 [37] standard series (especially with regard to the ergonomic design of machine displays and controls). Furthermore, recent standardization activities should be considered in the design of external communication with the vehicles on public roads [38]

[33] European Commission (2006). Guide to application of the Machinery Directive 2006/42/EC. Retrieved online at: https://ec.europa.eu/docsroom/documents/38022

[34] Leuteritz, J.-P., Fritz, N., Widlroither, H., Terfurth, L., Strand, N., Solis Marcos, I. (2020). D4.5 Vehicle-VRU Interaction Concept Report. Deliverable of the European H2020 project BRAVE.

[35] Forke, J.; Fröhlich, P.; Suette, S.; Gafert, M.; Puthenkalam, J.; Diamond, L.; Zeilinger, M.; Tscheligi, M. Understanding the Headless Rider: Display-Based Awareness and Intent-Communication in Automated Vehicle-Pedestrian Interaction in Mixed Traffic. *Multimodal Technol. Interact.* **2021**, *5*, 51.

[36] EN 61310-1:2008 Safety of machinery - Indication, marking and actuation - Part 1: Requirements for visual, acoustic and tactile signals (IEC 61310-1:2007); EN 61310-2:2008 Safety of machinery - Indication, marking and actuation - Part 2: Requirements for marking (IEC 61310-2:2007).

[37] EN 894-1:1997+A1:2008 Safety of machinery - Ergonomic requirements for the design of displays and control actuators.

[38] SAE International. 2019. Autonomous vehicle lighting (J3134) Retrieved April 4, 2020 from https://www.sae.org/standards/content/j3134/

8. Conclusions

In this document, the user and stakeholder expectations and requirements for future Automated Ground Goods Transportation Systems have been summarized. Furthermore, specific user- and stakeholder driven approaches and solutions to meet these needs have been proposed, from the perspectives of each of the use cases and stakeholder groups. In the following, we provide conclusions with regard to subsequent activities within the project, technical specification and demonstration, namely business modeling and exploitation, user-centered design of fleet management interfaces, as well as demonstration and evaluation.

Technical Specification and Development

The project has set out to meet targets like 24/7 operations throughout a large array of weather conditions in different locations around Europe. The AWARD value proposition will include smooth functioning of automated transport operations around the clock and in adverse weather conditions. When looking at the user and stakeholder expectations and requirements analysis presented in section 0, many of these can be translated into technical expectations for f automated ground goods transport systems (AGTS). This especially concerns the requirements groups “Reliability”, “External Conditions”, and “Fleet Operation”.

One of the key requirements and expectations of the stakeholders is that the vehicle (or fleet of vehicles) operates in both public and private areas. This requirement reflects the expectation of both stakeholders and the general public regarding the adaptation of automated vehicles to different environments (see requirements R5, R7, R8 and R10). In this respect, it is especially expected that the AGTS operates under adverse weather conditions (requirement R6). The stakeholder inquiry thus corroborates this all-weather capability as a key to reaching the expected level of profitability. Obviously, such adaptation requires a high level of technical and functional sophistication, as well as some considerations on the part of insurers and traffic regulations.

The implementation of environment-friendly vehicles is another point to highlight (requirements R9, R11). From the interviews, it was observed that this last requirement is essential for the acceptance of the general public, while for the stakeholders it is not a primary issue. Finally, it was observed that the security of the AGTS against possible digital attacks (requirements R18, R19) is a very present issue within the demands/expectations of the stakeholders. As can be seen, these requirements have direct relevance to the technical development of this project, or in other words: several user requirements have an impact on the functional requirements defined in Task T2.4. Please see Annex 2 for a comprehensive and systematic description of the affectations of the functional requirements by the user requirements.

Business Modeling and Exploitation

The analysis of stakeholder expectations confirms a multitude of business opportunities along the value chain of automated ground goods transport systems (AGTS) to be developed by AWARD. Strategic business modeling and exploitation planning is required to develop ‘AGTS as a Service’, as part of an overall ‘Logistics as a Service’ (LaaS) framework. It is recommended to develop business models for each of the components of the AGTS system of systems. In particular, potentials for the ADV software and integrated vehicles developed in AWARD should be further evolved into other transport vehicles and existing assisted systems and can be further advanced. Likewise, the LOFM (fleet management system) has found to be a necessary missing link for the successful deployment of automated vehicle fleets. One important aspect here is to achieve an integrated fleet management service architecture and user interface components that best support future operators. It is important to shape the business model in close cooperation with the human-centered design of the fleet management system.

In order to provide a foundation and guidance for further business-related activities within the AWARD project, a number of conclusions can be drawn from the in-depth analysis of actors of the AGTS value chain. While all 26 aggregated requirements presented in section 0 are highly relevant as a pre-condition for business success, some are directly depending on operations and business development activities (see requirements group "business model"). Efficiency and higher transport capacities, profitability, 24/7 operability, and optimization of movements and time (see requirement R22, R23, R24) not only depend on technology improvements, but also on a dedicated design of business processes.

Consequently, follow-up activities within the AWARD project should especially focus on these to ensure the exploitability of the project results. To this end, standardized processes to ease the AGTS in implementation of logistics use cases and the readiness of technologies are key (R22). A related challenge here is to efficiently capture and incorporate the expertise of use case-related operational expertise. The need for integration of AGTS into other automated processes is something that cannot directly be solved through a single project like AWARD – however, through the specific use case analyses, demonstrations and evaluations, important learnings for enabling business value of the AGTS in the overall logistics process will be enabled.

Apart from these directly business-related expectations and requirements, also several intra- and extra-organizational requirements are important to analyze, in order to find ways to foster dynamics within the surrounding ecosystem. On the one hand, strategies need to be identified to enable real-life operation within changing legislative conditions at a national and European level (R25). Also, ways how to achieve organizational business readiness for AGTS in logistics services are necessary to investigate. To this end, demonstration of good practice needs to be delivered on how to achieve internal and external corporate communications and training (R3, R4), HR management (R1), as well as to achieve acceptance on an organizational and sectoral level (R3). Complying with end-user and customer requirements play a crucial role in adoption and use of the technologies developed in AWARD.

Thus, it is important to understand better the problem, expectations, and requirements of this stakeholder group. It is recommended to deploy further detailed analysis in WP8 and WP9 to identify the tasks, pains, gains of the customers.

Human-centered Design

The requirements analysis presented in this report clearly confirms the central role of human operators within future AGTS. This not only concerns the abovementioned critical aspect of workforce acceptance, but also the communication with other traffic participants and especially the operation of the automated fleet interactions. In this regard, enabling the efficient and informed interventions by human operators is key (see R15 and R16), and transparency of ongoing information has to be enabled (R14). To lay a solid ground for the human-centered design of LOFM systems, the operators' tasks have been analyzed for each use case (see section 6.2) and the intervention task flows have been specified (section 7.3.2).

Several challenges for the design of automated fleet interventions are to be addressed in the further course of the project. First of all, suitable user interface components have to be designed and implemented that can support the needs of operators in the different phases (from the takeover request, the situational briefing, decision making, teleoperation, to the handover) of the vehicle and back to the other task. This is not a straight-forward task, as it represents an unprecedented usage scenario that is hardly comparable to other system types such as standard automated guided vehicles, industry machinery control or automated vehicle interactions.

A further challenge to be achieved is the design of an automated logistics fleet system, which is applicable to multiple use cases, and which integrates systems that have so far been separated: a scheduler for organizing the vehicles, the logistics management system, vehicle localization, path planning, and motion planning, where real-time modifications of the planned path are considered and information from the current environment are processed (e.g., from the door status). Another important task consists in the management of vehicles, which monitors the current status of the vehicles, such as battery status, error status, or maintenance status. Other information which enhances an automated logistics fleet management are control mechanisms like traffic control or weather conditions. When combining these elements in one consistent and general system, a crucial point will be the discussion on the possibilities of the digitalization of conventional processes or the efficient integration of legacy systems.

Fleet management and teleoperation are often regarded as separate issues, as the teleoperation driver needs special training and a driver's license. For example, in the case of transporting goods on a public road, a truck driver's license is needed. The current solution for connecting fleet- and teleoperation is by manually sending a teleoperation task from the fleet management to an always occupied teleoperation stand. The teleoperator is waiting at the teleoperation stand for new tasks and controls the vehicle if requested. Although this is a good separation of concerns, some context might be missing for the teleoperator to complete the required task as efficiently as possible. This includes the current position of the vehicle, the current load, why it failed and where it needs to go. To provide a more seamless hand over of the teleoperation task, the teleoperation and fleet management could be combined into a dedicated remote operator, who can, in case of a failure, also take over the control of the vehicle. It should be discussed in later work what method is more feasible. In any case, the workplace requirement of realistic simulation of the remote situation should be realized for situations in which teleoperation is required.

An aspect so far less regarded is the communication of the vehicle's awareness and intent, as well as their reliability, in order to calibrate operators' trust in the system capabilities. Another aspect that needs to be considered when realizing the above recommendation of integrating more spatial resolution and maps is a satisfactory Quality of Experience. Furthermore, with the increasing number of vehicles, more sophisticated attention management will be necessary, in order not to overload operators.

Demonstration and Evaluation
Successful planning and conduction of pilot operations are the central elements within the AWARD project. This requirement study in the first months of the project – especially the site visits and stakeholder interviews – has yielded a joint understanding and will enable detailed test planning and defining further technical requirements. One of the key results to be taken up from the present user and stakeholder requirements document are the use-case-specific operational process flow charts (section 6.2). These flow charts will be used as a central reference first to implement and finally to evaluate the AGTS performance. The operational phases give a frame for upcoming work: defining the operational scenarios (D2.3) and finalizing the functional requirements (D2.4).

When evaluating the success of AWARD pilot operations, the results and performance should be reflected against the stated user and stakeholder needs. The experiences, interviews and data from upcoming tests will be studied using a set of research questions to be defined. The collected user and stakeholder requirements help to select some key research questions per use case. Especially, the requirements highlighted evaluation whether using the systems was easy and safe, whether the feature set satisfactory, and how work and training changed with the introduction of new automated vehicles.

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10. Annex

10.1. Annex 1: List of User and Stakeholder Requirements

First aggregation	Second aggregation	Stakeholder groups from whom the requirement comes
Lack of qualified people to manage the AGTS system is expected Skilled workers needed	Highly qualified personnel shall be available to support/solve problems related to the automated system	Operator without direct sight (Fleet manager) Automated vehicle maintenance System developers and integrators
Working unions help is needed for acceptance of the ADV	Working unions help shall be required for acceptance of the automation process	System developers and integrators
Acceptance depend on job opportunities Acceptance depends on training, education and orientation Comfort and productivity The presence of an autonomous vehicle solves driver shortage The presence of an autonomous vehicle deletes hard jobs difficult to recruit Change on job conditions must be considered Everything the driver does must also be automated	For the acceptance of the automation process, it shall be clearly informed about the impact on working conditions (employment, qualification, tasks, etc.) as well as new job opportunities	Operations monitoring Teleoperator with remote access Certification bodies Research Logistics service provider Seaport terminal Dry port (inland port) Economic development department Traffic participants on closed area Operator without direct sight (Fleet Manager) Loader / Unloader Operator in sight Personal transport Combined operator Compliance assurance System developers and integrators Device designers and manufacturers Compliance design & implementation Users in non-automated vehicles Software and app developers Commercial vehicles

		Cyclists Traffic management Automated vehicle maintenance Continuous operations improvement
Training for personnel directly/indirectly involved should be carried out	Training for personnel directly/indirectly involved shall be carried out	Loader / Unloader Operator without direct sight (Fleet Manager) System developers and integrators Operations monitoring Continuous operations improvement Commercial vehicles Logistics service provider Users in non-automated vehicles
The ADV should interact with other road users (public and private areas) The ADV requires have a global vision of the environment (use of sensing systems, information from LOFM, etc.) The ADV should recognize road signals The ADV should maintain a security distance from objects	The vehicle shall be able to operate in public/private areas interacting with other traffic/road users	Operations monitoring Loader / Unloader Teleoperator with remote access Certification bodies Residents Regulatory department Logistics service provider Traffic management Research System developers and integrators Compliance design & implementation Public authorities & regulators Police Operator without direct sight (Fleet manager) Airport authorities Freight carriers Actors of local supply chain Traffic participants on closed area Device designers and manufacturers Compliance assurance Software and app developers Combined operator

		Commercial vehicles Users in non-automated vehicles Infrastructure maintenance
Weather conditions should be considered by the AGTS	AGTS operation shall be adapted to different weather conditions	Airport authorities Actors of local supply chain Software and app developers Operator without direct sight (Fleet Manager) Operations monitoring System developers and integrators Traffic management Cyclists
Automation should provide safer than human actions People is skeptical due to the possible presence of accidents The AGTS should ensure safety Safety in airport	The vehicle shall guarantee at all times the safety of all the people around it	Airport authorities Operator without direct sight (Fleet Manager) Operations monitoring System developers and integrators Compliance design & implementation Combined operator Compliance assurance Users in non-automated vehicles Commercial vehicles Infrastructure maintenance Logistics service provider Device designers and manufacturers Software and app developers
Speed of ADV adjusted to different maps	The behavior of the vehicle shall be adjusted according to the road conditions: area (public or private), surface (pavement, concrete), relief (slope, flat), and geometry (curve, line)	Airport authorities Combined operator System developers and integrators Compliance design & implementation Commercial vehicles Automated vehicle maintenance Operations monitoring
People living near the production site must be taken into account	For the implementation of the AGTS, the opinions / suggestions / requirements of the people who will live with the vehicle on a daily basis shall be considered	Traffic participants on closed area

Interaction with physical/digital infrastructure	The vehicle shall be able to interact with the available digital/physical infrastructure	System developers and integrators Research Infrastructure owners Operator without direct sight (Fleet Manager) Software and app developers Device designers and manufacturers Compliance design & implementation Loader / Unloader Commercial vehicles Platform and cloud computing providers
The ADV should be eco-friendly (low noise, CO2, and GHG emissions)	The vehicle shall be eco-friendly (low noise, low CO2/GHG emissions)	Airport authorities Actors of local supply chain System developers and integrators Compliance design & implementation Users in non-automated vehicles Operations monitoring Commercial vehicles Cyclists
The implementation of a stop button on the ADV should be considered Driver on board for feasibility Manual mode for the ADV is required	The vehicle shall be equipped with an emergency system, to be stopped and/or intervened by an in-site driver	Operator without direct sight (Fleet Manager) Actors of local supply chain Operator in sight System developers and integrators Device designers and manufacturers Software and app developers Compliance assurance
Physical inspection of the ADV should be done occasionally	A recurring physical inspection of the vehicle shall be done	Operator without direct sight (Fleet Manager) Teleoperator with remote access Fleet Management, Maintainer
The ADV should inform about transfer units (port) Internal communication about the state of the system is required Internal communication and information to all personnel directly involved about the state of the system	The vehicle shall inform the control system (LOFM) about its movements (actions, positioning, longitudinal and lateral motion, etc.) and status (sensors, tires, fuel/energy, etc.)	Operations monitoring Operator without direct sight (Fleet Manager) Airport authorities System developers and integrators Compliance design & implementation Logistic/Transportation business (Fleet Owners) Commercial vehicles Fleet Management, Maintainer
Easy use of the system Usability of the user interface	The user interface shall be easy to use	Teleoperator with remote access Operator without direct sight (Fleet Manager) Software and app developers System developers and integrators

		Compliance design & implementation Continuous operations improvement Device designers and manufacturers
Remote control for the ADV should be available	The vehicle shall allow remote intervention / control at any time	Teleoperator with remote access Traffic management Certification bodies Police Residents Members of cities councils Error handling System developers and integrators Research Operator without direct sight (Fleet Manager) Actors of local supply chain Remote operator Combined operator Compliance assurance Fleet Management Operations monitoring Commercial vehicles Maintainer, OEMs Fleet Management, Maintainer
For the operation of the ADV, a detailed planning of the route is needed The ADV and LOFM should be able to find alternative routes when blockages are present	The AGTS shall be able to define a detailed route before starting operations, as well as modify it in real-time if necessary (for example, under the presence of an obstacle/accident)	Teleoperator with remote access Operator in sight Loader / Unloader Residents Regulatory department Planning service Operator without direct sight (Fleet Manager) Operations monitoring System developers and integrators Logistics service provider
The AGTS should have high security against hackers and unskilled users	The AGTS shall be robust to face external attacks (e.g., cyber-attacks), as well as prevent misuse by internal unqualified personnel	Airport authorities Actors of local supply chain Software and app developers Compliance assurance System developers and integrators Device designers and manufacturers Automated vehicle maintenance Logistics service provider

		Operations monitoring Cyclists Commercial vehicles
Reliability Reliability depends on costs Implementation of a backup system Fault tolerance The ADV should respect the schedule	The AGTS shall be reliable and fault tolerance	Teleoperator with remote access System developers and integrators Research Operator without direct sight (Fleet Manager) Airport authorities Actors of local supply chain Device designers and manufacturers Compliance assurance Logistics service provider Continuous operations improvement Users in non-automated vehicles Commercial vehicles Traffic management
Time is required to reach optimum system performance	A delay time shall be considered for the implementation of the AGTS to achieve the desired performance	Commercial vehicles Infrastructure maintenance
Communications in airport Security issues in ports/airports No driver implies less checkpoints The AGTS should have its own security personnel/protocols Workflow on port An easy integration with existing systems is required Protection against possible theft Extensive tests in the defined scenarios should be done Return of merchandise should be considered Communications systems in port The definition of use cases makes easy the implementation of automation	The AGTS shall be integrated with existing systems avoiding any interference	Loader / Unloader Teleoperator with remote access Operator in the vehicle Logistics service provider Operator without direct sight (Fleet Manager) Airport authorities Logistic/Transportation business (Fleet Owners) Software and app developers System developers and integrators Compliance design & implementation Operator in sight Personal transport Compliance assurance Research Commercial vehicles Operations monitoring Traffic management Continuous operations improvement Infrastructure maintenance Users in non-automated vehicles

		Cyclists
Design of the logistics system bares great responsibility System Standardization	The AGTS shall be standardized to simplify its implementation in other use cases	Combined operator Compliance assurance
Increase in productivity is expected Increase transport capacities Reduce fuel costs Time optimization Operations 24/7	Automation shall result in higher profitability, coming from higher productivity (24/7 operability), higher transport capacities, and optimization of movements/time (and therefore, reduction in fuel/energy consumption)	Loader / Unloader Operations monitoring Actors of local supply chain System developers and integrators Software and app developers Operator in sight Operator without direct sight (Fleet Manager) Personal transport Compliance assurance Platform and cloud computing providers Device designers and manufacturers Automated vehicle maintenance Logistics service provider Users in non-automated vehicles Cyclists
Minimize human intervention Automation of other tasks	Tasks around the vehicle shall be automated	Operator without direct sight (Fleet Manager) Loader / Unloader Freight carriers Actors of local supply chain System developers and integrators Compliance design & implementation Operations monitoring Continuous operations improvement
A change in the law to include autonomous vehicles is needed	A regulatory change shall be made to consider the presence of autonomous vehicles	Compliance assurance Compliance design & implementation Regulatory department

		Airport authorities Combined operator Commercial vehicles Operations monitoring Cyclists Logistics service provider Public Authorities & Regulators
Ethical aspects must be considered	Ethical and social implications shall be studied	Residents Research Certification bodies Device designers and manufacturers Software and app developers Compliance assurance System developers and integrators

Table 7: Aggregation process for the extraction of user / stakeholder requirements.

10.2. Annex 2: Implications for Functional Requirements

In order to provide clear indications for technical development, the implications of user requirements on functional requirements have been analyzed in depth. These formed an important input for the work within T2.4 and D2.4, in which the functional requirements have been specified in detail. Table 8 in this Annex presents all these relationships in detail, and Figure 32 and Figure 33 illustrate the structure of this table. Below, we explain how the relationship between the user and functional requirements is shown. We start from the fact that a user requirement can address to one or more SoS systems. Once inside a system, the same requirement can address to one or more ODD categories. Finally, within each ODD category, it is possible to define one or more functional requirements to fulfill the user requirement. This structure is shown in Figure 32.

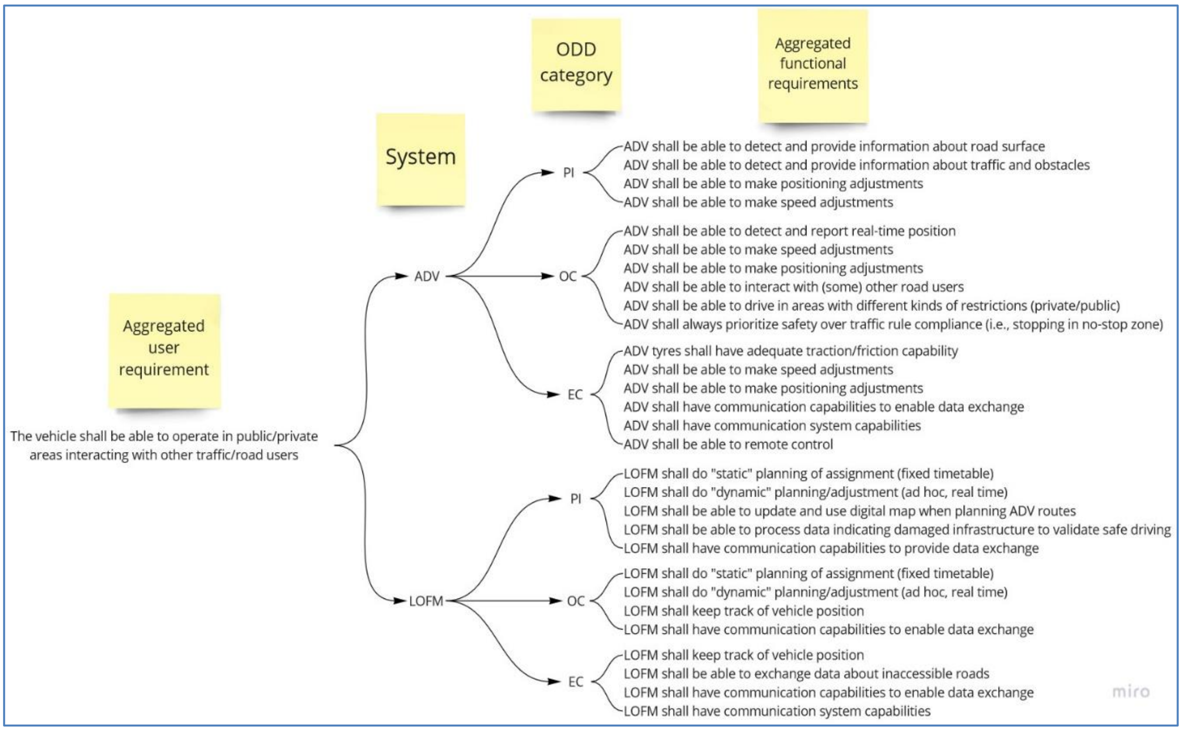


Figure 32: Scheme of implication of user requirements in functional requirements using the structure: User requirements – System – ODD Category – Functional requirements.

From Figure 32 we observe that, at the ODD category level, there is a certain degree of redundancy in the way that functional requirements are referenced. For example, for the ADV system, the functional requirement "ADV shall be able to make positioning adjustments" appears in all three ODD categories. To simplify the way to present these relationships, we place only the functional requirements at the system level, regardless of which ODD category they are taken from. So the repeated requirements will only be taken once. The result is shown in Figure 33. This time a user requirement relates to one or more SoS systems, and within each system to one or more functional requirements. Doing so, the relationship between user requirements and functional requirements can be analyzed based on a system level (cf. Figure 33).

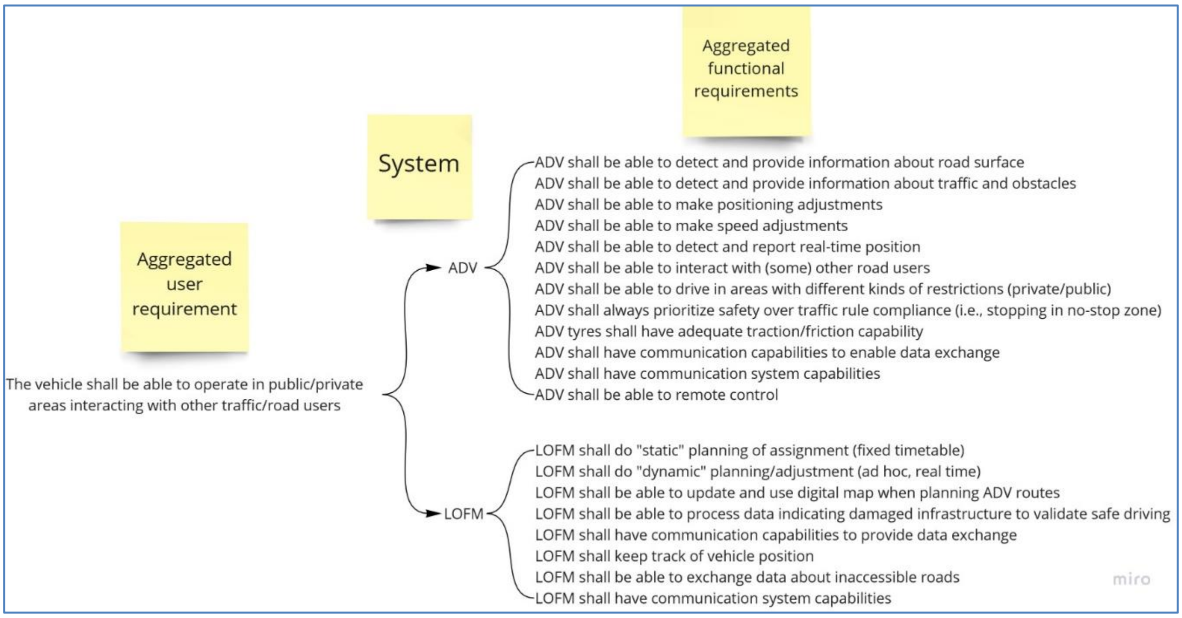


Figure 33: Scheme of implication of user requirements in functional requirements using the structure: User requirements – System – Functional requirements.

Following the structure of Figure 33, Table 8 shows the complete list of user / stakeholder requirements that have direct implications on the functionality of the system, as well as the corresponding functional requirements linked to these.

ID	Aggregated user requirements	System	Aggregated functional requirements
R5	The vehicle shall be able to operate in public/private areas interacting with other traffic/road users	ADV	ADV shall be able to detect and provide information about road surface
			ADV shall be able to detect and provide information about traffic and obstacles
			ADV shall be able to make positioning adjustments
			ADV shall be able to make speed adjustments
			ADV shall be able to detect and report real-time position
			ADV shall be able to interact with (some) other road users
			ADV shall be able to drive in areas with different kinds of restrictions (private/public)
			ADV shall always prioritize safety over traffic rule compliance (i.e., stopping in no-stop zone)
			ADV tyres shall have adequate traction/friction capability
			ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
			ADV shall be able to remote control
		LOFM	LOFM shall do "static" planning of assignment (fixed timetable)
			LOFM shall do "dynamic" planning/adjustment (ad hoc, real time)
			LOFM shall be able to update and use digital map when planning ADV routes
			LOFM shall be able to process data indicating damaged infrastructure to validate safe driving
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall keep track of vehicle position
			LOFM shall be able to exchange data about inaccessible roads
			LOFM shall have communication system capabilities
R6		ADV	ADV shall be able to detect and provide information about road surface

ID	Aggregated user requirements	System	Aggregated functional requirements
	AGTS operation shall be adapted to different weather conditions		ADV shall be able to detect and provide information about traffic and obstacles
			ADV shall be able to make positioning adjustments
			ADV shall be able to make speed adjustments
			ADV shall be able to detect and report real-time position
			ADV shall be able to interact with (some) other road users
			ADV shall be able to position the vehicle accurately to ensure efficiency when loading/unloading
			Key electronic components in ADV shall work within operating temperature range
			Shall protect electronics/sensors against weather conditions
			ADV shall adapt dynamically to all weather and weather induced conditions
			ADV tyres shall have adequate traction/friction capability
			ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
			ADV shall be able to remote control
		LOFM	LOFM shall do "static" planning of assignment (fixed timetable)
			LOFM shall do "dynamic" planning/adjustment (ad hoc, real time)
			LOFM shall be able to update and use digital map when planning ADV routes
			LOFM shall be able to process data indicating damaged infrastructure to validate safe driving
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall keep track of logistics processes
			LOFM shall keep track of vehicle position
			LOFM shall be able to handle harsh temperature conditions
			LOFM shall be able to exchange data about inaccessible roads
			LOFM shall have communication system capabilities
		SI	SI shall be able to detect and provide information about road surface
			SI shall be able to detect hindering objects or vehicles out of line of sight (behind hilltop, curves, etc.)
			SI shall establish and maintain infrastructure and marking condition
			SI shall be able to support positioning within the area upon request
			SI shall have communication capabilities to provide data exchange
			SI shall have communication system capabilities
			SI shall be able to detect and report real-time position
			SI shall provide information about traffic
			SI shall be able to handle barriers / gates
			Sensor of SI shall not be compromised by diverse weather conditions
			SI shall fulfil physical infrastructure requirement (snow edges, friction, temperature tolerance etc.)
			SI shall be able to sense during diverse light conditions (day, night, blurring...)
			SI shall be able to identify and exchange contextual information (e.g., warnings)
			SI shall be able to process request in near real time
		SLS	SLS shall be able to handle errors in automated loading/unloading process (inform and compensate)
			SLS shall do "dynamic" planning/adjustment in accordance with weather induced deviation
			SLS shall provide communication capabilities to enable data exchange
			SLS shall have communication system capabilities

ID	Aggregated user requirements	System	Aggregated functional requirements
			SLS allow manual override
R7	The vehicle shall guarantee at all times the safety of all the people around it	ADV	ADV shall be able to detect and provide information about traffic and obstacles
			ADV shall be able to make speed adjustments
			ADV shall be able to adjust positioning with high precision when (off)loading trailers
			ADV shall be able to detect and report real-time position
			ADV shall be able to interact with (some) other road users
			ADV shall be able to drive in areas with different kinds of restrictions (private/public)
			ADV shall always prioritize safety over traffic rule compliance (i.e., stopping in no-stop zone)
			ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
			ADV shall have fallback systems for positioning, detection, etc.
			ADV shall be able to remote control
		LOFM	LOFM shall be able to update and use digital map when planning ADV routes
			LOFM shall be able to process data indicating damaged infrastructure to validate safe driving
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall keep track of logistics processes
			LOFM shall keep track of vehicle position
			LOFM shall do "dynamic" planning/adjustment in accordance with weather induced deviation
			LOFM shall be able to exchange data about inaccessible roads
			LOFM shall have communication system capabilities
		SI	SI shall be able to detect and provide information about road surface
			SI shall be able to detect hindering objects or vehicles out of line of sight (behind hilltop, curves, etc.)
			SI shall establish and maintain infrastructure and marking condition
			SI shall be able to support positioning within the area upon request
			SI shall have communication capabilities to provide data exchange
			SI shall have communication system capabilities
			SI shall be able to detect and report real-time position
			SI shall provide information about traffic
			SI shall be able to handle barriers / gates
			SI shall be able to identify and exchange contextual information (e.g., warnings)
			SI shall be able to process request in near real time
			SI shall have fallback systems for communication system failure
		SLS	SLS shall carry out loading/unloading process
			SLS shall be able to handle errors in automated loading/unloading process (inform and compensate)
			SLS shall do "dynamic" planning/adjustment in accordance with weather induced deviation
			SLS shall provide communication capabilities to enable data exchange
			SLS shall have communication system capabilities
R8	The behavior of the vehicle shall be adjusted according to the road conditions: area (public or private), surface	ADV	ADV shall be able to detect and provide information about road surface
			ADV shall be able to detect and provide information about traffic and obstacles
			ADV shall be able to make positioning adjustments
			ADV shall be able to make speed adjustments
			ADV shall be able to detect and report real-time position

ID	Aggregated user requirements	System	Aggregated functional requirements
	(pavement, concrete), relief (slope, flat), and geometry (curve, line)		ADV shall be able to drive in areas with different kinds of restrictions (private/public)
			ADV shall always prioritize safety over traffic rule compliance (i.e., stopping in no-stop zone)
			ADV tyres shall have adequate traction/friction capability
			ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
			ADV shall be able to remote control
		LOFM	LOFM shall do "static" planning of assignment (fixed timetable)
			LOFM shall do "dynamic" planning/adjustment (ad hoc, real time)
			LOFM shall be able to update and use digital map when planning ADV routes
			LOFM shall be able to process data indicating damaged infrastructure to validate safe driving
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall keep track of vehicle position
			LOFM shall be able to exchange data about inaccessible roads
			LOFM shall have communication system capabilities
		SI	SI shall be able to detect and provide information about road surface
			SI shall be able to detect hindering objects or vehicles out of line of sight (behind hilltop, curves, etc.)
			SI shall establish and maintain infrastructure and marking condition
			SI shall be able to support positioning within the area upon request
			SI shall have communication capabilities to provide data exchange
			SI shall have communication system capabilities
			SI shall be able to detect and report real-time position
			SI shall provide information about traffic
			SI shall be able to handle barriers / gates
			SI shall fulfil physical infrastructure requirement (snow edges, friction, temperature tolerance etc.)
			SI shall be able to sense during diverse light conditions (day, night, blurring...)
			SI shall be able to identify and exchange contextual information (e.g., warnings)
			SI shall be able to process request in near real time
R10	The vehicle shall be able to interact with the available digital/physical infrastructure	ADV	ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
			ADV shall be able to detect and provide information about traffic and obstacles
			ADV shall be able to detect and provide information about road surface
		LOFM	LOFM shall do "dynamic" planning/adjustment (ad hoc, real time)
			LOFM shall be able to update and use digital map when planning ADV routes
			LOFM shall be able to process data indicating damaged infrastructure to validate safe driving
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall have communication system capabilities
			LOFM shall do "dynamic" planning/adjustment in accordance with weather induced deviation
			LOFM shall be able to exchange data about inaccessible roads
		SI	SI shall be able to detect and provide information about road surface
			SI shall be able to detect hindering objects or vehicles out of line of sight (behind hilltop, curves, etc.)
			SI shall establish and maintain infrastructure and marking condition

ID	Aggregated user requirements	System	Aggregated functional requirements
			SI shall be able to support positioning within the area upon request
			SI shall have communication capabilities to provide data exchange
			SI shall have communication system capabilities
			SI shall be able to detect and report real-time position
			SI shall provide information about traffic
			SI shall be able to handle barriers / gates
			SI shall fulfil physical infrastructure requirement (snow edges, friction, temperature tolerance etc.)
			SI shall be able to sense during diverse light conditions (day, night, blurring...)
			SI shall be able to identify and exchange contextual information (e.g., warnings)
R12	The vehicle shall be equipped with an emergency system, to be stopped and/or intervened by an in-site driver	ADV	ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
			ADV shall be able to remote control
		LOFM	LOFM shall have communication capabilities to provide data exchange
			LOFM shall have communication system capabilities
			LOFM shall do "dynamic" planning/adjustment (ad hoc, real time)
R14	The vehicle shall inform the control system (LOFM) about its movements (actions, positioning, longitudinal and lateral motion, etc.) and status (sensors, tires, fuel/energy, etc.)	ADV	ADV shall be able to detect and report real-time position
			ADV shall be able to detect and provide information about road surface
			Key electronic components in ADV shall work within operating temperature range
			ADV shall have communication capabilities to enable data exchange
			ADV tyres shall have adequate traction/friction capability
			ADV shall have communication system capabilities
		LOFM	LOFM shall be able to process data indicating damaged infrastructure to validate safe driving
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall keep track of vehicle position
			LOFM shall have communication system capabilities
R16	The vehicle shall allow remote intervention / control at any time	ADV	ADV shall be able to detect and report real-time position
			ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
			ADV shall be able to remote control
		LOFM	LOFM shall do "dynamic" planning/adjustment (ad hoc, real time)
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall keep track of vehicle position
			LOFM shall have communication system capabilities
R17	The AGTS shall be able to define a detailed route before starting operations, as well as modify it in real-time if necessary (for example, under the presence of an obstacle/accident)	ADV	ADV shall be able to detect and provide information about road surface
			ADV shall be able to detect and provide information about traffic and obstacles
			ADV shall be able to make speed adjustments
			ADV shall be able to make positioning adjustments
			ADV shall be able to detect and report real-time position
			ADV shall be able to drive in areas with different kinds of restrictions (private/public)
			ADV shall adapt dynamically to all weather and weather induced conditions
			ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities

ID	Aggregated user requirements	System	Aggregated functional requirements
			ADV shall be able to remote control
		LOFM	LOFM shall do "static" planning of assignment (fixed timetable)
			LOFM shall do "dynamic" planning/adjustment (ad hoc, real time)
			LOFM shall be able to update and use digital map when planning ADV routes
			LOFM shall be able to process data indicating damaged infrastructure to validate safe driving
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall keep track of vehicle position
			LOFM shall do "dynamic" planning/adjustment in accordance with weather induced deviation
			LOFM shall be able to exchange data about inaccessible roads
			LOFM shall have communication system capabilities
		SI	SI shall be able to detect and provide information about road surface
			SI shall be able to detect hindering objects or vehicles out of line of sight (behind hilltop, curves, etc.)
			SI shall have communication capabilities to provide data exchange
			SI shall have communication system capabilities
			SI shall provide information about traffic
			SI shall be able to handle barriers / gates
			SI shall be able to detect and report real-time position
			SI shall be able to identify and exchange contextual information (e.g., warnings)
R18	The AGTS shall be robust to face external attacks (e.g., cyber-attacks), as well as prevent misuse by internal unqualified personnel	ADV	ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
			ADV shall be able to remote control
		LOFM	LOFM shall have communication capabilities to provide data exchange
			LOFM shall have communication system capabilities
		SI	SI shall have communication capabilities to provide data exchange
			SI shall have communication system capabilities
		SLS	SLS shall provide communication capabilities to enable data exchange
			SLS shall have communication system capabilities
			SLS allow manual override
R19	The AGTS shall be reliable and fault tolerance	ADV	ADV shall always prioritize safety over traffic rule compliance (i.e., stopping in no-stop zone)
			ADV shall be able to drive from origin to destination without human intervention
			Key electronic components in ADV shall work within operating temperature range
			Shall protect electronics/sensors against weather conditions
			ADV shall adapt dynamically to all weather and weather induced conditions
			ADV shall have fallback systems for positioning, detection, etc.
			ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
			ADV shall be able to remote control
		LOFM	LOFM shall do "dynamic" planning/adjustment (ad hoc, real time)
			LOFM shall be able to update and use digital map when planning ADV routes
			LOFM shall be able to process data indicating damaged infrastructure to validate safe driving
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall be able to handle harsh temperature conditions

ID	Aggregated user requirements	System	Aggregated functional requirements
			LOFM shall do "dynamic" planning/adjustment in accordance with weather induced deviation
			LOFM shall have communication system capabilities
		SI	SI shall have communication capabilities to provide data exchange
			SI shall have communication system capabilities
			Sensor of SI shall not be compromised by diverse weather conditions
			SI shall fulfil physical infrastructure requirement (snow edges, friction, temperature tolerance etc.)
			SI shall be able to sense during diverse light conditions (day, night, blurring...)
			SI shall be able to identify and exchange contextual information (e.g., warnings)
			SI shall have fallback systems for communication system failure
		SLS	SLS shall be able to handle errors in automated loading/unloading process (inform and compensate)
			SLS shall do "dynamic" planning/adjustment in accordance with weather induced deviation
			SLS shall provide communication capabilities to enable data exchange
			SLS shall have communication system capabilities
			SLS allow manual override
R21	The AGTS shall be integrated with existing systems avoiding any interference	ADV	ADV shall be able to adjust positioning with high precision when (off)loading trailers
			ADV shall be able to interact with (some) other road users
			ADV shall be able to drive in areas with different kinds of restrictions (private/public)
			ADV shall be able to position the vehicle accurately to ensure efficiency when loading/unloading
			ADV shall adapt dynamically to all weather and weather induced conditions
			ADV shall have communication capabilities to enable data exchange
			ADV shall have communication system capabilities
		LOFM	LOFM shall do "dynamic" planning/adjustment (ad hoc, real time)
			LOFM shall be able to update and use digital map when planning ADV routes
			LOFM shall have communication capabilities to provide data exchange
			LOFM shall keep track of logistics processes
			LOFM shall do "dynamic" planning/adjustment in accordance with weather induced deviation
			LOFM shall have communication system capabilities
		SI	SI shall establish and maintain infrastructure and marking condition
			SI shall have communication capabilities to provide data exchange
			SI shall have communication system capabilities
			SI shall provide information about traffic
			SI shall be able to handle barriers / gates
			SI shall fulfil physical infrastructure requirement (snow edges, friction, temperature tolerance etc.)
			SI shall be able to identify and exchange contextual information (e.g., warnings)
		SLS	SLS shall carry out loading/unloading process
			SLS shall be able to handle errors in automated loading/unloading process (inform and compensate)
			SLS shall do "dynamic" planning/adjustment in accordance with weather induced deviation
			SLS shall provide communication capabilities to enable data exchange
			SLS shall have communication system capabilities

Table 8: User / stakeholder requirements and their link to the aggregated functional requirements.

10.3. Annex 3: Survey and Interview

The AWARD Acceptance Factors Survey has been distributed as an electronic survey with an aim to cover different regions and to include a large number of stakeholders. Analyzed responses represent 107 full responses (mean age: 40,4; 70 male, 14 Female, 22 not disclosed). Most participants came from Austria (37), followed by France (21), Germany (12), Norway (8), Finland (3), and Belgium (3). Further participants came from the United States (2), United Kingdom (1), Switzerland (1), Portugal (1), The Netherlands (1), Japan (1), and Israel (1) (18 did not disclose their country (18).

The survey has been created in order to explore potential benefits, concerns, and other considerations regarding automated road transport logistics systems. As with the interviews, the goal of this part of data collection was to understand and gain detailed insights into different factors that determine acceptance and to support the development of well-designed future automated logistics systems. The main interest was in collecting the needs and concerns of all affected stakeholders (people interacting directly or indirectly with an automated vehicle, people involved in related processes, and other, more general stakeholder groups).

Representing many users across stakeholder categories, the respondents in the survey were supposed to select their corresponding stakeholder category and use case to answer questions regarding acceptance and expectations of the future automated logistics. The time to complete the survey has been estimated to 10-15 min during which the four use cases have been first sketched followed by questions regarding Usefulness, Ease of Operation, Supporting Conditions, Safety, Security and Reliability, Acceptance by Others and General Support in the specific use case they have selected. Based on their perspective role as part of the stakeholder group they specified, they were asked to express their thoughts and considerations regarding each point and explain their evaluations about both positive expectations as well as concerns they might have.

Which of the four mentioned automated transport logistics use cases are you most related to or familiar with?
You will later be asked to answer the questions of the survey from the perspective of the use case you chose here.

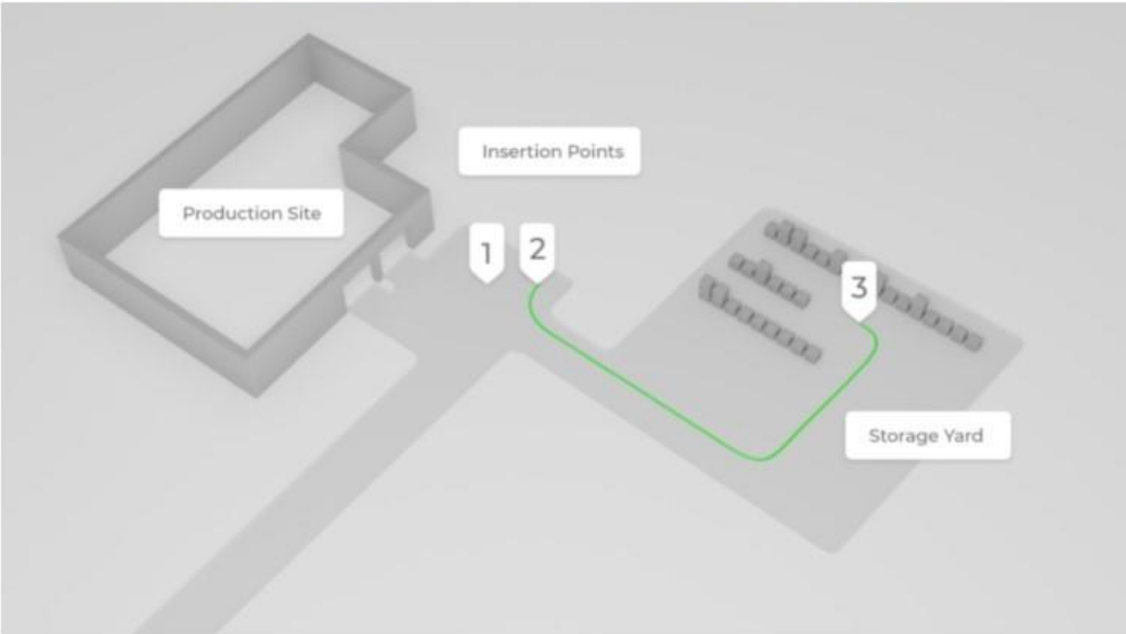
Choose one of the following answers
This question is mandatory

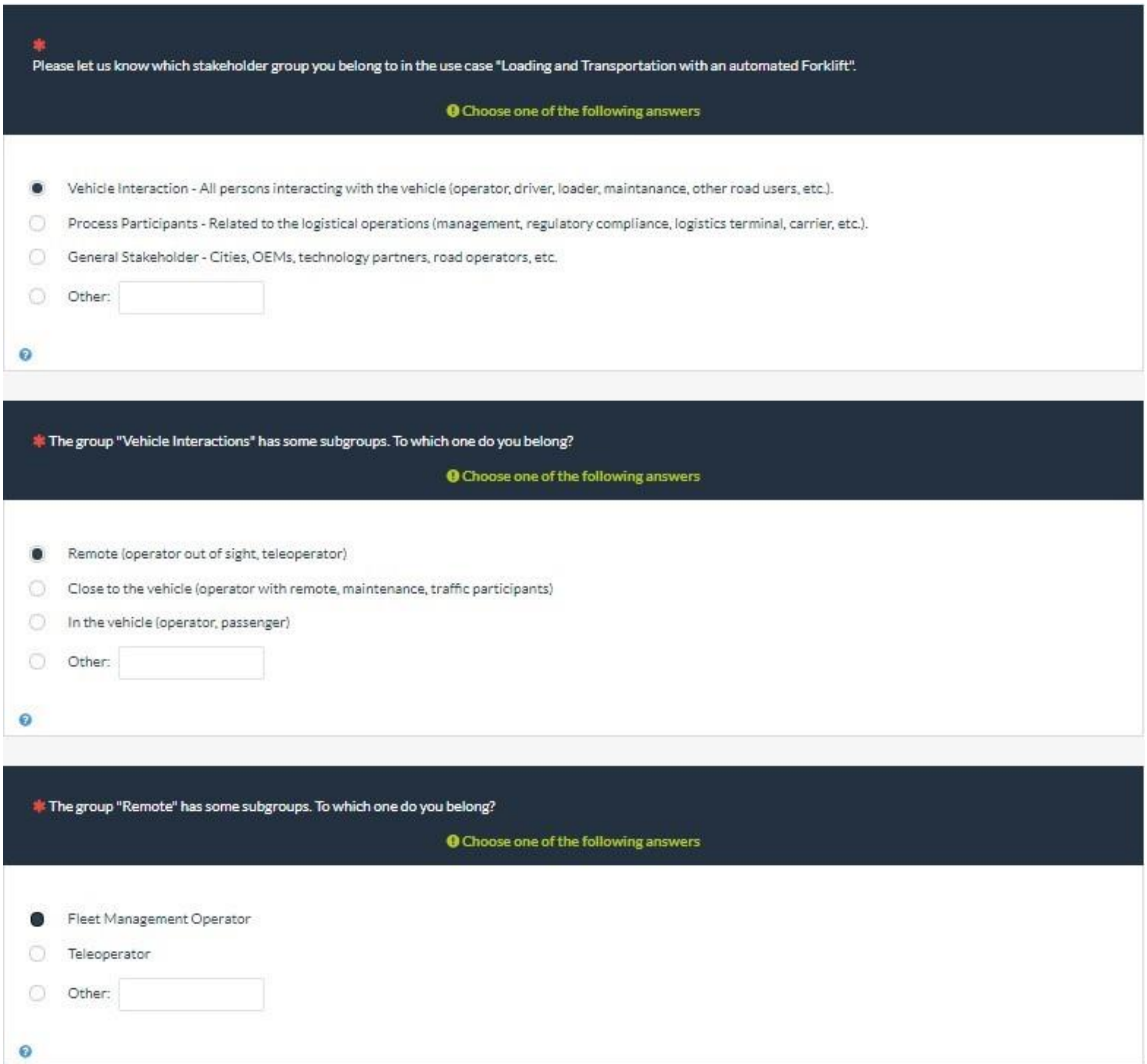
- [x] Forklift - Loading and transport with automated forklift
- [ ] Hub to Hub - Hub-to-hub shuttle service from warehouse/production site to logistics hubs
- [ ] Airport - Automated baggage tractor on an airport
- [ ] Port - Trailer transfer operations and automated boat loading in a port
- [ ] I am familiar with another use case which is not mentioned here

Use Case 1: "**Loading and transport with automated forklift**"

This use case focuses on the highly automated movement of lattice boxes with forklifts indoors and outdoors. An example application situation could be:

1. A production site receives goods in lattice boxes.These goods are consumed during production processes. Once the lattice boxes are empty, they are collected from the production line by a manually driven forklift. From the indoor production line, the forklift takes the lattice boxes to insertion points just outside a factory building.
2. An highly automated forklift picks up the empty lattice boxes from these points and transports them to a storage yard.
3. At the storage yard, the automated forklift automatically stacks the boxes and subsequently the boxes await shipment back to the parts suppliers.





* Please let us know which stakeholder group you belong to in the use case "Loading and Transportation with an automated Forklift".

Choose one of the following answers

- (selected) Vehicle Interaction - All persons interacting with the vehicle (operator, driver, loader, maintanance, other road users, etc.).
- Process Participants - Related to the logistical operations (management, regulatory compliance, logistics terminal, carrier, etc.).
- General Stakeholder - Cities, OEMs, technology partners, road operators, etc.
- Other:

* The group "Vehicle Interactions" has some subgroups. To which one do you belong?

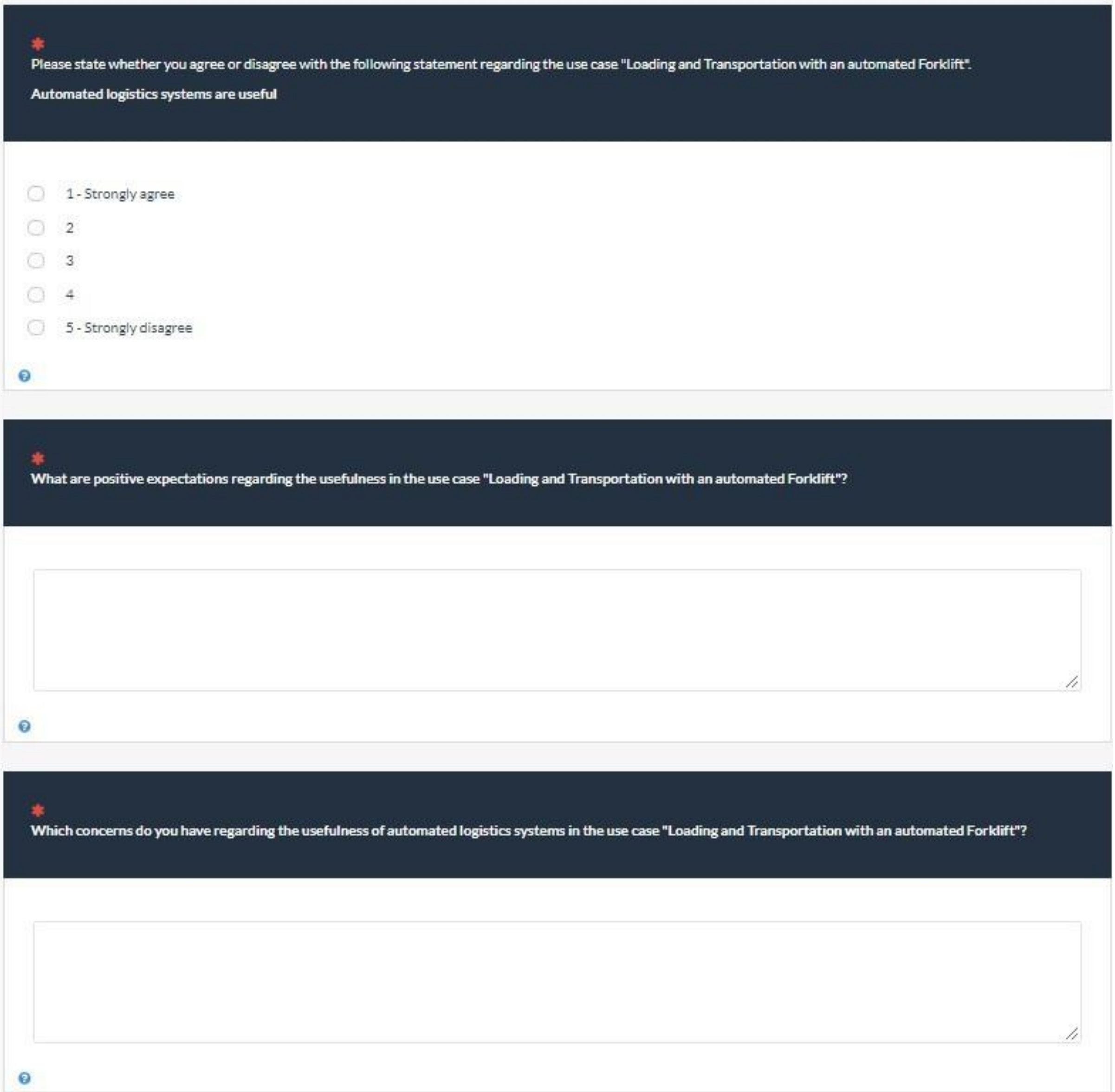
Choose one of the following answers

- (selected) Remote (operator out of sight, teleoperator)
- Close to the vehicle (operator with remote, maintenance, traffic participants)
- In the vehicle (operator, passenger)
- Other:

* The group "Remote" has some subgroups. To which one do you belong?

Choose one of the following answers

- (selected) Fleet Management Operator
- Teleoperator
- Other:



*
Please state whether you agree or disagree with the following statement regarding the use case "Loading and Transportation with an automated Forklift".
Automated logistics systems are useful

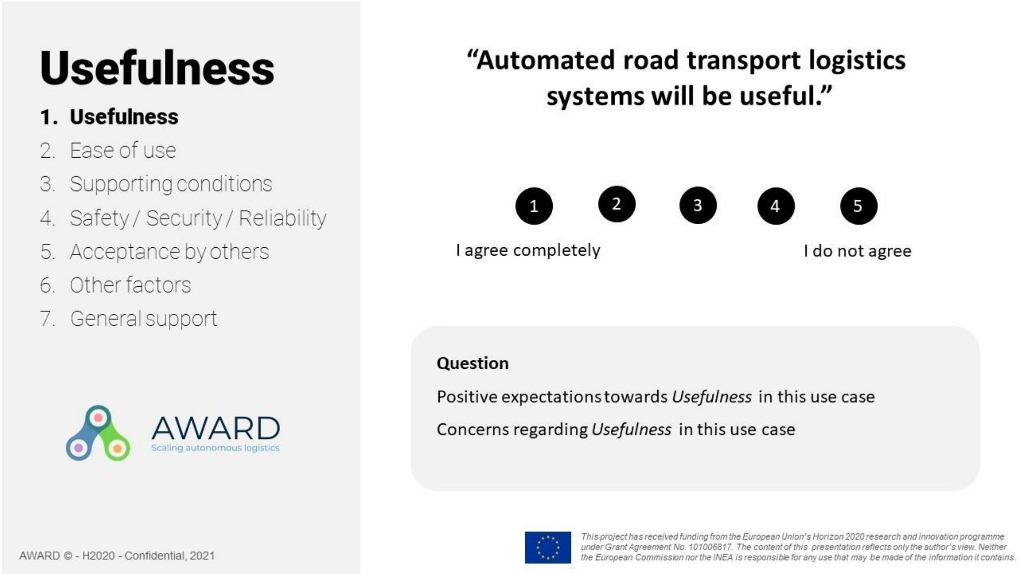
- 1 - Strongly agree
- 2
- 3
- 4
- 5 - Strongly disagree

*
What are positive expectations regarding the usefulness in the use case "Loading and Transportation with an automated Forklift"?

*
Which concerns do you have regarding the usefulness of automated logistics systems in the use case "Loading and Transportation with an automated Forklift"?

Interviews

One on one in-depth interviews with different stakeholder categories about their working environment, role and task flow were performed to extend insights into the requirements of future automated logistics workplaces. Each interview took on average one hour and was conducted in Microsoft Teams, with audio and sound recording. Sharing a screen of a presentation that contains an interview guide, the interviewer guided in a semi-structured manner the respective stakeholder through a set of questions and topics related to acceptance factors. The aim was to get an understanding of the future work roles and work environments related to a specific use case scenario. Following the structure of the survey questioning from the perspective of a chosen stakeholder role, the interviewer first presented the use cases in more detail and then asked the stakeholder to describe their current workplace situation as detailed as possible. The interview then continues as an in-depth investigation into the context in which a stakeholder would perform their future operations and about their expectations and requirements in this role.


Usefulness
1. Usefulness
2. Ease of use
3. Supporting conditions
4. Safety / Security / Reliability
5. Acceptance by others
6. Other factors
7. General support
AWARD
Scaling autonomous logistics
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"Automated road transport logistics systems will be useful."
1
2
3
4
5
I agree completely
I do not agree
Question
Positive expectations towards Usefulness in this use case
Concerns regarding Usefulness in this use case
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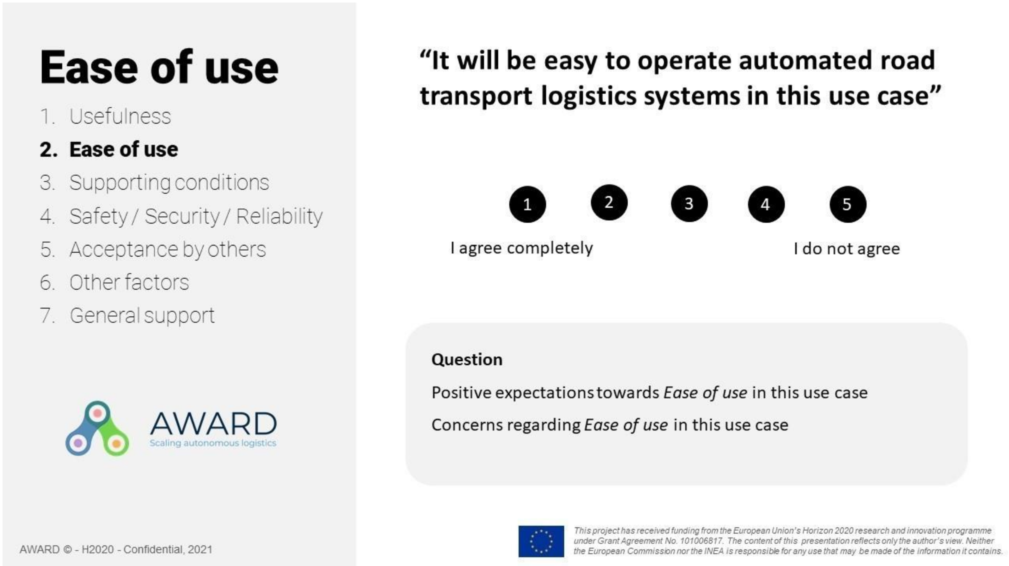
Ease of use
1. Usefulness
2. Ease of use
3. Supporting conditions
4. Safety / Security / Reliability
5. Acceptance by others
6. Other factors
7. General support
AWARD
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"It will be easy to operate automated road transport logistics systems in this use case"
1
2
3
4
5
I agree completely
I do not agree
Question
Positive expectations towards Ease of use in this use case
Concerns regarding Ease of use in this use case
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Supporting conditions
1. Usefulness
2. Ease of use
3. Supporting conditions
4. Safety / Security / Reliability
5. Acceptance by others
6. Other factors
7. General support
AWARD
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"Good supporting conditions can be expected for this use case"
Training, job profile adjustments, internal communication, supporting infrastructure, policy changes
1
2
3
4
5
I agree completely
I do not agree
Question
Positive expectations towards Supporting conditions in this use case
Concerns regarding Supporting conditions in this use case
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Safe. / Sec. / Reliability
1. Usefulness
2. Ease of use
3. Supporting conditions
4. Safety / Security / Reliability
5. Acceptance by others
6. Other factors
7. General support
AWARD
Scaling autonomous logistics
AWARD © - H2020 - Confidential, 2021
"The system will be safe, secure and reliable"
1
2
3
4
5
I agree completely
I do not agree
Question
Positive expectations towards Safety, Security and Reliability in this use case
Concerns regarding Safety, Security and Reliability in this use case
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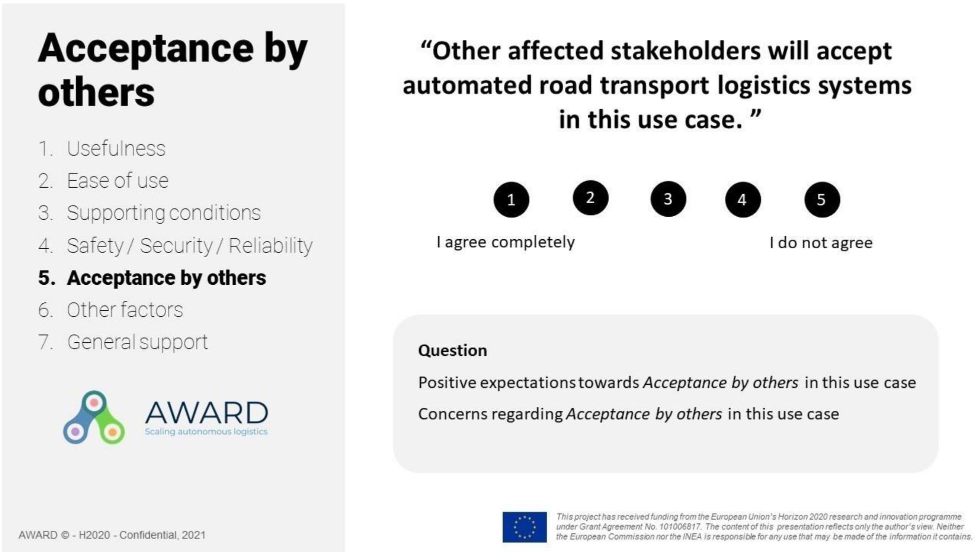
Acceptance by others
1. Usefulness
2. Ease of use
3. Supporting conditions
4. Safety / Security / Reliability
5. Acceptance by others
6. Other factors
7. General support
AWARD
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"Other affected stakeholders will accept automated road transport logistics systems in this use case. "
1
2
3
4
5
I agree completely
I do not agree
Question
Positive expectations towards Acceptance by others in this use case
Concerns regarding Acceptance by others in this use case
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Other factors
1. Usefulness
2. Ease of use
3. Supporting conditions
4. Safety / Security / Reliability
5. Acceptance by others
6. Other factors
7. General support
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Is there anything else?
Positive expectations
Concerns
Arising Problems
Advantages / Disadvantages
Opportunities
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General supp.
1. Usefulness
2. Ease of use
3. Supporting conditions
4. Safety / Security / Reliability
5. Acceptance by others
6. Other factors
7. General support
AWARD
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"I would generally support the use of automated logistics systems"
1
2
3
4
5
I agree completely
I do not agree
Question
Positive expectations towards General support
Concerns regarding General support
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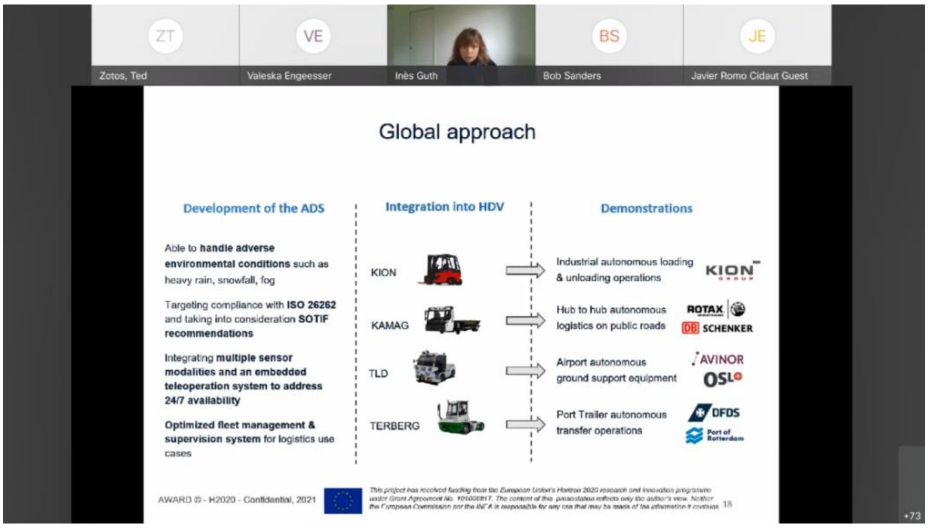
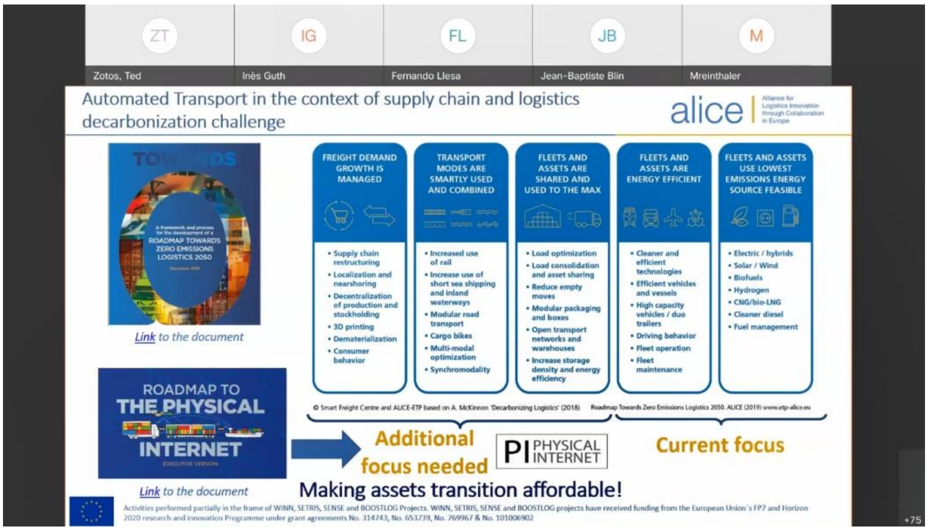
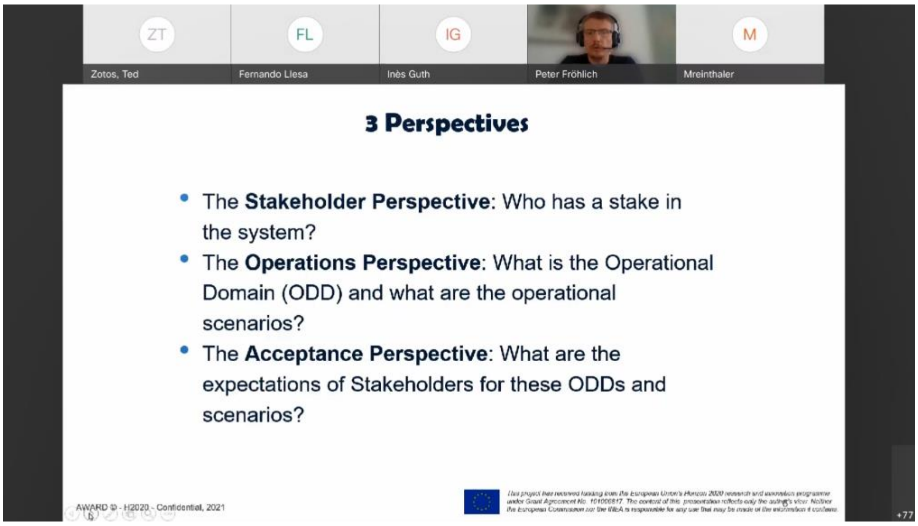
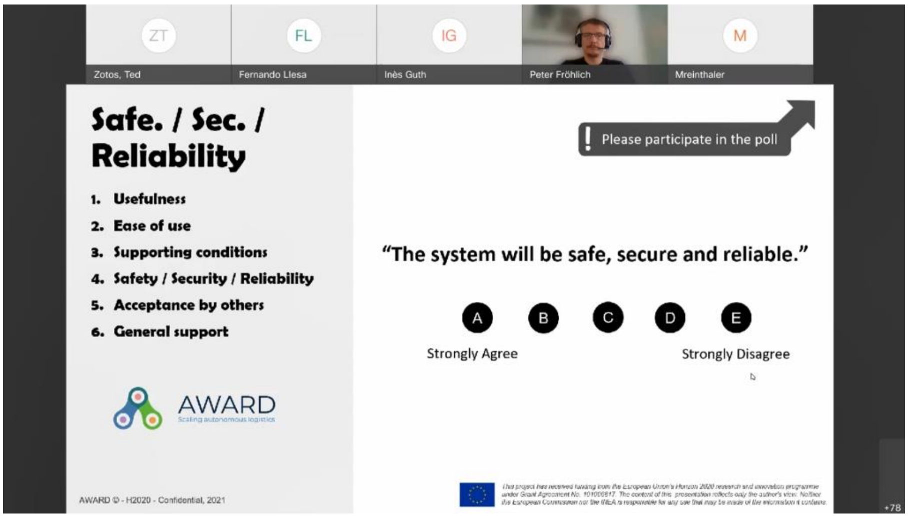
10.4. Annex 4: Stakeholder Workshop

On 2 June 2021, AWARD held its first workshop with the aim of sharing its vision and current status of novel automated transport logistics to 80 participants coming from public authorities, academia, industry and representative bodies (. During this workshop, requirements from different stakeholder perspectives were discussed and refined. The workshop consisted of three sessions in which participants actively participated and listened to the speakers‘ presentations. Session 1 looked into the challenges and opportunities for future automated transport logistics. Speakers included Ines Guth, the AWARD project coordinator, who gave an overview of the project and introduced its use cases. Fernando Liesa, the ALICE Secretary General, informed participants about ALICE’s activities on freight transport and automated mobility. Further elaboration was carried out on automated transport in the context of supply chain and logistics decarbonization challenge. Topics such as infrastructure use, intermodality, electric vehicles, total cost of ownership and driver shortage were also presented. Lastly, Peter Fröhlich from AIT, AWARD’s WP2 leader, presented acceptance factors for autonomous transport logistics. AIT presented the AWARD system of systems while also introducing the three perspectives when considering acceptance and user requirements. These perspectives can be classified as being the stakeholder perspective, the operations perspective and the acceptance perspective. Poll questions were used to gather views from participants on usefulness of automated road transport logistics systems, the ease of operation, supporting conditions, safety, security and reliability, acceptance by others and general support. The poll results were analysed and discussed in Chapter 6 of this Deliverable.



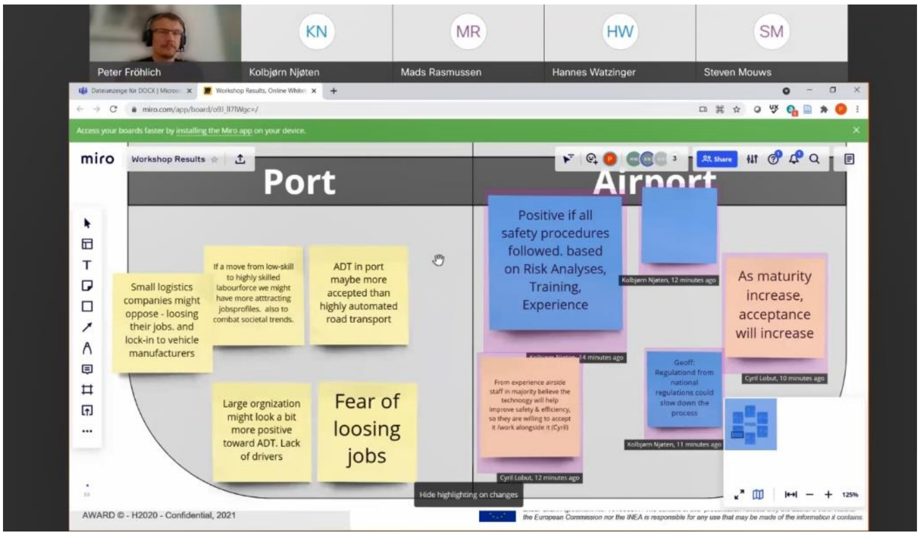






In Session 2, participants were allocated to a breakout session according to their background and area of expertise. The breakout sessions were named after the project's four use cases which are split in the following domains: Warehouse, Hub-to-hub, Airport and Port. The Warehouse use case consists of automated goods handling within the logistics hub. The Hub-to-hub use case focuses on hub-to-hub transport on public roads. The Airport use case focuses on automated transport for airport baggage handling while the Port use case deals with automated trailer transfer with port terminal systems.

Session 3 was used to discuss the main findings from the breakout sessions. Each breakout session was given a rapporteur who reported back once participants returned from the breakout sessions.



Agenda

▲ 09:00-09:15 Welcome and introduction

Grab a coffee and get comfortable!

▲ Session 1: Challenges and opportunities for Future Automated Transport Logistics

- Scaling Autonomous Logistics – the AWARD Approach (Ines Guth, Easymile)
- Automated transport towards sustainable and efficient logistics (Fernando Liesa, ALICE)
- Acceptance Factors for Autonomous Transport Logistics (Peter Fröhlich, AIT)

▲ 10:00-10:10 Coffee break

Networking time!

▲ 10:10-11:10 Session 2: Defining Requirements for Key Scenarios (Breakout Sessions)

- Automated goods handling within the logistics hub
- Hub-to-hub transport on public roads
- Automated transport for airport baggage handling
- Automated trailer transfer with port terminal systems

▲ 11:10-11:50 Session 3: Main Findings from Breakout Sessions

Results and key findings from the breakout sessions by moderators.

▲ 11:50-12:00 Conclusion and next steps

Keep following AWARD!

AWARD workshop #1

Automation in Freight Transport & Logistics
User requirements Workshop

Organised by IRU and AIT on the 2nd of June 2021

At its first interactive workshop, AWARD's vision and current status of novel automated transport logistics will be presented to a group of experts from public authorities, industry and representative bodies. During this workshop, requirements from different stakeholder perspectives will be discussed and refined.

Discussions will take place on the state of the art, current project findings and challenges related to the project's four use cases:

Warehouse

Automated goods handling within the logistics hub

Hub-to-hub

Hub-to-hub transport on public roads

Airport

Automated transport for airport baggage handling

Port

Automated trailer transfer with port terminal systems

The inputs will be used and included in the AWARD stakeholder and user requirements report that is planned to be submitted to the European Commission in September 2021.

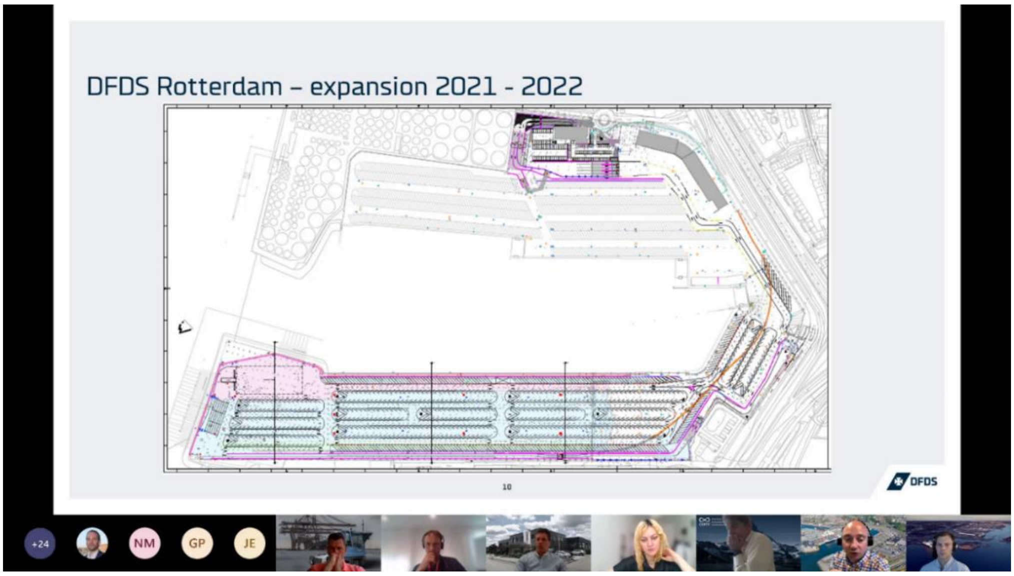
This workshop is a closed event with a limited number of participants. The workshop participants will consist of experts in the field of autonomous logistics. Please contact us if you are interested in this workshop and its results: info@award-h2020.eu.

10.5. Annex 5: Site Visits

For each use case, the possibility of virtual tours provided an opportunity to get familiar with the site of the future automated logistics operations and to discuss specific user requirements. For each use case, a virtual visit through Microsoft Teams was made available to online meeting participants by the live streaming from the site of future operations. Depending on Covid restrictions at the time of the visit, sites were able to provide also in-person attendance. Apart from the Port use case, all other use cases were able to allow on-site participation as well – Airport, Hub to hub and Forklift use cases. The representatives for each use case first presented to the participants the specifics of the AWARD project in regard to their on-site operations. Afterwards, a guided tour was provided during which participants could ask questions. Table 9 provides an overview of the participants of the physical and the virtual format.

	Forklift	Port	Hub-to-Hub	Airport
Participants **(Physical)** **(Virtual)**	 6 21	 1 40	 17 22	 4 27

Table 9: Site Visits performed during the requirements gathering phase.


DFDS Rotterdam – expansion 2021 - 2022
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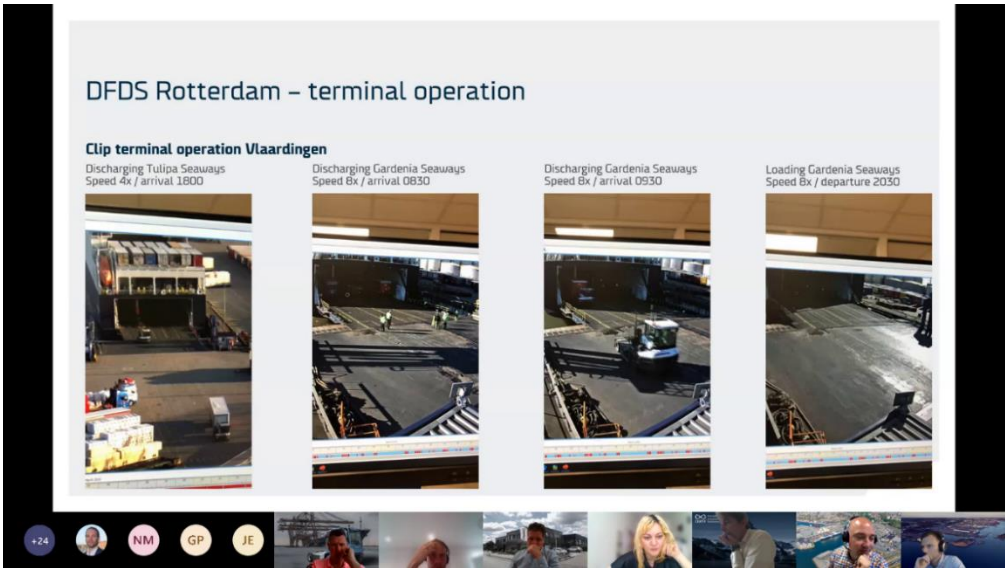
DFDS Rotterdam – terminal operation
Clip terminal operation Vlaardingen
Discharging Tulipa Seaways
Speed 4x / arrival 1800
Discharging Gardenia Seaways
Speed 8x / arrival 0830
Discharging Gardenia Seaways
Speed 8x / arrival 0930
Loading Gardenia Seaways
Speed 8x / departure 2030
+24
NM
GP
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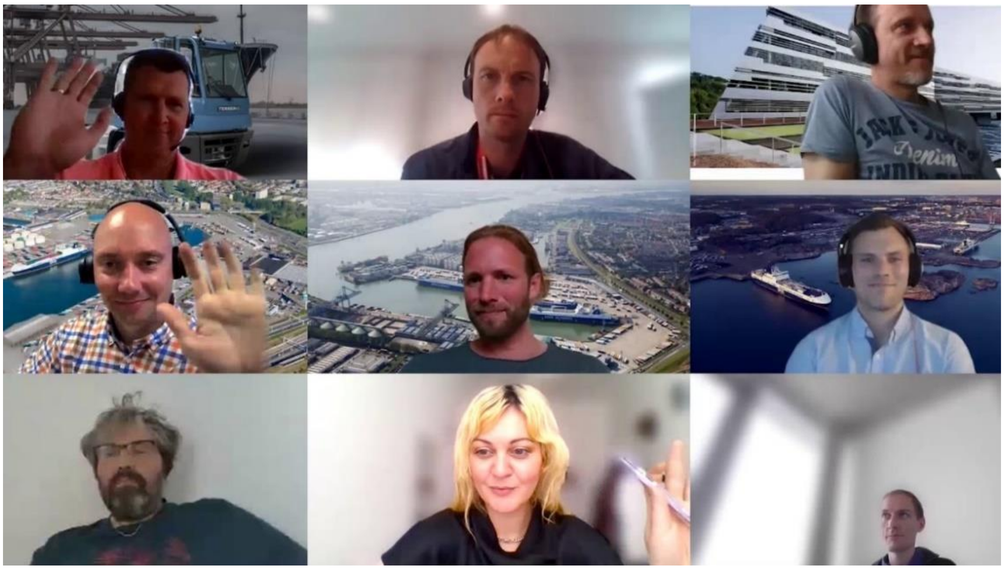
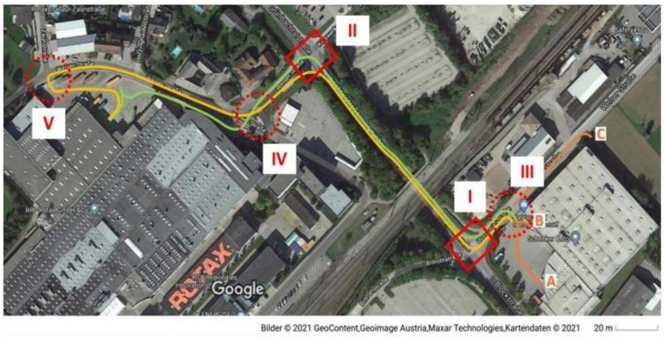
video material ©DFDS



The Port use case site visit (UC4 - trailer transfer operations and automated boat loading in a port) took place online on 6 June 2021 with 40 online participants, DFDS representatives who introduced the project and operations followed by a guided tour with a site manager in Vlaardingen part of the Rotterdam port, The Netherlands. During the virtual tour, the site of operations with its current infrastructure was presented and the future routes and operations of AV were discussed.

The Warehouse use case site visit (UC1 - loading and transport with an automated forklift) took place on 25 August at Linde Material Handling in Aschaffenburg, Germany with about 6 physical and 21 virtual participants. The site visit first introduced the use case, followed by a demonstration of the forklift operation and the route of future AWARD project truck operations.

Route Overview – Intersections



Route from Rotax to DB Schenker
Route from DB Schenker to Rotax
Different target points at DB Schenker

A Target terminal "A", terminal for 3 out of 4 cases
B Target terminal "B", terminal for every 4th case
C New terminal, in planning phase (to be built in 2022)

I, II, III: Goal is to have C-ITS compatible traffic lights (incl. RSU).

IV: Unregulated crossing. Measures tbd

V: Exit of Rotax site; unregulated, limited view. Measures tbd

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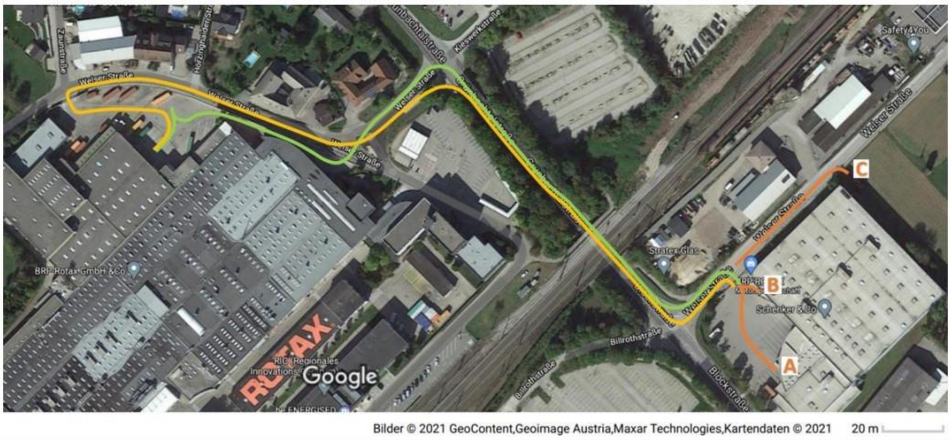
Route Overview

Route from Rotax to DB Schenker
Route from DB Schenker to Rotax
Different target points at DB Schenker

A Target terminal "A", terminal for 3 out of 4 cases
B Target terminal "B", terminal for every 4th case
C New terminal, in planning phase (to be built in 2022)



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Overview Vehicle

- Currently: Operation with conventional/human driven (Diesel) truck

- Goal: autonomous electrical truck (KAMAG Wiesel)
  - Phase 1, with safety driver
  - Phase 2, without safety driver

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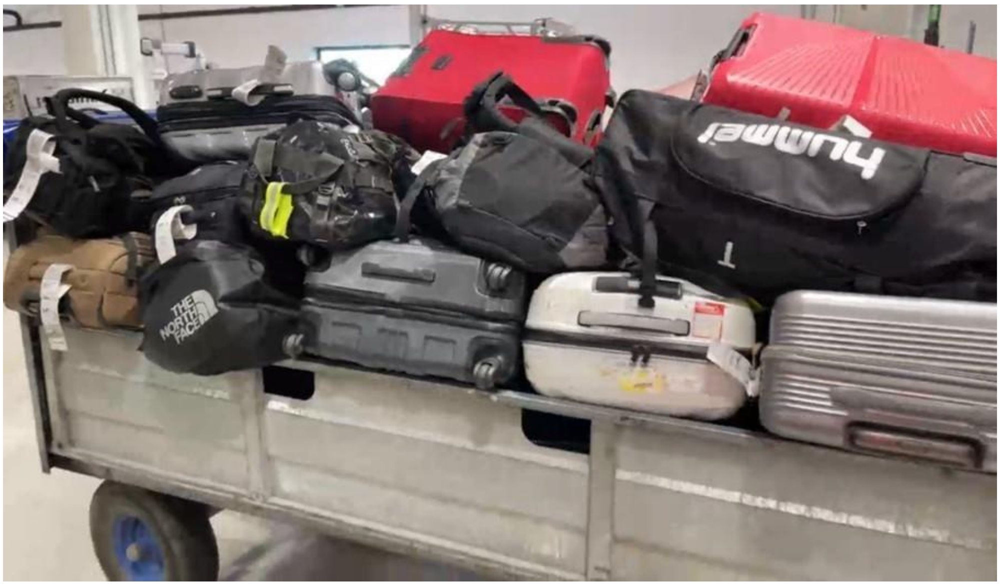
The Hub to Hub use case site visit (UC2 - shuttle service from warehouse/production site to logistics hubs) took place online and in-person on 26 August 2021 at the site of two companies BRP-Rotax GmbH & Co KG and DB Schenker in Gunskrichen, Austria. Some 22 virtual and 17 physical participants met to inspect the course of the 600-m-long track, which is to be covered by an autonomous e-transporter in all weather conditions. This included observation of a truck entering the site, parking, and unloading.


SAS
SE-ROL


hummel
THE NORTH FACE


AKH 90367
AEROFLOT
AKH 907
AEROFLOT
Russian Airlines

The Airport use case site visit (UC3 - automated baggage tractor on an airport) took place on 31 August 2021 on the site of Gardermoen airport in Oslo, Norway. This site visit was attended by 27 online participants and 4 physical. The main aspects of this presentation consisted of a walk through the operations during the turnaround process of an airplane, and then the route and the trajectories of the baggage tractor. The luggage handling process inside the airport building has been also resented while discussion touched upon topics such as the processes that would still need to be handled manually in the future (hooking/unhooking).

10.6. Annex 6: List of relevant projects and initiatives

Several national and EU-funded initiatives, programs and projects have or currently are working on interrelated topics which AWARD is investigating and elaborating upon. Table 10 and Table 11 summarize some of roadmaps these projects which AWARD can make use of when carrying out its own research. Prior and current work highlight how user acceptance and awareness is an area of interest for freight transport. In addition, needs and requirements of users are also considered while piloting activities mostly focus on platooning, in particular multi-brand.

National and EU roadmaps on connected and automated driving

Roadmap	Year	Link
ERTRAC New Mobility Services Roadmap	2021	https://www.ertrac.org/uploads/documentsearch/id74/ERTRAC%20New%20Mobility%20Services%20Roadmap.pdf
CCAM Partnership Strategic Research and Innovation Agenda	2020	https://www.ertrac.org/uploads/images/CCAM%20Partnership%20SRIA%20v1.0%2002-11-2020.pdf
UK Connected and Automated Mobility Roadmap to 2030	2020	https://zenzic.io/content/uploads/2020/10/Zenzic_Roadmap_Report_v3.pdf
Ensuring American Leadership in Automated Vehicle Technologies – United States	2020	https://www.transportation.gov/sites/dot.gov/files/2020-02/EnsuringAmericanLeadershipAVTech4.pdf
Cross-Ministerial Strategic Innovation Promotion Program (SIP) Automated Driving for Universal Services R&D Plan – Japan	2020	https://en.sip-adus.go.jp/sip/file/sip_2020_plan_en_s-1.pdf
ERTRAC Connected Automated Driving Roadmap	2019	https://www.ertrac.org/uploads/documentsearch/id57/ERTRAC-CAD-Roadmap-2019.pdf
ERTRAC Long Distance Freight Roadmap	2019	https://www.ertrac.org/uploads/documentsearch/id56/ERTRAC-Long-duty-Freight-Transport-Roadmap-2019.pdf
National and Land Transport Technology – Action Plan – Australia	2019	https://www.infrastructure.gov.au/transport/land-transport-technology/files/national_land_transport_technology_action_plan_2020-2023.pdf
Development of Autonomous Vehicles Strategic Orientations for Public Action – France	2018	https://www.ecologique-solidaire.gouv.fr/vehicules-autonomes
Paths to a self-driving future – The Netherlands	2017	https://knowledge-base.connectedautomateddriving.eu/wp-content/uploads/2019/08/Pathstoaself_drivingfuture.pdf
Strategy for Automated and Connected Driving – Germany	2015	https://www.bmvi.de/SharedDocs/EN/publications/strategy-for-automated-and-connected-driving.pdf?__blob=publicationFile

Table 10: National and EU roadmaps on connected and automated driving

Table 11 provides an overview over related ational and EU research and innovation projects related to AWARD

Project name	Objective	Duration	Relevance to AWARD	Link
BRAVE	Improve safety and market adoption of automated vehicles, by considering the needs and requirements of the users, other road users concerned (drivers and vulnerable road users) and relevant stakeholders (i.e. policy makers, standardisation bodies, certifiers, insurance companies, driving schools), assuring safe integration of key enabling technology advancements.	2017 - 2020	The production of a methodology for the development process of vehicle-driver interaction and driver monitoring concepts, specifying the requirements in terms of use cases, scenarios, and success criteria.	https://www.brave-project.eu/
DigiTrans	Set up and operate a test region for automated and connected driving with a focus on the transport of goods in the central area of Upper Austria (triangle Wels - Linz - Steyr).	2018 - 2023	Requirements from different industrial areas and infrastructure operators are being addressed to implement them jointly in a sustainable operating model in a need-oriented and effective manner.	https://www.digitrans.expert/
ENSEMBLE	Pave the way for the adoption of multi-brand truck platooning in Europe to improve fuel economy, traffic safety and throughput.	2018 - 2021	Impact of platooning on logistics, road safety, other drivers' behavior, traffic and congestion, and infrastructures is assessed and necessary mitigation measures are proposed.	https://platooningensemble.eu/
LEVITATE	Develop a wide-ranging evaluation framework to assess the impact of Connected and Automated Transport (CAT) on all aspects of transport and individual mobility as well as at societal level.	2018 – 2021	The project provides insights on future autonomous freight transport. *Deliverable 7.1 Defining the future of freight transport* looked into the expected development of freight transport, current literature on advanced driver assistance systems (ADAS), and indicators for the importance of freight applications.	https://levitate-project.eu/

Project name	Objective	Duration	Relevance to AWARD	Link
TANGO	Improve the user's experience and the acceptance of automated driving functions for trucks.	2016 - 2020	Development of an "attention and activity assistant" (Figure) is at the core of the TANGO project. It provides the drivers with diverse secondary tasks based on their current status, the current traffic situation, automation level and the interaction channel being used. By doing so, the project combines proven environment sensors with new cabin-interior sensors and new HMI-concepts.	https://projekt-tango-trucks.com/en/
Sweden4Platooning	Create common solutions that enable Volvo and Scania trucks to be connected in the same platoon.	2017-2019	Concrete specifications for how communication should be used so that the vehicles can understand each other, and safety requirements and business needs are met. Similarly, solutions are proposed for the supporting IT systems	https://www.ri.se/en/what-we-do/projects/sweden-4-platooning

Table 11: National and EU research and innovation projects related to AWARD

10.7. Annex 7: Technology Acceptance: Regressions and Correlations

In this annex document, we explain the background, characteristics, data capture and preliminary validation of our acceptance model[39].

Background

Several technology acceptance models have been developed, adapted and extended in recent decades to improve understanding of the processes underlying technology acceptance and to clarify the factors and antecedents that clearly influence the acceptance of different types of technologies. Most prominent among these models are the Technology Acceptance Model TAM, developed by Davis[40], that established "Perceived Usefulness" (U), "Perceived Ease of Use" (E) and "Behavioral Intention to Use" (BI) as core factors indicating actual system use. This model was extended to TAM2[41] and TAM3[42], which include "Social/Subjective Norms", "Experience" and "Voluntariness" as further factors impacting BI, as well as a growing list of antecedents to U and E. The Unified Theory of Acceptance and Use of Technology Model UTAUT[43] was an attempt to improve the TAM by integrating it with a number of existing related models, therefore increasing the explanatory powers and simplifying model choice for researchers.

These models serve as a base to assess user acceptance and understand the importance of a variety of factors in shaping acceptance. They have been applied in a wide range of contexts including automotive technologies, most prominently the C-TAM [44] which builds on the U-TAUT and extends it to include several trust-related factors (towards the technology and oneself). Neubauer and Schauer[45] took a closer look at core acceptance factors for automated road transport logistics through the development of scenarios and stakeholder interviews. They identified "Perceived Usefulness", "Job Relevancy" (as in clear definition of

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[39] This description has been originally made by the project team in the following publication: Fröhlich, P., Gafert, M., Diamond, L., Reinthaler, M., Neubauer, M., Hammer, F., Koskinen, S. (2021). Towards a Comprehensive Understanding of Stakeholder Requirements for Automated Road Transport Logistics. CEUR Workshop Proceedings, Vol-2905 (2021), ISSN: 1613-0073; Paper-Nr. 3, 7 S.

[40] Davis, F.D.. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly 13*, 3: 319–340.

[41] Venkatesh, V. and Davis, F.D:. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science 46*, 2: 186–204.

[42] Venkatesh, V. and Bala, H.. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences 39*, 2: 273–315.

[43] Venkatesh, V., Morris, M.G., Davis, G.B., and Davis, F.D.. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly 27,* 3: 425–478.

[44] Osswald, S., Wurhofer, D., Trösterer, S., Beck, E., and Tscheligi, M. (2012). Predicting information technology usage in the car: towards a car technology acceptance model. In *Proceedings of the 4th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (pp. 51-58).

[45] Neubauer, M. and Schauer, O. (2017). Human factors in the design of automated transport logistics. In *International Conference on Applied Human Factors and Ergonomics* (pp. 1145-1156). Springer.

new job profiles & related training), "Social Dimension" (as in acceptance by different stakeholder groups), and "Perceived Safety" as factors central to the acceptance of automated road transport logistics. The authors further emphasized the importance of clear communication in order to align expectations and technology performance, as well as careful consideration of the appropriateness of automation.

Characteristics of the ARTLAM framework

Based on these insights, we have developed an automated road transport logistics acceptance model (ARTLAM) which includes the four dimensions emphasized by Neubauer & Schauer[46] and the traditional ease of use (ease of operation) factor that we expect to be a sensitive and relevant acceptance component in this context. We have further extended both safety and job relevancy into the broader concepts of trustworthiness and facilitating conditions, therefore incorporating some of the spirit of the C-TAM, as well as learnings from behavioral models that point to the high impact of situations constraints on adopting behaviors[47]. The developed model, on which serves as the base for the data capturing activities and the derivation of requirements insights is depicted in Figure 4.

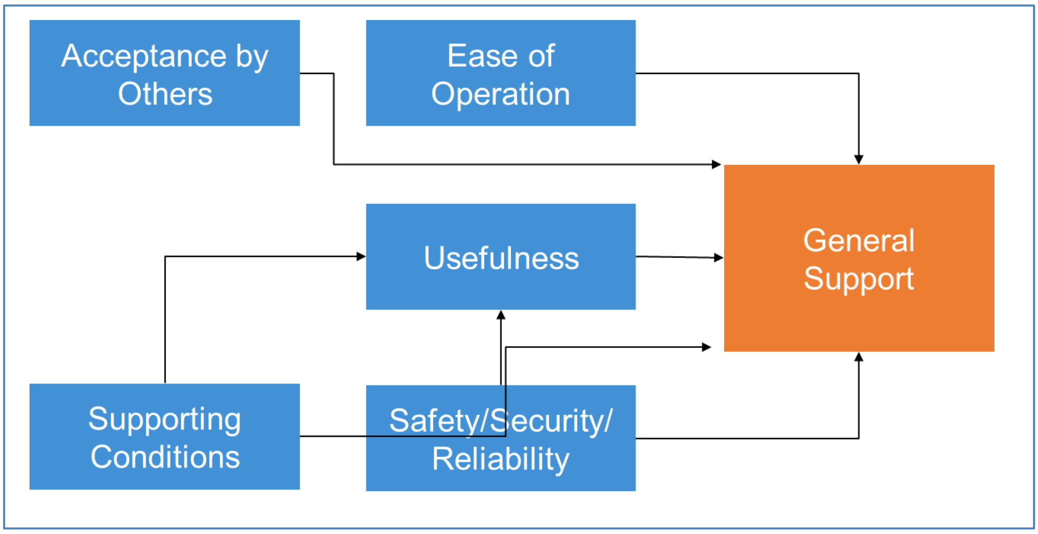

Figure 34: The Automated road transport logistics Acceptance Model (ARTLAM) developed for the Requirements Analysis

Data Analysis

Based on the data from the survey and interview, we conducted We performed correlations and a multiple regression analysis in order to check the suitability of the ARTLAM model.

[46] Neubauer, M. and Schauer, O. (2017). Human factors in the design of automated transport logistics. In *International Conference on Applied Human Factors and Ergonomics* (pp. 1145-1156). Springer.

[47] Klöckner, C.A. and Blöbaum, A.. (2010). A comprehensive action determination model: Toward a broader understanding of ecological behaviour using the example of travel mode choice. *Journal of Environmental Psychology 30*, 4: 574–586.

Results

Without distinguishing between cases, the strongest correlations with general support can be observed with usefulness (r=0.48, p<.000), security (r=0.5, p<.000) and stakeholder acceptance (r=0.41, p<.000). Correlations of medium support can be observed for safety (r=0.38, p=.000) and reliability (r=0.30, p=.001) and very weak to non-significant correlations could be observed for supporting conditions (r=0.17, p=.047) and ease of operation (r=0.1, p=.159). This is reflected in the regression model that reaches its potential with 38% (adjust. R^2=0.34, p <.000) of the variance explained under consideration of the usefulness (Beta=0.27, p=.007), security (Beta=0.33, p=0.002) and stakeholder acceptance (Beta=0.19, p=0.034) factors. None of the other factors proved to contribute significantly to explaining the observed variance of general support ratings. We assume that the limited relevance of the other factors is due to the high level of perspective and that the importance of other factors such as safety, reliability, facilitating conditions and ease of operation would increase with the readiness of the technology. Based on this analysis we identity usefulness, security and stakeholder acceptance as high level or concept factors that are already of particular importance during the conceptual stages of the development and safety, reliability, facilitating conditions and ease of operation as low level or implementation acceptance factors that come more strongly into play additionally when more practical questions of actual implementation and use have to be answered.

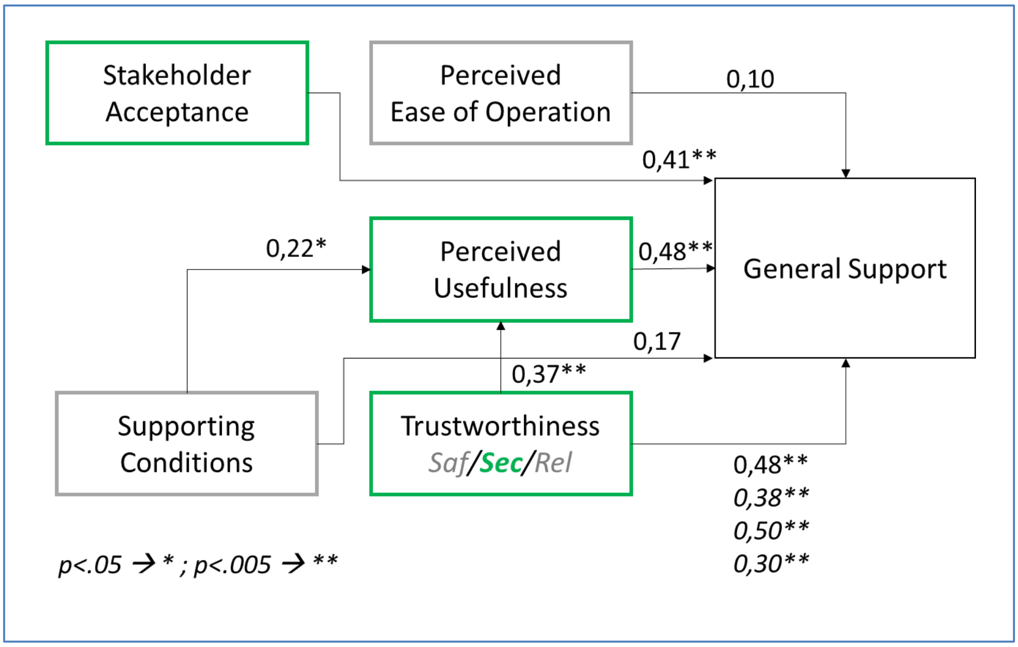

*Figure 35: Correlations between the ARTLAM factors. Concept acceptance factors are displayed in green, and implementation acceptance factors in grey. *The correlation is significant at a level of p<0,05; **The correlation is significant at a level of p<0.005*