Defining the future of freight transport

Deliverable D7.1 – WP7 – PU

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List of abbreviations

ACC	Adaptive Cruise Control
ADAS	Advanced Driver Assistance Systems
AEB	Autonomous Emergency Braking
AV	Automated Vehicle
ALICE	Alliance for Logistics Innovation through Collaboration in Europe
CACC	Cooperative Adaptive Cruise Control
CAFE	Corporate Average Fuel Economy
CATS	Connected and automated transport systems
C-ITS	Cooperative Intelligent Transport Systems
CV	Connected Vehicle
DisA	Distraction Alert
DrowA	Drowsiness Alert
ERRAC	European Rail Research Advisory Council
ERTRAC	European Road Transport Research Advisory Council
EU	European Union
FCW	Forward Collision Warning
FHWA	Federal Highway Administration
FOT	Field Operational Trial
GDPR	General Data Protection Regulation
IMA	Intersection Movement Assist
ISA	Intelligent Speed Assist
IVS	In-vehicle Signage
ITF	International Transport Forum
LCA	Lane Change Assist
LDW	Lane Departure Warning
LKA	Lane Keeping Assist
NHTSA	National Highway Traffic Safety Administration
NRC	National Research Council
PI	Physical Internet
PST	Policy Support Tool
SAE	Society of Automotive Engineers
SRG	Stakeholder Reference Group
TA	Turn Assist
TTC	Time to Collision
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle to everything
VKT	Vehicle Kilometres Travelled

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Executive summary

The aim of the LEVITATE project is to develop a new impact assessment framework to enable policymakers to manage the introduction of connected and automated transport systems, maximise the benefits and utilise the technologies to achieve long-term visions and goals. An essential part of this work seeks to forecast societal level impacts of connected and automated transport systems (CATS). These include impacts on safety, environment, economy and society.

The aim of this report is to provide a working framework under which the future of automated freight transport and resulting impacts can be defined. Findings will include the expected development of freight transport, current literature on advanced driver assistance systems (ADAS), and indicators for the importance of freight applications. These findings will be the foundation of subsequent work to look at short-, medium- and long-term impacts, respectively. The results presented in this report are based on reviewing roadmaps of European associations, reviewing scientific literature, and consulting stakeholders in the stakeholder reference group workshop.

The roadmaps differentiate between long-distance freight transport and urban freight transport. The timeline of implementation / commercialisation is different, and this is due to their complexity. Applications for the former, such as hub-to-hub automated transport, will be implemented earlier than applications for the latter, such as automated urban delivery.

Literature search on ADAS (SAE automation level 1 and 2) show their impacts on traffic, safety, environment, mobility and society. The systems are similar to those of passenger cars, with the exception of a few systems such as speed limiters or automatic electronic tolling system which are more relevant for freight vehicles. In general, literature suggests the future of CATS to be positive in terms of their impacts on traffic, safety, environment, economy and mobility according to most studies.

A stakeholder reference group workshop was conducted to gather views on the future of CATS and possible applications of freight transport from city administrators and industry. The consensus was that collaboration between freight operators should be enforced by facilitating data sharing, utilising consolidation centres, and improving the last mile solutions. This statement is not limited to CATS applications.

All these findings play an important role in the further development of the freight transport use case. The list of potential interesting sub-use cases was compiled, will be prioritised and refined in the next step during Tasks 7.2, 7.3 and 7.4. Finally, specific assessment methodologies will be developed, and the results integrated into the Levitate policy support tool (PST).

1 Introduction

1.1 Levitate

Societal **Lev**el **I**mpacts of Connec**t**ed and **A**utoma**t**ed Vehicl**e**s (Levitate) is a European Commission supported Horizon 2020 project with the objective to prepare a new impact assessment framework to enable policymakers to manage the introduction of connected and automated transport systems, maximise the benefits and utilise the technologies to achieve societal objectives.

Specifically Levitate has four key objectives:

To incorporate the methods within a **new web-based policy support tool** to enable city and other authorities to forecast impacts of Connected Automated Transport Systems (CATS) on urban areas. The methods developed within Levitate will be available within a tool box allowing the impact of measures to be assessed individually. A decision support system will enable users to apply backcasting methods to identify the sequences of CATS measures that will result in their desired policy objectives.

To develop a range of **forecasting and backcasting** scenarios and baseline conditions relating to the deployment of one or more mobility technologies that will be used as the basis of impact assessments and forecasts. These will cover three primary use cases – automated urban shuttle, passenger cars and freight services.

To establish **a multi-disciplinary methodology** to assess the short, medium and long-term impacts of CATS on mobility, safety, environment, society and other impact areas. Several quantitative indicators will be identified for each impact type

To apply the methods and **forecast the impact of CATS** over the short, medium and long term for a range of use cases, operational design domains and environments and an **extensive range of mobility, environmental, safety, economic and societal indicators**. A series of case studies will be conducted to validate the methodologies and to demonstrate the system.

1.2 Work package 7 and Deliverable 7.1 within Levitate

In Levitate the CATS applications and interventions are covered in three use cases:

- urban transport (WP5),
- passenger cars (WP6) and
- freight transport (WP7).

Therefore, this work package focuses on innovative logistic concepts enabled by CATS. It considers the specific sub-use cases in urban areas, but also between cities. It will be based on the methodology developed in WP3 and the scenarios developed in WP4 to identify and test specific scenarios regarding the impacts of CATS in freight transport. More specifically, the purpose of work package 7 is:

- To identify how each area of impact (safety, environment, economy and society) will be affected by the introduction and transition of CATS in freight transport.

- To assess its short, medium and long-term impacts, benefits and costs.
- To test interactions of the examined impacts of freight transport and
- To prioritise considerations for a public policy support tool to help authority decisions.

For analysing short-, medium- and long-term impacts of CATS, in this project, we are considering those defined by the types of impacts identified in our deliverable 3.1 by Elvik et al. (2019). They have classified range of impacts into three categories: direct impacts, systemic impacts and wider impacts. Direct impacts are changes that are noticed by each road user on each trip. These impacts are relatively short-term in nature and can be measured directly after the introduction of intervention or technology. Systemic impacts are system-wide impacts within the transport system. These are measured indirectly from direct impacts and are considered medium-term. Wider impacts are changes occurring outside the transport system, such as changes in land use and employment. These are inferred impacts measured at a larger scale and are result of direct and system wide impacts. They are considered to be long-term impacts.

The purpose of Deliverable 7.1 is to summarise the literature and workshop findings with focus on identifying the future role of CATS in freight transportation and logistics. This will pave the way for choosing the suitable and more realistic sub-use cases to forecasting its impact. The document will be informed by work conducted in work packages 3,4 and 8 and will complement the relevant ones of 5.1 and 6.1.

2 Methods

The basis for this deliverable on the future of freight transport are the following sources:

A targeted review of
- recent scientific literature;
- roadmaps of European associations, platforms, and alliances;

A dedicated stakeholder consultation, with relevant stakeholders (related to freight transport) and Levitate partners. The workshop gathered opinions on what is coming for connected and automated freight transport and provided insights from the experience of stakeholders. Structured discussions considered the situation/problem from the current standpoint (what is currently being done well/badly), describe an ideal future and identify the major steps to be achieved/hurdles to be overcome to reach the desired future.

2.1 Literature review strategy

The scientific literature review was carried out with focus on each of the sub-use cases. In addition, a focused research on ADAS technologies was performed. The roadmaps were taken from main European associations and technology platforms:

- ERTRAC (European Road Transport Research Advisory Council): https://www.ertrac.org/index.php?page=ertrac-roadmap
- ALICE (Alliance for Logistics Innovation through Collaboration in Europe): http://www.etp-logistics.eu/?page_id=96
- ITF (International Transport Forum) https://www.itf-oecd.org/
- ERRAC (European Rail Research Advisory Council): https://errac.org/

For this deliverable, the criteria for choosing these roadmaps was ideally finding intersection points between urban transportation, CATS, and freight transport on the scale of EU and EU policies. Related contents were screened and summarised in section 3.3.

2.2 Workshop details and planning

The first workshop was planned with the goal in order to gain receive the input of experts on the three use cases. Therefore, this section is identical among all three deliverables: D5.1 - Defining the future of urban transport, D6.1 - Defining the future of passenger cars, and D7.1 - Defining the future of freight transport. For the sake of completeness and better readability, we included this section it in all three documents. The workshop agenda can be found in the appendix.

2.2.1 Background

The project is supported by a reference group of core stakeholders comprising of international / twinning partners, key international organisations, road user groups (i.e. pedestrians, cyclists, professional drivers), industry, insurances and health sector, representing the most influential organisations that can affect mobility, environment, road safety and help improve casualty reduction among travellers. The main role of the

Stakeholder Reference Group (SRG) is to support the project team in ensuring the research continues to address the key issues as well as providing a major route to implementation of the results and consequent impact on mobility and road safety of all travellers. The group will meet to support and give feedback on the project's activities, as well as to contribute to the exploitation plans and to draft policy recommendations. All SRG were invited to the workshop. The experts who have confirmed their involvement are (Letters of Support (LoS) signed, partner) among others:

- Cities and Regions: City of Vienna (partner), Transport of Greater Manchester (partner), Transport of London (LoS), Madrid (LoS), Aarhus (LoS), Stuttgart region (LoS), KiM Dutch Ministry of Transport (LoS), ETSC (LoS), Rijkswaterstaat (LoS), Provincie Gelderland (LoS), City of Paris (LoS), Berlin (LoS), Catalonia (LoS), Amsterdam (LoS), Gothenberg, (LoS), City of Wels (LoS)
- OEMs, Tiers and Infrastructure Providers & Operators: DigiTrans consortium incl. associated partners: ASFINAG (Austrian infrastructure operator), BOSCH, Blue Danube Airport, AVL, DB Schenker, Magna, Rotax, MAN, etc. (LoS)
- Civil Society Organisations: contact to interest groups is sought during project life-time, e.g. Bicycle Lobby Vienna (claimed interest)

2.2.2 Date of workshop and Desired outcomes

The first SRG workshop was held in Gothenburg on 28th of May and the intended outcomes were:

- The future of CATS with respect to the short, medium and long-term (WP5,6,7)
- Goal dimensions and indicators of the desired future city (WP4)
- Which sub-use cases are of most interest; are there any missing? (WP5,6,7)
- Initial feedback on Policy Support Tool (PST) (WP8)

2.2.3 Workshop participants

Those members from SRG that were relevant to Task 7.1 in project LEVITATE were invited to the workshop and below is the list of type of organisations whom the participants belong to.

- Representatives of European cities
- Representatives of the European Commission, European decision makers
- Local/regional and national authorities and policy makers
- Automobile manufacturers
- Researchers in automotive industry or CATS sector in general, and Consultants
- Researchers from previous European projects about CATS
- Groups representing freight transport

In overall, there were 40 participants at the workshop. Figure 1 shows participants by organisation. Majority of participants (53%) were from local and national authority organisations. Whereas, rest of the participants were from specialist groups (association related to car, cycles, pedestrian), research organisations and, R&D departments within commercial organisations.

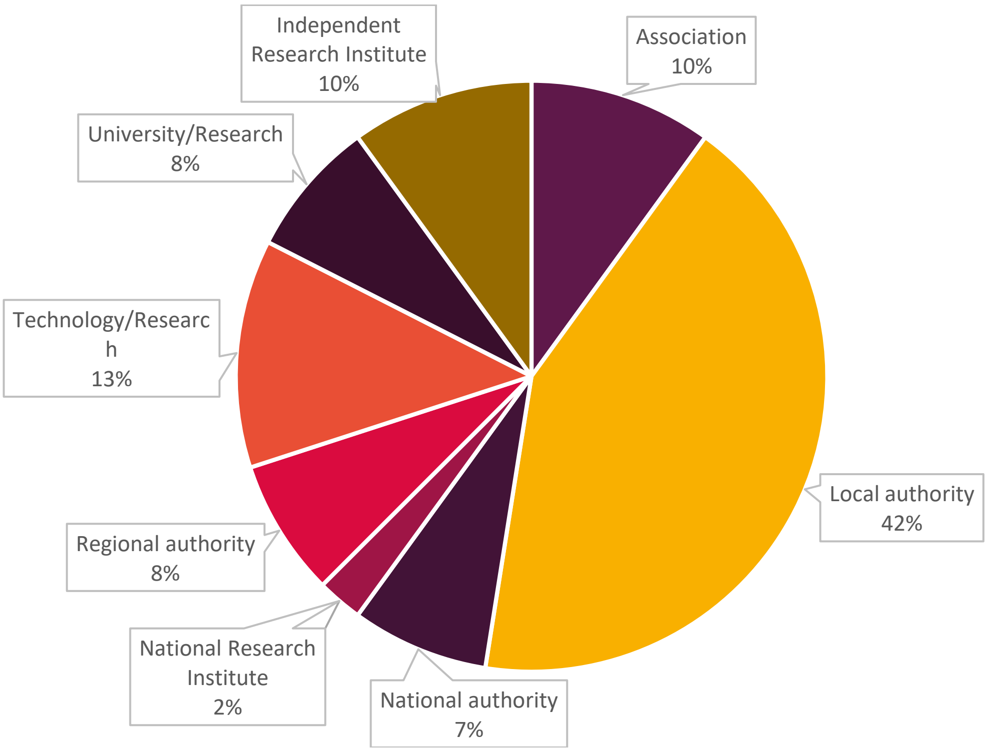

Figure 1: Participants by type of organisation.

Figure 2 shows participants by country. There was a good mix of partners from Europe. However, the majority were from western Europe possibly due to convenience of location of the Workshop.

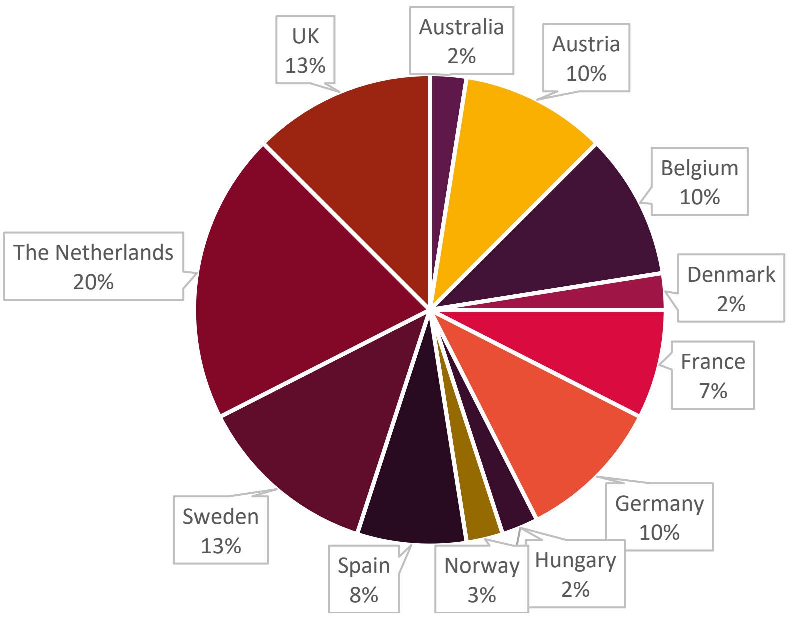

Figure 2: Workshop participants by country.

Figure 3 shows participants by their job functions. It can be ascertained that all participants were involved in jobs that were highly influential in decision-making within their own organisations. There were a few exceptions whose job titles were either missed to collect or were not provided. However, it was certain that they are involved in jobs that is influential in future directions of CATS.

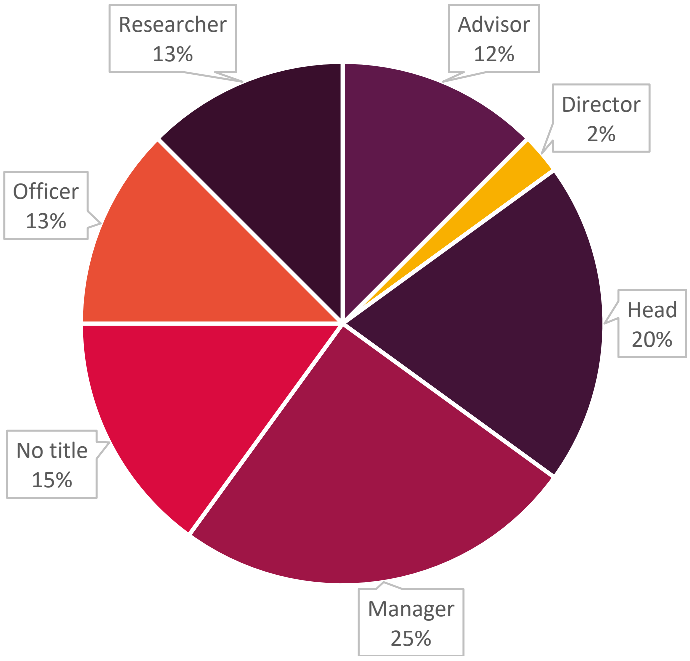

Figure 3: Participants by their job function.

Participants were further divided into smaller groups to discuss futures of automated urban transport (22 persons), passenger cars (11 persons), and freight transport (7 persons).

2.2.4 Ethics

During the workshop, the interviews and generally, when data is being collected within Levitate project, all relevant data protection rules are followed. Levitate complies with the General Data Protection Regulation (GDPR) and provides confidentiality of any personal information collected within the project, e.g. no transfer of personal information between partners i.e. personal information is processed and un-personalised within the organisation that collected the data, dataset is cleared of personal data as soon as possible after collection, only personal data that is really necessary is collected, asked for informed consent.

A survey was conducted between partners to aid in understanding the ethics issues that are likely to be faced and simultaneously, to provide the basis for a public statement on the way GDPR requirements are managed within the project. All appropriate measures are taken within Levitate to assure that ethical requirements are addressed appropriately.

2.2.5 Pre-workshop pilot interviews

Before the workshop, three interviews were conducted as a scoping exercise to improve the understanding of the sub-use cases that are of most interest to city administrations and ensure the project is addressing the most important mobility interventions. Two representatives from Transport for Greater Manchester and one from Transport for London were interviewed. The interviews were designed according to the workshop structure, lasted 30 minutes each and the aim was to define the short, medium & long term future of passenger car, urban and freight transport. The interview questions can be found in the 6.4 section of the Appendix. The main points for the discussion were sent to the participants 2 hours before the interview and were structured into the following parts:

Part 1: First thoughts on future cities and CATS
Part 2: What is currently being done for future planning and is it working?
Part 3: Specific future vision
Part 4: Sub-use cases
Part 5: The Policy Support Tool

Below there is a synthesis of the stakeholders' key comments regarding the future of freight transport.

Future of Freight transport

In this sector there is a huge potential for improvement with new vehicles and more data, first & last mile access services and more efficient route planning and drop offs, that would lead to less congested city centres or business regions. Hence, top uses cases would include automated LGVs for more efficient delivery with first and last mile access to consolidation centres, therefore avoidance of congestion due to reduction of the trips' number in the city centre.

2.2.6 Pre-workshop online survey

Before the workshop, SRG members who registered for the workshop were also asked to complete an online survey to obtain a general assessment of the proposed indicators and to allow using the survey results as an impulse for inspiring discussions during the workshop. The questions were focused on the importance of goal dimensions and indicators of the future cities, as well as ongoing and planned activities on sub-use cases and interventions. A summary of relevant results can be found in the appendix.

3 Literature review findings

3.1 Introduction (Background and Research Problems):

In this chapter, we review the existing literature on ADAS technologies and the expected future of CATS in freight transport. ADAS are technologies that are currently available now (SAE level 1, level 2 technologies, see deliverable D3.1), whereas the considerations on the future of freight transport will be based on roadmaps of European platforms and associations such as ERTRAC (European Road Transport Research Advisory Council) or ALICE (Alliance for Logistics Innovation through Collaboration in Europe). The latter gives an indication of what applications are expected to be enabled by CATS in the future. This helps identify the sub-use cases of interest and summarise the predicted or estimated impacts.

3.2 Current ADAS Technologies

In the following, the current ADAS technologies and their impacts are discussed. As these systems are the closest existing comparison to future CATS systems, information in this section can be used as a basis for prediction of impacts and penetration rate evolution of future CATS systems. Since there is overlap between systems for freight transport, urban transport and personal cars, section 3.2 of deliverables 5.1, 6.1, and 7.1 are similar. However, this section contains specific technologies for freight transport.

3.2.1 Which technologies are already out there?

ADAS can be grouped in different ways. Systems can for example be grouped by their operational domain: lateral control, longitudinal control, a combination of both, systems concerned with the state of the driver, and systems designed for special manoeuvres. Another way to group the systems is to look at the level of guidance they provide; systems can inform or warn the driver, may take over part of the driving task or can intervene when necessary. Table 3.1 provides an overview of the available ADAS in different groups.

There are many different driver-assistance systems on the market, not all of these systems are informative for the current issue. Most relevant to future CATS (Level 3-5) are those that influence lateral and/or longitudinal movements by either warning, performing autonomously, intervening, or a combination of these. As such the current review focuses on these. Systems that do not translate to future CATS, such as Seatbelt Reminders and Adaptive Headlights, will not be discussed in more detail. Assistance systems that are only in use during special manoeuvres or monitor driver state are also not discussed. These include Back-up Cameras, Back-up Warning, Rear Traffic Warning, Drowsiness Alert (DrowA), Distraction Alert (DisA), and Alcohol Interlock systems.

ADAS that influence lateral movement are Lane Departure Warning (LDW) that warns the driver when the vehicle moves too close to the edge of the lane. Lane Keeping Assist (LKA) uses the same technique but steers the vehicle back towards the centre of the lane when necessary. Lane Change Assist (LCA) warns the driver when a vehicle is present in a blind spot during lane changes.

Systems involved with longitudinal movement inform about and adjust the speed of the vehicle when necessary. Speed limiters prevent the vehicle from going faster than a single pre-set limit, often only relevant on motorways. Intelligent Speed Assist (ISA) helps drivers by displaying the current speed limit. Some versions of this system warn the user when they surpass the speed limit or even prevent speeding on many roads. Stability and rollover systems warn the driver when the current speed is inappropriate for the planned manoeuvre, e.g. a sharp turn. Forward Collision Warning (FCW) detects a slower moving vehicle in front and warns the driver when a collision is likely to appear. Autonomous Emergency Braking (AEB) is similar to FCW but intervenes when a collision would otherwise occur. Adaptive Cruise Control (ACC) allows the driver to set a desired speed and distance to the next vehicle. Speed will then be automatically adjusted, and acceleration and braking will occur within limits when needed.

Bicycle and Pedestrian Detection systems assist the driver by issuing a warning when trajectories of the vehicle and person intersect. More advanced versions intervene by braking when a collision is deemed likely. These systems often focus on turning, backing and other slower manoeuvres.

Automatic Electronic Tolling systems allow trucks to be tolled when driving on enabled roads. These systems can replace current toll booths and allow drivers to pass without slowing down.

Table 3.1. Overview of effective areas from different ADAS. The '+' sign indicates more advanced versions of a system

	Inform	**Warn**	**Automate**	**Intervene**
Lateral		LCA, LDW	LKA	LKA
Longitudinal	ISA	Stability/Rollover, FCW, ISA	ACC, ISA	Stability/Rollover, AEB, ISA, Speed limiter
Combined		Bike and ped. detection		Bike and ped. detection
Driver State		DrowA, DisA		DisA+, alcohol interlock
Special Manoeuvres	Back-up cameras	Back-up warning, Rear traffic warning		Back-up warning+, Rear traffic warning+
Other		Seatbelt reminders	Adaptive headlights, Automatic Electronic Tolling	

3.2.2 Examples of societal level impacts of these systems

This section focuses on the systems that are more closely related to AVs. These systems influence lateral and/or longitudinal movements and are capable of warning, performing autonomously and/or intervening. Only those systems that influence specific impacts are discussed in each paragraph.

3.2.2.1 Safety impacts

The expected impacts of the different systems are most often estimated by using historic crash data and determining what percentage of these crashes would be prevented if the systems were present. This can be done by comparing crash data to known effective scenarios of systems (e.g. Jermakian, 2012), or by extrapolating field test results (e.g. Battelle, 2007). Actual impacts of the systems are determined by using data gathered from various Field Operational Trials (e.g. Bayly, Fildes, Regan, & Young, 2007)

LCA influences crashes occurring during intentional lane changes. These crashes account for around 11% of all truck crashes (Jermakian, 2012). The system was expected to prevent 44% of all relevant crashes, 18% of relevant fatal crashes and 35% of injury crashes per year (Jermakian, 2012; Paine, 2003). This accounts for 8% of all truck crashes (Hummel, Kühn, Bende, & Lang, 2011; Paine, 2003). The overall actual effects on crash involvement show no significant change in the number of crashes, largely because drivers only utilised the system some of the time (Bayly et al., 2007).
LDW and **LKA** influence unintended lane departure crashes, accounting for around 6% of all truck crashes. LDW was expected to reduce all crashes between 2-3%, injury crashes by 2-3% and fatal crashes between 0-5% (Hummel et al., 2011; Jermakian, 2012). Actual effects of the LDW system show heavy vehicles without the system have a related crash rate 1.9 times higher than equipped vehicles (Hickman et al., 2015). A 31% decrease in conflicts is reported during a FOT (Orban, Hadden, Stark, & Brown, 2006). However, no significant change in the amount of relevant crashes were found in 2 different field trials (De Ridder, Hogema, & Hoedemaeker, 2003; Sayer et al., 2010). Lane Keep Assist expected impacts are similar to LDW but keep to the higher end of expectation, reducing all crashes by 3%, injury crashes by 3% and fatal crashes between 3-5% (Hummel et al., 2011; Visvikis, Smith, Pitcher, & Smith, 2008). Actual impact of LKA systems could not be determined due to a lack of data.

Stability and rollover systems influence crashes that happen due to reduced stability, mostly during manoeuvres around corners. These crashes account for over 6% of all truck crashes. Expected impacts were between 19-42% of all relevant crashes, 53% injury crashes and 44% of relevant fatal crashes (Jermakian, 2012; Woodrooffe et al., 2009). This accounts for 6% of all heavy vehicle crashes (Hummel et al., 2011; Jermakian, 2012). Actual effects on relevant crash involvements show a decrease of 33% (Battelle, 2003).

FCW and **AEB** systems influence rear-end crashes, accounting for close to 10% of all truck crashes (Jermakian, 2012). FCW expectations range from 19% reduction in relevant crashes (Battelle, 2007), up to a reduction of 51% (Jermakian, 2012; Paine, 2003). Actual effects show a reduction of 22% for relevant crashes (Battelle, 2007). However, other research shows no significant effect on the amount of conflicts (Sayer et al., 2010). Autonomous Emergency Braking was expected to reduce 6% of all heavy vehicle crashes (Hummel et al., 2011). No actual impact of AEB could be determined due to a lack of sufficient data.

ACC influences crashes related to vehicle headway and speed. Expected impact was 22% reduction in all relevant crashes (Battelle, 2007). However, actual results from the same

FOT show a non-significant reduction of 8%. When ACC is combined with FCW and AEB, the impact is a reduction in relevant crashes of 26% (Battelle, 2007).

ISA and **Speed Limiter systems** impact crashes related to speed. Speed limiters only influence motorways, while ISA is effective on most roads. Speed limiting was expected to reduce relevant injury crashes by 4%, and fatal crashes by 9%. ISA was expected to reduce all heavy vehicle injury crashes by 2%, and fatal crashes by 8% (Transport & Mobility Leuven, 2013). Actual results from a FOT show a reduction in travel above the speed limit of up to 18%, lower average speed and lower speed deviation. (Biding & Lind, 2002). Crash reductions are not given.

Bike and Pedestrian Detection influences crash rates with pedestrians and cyclists, in the case of heavy vehicles often around corners and when backing-up. These crashes account for around 10% of truck crashes (Hummel et al., 2011). The system was expected to prevent 5% of all heavy vehicle crashes (Hummel et al., 2011). No relevant data for actual impacts of the system was found.

Table 3.2 summarizes how the actual impacts of the systems relate to the estimated impacts. For many systems it is not possible to make a comparison due to a lack of data on actual effects.

Table 3.2. Estimate comparison to actual effects

Impact type	Not clear	Low estimate	Good estimate	High estimate
Effect on all relevant crashes	FCW, ACC, ISA, Bike and Ped. detection	AAC	Stability/Rollover	Lane change assist, LDW

3.2.2.2 Traffic impacts

ACC is expected to influence traffic flow on motorways. Only a minor change, 0.1%, in average speed is found when comparing routes without ACC to the exact same route with ACC (Kessler et al., 2012). However, when all travel was considered, higher overall speeds were found when the ACC system was active, compared to the time it was not. This could be due to changes in traffic situations, with ACC only being active in low traffic situations that allow for reaching the speed limit. Lower speed deviations may result in less congestion with ACC (Kessler et al., 2012).

The implementation of (mandatory) **ISA** systems can increase the travel time and reduce speed deviations, mainly on non-motorway roads (Biding & Lind, 2002; Transport & Mobility Leuven, 2013). This is a result of the automatic strict adherence to the speed limit.

Automatic Electronic Tolling reduces the need to slow down or stop when entering a toll enabled road. This reduces the average wait time by up to 3 minutes when compared to regular tolling stations (AlDeek, Mohamed, & Radwan, 1997). National truck toll systems make it less attractive to carry empty loads, thereby increasing trucking efficiency (Broaddus & Gertz, 2008).

3.2.2.3 Economic impacts
With the many different types of ADAS considered within the literature, no clear equipment cost can be determined. However, it is clear that vehicles that have these systems implemented cost more to produce and buy. The installation, maintenance and possible repair costs of ADAS equipped vehicles are higher than comparable vehicles without these systems. The reduction in crashes due to these systems results in lower costs long-term, ultimately benefitting individuals, companies and society.

National Automatic Electronic Tolling systems create additional revenue from truck drivers. This extra income is often distributed across the transportation system, enabling investments in roads, rail, and water transport (Arnold et al., 2010; Broaddus & Gertz, 2008).

Field tests give insight in the possible impacts **ACC** and **ISA** can have on fuel consumption. ACC results in a 1.8% reduction of fuel consumption on motorways (Kessler et al., 2012). While this trial lacks data on other road types, motorways account for the biggest part of most heavy-vehicle journeys. ISA shows a reduction of 2% (Biding & Lind, 2002), up to 5% on urban roads (Kessler et al., 2012).

3.2.2.4 Environmental impacts
The reductions in fuel consumption also translate to reductions in emissions. With the increase in speed found with **ACC** driving, emissions increase by 1-2% (Kessler et al., 2012). This effect can be somewhat mitigated by the decrease in speed variability. The decrease present with **ISA** availability reduces emissions by up to 8% (Biding & Lind, 2002). Whether ADAS have an impact on the lifecycle of freight vehicles is an open question since no studies could be found at the moment.

The reduced need to stop or slow down when using Automatic Electronic Tolling translates directly to a reduction in emissions. Simulations and real world data show a decrease of up to 41% in truck related emissions (Lin & Yu, 2008; Saka, Agboh, Ndiritu, & Glassco, 2001).

3.2.2.5 Societal/mobility impacts
Because many of the current systems are not present on a significant number of vehicles yet, no discernible impacts on society are currently present. Many of the systems reduce driver stress during normal driving operation, allowing for more comfort and possibly reducing driver fatigue.

Results from an ISA field trial show that while fleet operators are happy with the system, company drivers were not. Some of the drivers even went so far as to sabotage the equipment during the trial (Biding & Lind, 2002).

3.2.3 Which factors influenced the adoption of these systems?

The adoption of new systems is influenced by several different factors. Trust, awareness and cost are the most important in determining the rate of adoption. Implementation in heavy vehicles follows a different trend than personal vehicles. Due to the higher costs involved with the purchase of a new truck, vehicles equipped with the latest technology will mostly be bought by larger fleets (SAFE, 2017). Smaller fleets will most likely rely on older trucks, which is also indicated by the average lifecycle of a vehicle being 10-15 years (Bedinger, Walker, Piecyk, & Greening, 2016). After-market systems play an important role in increasing the prevalence of the assistance systems, allowing older vehicles to be upgraded to modern safety standards (SAFE, 2017).

Acceptance of the systems seems to be high for some time already (Marchau, Wiethoff, Penttinen, & Molin, 2001). However, differences between the drivers of a heavy vehicle and the operators of a fleet are present. Where drivers prefer more environmentally-friendly systems, operators rely more on the costs during decision making (Bedinger et al., 2016). In the end, the fleet operators make decisions about which systems are included on the new vehicles.

3.2.4 What was the penetration rate evolution of these systems?

With the introduction of mandatory AEB, LDW and Speed limiters for heavy vehicles (Council Regulation (EC) 661/2009, 2009), penetration rates for newly produced vehicles are high. Mandatory speed limiters were introduced in 2004. Taking into account a maximum lifecycle of 15 years for a heavy vehicle (Bedinger et al., 2016), the penetration rate of the system should be close to 100% by the end of 2019. Penetration of LDW and AEB is still developing, with LDW being present in 2% of all heavy vehicles in 2006 (Trost, 2006), increasing to 11% in 2015 (SAFE, 2017). FCW and AEB were present in 15% of heavy vehicles in 2015 (SAFE, 2017). No data from earlier years was found.

Stability systems show a strong increase in penetration rates, being equipped on only 5% of vehicles in 2005 (Trost, 2006) but increasing to almost a third of all vehicles in 2015 (SAFE, 2017). Recent numbers for ACC are not present, but an increase from the 1.4% of all heavy vehicles in 2006 (Trost, 2006) is expected. Blind spot warning systems show a low penetration rate, being installed in only 4% of the fleet in 2015 (SAFE, 2017). This might indicate the difference in penetration rate evolution between systems being supported with legislature and those systems without.

Figure 4 gives an overview of the penetration rate for the above mentioned systems.

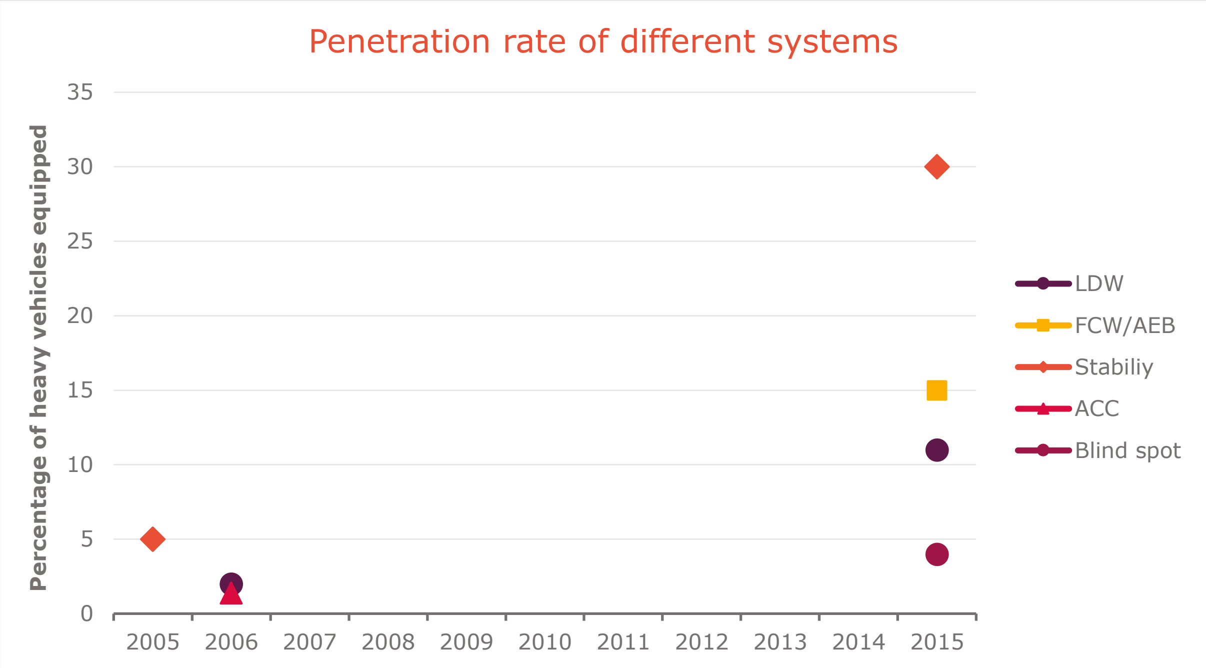

Figure 4: Penetration rate of different systems in heavy vehicles

Unlike passenger cars, user acceptance of ADAS in freight vehicles is likely to be less of an issue. Research shows that truck drivers have on average a higher preference for assistance systems compared to other drivers (Marchau et al., 2001). High costs of a system are also less of an issue for truck drivers, most likely due to the already high cost of these vehicles.

3.3 The expected future of freight transport

It is expected that CATS will have substantial impacts on freight transport and logistics supply chain. Freight transport can be roughly divided into two categories: long-distance freight transport and urban freight transport. Although Levitate is focused on cities and urban areas, it is important to consider long-distance freight as well due to its importance. In this section we summarise the findings on the future of freight transport which is mainly based on the roadmaps, strategy and position papers of European associations, platforms, and alliances. We discuss the technological possibilities, their societal impacts, the opportunities and challenges which will arise with CATS.

Long-distance freight transport

The most relevant modes of transport within EU consists of road, rail, inland waterways and a small percentage for air cargo. Among these, road transport via trucking takes a share of 77% with an increasing tendency (Eurostat, 2019) and the volume reached 1800 billion tonne-kilometres in 2016 (European Environment Agency, 2018). A major reason is the strongly growing e-commerce sector, which puts a tremendous demand in freight transport (Ecommerce Foundation, 2017).

The long-distance or long-haul freight transport via trucks on road, despite of not being environmentally friendly per se, offers some substantial advantages over other modes:

- Flexibility due to the large number of trucking providers and dense road network

- Feasible for a relatively low amount of goods to be transported since the base unit is a single container compared to rail where sometimes a whole train needs to be booked
- Cost-efficiency compared to air-cargo

On the supply side, there is an enormous lack of professional truck drivers worldwide and the situation is becoming more severe in the medium-term future (Costello, 2019 and IRU Global industry association for road transport, 2019). Figure 5 shows the tendency of driver shortage in the US.

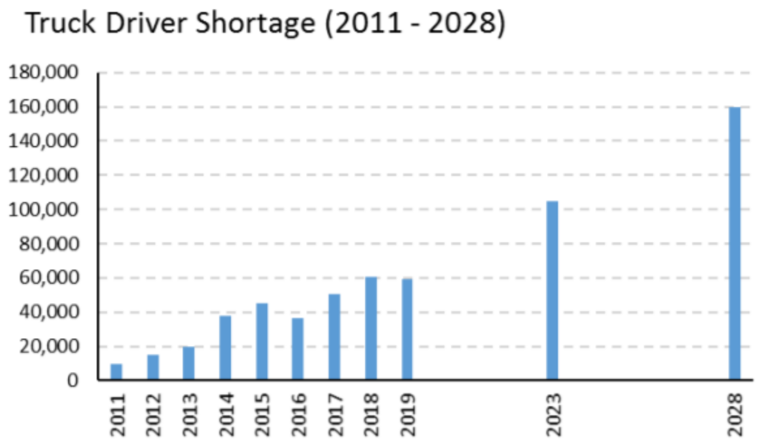

Figure 5: Lack of professional truck drivers in the US (Costello, 2019).

The high demand for road freight transport and the lacking supply of truck drivers are main driving factors for the development of CATS for freight. While a number of ADAS are already available to support drivers (see section 3.2), major changes will come with level 3 (conditional automation) and level 4 (high automation). A schematic diagram of these levels is presented in Figure 6. A level 3 automated truck brings significant ease since all safety critical functions are automated, and the driver needs to take over in certain traffic and environmental conditions. A level 4 automated truck is able to perform all safety-critical functions within certain operational design domains (e.g. highway). These changes will make the long-haul easier, which is by far the most exhausting part of trucking.

Urban freight transport

The growing importance of urban freight transport is linked to the growth of the urban population or urbanisation, a major phenomenon of the 21st century. More than half of the world's population now lives in cities, and one in five lives in a city with more than 1 million inhabitants. The UN estimates that by 2030 the world will have 41 megacities with more than 10 million inhabitants and about 70% of world's population will live in urban areas by 2050 (United Nations, 2015). Together with the growing e-commerce sector, this leads to an increasing demand for freight transport services and to construction logistics for new buildings in urban areas. For example, a study in the Netherlands shows that although the number of vans operating in urban environment and the total kilometres driven caused by e-commerce is still small (<5%), the annual growth of e-commerce is expected to be 20% in the Netherlands (Connekt and Topsector Logistiek, 2017).

There is not much research on CATS in urban freight since this is the most difficult part to be automated (ERTRAC 2019). The trends of city logistics indicate that the last mile delivery is one of the more expensive, least efficient and most polluting sections of the entire logistics chain (Gevaers et al 2014). With the introduction of CATS, new business models and operational concepts will emerge that bring large changes. One of the major cost factors today is the driver or personnel in general (Panteia 2015). Hence although the automation of urban freight transport is substantially more difficult, and the implementation is not expected in the short or medium-term, it has more possibilities and opportunities to bring substantial changes to the logistic system.

The Connected Automated Driving Roadmap (ERTRAC 2019) focuses on level 4 (highly automated) commercial freight transport vehicles for operation in dedicated areas. The main applications are hub-to-hub transport, transport on highways, open roads, and in urban areas. The development can be summarised in these main steps:

- Level 1 and 2 will bring small shifts from driver-controlled variables to automated ones, which mainly contribute to safety benefits.
- Level 3 will bring significant changes since most of the miles can be driven autonomously on the highway. The driver is required in case of subpar weather events that limit connectivity and/or visibility.
- Level 4 vehicles will take on hub-to-hub transports and operate in designated corridors. These can either be highly automated trucks with driver cabin or potentially also unmanned vehicles with remote support / supervision.
- Level 4 vehicles will perform automated operations on open roads in urban environment and handle mixed traffic in all typical scenarios without driver intervention.

The roadmap also indicates a rough timeframe when these steps might be implemented, see Figure 6.

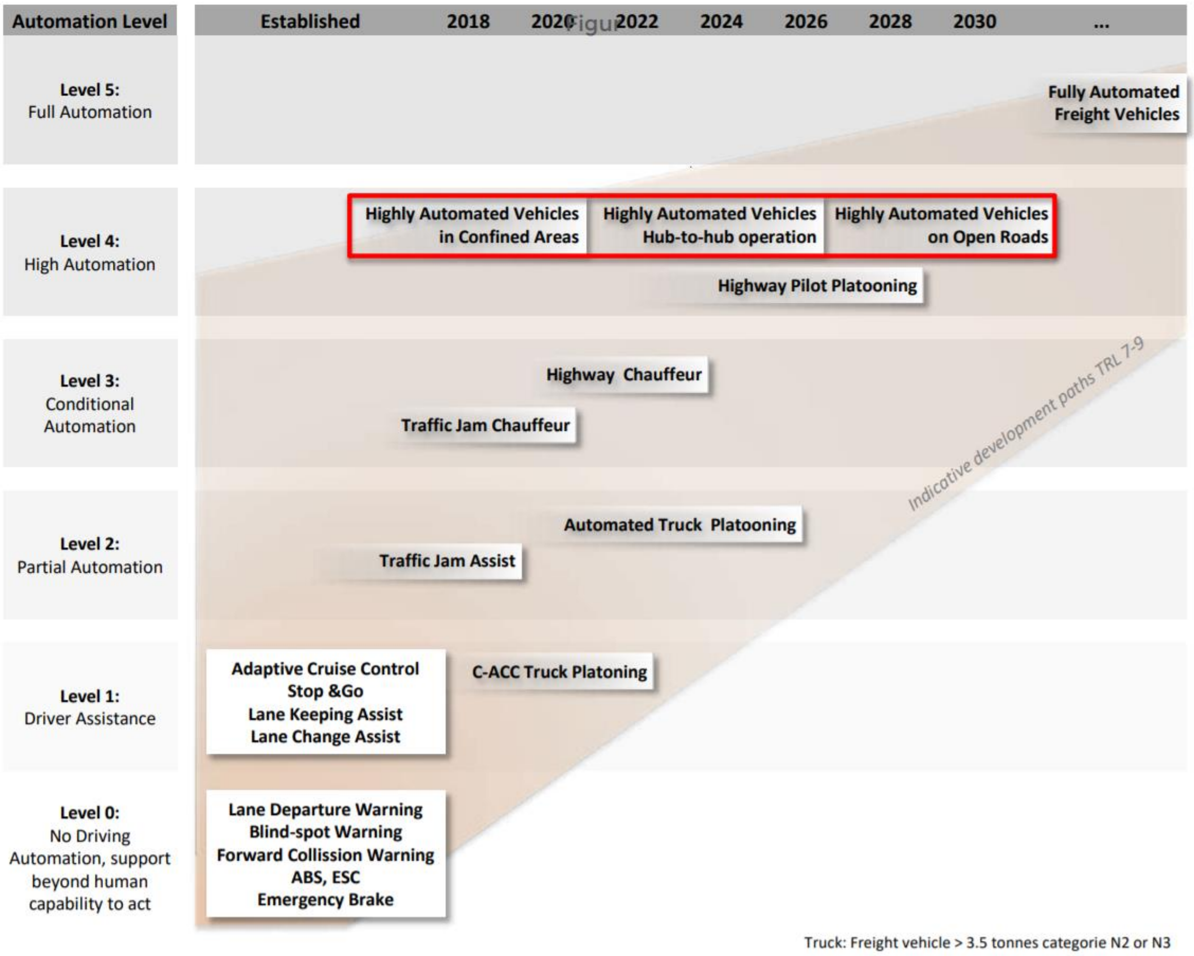

Figure 6: Automated Freight Vehicles Path (ERTRAC 2019).

3.3.1 How will CATS technology evolve?

The ADAS will continue to improve their efficiency and reliability. There is no conclusion on the type and configuration of hardware and software for each component yet. For example, on the hardware side there are camera, radar, and lidar[1] systems for the visual component of automated trucks, but at least for the near future there is no clear winner. It is envisaged that all three systems (instruments) will work together for the time being.

Based on the current state of the technology, using unmanned vehicles is both promising and challenging. The main concept is a hybrid operating model where the trucks do not have fall-back drivers within the cabin, but instead the fleet is connected to a pool of experienced remote drivers in a control centre who are able to intervene and remotely

[1] A system for measuring the distance to a target by illuminating the target with laser light and capturing the reflected light with a sensor.

control a given vehicle in case of emergency (ITF 2017). These remote drivers could be in place as a necessity (at level 3) or as risk mitigation for higher levels of automation (at level 4 or 5). A sketch of this concept is shown in Figure 3. The advantage is a significant reduction in the personnel per vehicle rate while maintaining the same level of transport service. The challenges are threefold:

- There are some concerns about the jobs of millions of truck drivers that might be endangered (discussed in section 3.3.2.4).
- Arguments against the previous point is that the jobs will continue to exist, but with a different job profile. However, this transition also bears challenges.
- For this remote operating model, the amount of visual and other sensors data to be transferred in real time will be huge. However, with the introduction of 5G, it is expected that the bandwidth will not be an obstacle (Rao et al 2018).

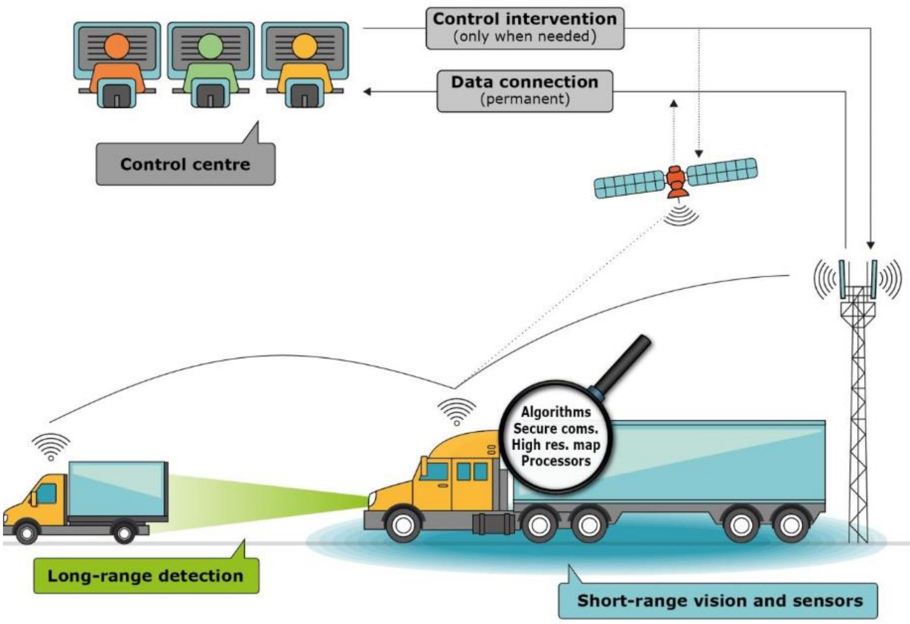

Figure 7: Stylised driverless truck operating environment with optional Control Centre (ITF 2017).

3.3.2 How do societal level impacts of these new systems emerge?

The Connected Automated Driving Roadmap (ERTRAC 2019) states that CATS will provide the opportunity to revolutionize the trucking industry and the way fleets operate. If used properly, automated commercial freight vehicles could improve fleet efficiency, flexibility, and the total cost of ownership. It has also great potential to effectively reduce traffic congestion-related costs through vehicle platooning, improve driver behaviours, reduce driver costs, and increase fleet mobility as well as safety. In this section we follow the categorisation of societal CATS impacts of Elvik et al (2019).

3.3.2.1 Impacts on safety

Safety is a critical issue since freight vehicles, largely composed of trucks, vans and other large vehicles, have the potential to cause severe crashes. The fatality rate of crashes involving freight vehicles is relatively high compared to the number of collisions (Eurostat 2015). This is the main driving factor behind the development of ADAS where a large number of them are for safety impacts, see detailed description in section 3.2. Beyond ADAS, the introduction of level 3 and level 4 automation, especially in urban areas, still requires substantial research and tests. ERTRAC (2019) states that technology must be proven to ensure functioning without any problems in various climates and traffic conditions and that during the transition phase, trials in a controlled or specific area at specific times should be encouraged.

3.3.2.2 Impacts on economy

Labour currently accounts for an estimated 35 to 45% of operating costs of road freight in Europe (Panteia, 2015). ERTRAC (2019) states that CATS provide the opportunity to revolutionize the trucking industry and the way fleets operate. If used properly, automated commercial freight vehicles could improve fleet efficiency, flexibility, and the total cost of ownership. According to the IRU report 'Managing the Transition to driverless road freight transport (2017), the operating cost reductions are likely to be significantly higher in long-distance freight where drivers will account for a greater share of the cost base than in urban freight. Overall, operating cost reductions for long-distance freight in the order of 30% are possible under driverless operation. This will pave the way for new business models and logistic concepts.

3.3.2.3 Impacts on environment

For freight transport, vehicle automation does not necessarily lead to direct environmental impacts per se. ERTRAC (2019) identifies vehicle design, drivetrain, energy composition, and operational efficiency as main factors for the sustainability of freight transport. We have to keep in mind though that these factors are not necessarily directly connected to CATS. Essentially, there is not much of a difference between achieving the freight volume (expressed in tonne-kilometres) by vehicles driven by conventional drivers or automated transport.

However, CATS do contribute to environment impact in a broader sense:

- For platooning, lots of scientific research has been done and they indicate that it can reduce the fuel consumption (e.g. Mello 2019).
- For drivetrain and energy, there is a correlation between E-mobility and CATS on the level of technology innovation. Therefore, CATS indirectly reduce CO_2 emissions – if electric energy is generated in an environmental friendly way.
- New business models and logistic concepts enabled by CATS will likely increase the operational efficiency and therefore reduce energy consumption in general.

3.3.2.4 Impacts on society

As mentioned in section 3.2, CATS will have a huge impact on truck drivers. On the one hand, truck driving is not considered as an attractive job in general because of the modest payment, exhausting long-haul trips, and hard to combine with family life. Professional drivers often are on consecutive trips that last for several days, which causes them to have very limited availability for family and personal matters (Costello, 2017).

On the other hand, there are concerns that with CATS, millions of truck driver jobs are at the risk of being eliminated since they can be automated relatively soon (Frey et al 2017). This topic is very controversial though and there are studies pointing out that the loss of truck-driving jobs is overstated. Arguments are that only the job profile would change: "Drivers" will take over non-driving tasks which are still at high demand, while the long-haul trucking will be automated (Gittleman et al 2019). If this is true, CATS will bring benefits for the drivers and not eliminate them. They will take over the short-haul and the last mile, therefore they can work in the area they are living.

For end-consumers the changes with the introduction and penetration of CATS in freight transport are 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 packages that are delivered to them.

3.3.3 Which opportunities and challenges will CATS bring for freight transport?

The roadmap on urban freight (jointly released by ERTRAC and ALICE in 2015), states that topics related to freight traffic, and to the exploration of potential synergies between passenger and freight transport at the urban level are major focal points. There are important challenges related to the use of land for urban freight, and the location of logistics activity in and around the urban environment. Further exploitation of the potential of integrating urban freight and passenger transport systems will optimise the use of road, rail and inland waterways infrastructures in space and time, and contribute to healthier cities in terms of less traffic and congestion. This requires a change of paradigm towards a freight/passenger integrated mobility planning and exploring more opportunities and new business models for the integration of urban freight with private or public transport at infrastructure and vehicle levels.

An essential application of urban freight will be automated parcel delivery. On the delivery side, there are lots of projects on (sidewalk) delivery robots. They are much smaller than conventional delivery vans and based on electricity. This addresses two current problems, namely emissions and restrictions of road vehicles in narrow and crowded areas typically found in the city centres. Technical capabilities, limitations, challenges and potential time/cost savings of current technologies can be found in a study by Jennings and Figliozzi (2019). On the receiving side, there are needs for compatible infrastructure for these delivery robots. The automated parcel locker system is natural solution for this. These lockers are already commercially used where consumers can either receive or send a parcel.
For logistics companies, investment in parcel lockers can reduce costs in the logistics chain, increased delivery efficiency and generate new market opportunities (International Post Corporation, 2018). A challenge still to overcome is that usually every logistics company uses its own system. For a more efficient and sustainable solution, the trend should move towards white-label systems, which is open for all delivery companies.

Similar to (the lack of) infrastructure sharing, there are shortcomings with respect to data. ALICE (2015) states that a major bottleneck for improving the operational efficiency of freight transport in urban environment is the lack of data availability and data sharing. Fierce competition among service providers opposes the need and opportunities to share and communicate data. However, collaborative transportation systems have become an increasingly popular practice due to the crisis. Collaborative transportation is appearing as a good city logistics alternative to classical urban consolidation centres. There is therefore a strong need to acquire targeted consistent and homogeneous data in order to properly assess the problem and monitor the evolution of the different Key Performance Indicators (KPIs) as different sets of measurements are adopted. It is expected that better data, knowledge and information will make it easier to identify opportunities for improvement.

Data availability is also a requirement for an efficiently working physical internet (PI). It follows the concept of improving freight transport through processes automation and autonomous decision making, which is in line with the principles of CATS. Enabled by V2X communication technologies, the challenge of PI lies in the automated distributed handling, automated storage management and automated routing (Crainic and Montreuil 2016).

Queinnec (2018) states that on the service level, new technology, data and business models of the future will evolve around the following sectors:

- Freight technology solution provider: Third-party solution providers are leveraging new technologies such as RFID tracking, hybrid powertrains and predictive maintenance, which make intercity transport more efficient.
- Digital freight brokerage: Using a digital broker application and algorithm-based pricing models will match freight supply with demand, enabling customers to find available freight capacity at competitive prices.
- Fourth party logistics (4PL): Unlike digital brokers, 4PL companies manage the entire supply chain. Because they own assets such as warehouses and truck fleets, customers can outsource all logistics.
- Collaboration: The sharing economy and the goal of zero-emissions requires collaboration on a new scale: transport companies may own the towing vehicle only, with trailers and semi-trailers becoming part of common-usage equipment available at different sites.

These statements indicate that

- Passenger transport and freight transport should seek collaboration (e.g. via automated multi-purpose vehicles).
- Collaborative transportation, supported by city hubs and consolidation centres, are necessary to improve operational efficiency. CATS, especially automated hub-to-hub transport and automated freight consolidation, will contribute to this point significantly.
- Multimodality and synchromodality are important factors to aim towards a sustainable logistic supply chain.
- All the above points require homogenous and shared data among operators, which is perhaps the most difficult part due to competition between service providers and freight operators.

CHALLENGE	IMPACT
Identifying and assessing opportunities in urban freight.	• Increase load factors. • Reduce freight vehicle movements. • Increase effectiveness. • Reduce congestion.
Towards a more efficient integration and management of urban freight in the transport system of the city.	
Towards a more efficient integration of urban freight in the urban transport system.	• Increase the number of available loading/unloading zones. • Reduce the average number of kilometres per vehicle. • Increase asset utilization.
Better understanding of the impact of land use on urban logistics activities.	• Increase the number of available loading/unloading zones. • Reduce the average number of kilometres per vehicle. • Create opportunities for the use of shorter-range, but more energy and emission efficient vehicles. • Increase the load factor of vehicles. • Properly locate the available loading/unloading zones.
Enabling a more efficient management of goods.	• Reduce the number of km per vehicles. • Increase the load factor of vehicles. • Increase the rate of available loading zones.
Improving the interaction between long distance freight transport and urban freight.	• Reduce the average number of kilometres per vehicles. • Optimise the network of consolidation/transhipment centres. • Allow the use of electric vehicles for last mile deliveries.
Better adapting the vehicles to innovative urban freight delivery systems.	• Increase the load factor of vehicles. • Reduce the number of km per vehicle. • Increase the availability of loading and unloading areas.

Figure 8: Summary of challenges and impacts according to ALICE (2015).

3.4 First Identification of sub-use cases

The PST developed with Levitate will support policy makers by allowing consideration of the potential impacts of interventions and scenarios relevant to each of the key use cases (freight transport, passenger cars and urban transport). Within the work on freight transport, a set of sub-use cases and interventions will be developed to inform the predicted impacts of CATS. The final sub-use cases to be used in the PST will be developed and refined over multiple steps of which, the first 3 are presented in the current report. These steps are,

1. Initial generation of sub-use cases (section 3.4)
2. Definition and categorisation of sub-use cases (section 3.4)
3. Consultation with stakeholders (section 4.3)
4. Predictability assessment (Tasks 6.2, 6.3, 6.3)
5. Refinement and clustering (Tasks 6.2, 6.3, 6.3)
6. Prioritisation (Tasks 6.2, 6.3, 6.3)

As a first step to develop sub-use cases, an overall list was developed from the existing expertise of the project partnership and existing knowledge from scientific literature. This was subsequently refined; their descriptions were clarified, and they were classified into their logical categories. Also, impact indicators and assessment methodologies for those sub-use cases are currently being identified in a separate work packages in this project (WP4 and WP3, respectively). Some sub-use cases were renamed to remove field specific words and jargons so that it is more understandable for broader audience such as city administrators or SRG members (e.g. "System-aware route optimization" renamed to "Centralized traffic management").

Furthermore, we use three categories for the classification:

- Interventions: We see them as city / government driven policy interventions with the goal of actively regulating the use of CATS. For Example, automated freight vehicles have to follow centralised traffic control in urban areas.
- Applications: They cover the actual usage of CATS. Compared to interventions, applications are market / business driven. For Example, automated hub-to-hub transport performed by unmanned, but supervised trucks (see section 3.3.1).
- Technology: These are (sub) systems for certain CATS functionalities and therefore enable other technologies or applications. For example, cooperative adaptive cruise control system that uses V2V communication to control speed, which is required for vehicle platooning.

In terms of predictability (step 4), each sub-use case will be visited (first glance) to examine whether it would be possible to predict quantifiable impacts using methods that are developing in task 3.2 of this project.

Regarding step 5, the refinement of sub-use cases is an ongoing work and will continue in the tasks 6.2, 6.3 and 6.4 (Assessing the short-, medium- and long-term impact, cost and benefits) within WP6 of this project. The work includes following:

- Prioritisation of the sub-use cases to enable their inclusion in pilot version of the PST.
- Clustering of sub-use cases to facilitate the assessment methodologies (T6.2, 6.3 and 6.4) and the inclusion into PST (WP8).
- Extend the list of interventions specific to passenger cars.

Finally, in step 6, the prioritisation of the sub-use cases will mainly take these three input directions into account:

- Scientific literature: They indicate the scientific knowledge and the available assessment methodologies for the sub-use cases. However, this might not be directly linked to their importance / relevance for practice.
- Roadmaps: They indicates the relevance of sub-use cases from the industrial/political point of view, independent of available scientific methodologies.
- SRG Workshop: They contain first hand feedback for the sub-use cases, but might only reflect the opinions of organisations and people who participated.

In Table 3.3 and Table 3.4, we show the sub-use cases which are seen as general, i.e., relevant for all three use cases, and those which are specific for freight transport.

Table 3.3: General sub-use cases that are applicable for all Use Cases

Sub-Use Case	**Description**	**Category**	**Indicator**

			Literature (L) Roadmap (R) Workshop (W)
Geo-fencing based powertrain use	Different powertrains on hybrid vehicles are used according to defined zones (e.g. low-emission zone in the city center).	Application	L
Green light optimized speed advisory	Vehicles approach traffic lights with optimal speed to avoid stopping at red, hence increasing energy efficiency.	Application	LR
C-ITS day 1 services	Hazardous location notifications (slow or stationary vehicle, road works warning, emergency brake light, …) Signage applications (in-vehicle signage, in-vehicle speed limits, signal violation / intersection safety, …)	Application	LR
C-ITS day 1.5 services	Charging stations info, vulnerable road user protection, on street parking management, off street parking info, park & ride info, connected & cooperative navigation, traffic info & smart routing	Application	LR
Road use pricing	Prices are applied on certain road (segments) with the goal to achieve load-balancing. Can be dynamic depending on area, traffic load, and time.	Intervention	LRW
Centralized traffic management	Routing / navigation of vehicles is managed by a centralized system with access to traffic loads. The goal is to balance the traffic load across the road network.	Intervention	LR
Segregated pathway operations	A policy measure where automated vehicles operate on separate roads/ lanes, for example a dedicated CATS lane or an automated urban transport lane	Intervention	LR
Option to select route by motivation	A multiple choice of routes available to users based on motivations. The motivations being, fastest, shortest, most environment friendly, safest, etc.	Application	W
Street re-design	Redesigning of streets would need to be considered for automated vehicles. For example, automated vehicles can make precise manoeuvres and so streets could be made narrower.	Intervention	LRW
Cluster-wise cooperative eco-approach and departure	Strategically coordinate CAVs' maneuvers to form clusters with following methodologies: initial vehicle clustering, intra-cluster sequence optimisation, and cluster formation	Application	L

	control. This could increase traffic throughput by 50% and reduce emissions by 20%		

Table 3.4: freight transport sub-use cases - Descriptions and categorizations

Sub-Use Case	**Description**	**Category**	**Indicator** Literature (L) Roadmap (R) Workshop (W)
Highway platooning	Trucks dynamically join and leave platoons on highways where vehicles move with shorter headways.	Application	LRW
Urban platooning	Vehicles dynamically join and leave platoons in the city. In contrast to highway platooning, the goal is less on saving energy but more on increasing the throughput.	Application	L
Intelligent access control for infrastructure / bridge	Bridges and other critical infrastructure need to coordinate vehicle platoons accessing them to prevent overloading.	Intervention	L
Automated urban delivery	Delivery of parcels and goods in urban area is automated. Appropriate infrastructure for handover is required.	Application	RW
Hub-to-hub automated transport	Transfer of goods between two hubs (e.g. production, warehouse, consolidation center) which are mainly connected via highways / motorways.	Application	LRW
Automated intermodal transport	Automated freight transport across multiple modes (e.g., truck and train) and handling at transfer sites.	Application	RW
Local freight consolidation	Automated freight consolidation using hubs and terminals with the goal to increase transport efficiency, especially in dense urban areas.	Intervention	LRW
Multi-purpose vehicles	The use of automated MPVs for passenger and freight transportation. An application could be using MPVs for passengers during peak hours and freight during off-peak hours.	Application	W

3.5 Key outcomes

The literature review on ADAS indicate that the majority of level 1 and level 2 systems are mainly focused on improving the safety for freight vehicles. With potential policy measures to make (some of) them mandatory in new vehicles, together with a shorter average lifespan of freight vehicles compared to passenger cars, we can expect a steady improvement in terms of safety in freight transport throughout the short-term future.

Looking further ahead, automation will most likely affect long-distance freight transport before it arrives for urban logistics. The first part to be commercialised are most likely the automated long-haul trips. Though the direct impacts are more apparent and positive, debates exist for the wider impacts such as employment. There is a controversy about the lack of truck drivers on the one hand and the fear of jobs being eliminated on the other hand. For urban freight transport, the challenges are much more complex due to urban traffic situations and mixed road users.

4 Workshop outcomes

In this section we summarise the main results of the first Stakeholder Reference Group (SRG) workshop and the pre-workshop online survey described in section 2.2.

The workshop was organised in Gothenburg, Sweden on 28th May 2019. There were 35 participants and 10 Levitate project members. The participants came from varied sectors such as municipality, city councils, traffic management, industry and research. The workshop was split into 4 sessions:

1. Defining the future of CATS
2. Goal dimensions and indicators of the desired future city
3. Identification of sub-use cases
4. Initial feedback on Policy Support Tool (PST)

In session 1 and 3, participants were split into self-selecting groups based on their expertise/subject area for passenger cars, urban transport and freight. Since the group for urban transport was large, it was split into further two, creating four groups overall. In session 2, the participants were randomly split based on the coloured dots that were provided on their name badges. The coloured dots represented impact dimensions – safety, environment, economy and society. The workshop agenda can be found in the appendix.

In the following we cover the outcomes of the pre-workshop online survey and sessions 1 and 3, since the other two are not within the scope of this deliverable (session 2 contributes to WP4 and session 4 contributes to WP8).

4.1 Pre-workshop online survey

The online survey was sent to all registered participants prior to the workshop to obtain a general assessment of the proposed indicators and to allow using the survey results as an impulse for inspiring discussions during the workshop. The details of the setting and outcome can be found in deliverable D4.1. Here we provide a summary on:

- the number and organisation type of the participants (Figure 9)
- their indicated importance of the goal dimensions (Figure 10)
- the number of ongoing and planned activities on the sub-use cases (Figure 16) and broken down to organisation types:
    - governmental organisations (Figure 11)
    - municipalities (12)
    - research and developmental organisations (Figure 13)

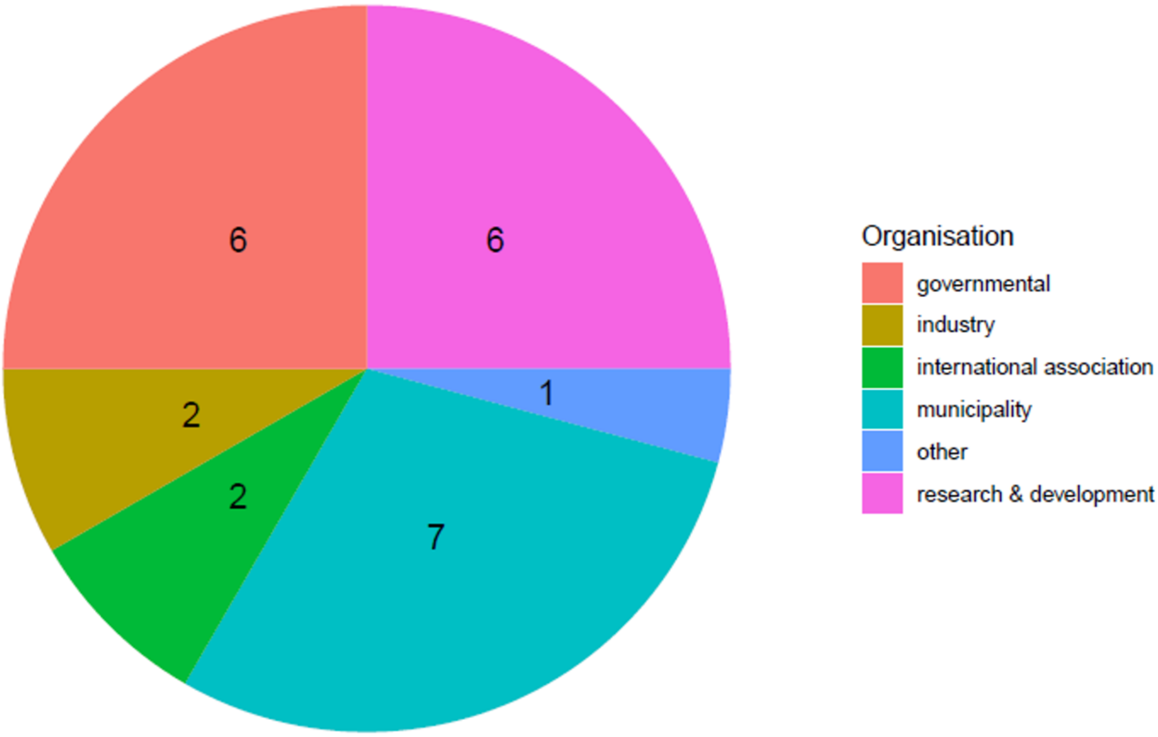

Figure 9: Number of participants for each organisation type. N=24.

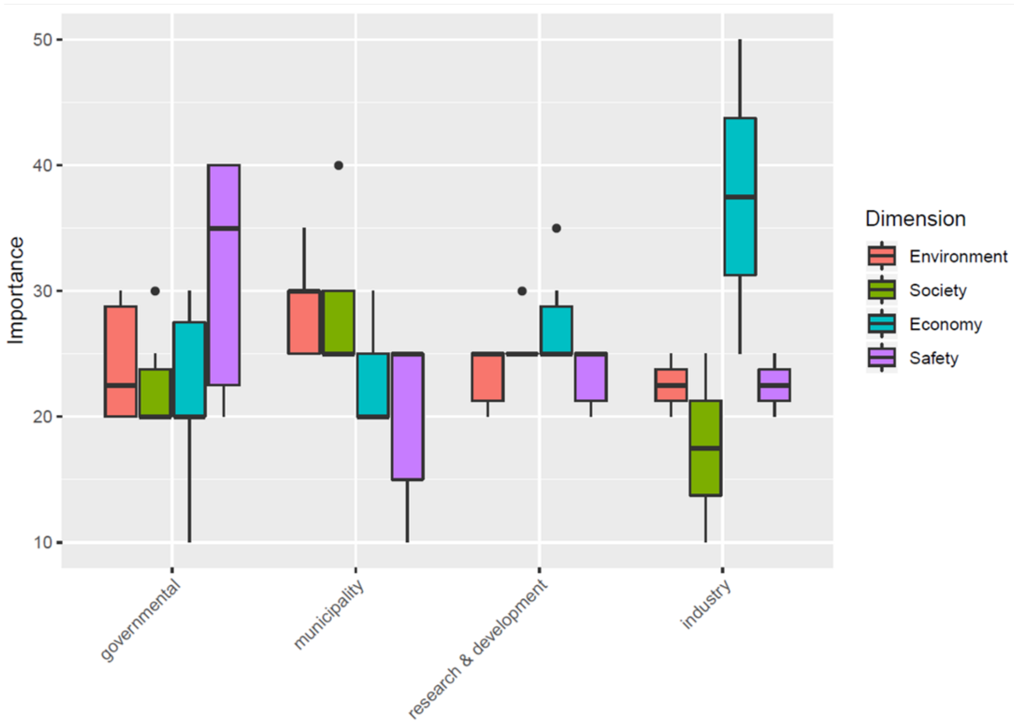

Figure 10: Indicated importance of goal dimensions, results for each organisation type. N=24.

Figure 11: Ongoing and planned activities on the sub-use cases within governmental organisations. N=24.

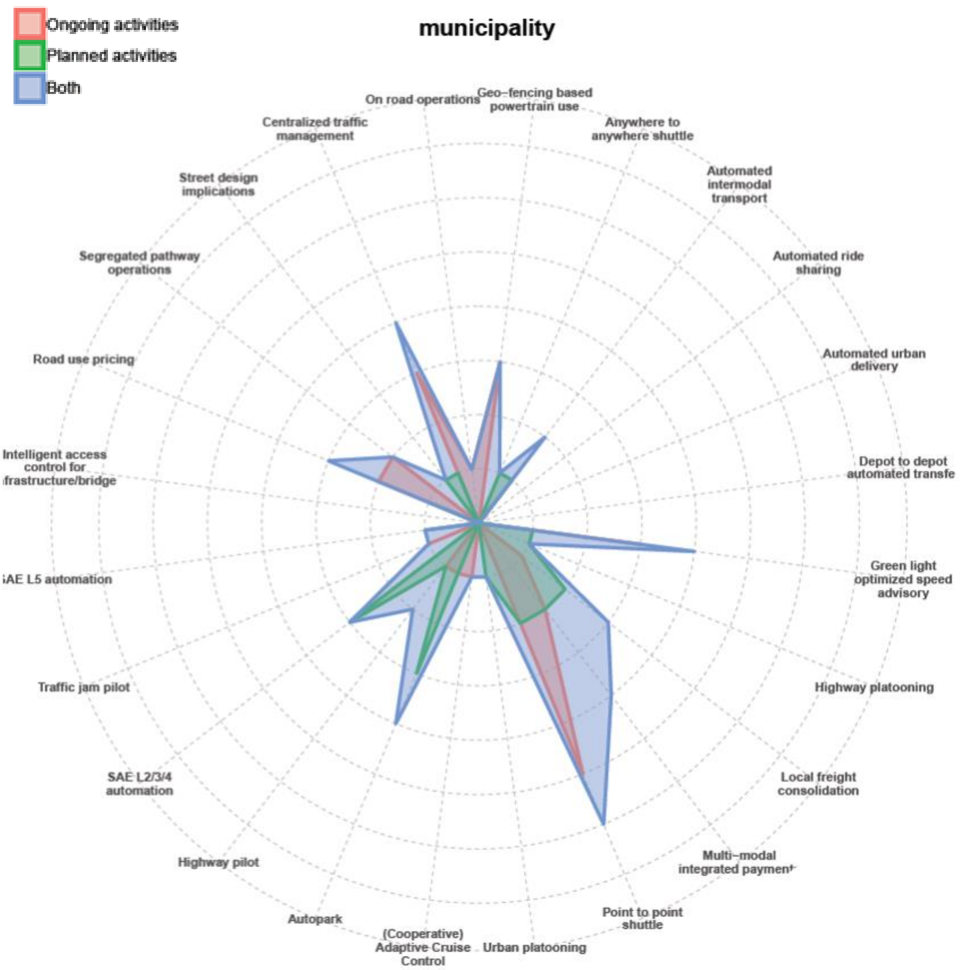

Figure 12: Ongoing and planned activities on the sub-use cases within municipalities. N=24.

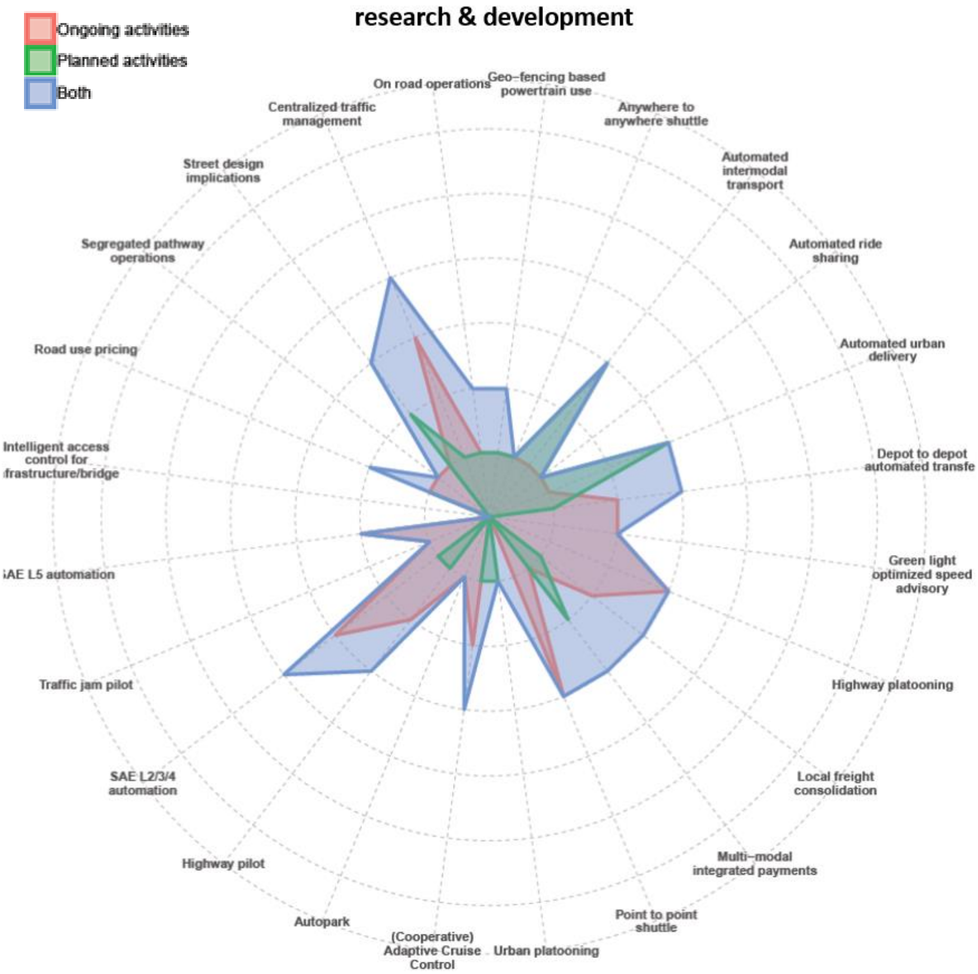

Figure 13: Ongoing and planned activities on the sub-use cases within research and developmental organisations. N=24.

4.2 Session 1 – Defining the future of CATS

Session 1 aimed to understand how participants viewed the future of Connected and Automated Transport System (CATS) in terms of time-scale, identify technologies that will play a role in that time-scale and identify parameters/indicators that enable/assist them in making decisions.

4.2.1 Future overview

Question

When you think of future cities what positive outcomes do you think CATS will bring.

Response:

Response from participants is summarised in Figure 14. Comments are grouped into appropriate categories.

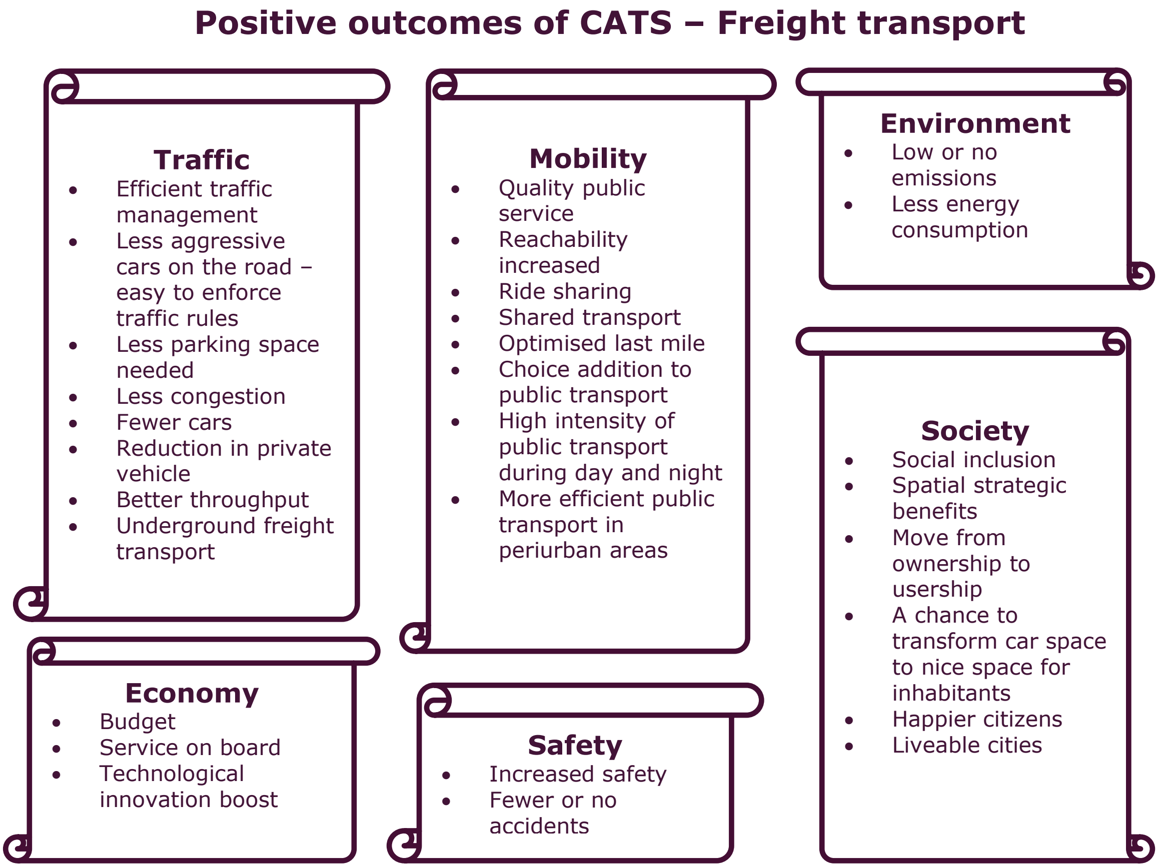

Figure 14: Summarised comments from the workshop participants on positive outcomes of CATS.

Question

When you think of future cities and CATS what are the biggest challenges will need to be overcome to achieve the positive outcomes that you think of?

Response:

Response from participants is summarised in Figure 15. Comments are grouped into appropriate categories.

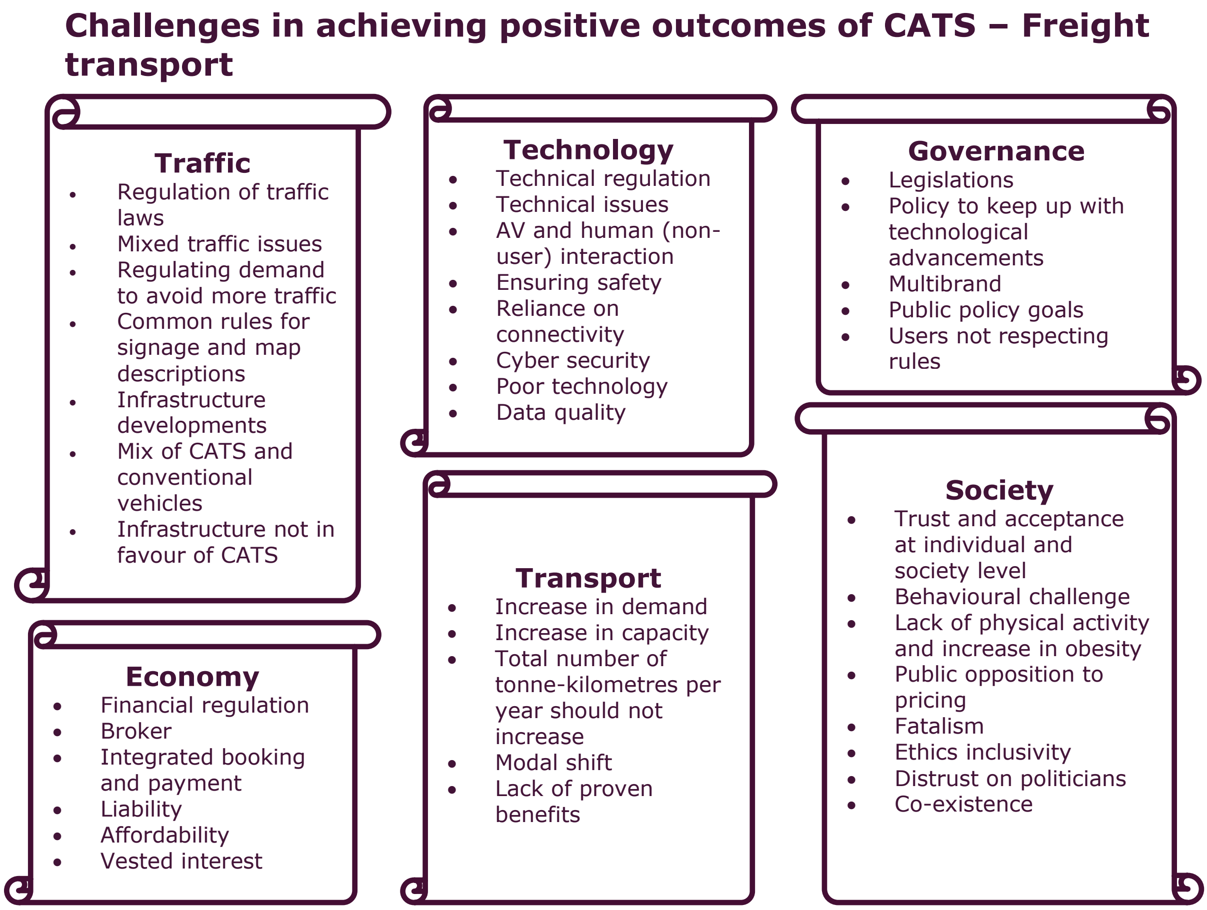

Figure 15: Summarised comments from the workshop participants on challenges to overcome to achieve positive outcomes of CATS.

It is clear that CATS are expected to bring benefits to the society, economy and environment through increase in safety and mobility and optimised traffic. However, there are organisational and societal level challenges that need to be addressed. Not surprisingly, the technological and traffic management related issues are immediate but there is also rising need for governance. Financial regulation will need to be in place to avoid vested interests and have affordable transport for public. There are questions arising in terms of adoption of the technology, behavioural change and public health. On extreme cases, there is also fear of fatalities.

4.2.2 Current approaches to future planning

Set of questions:

- *Describe the current approach to plan for the future of freight transport.*
- *What are the main principles of the approach?*
- *How far in the future do you plan, is short, medium and long-term defined?*

- *What features of a future do you expect to occur/take into account when planning? E.g. technologies (mobility as a service, vehicle platooning, V2X communications), infrastructure (parking space availability), change in driver behaviour (reduced vehicle use), change to economy, change in employment skills etc*
- *What are the biggest difficulties to planning (find the "pain points" the PST might help with.*

Responses:

Planning

- Innovation and changes in the last mile delivery are essential for an ecologically sustainable and economically efficient system that will define the future of freight transport, especially in the urban area. This is supported by the development of CATS but cannot be tackled alone with technology.
- ADAS, point to point transportation and city hubs are key elements and enabling factors.
- On the software side, data sharing is a big issue necessary for consolidation, which goes hand in hand with automated consolidation centres and automated intermodal transfers. However, this aspect requires more than just a software solution, but a framework of who and how to manage the data.

Timeline

The workshop participants agreed that a possible and desirable development path would be to facilitate data sharing in the short-term, enforce consolidation centres/city hubs in the medium-term and introduce advanced last mile solutions in the long-term. In contrast to the definition of short-, medium- and long-term impacts that are defined in Levitate as direct impacts, systemic impacts and wider impacts, the timeline during the workshop referred short-term to "in 5 years", medium-term to "in 10-20 years" and long-term to "in 30-40 years".

4.2.3 Expectations of the future

Set of questions:

Mind map voting and parameter notes

- *Place your dots on the features which you expect will have greatest importance for the short, medium and long term?*

Responses:

Several short-, medium- and long-term features were identified and rated. A mind map was generated during the workshop discussions and is provided in Figure 18. Table 5 shows the features from mind map that were given ratings.

Table 5: Voting of parameters that were identified during the discussions of freight transport in workshop. Number of occurrences of letters in the table shows number of voting. Parameters are shown in bold whereas the elements that were considered within that are shown in italics. N=7.

Parameters/Elements	Short-term (S)	Medium-term (M)	Long-term (L)
Policy			

Data sharing	S		
Freight sharing		M	
Public scenario databases	SS		
Geo-fencing	S		
Safety			
Advanced driver assistance systems	S		
Environmental pollution			
Last mile solutions that are emission-free			LL
Technology			
Cooperative adaptive cruise control	S		
Infrastructure			
City hubs	S		
Transport system			
Hub-to-hub automated transport		MM	

4.3 Session 3 – Identification of sub-use cases

Session 3 considered prioritisation of sub-use cases, especially the applications, which have potential to be included in the Levitate PST. Participants were asked to discuss which sub-use cases were important to achieve in the short- medium- and long-term future of CATS and how difficult they would be to implement.

We collected an initial round of feedback before the workshop using an online survey. The workshop participants were asked about ongoing and planned activities for the respective sub-use cases, which indicates the priority. The result shown in Figure 16 was taken as a basis for discussion during the workshop. In this figure we clustered the sub-use cases according to their category and SAE automation level. The thickness of the boxes shows their priority, going from thickest with high priority (most ongoing/planned activities) to thinnest for low priority (few or no activities). The results show that the priorities of sub-use cases related to freight transport (second and fourth box on the top level) are roughly equal.

During the workshop, a key message for the freight use case was that the applications need to be considered on multiple levels, namely users, providers, enablers, and shippers. If the impact is only measured on a single level, the output might be incomplete. In the table sub-use cases, the addition of multi-purpose vehicles as application and the importance of the cooperative adaptive cruise control were mentioned. However, no definitive conclusions about the relevance sub-use cases for the short-, medium, and long-term were made.

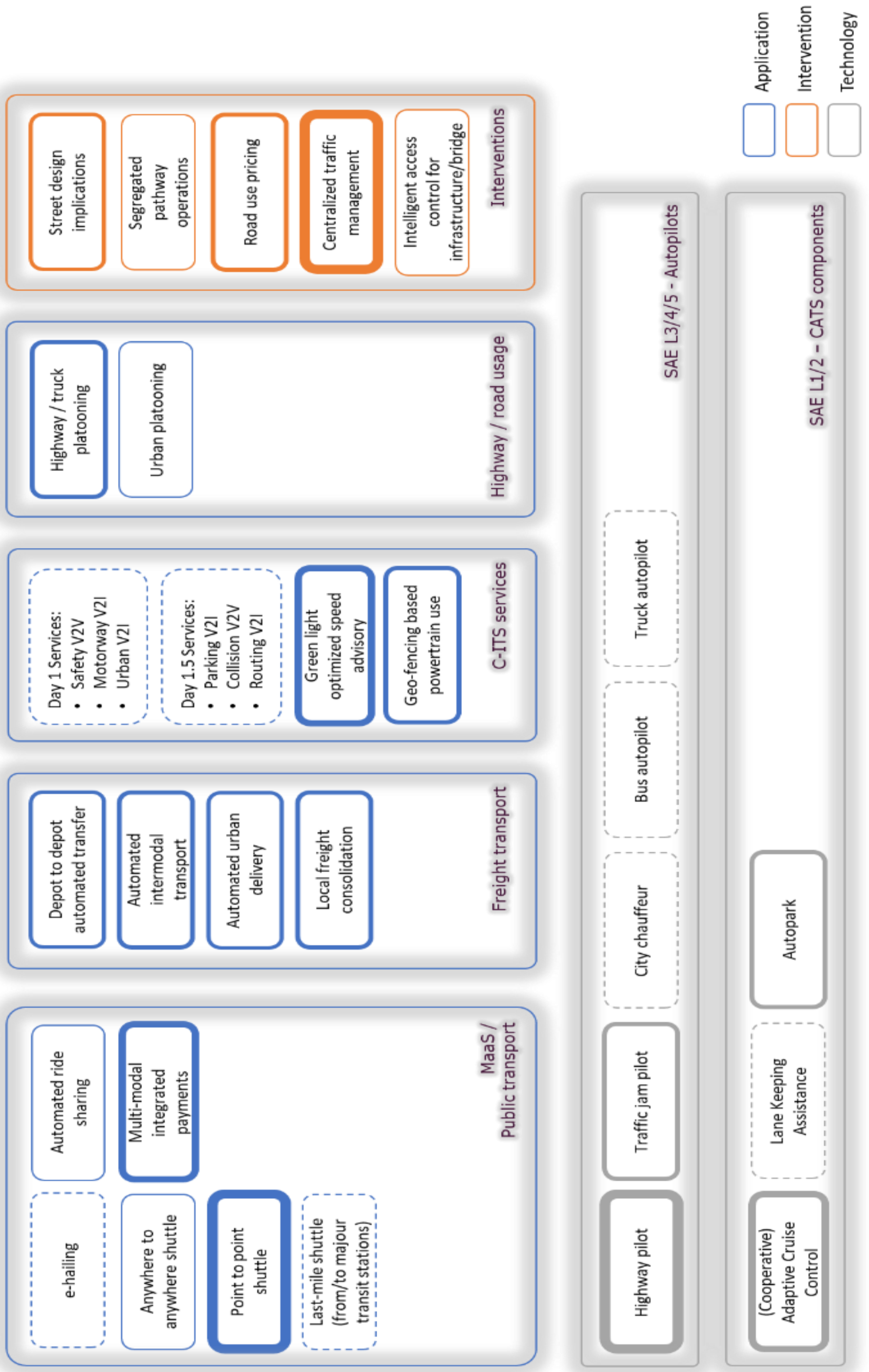

Figure 16: List of sub-use cases and their priorisation according to the pre-workshop online survey.

4.4 Key outcomes

The aim of the workshop was to gauge stakeholders' view on defining future of CATS and prioritising use cases of freight transport, which in the framework of this project are called sub-use cases. It appears that the stakeholders have high expectations from CATS and they also recognise challenges in achieving those. In their opinion, public acceptance, appropriate policies, technology adoption and different levels of actors in the supply chain were the most important things to consider in planning.

In terms of sub-use cases in freight transport, we conclude that hub-to-hub automated transport and automated urban delivery as a last-mile solution have the most attention, followed by freight consolidation. The multi-purpose vehicles will be added to the list of sub-use cases as a collaborative application between passenger transport and freight transport.

5 Conclusions

5.1.1 Defining the future of freight transport

The future development of freight transport for long distance and urban area were examined based on roadmaps of European associations. Literature on potential impacts of automation technologies within freight transport domain was discussed. Compared to passenger cars, we observed that the penetration rate and user acceptance of CATS technology play a less important role. Freight vehicles can be regarded as tools and driving is a job. Therefore, driver comfort has a totally different meaning and commercialisation of automated freight vehicles has different driving factors than automated passenger cars.

According to stakeholders, CATS should assist the development towards improving the operational efficiency. This should be achieved by facilitating data sharing in the short-term, enforcing consolidation centres/city hubs in the medium-term and introducing advanced last mile solutions in the long-term.

5.1.2 Freight transport sub-use cases

The scientific literature, roadmaps and the stakeholder reference group workshop indicate the relevant sub-use cases in freight transport. In a first estimation, depot-to-depot automated transport and automated urban delivery are identified to be most relevant. Platooning is a topic with comparably lots of existing scientific literature, but this also means that there is available data to be used for the PST. In addition to the originally proposed sub-use cases, multi-purpose vehicles will be added which acts as a shared resource for passenger transport and freight transport in urban area. We will prioritise these sub-use cases in the upcoming tasks within WP7 where we will develop and apply the actual assessment methodologies.

5.2 Future work

Further work to be carried out in WP7 is mentioned below.

1. Prioritisation of sub-use cases
2. Literature review specific to sub-use cases and impacts
3. Analysing impacts using appropriate methodologies (from task 3.2)
4. Provide input to WP8.

On step 3, tasks 7.2, 7.3 and 7.4 will respectively assess short-, medium- and long-term impacts on society, economy, environment and safety from introduction of interventions and sub-use cases that have been identified in this deliverable. These introductions would be considered case-by-case. The assessment will be done by appropriate methodologies and tools – task 3.2 will develop a set of base methodologies while and tasks 7.2, 7.3 and 7.4 will further add specific methodologies for the freight transport sub-use cases. For example, traffic micro-simulations (WP3) can provide short-term impacts and the general traffic situation with a certain penetration rate of CATS. The traffic will be used as a basis for specific methodologies such as fleet management and tour optimization (WP7) for automated urban delivery. These results will be integrated into WP8 as input for the PST.

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6 Appendix A

6.1 A copy of online pre-workshop survey questionnaire

Part 1

Thank you very much for participating in this survey, which will give us a first impression about expectations and activities in relation to Connected an Automated Vehicles in different cities in Europe. We will ask you about general development plans and different potential measures in your region. Please answer the questions to the best of your knowledge. The survey will take you about 10 minutes.

Part 2: Background

a. Please provide some information about your background:

a. Organisation: ☐ *Required*

b. Position: ☐ *Required*

c. Type of organisation: ☐ *Required*

- governmental
- municipality
- civil society
- organisation
- international
- association industry
- research &

d. Country: ☐ *Required*

e. Please indicate the city or region you will be referring to in your answers. ☐ *Required*

Part 3

2. Please assess the importance of the following general goal dimensions in the strategic development of your region in relation to each other by allocating specific percentages to the four goals. Please make sure that the sum of the percentages for all the 4 goal dimensions is 100%.

b. Environment

c. Society

d. Economy

e. Safety

Part 4: Indicators & Goals

3. Please indicate for the following selection of indicators for the development of a livable city are monitored (regularly measured) in your city and whether there are related specific goals (values) defined for the short (appr. 5-10 years), medium (appr. 15-20 years) or long term (appr. 25-30 years).

Indicators

Please don't select more than 4 answer(s) per row.

	Monitored	Short term goal defined	Mid term goal defined	Long term goal defined
Transport safety: Number of injured per million inhabitants	☐	☐	☐	☐
Transport safety: Number casualties per million inhabitants	☐	☐	☐	☐
Transport safety: other important indicators (please specify on next page)	☐	☐	☐	☐
Reachability: Average travel time per day	☐	☐	☐	☐

Reachability: Number of opportunities per 30 minutes per mode of transport	☐	☐	☐	☐
Reachability: other important indicators (please specify on next page)	☐	☐	☐	☐
Energy consumption per person in total	☐	☐	☐	☐
Energy consumption per person transport related	☐	☐	☐	☐
Energy consumption: other important indicators	☐	☐	☐	☐
Emissions: SO2	☐	☐	☐	☐
Emissions: PM2,5	☐	☐	☐	☐
Emissions: PM10	☐	☐	☐	☐
Emissions: NO2	☐	☐	☐	☐
Emissions: NO	☐	☐	☐	☐
Emissions: Nox	☐	☐	☐	☐
Emissions: CO	☐	☐	☐	☐
Emissions: O3	☐	☐	☐	☐
Emissions: other important indicators (please specify on next page)	☐	☐	☐	☐
Public space: Lane space per person (e.g. Vienna: multi- purpose area map)	☐	☐	☐	☐
Public space: Pedestrian/cycling space per person	☐	☐	☐	☐

Public space: urban atlas data (Eurostat)	☐	☐	☐	☐
Public space: other important indicators	☐	☐	☐	☐
Urban sprawl: Building volume per square kilometre in total	☐	☐	☐	☐
Urban sprawl: Building volume per square kilometre per built-up area	☐	☐	☐	☐
Urban sprawl: Population density (Eurostat)	☐	☐	☐	☐
Urban sprawl: other important indicators (please specify on next page)	☐	☐	☐	☐
Inclusion: Distance to nearest publicly accessible transport stop (including MaaS)	☐	☐	☐	☐
Inclusion: Affordability/discounts	☐	☐	☐	☐
Inclusion: Barrier free accessibility	☐	☐	☐	☐
Inclusion: Quality of access restrictions/scoring	☐	☐	☐	☐
Inclusion: other important indicators (please specify on next page)	☐	☐	☐	☐
Transport system satisfaction: Satisfaction with active transport infrastructure in neighbourhood (walking and/or cycling)	☐	☐	☐	☐

Transport system satisfaction: Satisfaction public transport in neighbourhood	☐	☐	☐	☐
Transport system satisfaction: other important indicators (please specify on next page)	☐	☐	☐	☐
Prosperity: Taxable income in relation to purchasing power	☐	☐	☐	☐
Prosperity: other important indicators (please specify on next page)	☐	☐	☐	☐

Part 5

4. Please list other important indicators related to the development of a livable city you are monitoring.

Part 6

5. Are there any other specific goals you have defined for a certain time period? Please specify.

Part 7: Strategies

6. Which of the following strategic measures are being taken in your country/by your organisation?

- ☐ National
- ☐ strategy Action
- ☐ Plan
- ☐ Pilot Testing
- ☐ Methodological
- ☐ standards Research
- ☐ Programme Legal

Part 8: Interventions and activities

7. In which of the following areas in relation to CATS have you started or are you planning to start activities?

Application: Geo-fencing based powertrain use

☐ More info

- ○ Ongoing
- ○ activities
- ○ Planned
- ○ activities No

Application: Anywhere to anywhere shuttle

☐ More info

- [ ] Ongoing
- [ ] activities
- [ ] Planned
- [ ] activities No

Application: Automated intermodal transport

☐ More info

- [ ] Ongoing
- [ ] activities
- [ ] Planned
- [ ] Don't know

Application: Automated ride sharing

☐ More info

- [ ] Ongoing
- [ ] activities
- [ ] Planned
- [ ] activities No

Application: Automated urban delivery

☐ More info

☐ Ongoing activities
☐ Planned activities
☐ No

Application: Depot to depot automated transfer

☐ More info

☐ Ongoing activities
☐ Planned activities
☐ No

Application: Green light optimized speed advisory

☐ More info

☐ Ongoing activities
☐ Planned activities
☐ No

Application: Highway platooning

☐ More info

- [ ] Ongoing
- [ ] activities
- [ ] Planned
- [ ] activities No

Application: Local freight consolidation

☐ More info

- [ ] Ongoing
- [ ] activities
- [ ] Planned
- [ ] activities No

Application: Multi-modal integrated payments
☐ More info

- [ ] Ongoing
- [ ] activities
- [ ] Planned
- [ ] activities No

Application: Point to point shuttle

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Application: Urban platooning

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Technology: (Cooperative) Adaptive Cruise Control

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Technology: Autopark

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Technology: Highway pilot

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Technology: SAE L2/3/4 automation

☐ More info

☐ Ongoing activities

☐ Planned
☐ activities No
☐ activities Don't

Technology: Traffic jam pilot

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Technology: SAE L5 automation

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Intervention: Intelligent access control for infrastructure/bridge

☐ More info

☐ Ongoing
☐ activities
☐ Planned

☐ Don't know

Intervention: Road use pricing

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Intervention: Segregated pathway operations

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Intervention: Street design implications

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Intervention: Centralized traffic management

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Intervention: On road operations

☐ More info

☐ Ongoing
☐ activities
☐ Planned
☐ activities No

Other:

Part 9: Final Part

Thank you for taking the time to complete this survey!

*Here is a link to **Levitate** project:*

https://levitate-project.eu/about/

6.2 Agenda of the SRG workshop

LEVITATE 1st Stakeholder Workshop

28 May 2019, Gothenburg

Lindholmen Conference Centre, Lindholmspiren 5, 417 56 Gothenburg

Societal Level Impacts of Connected and Automated Vehicles	
08:30-09:00	*Registration & Coffee*
09:00-09:20	**Welcome & Introduction to the project** *Pete Thomas, Loughborough University*
09:20-09:30	**Presentation of pre-workshop survey results: Landscape of Goals and Plans** *Alexandra Millonig, AIT Austrian Institute of Technology*
09:30-10:30	**Discussion Round 1: Visions of CAT Futures** *Ashleigh Filtness, Loughborough University* Parallel Group Discussions: • Automated Urban Transport • Passenger Cars • Freight Transport & Logistics
10:30-10:50	*Refreshment Break*
10:50-11:00	**Introduction: Building Ideal Futures with Conflicting Goals** *Alexandra Millonig, AIT Austrian Institute of Technology*
11:00-12:00	**Discussion Round 2: Ideal Futures** *Alexandra Millonig, AIT Austrian Institute of Technology* Parallel Group Discussions: • Environment • Society • Economy • Safety
12:00-13:30	*Lunch Break (including demo visits and video interviews)*
13:30-13:50	**Plenary Discussion: Overlaps & Conflicts** *Alexandra Millonig, AIT Austrian Institute of Technology*
13:50-14:50	**Discussion Round 3: Selecting Interventions & Activities** *Julia Roussou, National Technical University of Athens* Parallel Group Discussions: • Automated Urban Transport • Passenger Cars • Freight Transport & Logistics
14:50-15:30	**Introduction to the Policy Support Tool (PST), followed by discussion on expectations and needs regarding the PST** *Julia Roussou, National Technical University of Athens*
15:30-16:00	**Closing & networking coffee, demo visits, video interviews**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 824361.

Figure 17: Agenda of the SRG Workshop on 28 May 2019.

6.3 Results from the stakeholders' engagement workshop

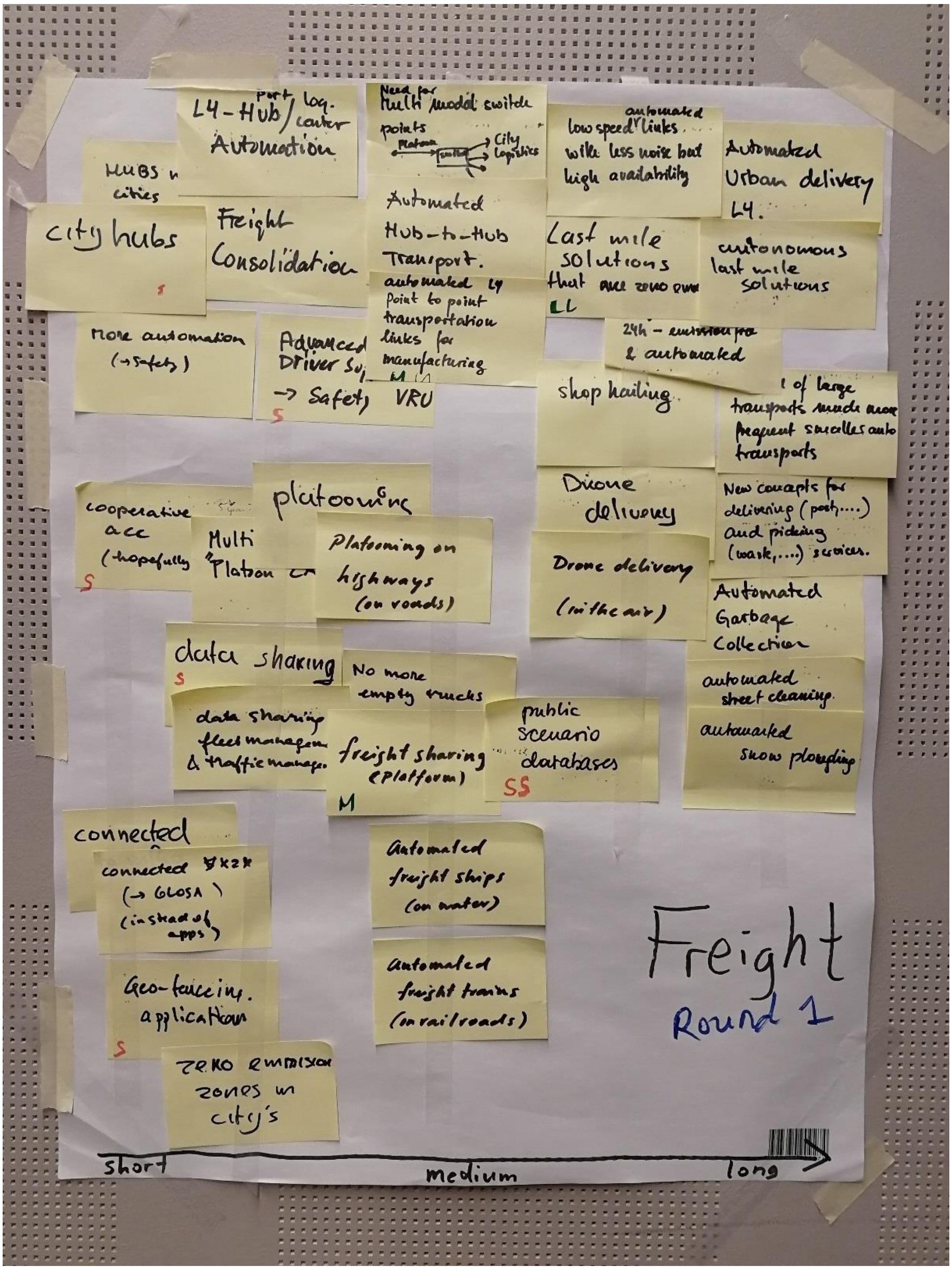

Figure 18: Result of session 1 of the workshop on freight transport.

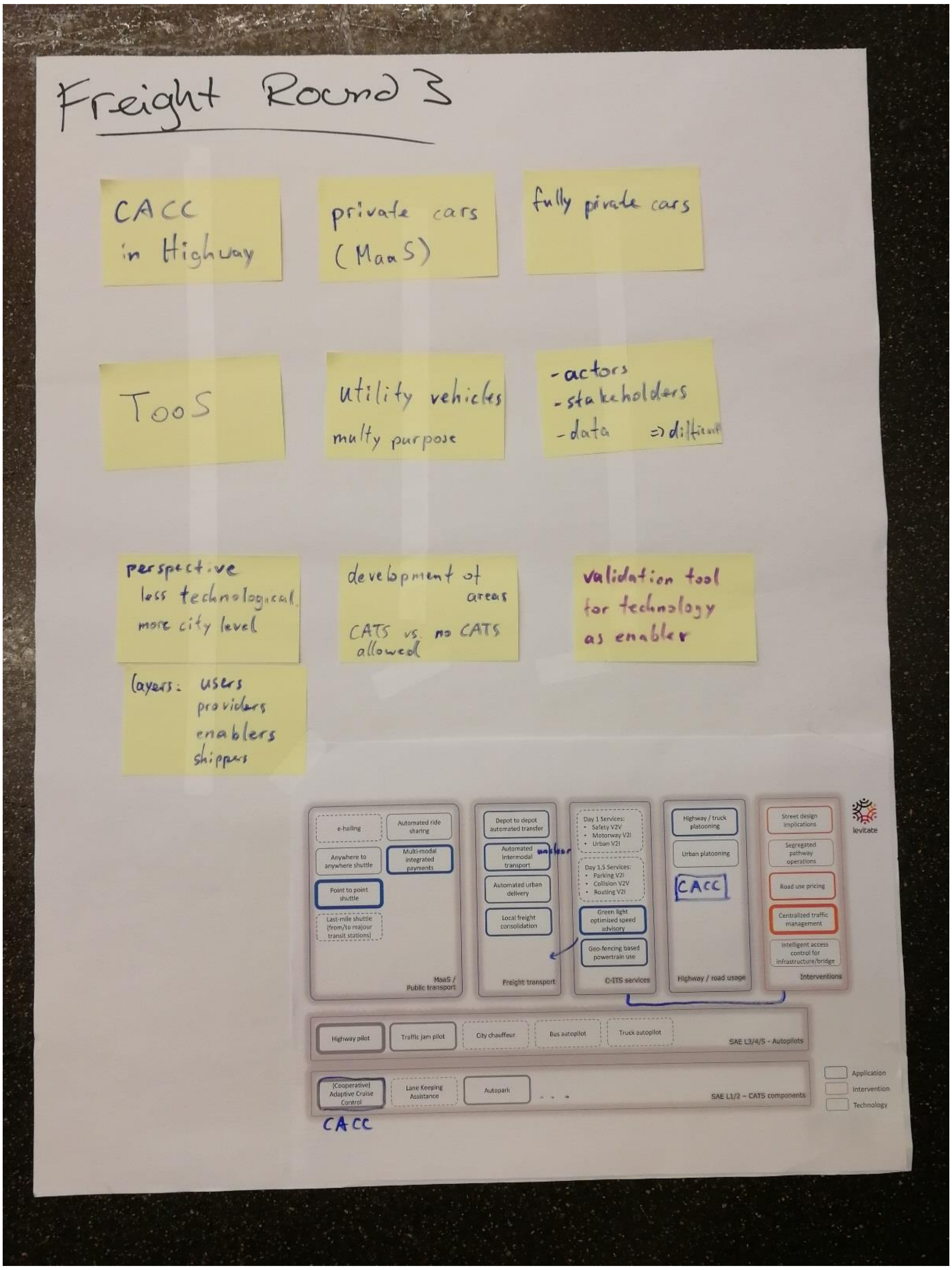

Figure 19: Result of session 3 of the workshop on freight transport.

6.4 Stakeholders' pre-workshop interview– Defining the future of passenger cars, urban and freight transport

Introduction
• Welcome, thank you for your time • Aim of interview – Defining the short, medium & long term future of passenger cars, urban and freight transport • Approx. 30min discussion • All data protection rules are followed.

Part 1: First thoughts on future cities and CATS

- When you think of future cities and CATS, what do you think of?

Part 2: What is currently being done for future planning and is it working?

- *Please describe what is currently being done to plan for the future of CATS and what are the main principles?*
- *Consider any project or experience you have regarding CATS introduction, what were the challenges and obstacles you faced?*
- Which approach is working well, and which not? Why?

Part 3: specific future vision

- *What do you envisage the short, medium and long term future of passenger cars will look like?*
- *What do you envisage the short, medium and long term future of urban transport will look like?*
- *What do you envisage the short, medium and long term future of freight will look like?*

(Penetration, Vehicles, Infrastructure, People acceptability)

Mention as many features of this future as you can. Are there any obstacles mentioned previously (Q2) that are relevant?

Part 4: Sub-use cases

A list of proposed sub use cases can be mentioned from the interviewer.

- *Could you think of any other use cases that are missing and would be valuable?*
- *Could you select top use cases within each type (urban transport, passenger car, freight) that you would most like to be able to explore in the future PST?*
- *What problems and questions is each use case addressing?*
- *What are the expected results given your experience?*

Part 5: the PST

- *Considering the future you are trying to plan for, what are the features you would like to see in the PST?*
- *How useful would you find it?*

Closing

- Comments and questions
- Thank you

6.5 EU Projects on CATS

Table 6.1: Past and current EU Projects on CATS.

EU Projects on CATS		
CoEXist 05/2017 – 04/2020	https://www.h2020-coexist.eu/ Polis is a project partner	focusing on the technological development of microscopic and macroscopic transport modelling tools, CAV-simulators and CAV control logistics and aims to strengthen the capabilities of urban road authorities for the planning and integration of CAVs on their networks
AUTOPILOT 01/2017-31/12/2019	http://autopilot-project.eu/	AUTOPILOT brings together relevant knowledge and technology from the automotive and the IoT (internet of Things) value chains in order to develop IoT-architectures and platforms which will bring automated driving towards a new dimension
Connected automated driving.eu (SCOUT, CARTRE) Both completed	https://connectedautomateddriving.eu/about-us/	two projects (SCOUT, CARTRE) that work together with a broad range of international stakeholders to ensure that these technologies are deployed in a coordinated and harmonised manner, which will accelerate the implementation of safe and connected automated driving in Europe.
SCOUT (H20202) 01/07/2016-2018	https://connectedautomateddriving.eu/about-us/scout/	aims to promote a common roadmap of the automotive and the telecommunication and digital sectors for the development and accelerated implementation of safe and connected and high-degree automated driving in Europe. It will support identification of deployment scenarios in Levitate.
CARTRE (H2020) 01/10/2016-2018	https://connectedautomateddriving.eu/about-us/cartre/	aims to establish a joint stakeholders forum in order to coordinate and harmonise automated road transport approaches at European (e.g. strategic alignment of national action plans for automated driving) and international level (in particular with the US and Japan).
ARCADE (will continue the work of CARTRE) 01/10/2018-2021	https://connectedautomateddriving.eu/arcade-project/	aims to coordinate consensus-building across stakeholders in order to enable smooth deployment of connected and automated driving (CAD) on European roads and beyond. EC, Member States and industry are committed to develop a common approach to development,

		testing, validation and deployment of connected and automated driving.
interACT 01/05/2017-30-04/2020	https://www.interact-roadautomation.eu/	Works towards cooperative interaction of automated vehicles with other road users in mixed traffic environments
L3Pilot 09/2017-2021	http://www.l3pilot.eu/home/	The overall objective of L3Pilot is to test the viability of automated driving as a safe and efficient means of transportation, exploring and promoting new service concepts to provide inclusive mobility (assessment of level 3 & 4 in-vehicle functions).
AdaptIVe Level1 -level 4 of automation 01/2014-06/2017	https://www.adaptive-ip.eu/	AdaptIVe develops various automated driving functions for daily traffic by dynamically adapting the level of automation to situation and driver status. Further, the project addresses legal issues that might impact successful market introduction.
iTETRIS 2008-2010?	http://www.ict-itetris.eu/simulator/	iTETRIS integrates wireless communications and road traffic simulation platforms in an environment that is easily tailored to specific situations allowing performance analysis of cooperative ITS at city level. The accuracy and scale of the simulations leveraged by iTETRIS will clearly reveal the impact of traffic engineering on city road traffic efficiency, operational strategy, and communications interoperability.
FUTURE-RADAR (H2020) *Jan 2017 – Dec 2020*	https://www.ertrac.org/index.php?page=future-radar POLIS is project partner	- support action for ERTRAC and EGVIA to create and implement the needed research and innovation strategies for a sustainable and competitive European road transport system. ERTRAC has a Working Group on road transport automation.
CIVITAS SATELLITE (H2020) *2002-2020*	https://civitas.eu/ POLIS is project partner	- CIVITAS can help to maximise the outreach of Levitate results. This includes, among others, making tools available in the online CIVITAS transport tools inventory.
Drive2theFuture (H2020) *2019-2022*	https://www.ait.ac.at/en/research-fields/integrated-	- The aim of the Drive2theFuture project is to prepare future "drivers" and travellers for

	mobility-systems/projects/drive2thefuture/	networked, cooperative and automated means of transport and to increase acceptance accordingly.
MAVEN (H2020) *2016-2019*	http://maven-its.eu/ POLIS is project partner	- aims to provide solutions for managing automated vehicles in an urban environment (with signalised intersections and mixed traffic). - It develops algorithms for organising the flow of infrastructure-assisted automated vehicles.
CityMobil 05/2006 – 12/2011	http://www.citymobil-project.eu/	- Safety applications and technologies: safe speed and safe following, lateral support, intersection safety, active 3D sensor technology for pre-crash and blind spot surveillance.
PICAV 08/2009 – 09/2012	https://cordis.europa.eu/project/rcn/91186/factsheet/en	- Passenger transport, urban traffic, car sharing, networking, assisted driving, vulnerable road users.
CATS 01/2010 – 12/2014	https://cordis.europa.eu/project/rcn/93669/factsheet/en	- Robotic driverless electric vehicle, passenger transport, transport management, urban transport.
FURBOT 11/2011 – 02/2015	http://www.furbot.eu/	- Fully electrical vehicle for freight transport in urban areas, robotics.
V-Charge 06/2011 – 09/2015	http://www.v-charge.eu/	- Autonomous valet parking, EVs coordinated recharging, smart car system, autonomous driving, multicamera system, multi-sensor systems.
Cargo-ANTs 09/2013 – 08/2016	https://ict.eu/case/eu-fp7-project-cargo-ants/	- Create smart Automated Guided Vehicles (AGVs) and Automated Trucks (ATs) that can co-operate in shared workspaces for efficient and safe freight transportation in main ports and freight terminals.
CityMobil2 09/2012 – 08/2016	http://www.citymobil2.eu/en/	- Automated road transport system, automated vehicle, driverless, urban transport, safety, infrastructure, legislation.
PReVENT	https://trimis.ec.europa.eu/project/preventive	- Development and demonstration of preventive

02/2004 – 03/2008	-and-active-safety-application	safety applications and technologies (advanced sensor, communication and positioning technologies). -
Have-it 02/2008 – 07/2011	https://cordis.europa.eu/project/rcn/85267/factsheet/en	- Automated assistance in congestion, temporary auto-pilot.
ASSESS 07/2009 – 12/2012	https://cordis.europa.eu/project/rcn/91187/factsheet/en	- To develop a relevant set of test and assessment methods applicable to a wide range of integrated vehicle safety systems, mainly AEB for car to car. Methods developed for driver behavioural aspects, pre-crash sensing performance and crash performance under conditions influenced by pre-crash driver and vehicle actions.
Digibus Austria (National Austrian Funding) *2018-2021*	https://www.digibus.at/en/ AIT is project partner	- pursues the goal to research and test methods, technologies and models for proofing a reliable and traffic-safe operation of automated shuttles on open roads in mixed traffic in a regional driving environment on automated driving level 3 ("Conditional Automation") and creating foundations for automation level 4 - The results form the basis for an Austrian reference model for the real testing and operation of highly or fully automated vehicles in local public transport. -
DIGITrans (National Austrian Funding) *2018-2023*	https://www.testregion-digitrans.at/ AIT is project partner	- Exploration of needs and cases of application regarding heavy duty and special purpose vehicles - Use of automated vehicles in areas of logistics hubs, e.g., inland ports like Ennshafen, airport or company sites - Common use of infrastructure for test regions regarding automated driving

auto.Bus - Seestadt (National Austrian Funding) *2017-2020*	https://www.ait.ac.at/en/research-fields/integrated-mobility-systems/projects/autobus-seestadt/	- The findings of the project will be: (a) robustness through the use and fusion of modern image processing technology, (b) trust and acceptance-building interactions with passengers and other road users as well as their impact, and (c) planning and design principles. - These findings form the central prerequisites to enable a successful use of autonomous buses for public transport covering tomorrow's mobility needs.

Further list of projects can be found in Annex of Automated Driving Roadmap document from ERTRAC available at:
https://www.ertrac.org/uploads/documentsearch/id38/ERTRAC_Automated-Driving-2015.pdf