Business Challenges of Autonomous and Connected Transport

WG3: Thematic Report

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Chapter 1: Introduction

During the 2010s there have been a growing number of bold claims about the economic potential of revolution in the transport sector (e.g. Lerner 2011, Graham 2013, Van Audenhove et al. 2014, Bouton et al. 2015). Arthur D. Little (Lerner 2011), for example, identified *'niches of potential'* related to 39 *'key technologies'* and 36 *'potential urban mobility business models'*[1]. The totality of these niches, which do not extend to consider automation in the freight sector, was predicted to be worth $829 billion per annum by 2050. With the total freight logistics sector worth US$4.6 trillion globally, the potential added value of automation is significant, although would include the non-transport activities, notably warehousing, where adoption is further advanced[2].

Parkhurst and Lyons (2018), drawing on Fagnant & Kockelman (2015), summarized the potential benefits that have been attributed to Autonomous & Connected Transport (ACT) in the passenger subsector but noted that all the benefits came with potential socioeconomic and environmental risks. Two of these benefit-risk pairings had particular relevance for business opportunities in both the passenger and freight domains:

- **Transport system efficiency** – that there might be greater effective road capacity resulting from connecting and automating vehicles through reduced vehicle headways and/or increased throughput of people movement due to higher vehicle occupancies and smoothed traffic flow, **but**, if not shared, vehicle occupancy would remain low, or fall, and vehicles would run empty between picking up passengers, and a downwards pressure on efficiency could result, affecting road freight as well as passenger mobility. **Hence the business model of ACT usage is key in determining road system economic efficiency, with major consequences also for social and environmental costs of the road transport system.**

- **Monetary cost of mobility** – that there would be a modest increase in vehicle purchase costs due to the specification of equipment for automation and connectivity (rather higher in the short-run but modest once production logistics are fully optimized), but use costs would reduce, for private owners and fleet operators, due to more energy-efficient operation and reduced wear-and-tear. However, again, **a 'benign' operating environment would be dependent upon a space-efficient model of ACT usage emerging**.

A difference between the freight and passenger sectors, however, is that automation in the freight sector is driven by necessity as well as opportunity (Daher et al., 2019); the need to cope with huge increases in freight demand as the world economy continues to undergo spatial specialisation in activity, whilst also coping with forecast shortages of human labour in some specific locations (Costello and Karickhoff, 2019). Various projects (e.g. H2020 WE-TRANSFORM) have been focusing on relevant impacts of automation on the labour force. Such concerns have been exacerbated during the COVID-19 pandemic when global demand for deliveries has increased significantly, so it has been pertinent to focus on these.

Hence, ACT triggers a wide variety of business opportunities for both passenger and freight transport, but pursuing those opportunities will have major implication for public policy, including, but by no means limited to, transport policy. Amongst the range of possible business models will be options that can be profitable for the private sector as commercial services, and those that would require public financial support, and therefore would be expected to deliver public policy objectives. As well as examining these extremes, the work undertaken in the WISE-ACT Working Group 3 (WG3) seeks to identify the 'win-win' zone where commercial and sustainable development benefits align.

The remainder of the thematic report considers progress towards this broad objective working through the specific WG3 Tasks:

- T7: Examine business implications for the logistics sector

- T8: Classify viable business models

Furthermore, the WISE-ACT MoU Research Objective 5 also identified some specific foci including collaboration with local and national authorities to identify value creation activities beneficial to both the private and public sectors and considering issues of privacy and data management within passenger and freight transport.

The remainder of this report reviews relevant evidence and identifies some of the key literature in Section 2. It then turns to consider the implications for business (Section 3). Section 4 presents an analysis of business models as they emerge in the new mobility context, with the conclusions presented in Section 5.

Chapter 2
Overview of relevant literature

The WG3 team has adopted an approach of 'meta-review' drawing upon review, empirical and experimental work undertaken prior to and during the period of the WISE-ACT network activities. The studies drawn upon deployed a range of social and engineering systems research to examine the economic, labour market, business management and travel behaviour contexts of ACT adoption.

The following subsections consider some of the key literature identified against the two WG3 tasks, summarising the objectives, methods, and findings of those studies.

T7 Business Implications for the Logistics Sector

As noted in the Introduction (Section 1), the logistics sector has been defined by WG3 in its broader sense to encompass all freight activities. Freight sector innovation is aimed both at increasing available capacity in the context of global economic growth and reducing the environmental impact of that growing totality, whilst continuing to promote enhanced safety and security of operation (Ranaiefar, 2012). In the context of 'business implications', WG3 participants undertook a review of innovative freight technologies, including through a review of freight sector innovative technologies funded by the UK Government (Paddeu et al., 2019). A more in-depth overview is available in Paddeu and Parkhurst (2020).

Innovative solutions may support operators in the organisation of freight management and handling activities at freight terminals and, in particular, may promote intermodal transport by reducing handling times and costs at terminals (Gattuso and Pellicanò, 2014). Automated guided transport systems and vehicles for commercial purposes were introduced in the early 1950s in the USA and approximately ten years later in Europe, driven by the mechanisation of production, with the aim of optimising flows of materials and reducing labour needs. Initial applications of automation were in production and warehousing contexts (Flämig, 2016), but to date, automated freight transport systems are not used in public open spaces, since they require a specific and dedicated infrastructure as well as specific regulations.

Neuweiler and Riedel (2017) found that there is a gap in research related to identifying competitive advantages, with autonomous driving entering the market. In terms of technology, there has been great effort in investigating new technologies for transport systems, and notable progress has occurred in recent years. The literature recognises that automated systems might provide a significant benefit to the freight sector, especially in terms of fuel consumption reduction. However, there has been limited investigation into the microeconomic and macroeconomic benefits and costs of these developments as also pointed out by the WISE-ACT WG1, and more research is needed (Flämig, 2016).

Table 1: Key Studies on business implications of ACT for the freight sector

Source	Region	Aim/Study area	Methodology	Main findings	Link
ATRI (2016)	U.S.	In 2016 ATRI evaluated the main benefits that autonomous technology could bring into the US trucking industry.	In depth review of current state of autonomous vehicle (AV) technologies and analysis of the impacts of the deployment of autonomous systems.	High uncertainty towards the impact of AV technology on the trucking industry. It is uncertain if carriers would have a return-on-investment (ROI), as costs are mainly based on the current "demonstration" systems, with high speculation. The technology is not sufficiently mature to allow an accurate quantitative estimation of costs, and therefore ROI or economic advantages for trucking operators. In terms of benefits, productivity and safety emerge as the greater advantage. Depending on the degree of automation the systems will autonomously operate the vehicle, allowing the driver to rest or perform other activities. Several billions of dollars are projected as annual savings from the elimination of human error-related crashes.	**http://atri-online.org/wp-content/uploads/2016/11/ATRI-Autonomous-Vehicle-Impacts-11-2016.pdf**
Tavasszy (2016).	Europe	Understanding and quantifying economic benefits of truck platooning.	Multi-scenario analysis: definition of three value cases for truck platooning and evaluation of the related economic benefits.	Economic benefits due to the implementation of truck platooning would be greater than fuel consumption for logistics companies, allowing potentially for an average €8.8 billion saving per year. Drivers' working time would be improved, as drivers may be able to execute other tasks beside their driving task. In general, automated systems can increase the productivity of single truck/driver combinations. This would have a direct positive impact on operating costs.	**The-value-case-for-truck-platooning.pdf (researchgate.net)**
Aurambout et al. (2019).	Europe	Estimation of the potential market for drone deliveries in Europe.	Multi-scenario analysis, with the definition of a modelling framework using EU-wide high-resolution population and land-use data to estimate the potential optimal location of drone-beehives based on economic viability criterion.	With current technology (most realist scenario) up to 7% of EU citizens could get access to last-mile deliveries by drone. With advanced technological development, the potential market for drone deliveries increases up to 30% of the EU population. Differences in population and land-use patterns in the different EU Member States have been noted as there might be a different uptake. The UK, Germany, Italy and France appear to emerge as the countries where implementation might be more successful due to the greater economic advantage.	**Last mile delivery by drones: an estimation of viable market potential and access to citizens across European cities | SpringerLink**

Kunze (2016)	Europe	To understand what logistics in European cities will look in the year 2030.	Literature review, analysis of mega-trends in logistics, cross-impact matrix.	AV for urban goods distribution would require the establishment of loading/unloading systems or devices at both ends of the last-mile transport (which results in high costs). There is low compatibility of delivery recipients at the destination location (e.g. drop boxes, commercial unloading bays; etc.). Finally, there might be security and safety issues if no human is present. In general, large scale logistics applications of urban aerial drones are unlikely, due to the energy-inefficiency and the opposition from citizens (e.g. noise pollution, security, safety). 3D printing would imply a reduction in freight-kilometers travelled in the upstream supply chain, with a significant reduction in lead time. However, currently available multi-material 3D printers do not perform well in terms of quality. In general, high uncertainties towards business models.	**Replicators, Ground Drones and Crowd Logistics A Vision of Urban Logistics in the Year 2030 – ScienceDirect**
Lawrence et al. (2017)	UK	This discussion paper analyses the role of public policy in accelerating automation to foster productivity benefits, while ensuring that the dividends of technological change are shared among stakeholders.	Discussion paper to understand the impact of automation on employment, businesses, and policy framework.	Automation will transform (not fully replace) the nature of current works, which will see an evolution, supported by policies to avoid inequalities of wealth, income, and power. Companies will make ethical use of automation, which will support full productivity benefits and enable higher wages. They should be monitored by an Authority for the Ethical Use of Robotics and Artificial Intelligence The implementation and use of automated systems will require new models of capital ownership to ensure that automation broadens prosperity rather than concentrates wealth. Spreading capital ownership will help ensure automation creates an economy and a business eco-system where prosperity is underpinned by justice.	**Managing automation CEJ (ippr.org)**

T8 Classification of Emerging Business Models

The understanding of new business models surrounding Autonomous and Connected Transport, where interwoven relationships between technological management and social changes, requires a qualitative approach (Eisenhardt and Graebner, 2007). During a WISE-ACT Short-Term Scientific Mission (STSM), and using the personal networks established through different projects, 20 in-depth interviews with key stakeholders from the new mobility value chain were conducted. Those stakeholders came from different steps in the new mobility value chain. This purposive non-probabilistic sampling procedure focused on Europe, particularly from three countries: UK, Spain and Portugal (Euro-region: Galicia and North of Portugal). A screening stage, conducted by e-mail or telephone to confirm their relevance, eligibility and willingness to join this study, was performed. Data collection took place from November 2019 to March 2020. The interviewees have been experienced managers holding positions of responsibility within their organisation (e.g., owners, technology/product managers, area managers), so they have been able to offer detailed knowledge of a strategic perspective about ACT business models.

Table 2: Key Studies on business model impacts and classifications

Source	Region	Aim/Study area	Methodology	Main findings	Link
Antonialli et al. (2018)	France, Brazil	Drawing a typology model for the uses of Autonomous Vehicles in the scope of a Product-Service System (Tukker, 2004), through their core characteristics. Study area: Mostly urban.	Exploratory qualitative approach with a descriptive nature. Secondary sources and primary sources: 11 in-depth interviews and 3 focus groups.	Classification based on Tukker's PSS (2004) differentiating (1) transport of people and (2) transport of cargo. They can be (a) owned by a company (the service provider offers the transportation service including the ownership and maintenance of the fleet) or (b) privately-owned (the individual can offer the transportation service or renting his/her vehicle to a service provider to offer a service). Each option has three sub typologies: 1) carsharing, 2) ride-sharing and 3) last mile issue (divided into carsharing and ride-sharing).	**https://hal-centralesupelec.archives-ouvertes.fr/hal-02276296**
Calvert et al. (2019)	UK	Development of a conceptual framework to characterise and contrast different approaches to the application of new technologies in the passenger transport service sector.	Qualitative interviews with innovators and service providers structured using a novel classification of business model and wider policy objectives.	Most of the 15 shared-ride on-demand services consider challenging the alignment of their corporate goals with the broader environmental objectives in the new mobility innovation rhetoric.	**https://uwe-repository.worktribe.com/output/5536985**
Lagadic et al. (2019)	Paris, Copenhagen, Madrid, Lisbon	Overview of the different value propositions offered on the carsharing market and consider their limit. Study area: Urban.	Literature review, and on fieldwork in Paris, Copenhagen, Lisbon and Madrid. The data of Paris is based in Autolib case study. Results discussed for Copenhagen, Lisbon and Madrid were obtained through face-to-face semi-directive interviews: 27 actors (11 public, 14 service providers, 1 public-private, 1 expert).	Four types of service providers: 1) carsharing service providers, 2) traditional car renters (entering in the carsharing market), 3) OEM with their own service, 4) public operators and local authorities.	**https://www.sciencedirect.com/science/article/pii/S0967070X18307480?via%3Dihub**
Berg et al., (2020)	US	Report introducing the use of system dynamics to explore travel behavior as well as business models of transportation suppliers. Study area: not defined.	System Dynamics: causal interactions within a complex system leading to the development of a model to demonstrate not-so-evident dynamic behavior.	Four important building blocks applicable to any transportation mode: (1) Reinforcing cycle of technology adoption for customers to adopt a new product (word-of-mouth and other influencing factors), (2) The business model on transportation services should focus on the availability of labor, vehicles, how customers pay, and financial sustainability, (3) Reinforcing effects of services and users, the higher the service use, the more service added and the improved quality, (4) Balancing effects of use in case of congestion.	**https://rosap.ntl.bts.gov/view/dot/49813/dot_49813_DS1.pdf?**
Riggs and Beiker (2020)	References to US	Authors contextualise the impact of automation on the financial implications of shared mobility, where providers intend to achieve a sustainable business model. Study area: urban.	Not specified. Authors provide a reflection based on an analysis of the state-of-the-art.	Two types of opportunities due to Autonomous Vehicle deployment: "platform" and "place". New requirements in terms of partnerships, particularly within business-to-business markets and across sectors to attend challenges for shared and autonomous mobility.	**https://link.springer.com/chapter/10.1007/978-3-030-52840-9_4**
Van den Heulen et al. (2020)	Not defined	Identify and explain factors influencing Business Model Innovation in start-ups from the mobility industry.	Qualitative research. In-depth interviews using thematic analysis: 9 interviews.	Customer influence, legislation and business partners are core external factors that influence business model innovation. The firm's societal impact vision, a dedicated employee responsible for looking after business model innovation, the decision-making structure and internal use of technology are core internal factors that affect the business model innovation.	**https://www.sciencedirect.com/science/article/pii/S2210539520301061**

Chapter 3
MoU Task 7: Evaluate Business Implications

Three Foci of ACT Implementation in the Freight Sector

A review of the literature revealed three main freight transport domains in which automation is expected to play a role. These can be summarised in the following: long-haul road freight, trans-modal shipments, and last-mile deliveries. Further topics identified through this WG3 literature review include warehouse and terminal management, where technological innovation is relatively advanced, but these topics are considered to be beyond the WISE-ACT scope so are not included in this WG3 report.

With respect to **road freight**, the strongest automation prospects in the short-to-medium term relate to platooning of heavy goods vehicles (HGVs). 'Platooning' is the grouping of vehicles in operation on a highway in such a way that their control systems are temporarily linked, which enables the space between the vehicles to be reduced. In turn, greater proximity results in reduced consumption of road space and increased energy efficiency for the second and subsequent vehicles in a platoon. The technology is already mature, and the next step will be to develop, through trials, the appropriate regulatory frameworks and operating practices to enable the safe platooning of HGVs on public highways as discussed within the WISE-ACT WG1 report (Costantini et al., 2021). Over the longer term, there is potential for autonomous electric and connected vehicles to be utilised in the freight sector and meet wider industry and societal goals as outlined in Alonso Raposo et al. (2019).

In relation to long-haul rail transportation, various **transhipment systems** have been developed to automate the transfer of cargo containers between road and rail (e.g. CargoBeamer, the Lohr Railway System and InnovaTrain). A transhipment point is a place located between origin and final destination where goods or containers are in some way transferred from vehicle to vehicle, or vehicle to temporary storage facility. Reasons for transhipment might be changing of the means of transport during the journey, or consolidation/deconsolidation (e.g., combining small shipments into a large shipment or dividing the large shipment at the end of a 'trunk' haul). Such systems are deployable on sections of the European rail network that meet the required design standards e.g., loading gauge.

Emerging solutions for **last-mile deliveries** include autonomous vehicles, drones and 3D printing. These can be combined in 'urban freight systems' with local cross-docking centres for receiving and collecting goods: e.g., consolidation centres, pick-up points and package stations. With the establishment of the necessary regulatory frameworks, there is potential for such innovative solutions to reduce road freight movements in urban areas.

Drivers and constraints on innovation

Facilitating technologies are necessary to underpin the adoption of automation, such as the provision of spatially extensive and continuous superfast/gigabit broadband and high-speed mobile networks. Such high-capacity data transmission networks could unlock the potential for:

- the development and deployment of vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and vehicle-to-cloud (V2C) communication technologies, as required for the automation of road haulage vehicles;
- increased capacity to transmit logistics data between freight providers (and to customers), to improve efficiency in freight operations; and
- the operation of automated drones for last-mile deliveries.

However, compelling and reliable evidence of supply chain efficiency gains and cost reductions is necessary to incentivise private sector stakeholders to invest in these new technologies.

Conversely, a number of factors could stifle the adoption of automation in the freight sector, including:

- the absence of necessary complementary infrastructure required to capitalise on new technologies, such as roadside systems to enable operation of Autonomous Vehicles (AVs);
- a perception of limited added value and comparatively poor economies of scale associated with new technologies, which are likely to require high capital investments in the early development stages;
- a lack of compelling evidence that new technologies are safe, reliable and offer efficiency gains and cost savings; and
- a collective resistance to change operating practices among institutions and the labour force, which may arise in part from an ongoing social norm that places greater trust in human control than machine control.

Case-Study 1: Supporting Measures to Enable Innovation in the UK

To support its attempts to be a global leader in ACT technology development, the UK Government has established the Centre for Connected and Autonomous Vehicles[3] (CCAV), a specialist government service agency joint between two government departments (Department for Transport and Department for Business, Energy & Industrial Strategy). The UK Government had already taken some steps to facilitate automated vehicle use through primary parliamentary legislation (the Automated and Electric Vehicles Act of 2018[4]), addressing matters such as when a human or automated driver can be said to be legally in control of a vehicle, and the basis of liability insurance being in place where a human driver is not in control or in the event of a systems failure (Parkhurst et al., 2021).

Moving beyond the Act, CCAV is active in promoting links between the public and private sectors, for example fostering dialogues around more major regulatory change as to how the highway code could be adapted to enable automated and human-driven vehicles, although with other road users, can share street space. A key activity here was the promotion of a review of legal regulations as they apply to ACT using public roads, undertaken through a series of three public consultations by the Law Commissions of England and Wales, and of Scotland[5].

CCAV also provides co-funding for private sector-led research and development projects, in partnership with Innovate UK, which is the public sector innovation support agency in the UK. Most notable here have been a series of high-profile technology trials intended to increase public awareness and support for ACT, as well as developing the technologies in realistic environments. These two agencies, alongside other parts of government, academia, and the private sector have also established 'Zenzic'[6] a national multi-centre test facility; the 'CAM Testbed UK Ecoystem' which seeks to attract investment and customers from abroad. In its own words, Zenzic seeks to "*...energise the self-driving revolution by uniting industry, government and academia to set the world standard for excellence. Zenzic has a multiplier effect on the ecosystem by taking a collaborative approach and ensures coordination amongst stakeholders in the UK and between leading countries in connected and automated mobility.*"

A further part of the UK Government, the 'Government Office for Science' has commissioned several 'evidence reviews' of future mobility[7]. One of these, conducted by WISE-ACT members (Paddeu et al., 2019), concerned automation in freight transport and identified several facilitating measures for ACT adoption that the public sector would need to lead or foster:

1. Continued investment in nationwide high-speed, high-capacity data transmission networks (both fibre-optic and mobile).

2. Ensuring that legislative and regulatory frameworks are adapted to enable the use of AVs on the public highway network. This includes giving due consideration to standards for vehicles, roadside infrastructure and the regulation of AV operation on public highways.

3. Ensuring that the future rail freight strategy allows for the potential deployment of 'rolling motorways' on new sections of the rail network, along with complementary transhipment points, as is happening in continental Europe.

4. Developing a strategic plan to support the private sector to adopt and develop new systems of freight handling and movement, including:

    a. providing financial support for Research & Development programmes, with trials objectively and fully evaluated (to generate compelling evidence of efficacy relevant for knowledge transfer the sector); and

    b. training programmes to increase workforce capacity and skills regarding the adoption of new operating practices.

Out of these, the most challenging requirement is that of evolving a long-established regulatory framework for road use. The most important action to date has been a series of three sequential consultations. Although these have tended to emphasise considerations for passenger transport niches, the principles emerging would have wider relevance. They address, for example, the need for a national, independent AV incident investigation body. However, notably, Lawrence et al., (2017) went further, in calling for the establishment of a 'National Robotics and Artificial Intelligence Ethics Authority' to advise on the ethics of automation as also mentioned in the WISE-ACT WG1 report. The authority's potential remit could include:

- giving consideration to human safety in proximity to autonomous technologies;

- examining liability issues in cases where autonomous technologies fail; and

- advising on socially equitable strategies to deal with circumstances where human labour is replaced by automated technology.

Finally, it is noted that further primary research in the form of an in-depth analysis of the UK supply chain (considering different sectors, e.g. automotive, food, coal) is required to identify the prospects for applying different automated freight systems. Such an analysis could be carried out at regional and national levels, giving consideration to the major freight corridors across the UK.

Table 3. SWOT analysis for adoption of CAM enabled freight vehicles in the UK

Strengths	**Opportunities**
The UK was placed third overall in the 2020 Global Innovation Index and is hugely ambitious to play a leading role in the CAM revolution. The Government works in collaboration with industry and academia to support R&D on CAM technology development and deployment. Evidence of supply chain greater efficiency. Significant research works carried out to advance knowledge and understanding of CAM systems.	320,000 new jobs created, 25,000 of which are in automotive manufacturing by 2030 (SMMT, 2017) Improved efficiency and safety reduced (human) errors and overall operational costs. More flexible/customised response to increasingly demanding last-mile deliveries. Promising solution to the lack of human truck drivers. New market opportunities.
Weaknesses	**Threats**
High costs of investments in the short-medium term. Lack of economies of scale. Concern towards safety and liability issues.	Public acceptance, especially in the case of urban road solutions, such as AV trucks/vans, autonomous ground and aerial drones. IT/digital infrastructure needed to enable connectivity. Appropriate regulatory framework needed to enable CAM systems.

Case-Study 2: Initiatives to Promote Lithuania as a CAM Freight Pioneer

On 7th December 2018 the Lithuanian parliament voted a bill that opened up the country's roads to Autonomous Vehicles. Though the topic of driverless cars still divides the public and raises questions, Lithuania aims to be a pioneer in the sector. After accomplishment of this action, Lithuania is inviting world manufacturers of self-driving vehicles to try the new-generation cars in the country. On initiative of JSC Viltechna, which works in the area of intelligent transport systems, a driverless passenger vehicle from French manufacturer Navya was tested in Lithuania. Notwithstanding these facts, experimentation and studies are also in progress to make Connected and Autonomous Mobility (CAM) a reality in this Baltic country. The different aspects and scenarios of the physical and digital infrastructure of the system are being analysed to be fed as a potential variable to train decision making by such vehicles, particularly within the CAM freight sector in Lithuania. Bass model analysis is used currently to determine the adoption of the CAM enabled freight system based on historical sales statistics. Different parameters and scenarios that affect the sales and market of CAM freight system are analysed to obtain an overview of sales forecast to plan ahead in advance of any market fluctuations. The objective of this study is to determine the adoption rate towards a new technological introduction to the transportation market in Lithuania (Venkatesh, 2021). Bass diffusion business model is based on the analysis of the sales trend with respect to the market potential being considered as two categories of audiences based on the time required for them to show interest towards a new technology. The immediate adopters are called the innovators and the slow adopters are called the imitators which is governed by the factor of word of mouth. The model can be made more complex by including further factors such as advertising, marketing and others affecting sales. Policy and technical aspects were analysed with available data of the EVs penetration in market. Despite the other modes of freight transportation such as air and waterways, the road freight vehicles are the most popular due to the fact that there are relatively cheaper in cost and require the least amount of time for transportation compared to the others. This clearly explains the steady increase in the freight vehicles with the country's growing economy and population. The potential strengths, weakness, opportunities and threats can be analysed using a SWOT analysis method to understand the outcomes better and suggest an appropriate plan of action.

Venkatesh (2021) has shown that the sales peak of lorries are expected to be in the year 2032, during which alternate strategies can be developed for CAM enabled freight system in Lithuania. The system infrastructure, planning and cost analysis for the proposed implementation of CAM can be analysed to organise and structure the action plans. Several researchers have developed analysis on different aspects of adoption of CAM mobility which can be taken into consideration while performing the same for Lithuania. (Erhart et al., 2019; Hansson, 2020; Kassens-Noor et al., 2020). Furthermore, the infrastructure planning, strategy planning, cost estimation for CAM enabled freight system in Lithuania can provide the scope of future work to progress this into becoming a reality before 2032 (Venkatesh, 2021).

Table 4: SWOT analysis for adoption of CAM enabled freight vehicles in Lithuania (Venkatesh, 2021)

Strengths	Opportunities
Strong research basis in transport and CAM related areas. Research alliance with EU CAM for latest technologies and developments. Steady and constant need of freight system to serve public needs. Strong position in business and IT enabled services.	Reduced dependence on the availability of commercial vehicle drivers. Reduced operational costs, as driver charges may be eliminated. Increased quantity of goods transferred to serve needs better and quicker. Tactical strategy modal planning to obtain efficiency. Improved movement of goods.
Weaknesses	**Threats**
Expected high cost of CAM enabled vehicles. Taxation of vehicles and potentially increased insurance rates. Existence of secondary automobile market. Lack of OEM and transport-based parts manufacturing companies.	Conservative political approach to new technologies. Investments necessary for developing a CAM infrastructure is high. As CAM is under construction, the uncertainty of details such as features, legislation, standards, and parameters. The lack of technicians and their knowledge to handle CAM. The elevated market rate of CAM technology will affect the rate of market capture. Lack of information in the market might lead to rejection of CAM. Alternative fuel technology can affect market penetration as they are easier to adopt.

Chapter 4
MoU Task 8: Classify Viable Business Models

Although AVs are a topic of emerging interest within the social sciences research as demonstrated by the constantly increasing number of studies conducted since 2010 (Cavazza et al., 2019; Ghandia et al., 2019; Fagnant and Kockelman, 2015; Thomopoulos et al., 2021), there is a lack of focus on classifying and analysing related business models. Specifically, a business model (BM) *"is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money"* (Osterwalder, 2004, p.15). The BM lets describe how value is created, delivered, and captured for a firm and its customers (Osterwlader and Pigneur, 2010). And this description includes a series of elements that, integrated as a whole, allow the generation of revenues by firms. Specifically, the value proposition and how the strategy shapes it (Wirtz et al., 2015; Lasmar Jr. et al., 2019), the reconfiguration of the firm activities (Santos et al., 2009) and the ability to make alliances (Lagadic et al., 2019), are essential inputs in the new business models. But those businesses require a series of mechanisms to reach the market and generate revenues (Bohnsack et al., 2014) and also attract the attention of investors to obtain some funding (Zott et al., 2011).

When comparing contemporary human driven ride-hailing services such as Uber and Lyft with future driverless ACT, a key challenge arises. At the moment, ride-hailing services pay (often) no fee to human drivers when there is no passenger on board i.e. they incur no cost. At the same time, ride-hailing companies benefit by showing these no cost vehicles on their platform, generating demand. Additionally, there are external costs generated by such practice in the form of congestion and environmental externalities e.g. air pollution. Consequently, there is an ever-remaining need for ground-breaking innovation about the ACT business model (Gindrat, 2020):

> **"It is probably 10,000 times harder to deliver a commercial autonomous service at scale than to demonstrate that the vehicle can drive down the street"**
>
> Dan Ammann, President of Cruise

Towards a Conceptual Framework

Scholars have started to shift their attention towards viable business models focused on a cleaner mobility, characterized by lower emissions and a more efficient use of resources (Lagadic et al., 2019; Thomopoulos and Nikitas, 2019). Currently, society, governments and corporate actors are at a crossroads between disruptive changes in mobility modes and the traditional business (Athanasopoulou et al, 2019; Rode et al., 2017; Sarasini and Linder, 2018). In this line, current literature provides some examples.

Riggs and Beiker (2020) review the services opportunities emerging from platforms, whereas Berg et al. (2020) tested a financially sustainable business model based on a System Dynamics simulation, with its intrinsic limitations. Van den Heuvel et al. (2020) have conducted one out of a handful of studies which have attempted to offer relevant insights regarding business model innovations for mobility sector start-ups, but limited to eight transcribed interviews from the GECKO project with narrow managerial implications for wider audiences. A relevant GECKO report reviews four business models, namely about i) CCAM (Connected Cooperative Automated Mobility), ii) Infrastructure, Network and Traffic Management, iii) MaaS, iv) Shared and On-demand Mobility (Kao et al., 2020). Similarly, Calvert et al. (2019) found that most of the 15 shared-ride on-demand services consider challenging to align their corporate goals with the broader environmental objectives in the new mobility innovation rhetoric. Lagadic et al. (2019) conducted a research on the profitability of carsharing services, including a literature review and a field research in Paris, Copenhagen, Lisbon and Madrid, identifying four types of service providers:

1. carsharing service providers
2. traditional car renters (entering in the carsharing market)
3. OEM with their own service
4. public operators and local authorities

Similarly, Sarasini and Langeland (2021) explored business model innovations among 21 car-sharing operators in four Nordic countries and demonstrated that experimentation with different elements of car sharing business models has the potential to change user practices by modifying their elements or by recruiting new practitioners. Furthermore Antonialli et al. (2018) apply the Product-Service-System (PSS) approach suggested by Tukker (2004) to identify potential uses of AVs. They differentiate the (1) transport of people and the (2) transport of cargo; they could be business models (a) owned by a company (the service provider offers the transportation service including the ownership and maintenance of the fleet) or (b) privately-owned (the individual can offer the transportation service or renting his/her vehicle to a service provider to offer a service). In each option, the authors identify three sub typologies:

1. carsharing
2. ride-sharing
3. last mile issue (divided into carsharing and ride-sharing)

Those authors provide interesting contributions, but they lack an integrative approach. The suggestion of the PSS proposed by Tukker (2004) becomes very interesting to address the gap identified in the current literature on shared, connected and autonomous transport for passengers, namely a classification of business models.

Application of the Conceptual Framework to ACT

In order to classify viable business models regarding Autonomous and Connected Transport, the first step was understanding the core characteristics they should possess. New business models in mobility should shape their value proposition through a clear vision of their differentials, the identification of customer needs, the integration of stakeholders in co-creation process, and the enhanced capability of visualisation. They should be able to integrate new activities such as data analytics, connectivity, or software, while understanding market unsatisfied needs through collaborative processes. The managers of traditional or emerging business have to deal with cross-cutting products, technologies, user diversity, and very specific needs. Only upon these foundations it will be possible to find a sustainable and recurrent revenue stream, ranging from diversification and adaptation of current products to providing specific service solutions to specific user profiles and market segments. The capacity to reconfigure the key competencies of the firms and the continuous learning is essential, but also the capacity to personalize offerings and additional services linked to data analytics (e.g., consulting, product/service maintenance and performance analysis). Those findings require an internal reconfiguration of resources, the broader skills and knowledge (e.g., sociology, computing) and interdisciplinary teams are essential to take advantage of new mobility solutions. Managers may encourage the technical integration of different interfaces and databases from multiple systems to extract value from data, but they should also keep data manageable and generate confidence through transparency during data storage and use. And also require external resources, due to the complex environment. Following the social network theory, the capacity to establish strong ties with core partners, but also weak ties with potential partners is essential. Particularly, the creation of a collaborative ecosystem with strength sufficient to attract public and private investment with a mentality of spreading the benefits through the different partners.

The application of the PSS approach is useful in the classification of new business models, as it allows to reflect the efforts required to attend market needs. It includes ‘pure product’ where owning a vehicle is central, and the technological products and after-sales services are the core business. A series of ‘additional services’ in the opposite, including data management and personalized services, and entertainment, among others. In the middle of the PSS, it is possible to differentiate product oriented, use oriented and service-oriented business models.

In the first, the user belongs the vehicle, but is interested in sharing it to afford some costs; in this context appears repair and maintenance service expenses and functional designs specialised in sharing, and app and software developers that let contact offer and demand. The second, the use oriented provides a solution for a transport user, e.g., ICT, platforms, geo-location systems, fleet management, environmental information, and e-marketplaces are important in this category. Some examples are carsharing, ridesharing, micro-transit, Transport Network Companies, among others. The final group includes integral solutions for transport, combining different modes of transport with additional services to improve the experience of the clients: routing, ticketing, reservation of parking, as example. A series of new business models can arise, in the integration of operators but also as facilitators of services that make this transport possible. In summary, each type of approach has its specific characteristics, and provides both advantages but also disadvantages for users. The managers have to clearly identify their business model to ensure that they are viable in the long-term.

Future challenges and policy recommendations

As suggested, a series of future challenges arise as outlined in the previous sections. Firstly, the capacity to anticipate market needs in the mobility field, that will necessarily go through data analytics to attend social requirements. Thus, it is a must to deploy interdisciplinary teams within or across companies. This trend, jointly with the higher and unstoppable servitisation of mobility (MaaS) will result in more personalised or on-demand services. This means that the companies may be flexible in their configuration and they should have an open mind to creatively attend customers (either companies or final customers) needs. The combination of new proposals to market, like specific solutions or new products or services, will benefit from the data analysis and the higher personalisation as an outstanding revenue stream. This perspective can enhance customer experience and the adoption of ACT. Regarding public policies, they should provide support to those collaborative ecosystems with a high interdisciplinary nature, both vertically but also horizontally within the value chain. R&D efforts should consider this interdisciplinary approach, favouring the inclusion of companies with the initial idea, but also the participation of facilitators and users that can provide an integrated approach to solve mobility problems. It means including, not only companies or researchers and not only working about the technical perspective, but also focusing on market applications since it is the route to market which is currently missing.

Chapter 5
Conclusions

Autonomous and Connected Transport has arrived as a 'motor of change' with several effects on the traditional mobility systems. Of course, there are advantages and disadvantages in its implementation, but many questions are still pending to be answered. The current report provides an overview about advances made and evidence available to researchers participating in the WISE ACT COST Action who have focused on the business challenges of ACT. Of course, the consequences on the transport system efficiency or in the monetary cost of mobility is dependent upon its many drivers and constraints. The technology, particularly that related to high-speed data transmission networks and the related infrastructure, and the adoption in real business models remains an unknown element in terms of market value. In this path, the public administration should establish the guidelines for the adoption of the innovation defining a stable scenario for its application. In parallel, businesspeople and managers should understand the possibilities of the technology, but also the social needs it seeks to satisfy. Indeed, the public sector emerges as at least as important as the private sector in this sociotechnical partnership, playing the role of economic development agency and regulator of the transport system for social and environmental purposes as well as economic connectivity. These two roles have at least the potential to be in conflict.

In this regard, this report provides a series of recommendations within the transport domain, defining the long-haul road freight, trans-modal shipments and last-mile deliveries areas as those of particular interest, providing some suggestions for businesses participating in these markets. Furthermore, the report defines a series of capabilities required to make new business models viable, providing a classification about where the value-added lies for the different entrepreneurial activities emerging from ACT. While it is acknowledged that self-driving is a core competence i.e. necessary, it is by no means sufficient to create a new profitable business since optimising large fleets increases requirements at a geometric scale (Gindrat, 2020). In either case, data management, incentive customisation, inter-disciplinary teams, the necessity to go beyond technology and the emergence on niches are advisable for those businesses which intend to compete in this field.

Regarding the public sector, it is striking how many governments globally wish to establish their nations as global leaders about ACT and new mobility services. By definition, it is simply not possible for every state to be a leader. In particular, it is a huge challenge for European companies to compete with the investment models of the United States, with its widely available private venture capital finance, and China, where the Government offers what sometimes may seem as limitless 'grands projects'. Hence, two contrasting models of the national priorities for ACT place in a delicate position an industrial sector which Europe also regards as critical. This current weakness needs to be addressed through action at European level, taking advantage of the strong R&D partnerships existing between industry, academia and policymaking. Based on strong public support and respecting societal values through participatory and democratic approaches could form the foundation for a European sustainable business model to emerge as a valuable option in the contemporary fluid ACT business eco-system.

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Notes

1 A Business Model describes how value is created, delivered, and captured for a firm and its customers (Osterwlader and Pigneur, 2010).

2 The online-only supermarket Ocado already has an almost fully automated order fulfillment warehouse, and companies such as DHL and Amazon have many facilities with a high level of automation.

3 https://www.gov.uk/government/organisations/centre-for-connected-and-autonomous-vehicles

4 https://www.legislation.gov.uk/ukpga/2018/18/contents/enacted

5 https://www.lawcom.gov.uk/project/automated-vehicles/

6 https://zenzic.io/

7 https://www.gov.uk/government/collections/future-of-mobility

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