Deliverable **D1.5** /

Trends and business scenarios

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List of abbreviations and acronyms

Abbreviation	Meaning
5G	Fifth generation technology standard for cellular networks
ABS	Antilock Braking System
AD	Automated Driving
ADAS	Advanced Driver Assistance Systems
ADF	Automated Driving Functions
ADS	Automated Driving Systems
AI	Artificial Intelligence
AR	Augmented Reality
AV, AVs	Automated Vehicle, Automated Vehicles
B2B	Business to Business
B2C	Business to Consumers
BC	Business Case
BEV, BEVs	Battery Electric Vehicle, Battery Electric Vehicles
BM	Business Model
BMW	Bayerische Motorenwerke
BNEF	Bloomberg New Energy Finance
CACC	Cooperative Adaptive Cruise Control
CAGR	Compound Annual Growth Rate
CAM	Center of Automotive Management
CEO	Chief Executive Officer
CO2	Carbon Dioxide
CoP	Code of Practice
COVID-19	Corona Virus Disease 2019
D1.5, D1.6	Deliverable 1.5, Deliverable 1.6
DDT	Dynamic Driving Task
e-mobility	electric mobility
EC	European Community
EDR	Event Data Recorder
EICT	European Center for Information and Communication Technology
ESC	Electronic Stability Control
EV	Electric Vehicle
EU	European Union
EUCAR	European Council for Automotive Research and Development

Abbreviation	Meaning
FCA	Fiat Chrysler Automobiles
FCEV, FCEVs	Fuel Cell Electric Vehicle, Fuel Cell Electric Vehicles
FIA	Federation Internationale de l'Automobile
g	Grams
GA	General Assembly
GDP	Gross Development Product
GEAR2030	High-level group for the future of automotive sector established by the European Union
GM	General Motors Company
HMI	Human Machine Interface
HQ	Headquarters
ICE	Internal Combustion Engine
ICEV, ICEVs	Internal Combustion Engine Vehicle, Internal Combustion Engine Vehicles
IoT	Internet of Things
ISA	Intelligent Speed Adaption
IT	Information Technology
ITS	Intelligent Transport Systems and Services
ITS-5G	European implementation of WLANp for Intelligent Transport Systems and Services
Km	Kilometre
kWh	Kilowatt-hours
L3, L4, L5	Level 3, Level 4, Level 5
LIDAR	Light Detection and Ranging
LTE	Long Term Evolution (4th generation of technology standard for cellular networks)
ML	Machine Learning
NEDC	New European Driving Cycle
NOx	Nitrogen Oxides
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
P2P	Peer-to-Peer
PESTEL	Environmental Areas: Politics, Economy, Society, Technology, Ecology, and Legislation
PHEV, PHEVs	Plug-in Hybrid Electric Vehicle, Plug-in Hybrid Electric Vehicles
Q1-2019	1st quarter of 2019
R&D	Research and Development
RADAR	Radio Detection and Ranging
RDW	Rijks Dienst Wegverkeer (Netherlands Vehicle Authority)

Abbreviation	Meaning
SAE	Society of Automotive Engineers
SAV, SAVs	Shared Automated Vehicle, Shared Automated Vehicles
SDV	Software Defined Vehicle
TNO	Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (Netherlands Organization for Applied Scientific Research)
U/I-Matrix	Uncertainty/Impact-Matrix
UK	United Kingdom
U.S.	United States
UNECE	United Nations Economic Commission for Europe
V2X	Vehicle to X (X like infrastructure, other vehicles, …)
VRU	Vulnerable Road Users
VW	Volkswagen
WLTP	Worldwide harmonized Light vehicles Test Procedure
WP	Work Package
ZEV	Zero Emission Vehicles

Executive Summary

The L3Pilot project tests and studies the viability of automated driving as a safe and efficient means of transportation and explores new mobility services to provide mobility for the people. The project focusses on large-scale piloting of primarily SAE level 3 functions (SAE – Society of Automotive Engineers), with additional assessment of some SAE level 4 functions. The key to the success of automated driving (AD) on the market will depend on user acceptance as well as on a common understanding of legal restrictions, which first need to be discussed and resolved at an international level. Nevertheless, the large majority of people do not have any experience with vehicle automation even though new vehicles are increasingly equipped with advanced driver-assistance systems (ADAS) of SAE level 1 and 2. Therefore, the future of AD market introduction and user acceptance is still uncertain. In addition, the development of the required infrastructure with its very high investments and the agreement on a harmonized legal framework are big challenges without satisfying solutions so far. Given these uncertainties with regard to the future deployment of AD technology and its market implementation the applied L3Pilot *Exploitation and Innovation Approach* is based on a broad and open model that deals with a range of different business environment scenarios (1), and novel business models for new mobility solutions and possible deployment perspectives (2). The first is part of the present deliverable, the latter will be provided with D1.6 *Deployment strategies and business models for ADFs (automated driving functions)*, the second deliverable of work package 1.4.

Based on an outline of the so-called megatrends, which are expected to have a significant influence on the automotive industry, five key automotive business trends have been derived and their significance for the future automotive business environment has been discussed. The results of the trend analysis have then been reflected in the scenario development process. Since trends do not really allow making reliable statements about the speed of change and unexpected events, a structured scenario approach has been applied to deal with the long-term uncertainty of the future AD-related business. Guided by the research question *"What could the European business environment for AD-related business models look like in 2030?",* four plausible future business environment scenarios – **AD Paradise**, **Tantalus**, **Slowly but Surely**, and **Tech Push** – have been elaborated in a collaborative and participatory process that involved the whole L3Pilot consortium, an internal expert team, and external experts. *AD Paradise* describes the ideal environment for AD-related business since matured technological capabilities are accompanied by a significant increase in societal acceptance. *Tantalus*, named after the Greek mythology character, is also characterized by a high societal acceptance rate but the technological progress shows only an evolutionary increase. *Slowly but Surely* indicates a rather slow development for AD-related business. Technological progress follows an evolutionary development and societal acceptance is stagnating. Finally, in *Tech Push* the technology is in place but societal acceptance hampers AD business. For each scenario, a one-pager story and a complementary illustration as well as an animated video (https://www.youtube.com/watch?v=xCFkLaYEpK8) have been created as means for communication.

The four business scenarios are quite different regarding their framework conditions for AD-related business. Furthermore, critical driving forces like political support, harmonization of legislation, and infrastructure investments are expected to have a significant influence on the viability of future business models. Therefore, a detailed list of scenario-specific opportunities and threats has been derived and evaluated by external experts and the project internal core team, all representing different stakeholders from the automotive industry, academia, public authority, government administration, and a user organisation.

Finally, recommendations for strategic action for the stakeholders involved in AD business have been provided. Since L3Pilot is a multi-stakeholder project with a large consortium consisting of big automotive industry players, public authorities, user organisation, and academia, there is an accumulation of power that has the ability to influence future development. The recommendations on how to shape the future have been divided into 1) general recommendations, 2) stakeholder specific recommendations and 3) major conflicts that need to be resolved.

General recommendations focus on the need for cross-stakeholder cooperation to accumulate power. In addition, AD should be seen as a user-centric approach in the context of the entire mobility system.

Automotive industry players have to follow high safety, security, and reliability standards. Their business models need to concentrate on the customer value in use and embed them in the humans' life in a broad and powerful ecosystem. Politics and administration have to develop a legal framework on an international level, organize the infrastructure build-up, and manage the overall change of the traffic system. Academia should foster the innovation process and act as a trustful holistic assessor of AD.

However, the key challenges are the conflicts between different stakeholders; like conflicts between AD-related business models and urban transport plans (e.g. Robo-Taxis might create unwanted additional road traffic and cannibalize the urban public transport system). Ways for a fast and comprehensive build-up of AD infrastructure have to be found. The current corona crisis and its rather uncertain short-term and mid-term consequences make that even more challenging. Data-related business models conflict with viability and data privacy and security. Attractive solutions for customers' comfort should be found targeting the problem of a new comfort promise because of the relief from driving tasks and the discomfort caused by taking over requests in critical situations. These are only a few of the described conflicts.

Finally, an outlook on further activities of WP1.4 (WP – work package) is given. In deliverable D1.6 *Deployment strategies and business models for ADFs,* AD-related business models will be described and discussed, as well as the related conflicts. In addition, AD-related roadmaps will be analysed against the background of the business environment scenarios, and deployment perspectives for automated driving will be evaluated.

1 Introduction

1.1 L3Pilot project

Over the years, numerous projects have paved the way for AD. Significant progress has been made, but AD is not yet ready for market introduction. Nonetheless, the technology is rapidly advancing and is currently at a stage that justifies automated driving tests in large-scale pilot programmes. L3Pilot is taking the final steps before the introduction of automated cars in everyday traffic. The issues of automation will not be resolved simply by integrating more and better technology. The key to the success of AD on the market will depend on user acceptance as well as on understanding of the legal restrictions, which first need to be discussed and resolved on a broad level. Thus, the overall objective of the L3Pilot project is to test and study the viability of automated driving as a safe and efficient means of transportation and to explore and promote new service concepts to provide inclusive mobility. The project will use large-scale testing and piloting of AD with developed SAE Level 3 (L3) functions (Figure 1.1) exposed to different users and mixed traffic environments, including conventional vehicles and vulnerable road users (VRUs), along different road networks. L3Pilot will focus on large-scale piloting of ADFs, primarily L3 functions, with additional assessment of some L4 functions.

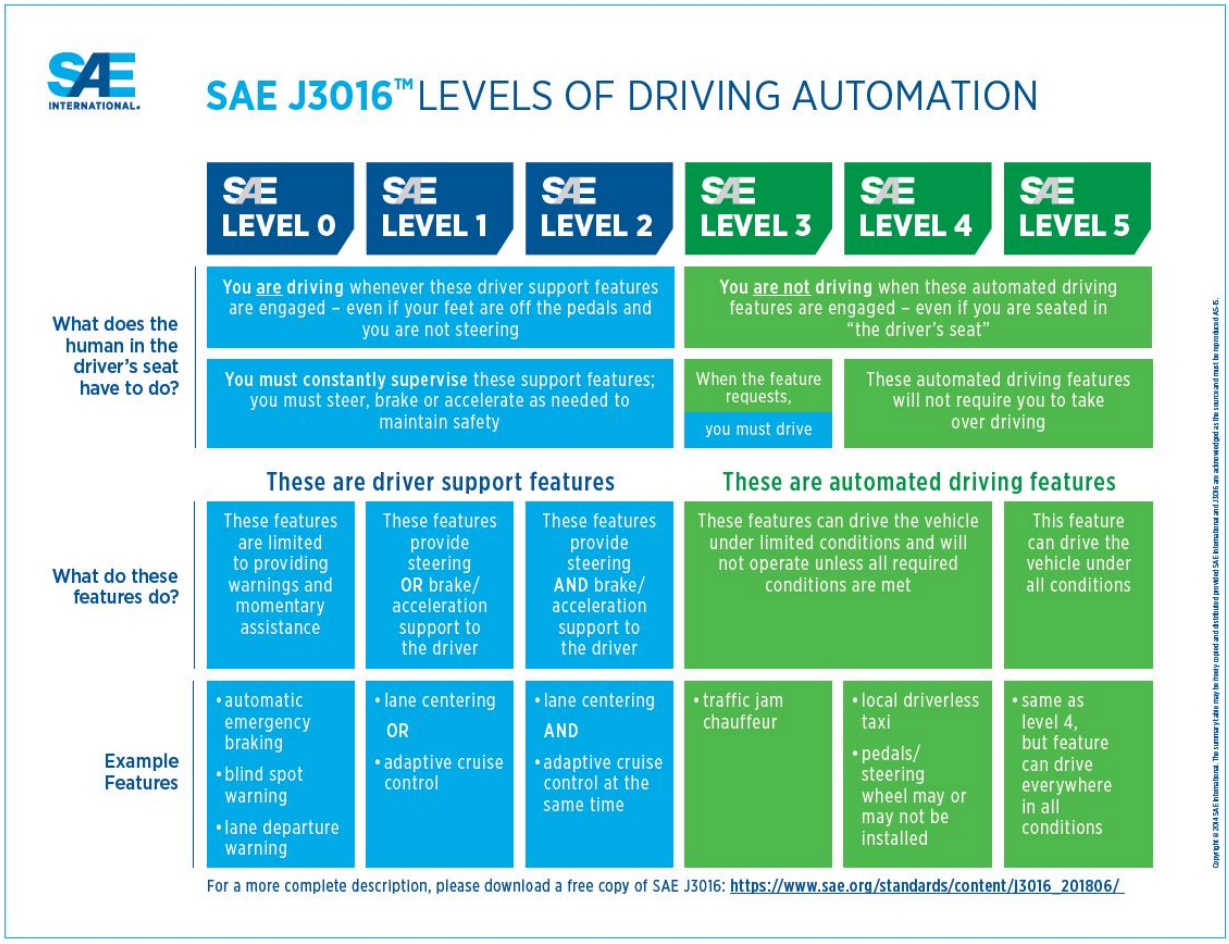


Figure 1.1: SAE Levels of driving automation J3016 (Copyright 2018 SAE International).

The key in testing is to ensure that the functionality of the systems used is exposed to variable conditions and that performance is consistent, reliable, and predictable. This will enhance a successful experience for the users (Figure 1.2). A good experience of using AD will accelerate the acceptance and adoption of the technology and improve the business case to deploy AD. The L3Pilot consortium brings together stakeholders from the whole value chain, including OEMs (original equipment manufacturers), suppliers, academic institutes, research institutes, infrastructure operators, governmental agencies, the insurance sector, and user groups. Since the development of ADFs, especially at SAE L3, is relatively well progressed, the aim is not only to pilot the ADFs, but also to study user acceptance and evaluation, reactions, and willingness to use vehicles equipped with such functionalities. This information leads the consortium to create plans for the market introduction of AD.

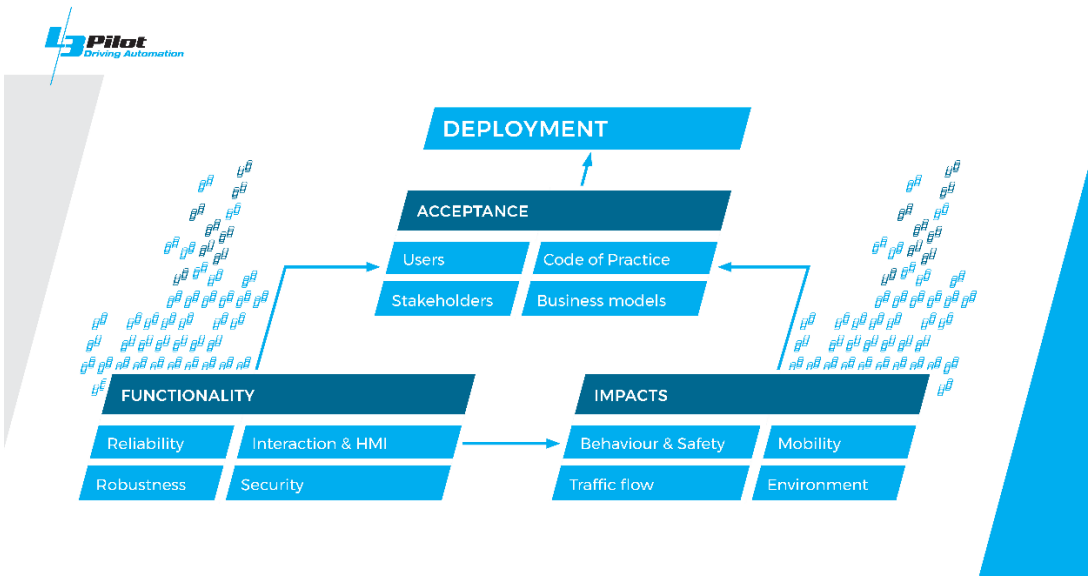


Figure 1.2: L3Pilot approach and the mechanism for deployment.

1.2 Role of the exploitation and innovation work package in L3Pilot

Since the SAE L3 functions tested in the project are relatively mature AD technologies, the work package *Exploitation and* Innovation aims to explore and promote new service concepts providing new mobility solutions, and studies the deployment potential for the market introduction of AD. The large European consortium of key players along the automotive value chain will accelerate the progress of automated driving functions. However, AD technology beyond SAE L2 is not yet on the market, and the large majority of people do not have any experience with vehicle automation, even though new vehicles are increasingly equipped with ADAS of SAE L1 and L2. Therefore, the future of AD market introduction and user acceptance is still uncertain.

1.3 Exploitation approach – development of future scenarios

The exploitation and innovation approach applied in L3Pilot has to deal with this uncertain future for the deployment of automated driving technology. Even experts' expectations and trend analyses diverge when it comes to the evaluation of speed and intensity of major future developments and trends, like the application of artificial intelligence, connected mobility, vehicle electrification, sharing models, etc. That will deeply influence the automotive business in general and automated driving in particular.

Otherwise, automotive industry players but also public authorities and decision-makers are eager to shape their desired future making automated driving success or promoting their interests with regard to the transformation of future mobility. Given the uncertainty of long-term future developments (10 years and more ahead), the L3Pilot exploitation approach is based on a broad and open model that deals with a range of different business environment scenarios, novel business models for new mobility solutions, and possible deployment perspectives.

The methodological approach of *scenario development* provides a structured method to describe and analyse alternative future developments instead of only one trend-based development[1] and allows to derive recommendations for action on how to prepare for these possible futures. Moreover, the scenario development is conducted as a collaborative process that elaborates scenarios in a participatory way and involves different stakeholders (L3pilot project internal and external) with their interests, perspectives, and expertise. This is seen as one of the method's major success factors.

With the business environment scenarios, a solid knowledge base and an orientation for private and public decision-makers will be offered to jointly design viable and sustainable future mobility solutions and thus to have a significant impact on the future deployment path of the European automotive industry.

1.4 Content and structure of the deliverable

This Deliverable, *D1.5 Trends and Business Scenarios*, is the first out of two deliverables of work package WP1.4 Exploitation and Innovation. D1.5 presents the development process of business environment scenarios for automated driving in the year 2030 and discusses recommendations for strategic action in order to shape or at least influence future development. Based on the findings of D1.5, the second deliverable D1.6 *Deployment strategies and business models for ADFs* will provide viable business models for AD and elaborate their fit to the possible future business scenarios developed.

The present deliverable is structured as follows: First, an overview of major automotive business trends is given, including a discussion of their status quo, expected future developments, and their impact on automotive business (chapter 2). This is followed by an analysis of the current automotive driving-related business strategies of the OEMs and some of the key tech companies in this field. Next, the methodological approach and the implementation of the scenario development process are described. This also contains the scenario descriptions and visualizations, and the evaluation of the scenarios (chapter 3). Chapter 4 then provides a detailed discussion of recommendations for strategic action and outlines major conflicts between different stakeholder groups that might occur with the market implementation of automated driving. Finally, an outlook of the second deliverable on viable business models for AD is given (chapter 4.4) and the impact of the business environment scenarios on the deployment perspectives of the automotive industry is shown (chapter 5).

[1] Nevertheless, major future trends for the automotive and mobility business provide the starting point for the scenario development process.

2 Automotive business trends

2.1 Overview of global megatrends

The following chapter focusses on future changes, which are expected to have a big influence on the automotive business. As a first step, an overview of so-called megatrends is given. From these megatrends, automotive business trends are derived and described in detail as a second step. Finally, the significance of these trends for the future automotive business environment will be discussed.

Megatrends “are transformative, global forces that define the future world with their far-reaching impacts on businesses, societies, economies, cultures, and personal lives” (Frost and Sullivan, 2016).

The literature on megatrends is manifold and differentiated (examples see Frost and Sullivan, 2016, Z. Punkt 2019 and Roland Berger, 2019). However, some key megatrends are affecting the automotive business, which can be found in the majority of the reports.

Climate change is the number one risk to our planet. It includes both global warming driven by human emissions of greenhouse gases and the resulting large-scale shifts in weather patterns. While there have been previous periods of climate change, changes observed since the mid-20th century have been unprecedented in rate and scale (Allen et al., 2018). The issue came to international public attention in the late 1980s but with regional differences with regard to public and private concerns and understanding. Anyhow, in recent years and especially with the global *Fridays for Future* movement, mainly driven by the younger generation, a new momentum has been generated and climate change ranks among the first topics on the global political agenda.

Demographic change describes current trends in population development. It focusses in particular on the changing age structure. In most developed countries, two long-term demographic trends are observed: birth rates below replacement fertility combined with rising life expectancy. The consequence is a major demographic change with a shift of the age composition: demographic ageing. An ageing society leads to many challenges and requires various response strategies, like supporting demographic renewal, boosting employment and raising productivity as well as ensuring health and long-term care to manage the demographic change (European Commission, 2006).

Social disparities or social inequality is one of the major problems of the contemporary world. Significant geographical disparities exist within nations of the developed world, as well as between these countries and the so-called developing countries (Stillwell, 2010). These regional but also group and ethnic disparities and inequalities cause many problems with regard to the coverage of basic needs, access to health care, education, and securing livelihood. This again causes serious political and social conflicts for societies and leads to a polarisation of societies and even to wars and increasing global migration.

Global power shifts from the western world to a new world order under an Asian/Chinese dominance is seen by many experts at least for a decade. The global prosperity guaranteed by American power and underwritten by an ever-expanding world market dominated by the West started to falter with 9/11 and the global financial crisis of 2008. Hence, the balance of power is shifting towards Asia and China. Many experts even expect a new disorder of the world. The tensions between Russia and the West are currently increasing. Ongoing conflicts in the Middle East and the election of Donald Trump in the U.S. lead to more and more uncertainties and instability in the international system. Europe is losing international significance, the Brexit is additionally challenging European stability (LSE, 2017).

Urbanisation refers to the population shift from rural to urban areas. It describes the process by which towns and cities are formed and become larger as more people begin living and working in urban areas. It is predicted that by 2050 about 64% of the developing world and 86% of the developed world will be urbanized (The Economist, 2012). Even today, megacities in Asia are home to more than 20 million people and the growth is rapidly increasing. With regard to this development, urban agglomerations are facing major challenges when it comes to the supply of the population with healthy food, housing but also city traffic, clean air and to secure a good quality of life for all urban citizens. In addition, rural areas are suffering from this trend, too, e.g. degrading healthcare infrastructure, food supply, or public services.

Digitalisation is one of the most influential global megatrends. It has fundamentally changed the foundation of all activities in the economy, society, and politics and will continue to do so. Digitalisation describes the process of converting analog information into a digital (i.e. computer-readable) format. The result is the digital representation of an object, image, sound, document, or signal. Digitalisation is crucial for data processing, storage, and transmission as digital data can more easily be shared and accessed (TechTarget, 2020). Technology trends emerging as a result of digitalisation, such as IoT (Internet of Things), AI (Artificial Intelligence), data analytics utilizing Big Data, and AR (Augmented Reality), not only have a considerable impact on society and the working environment but also business operations in industry. Despite the comprehensive advantages that digitalization brings, there are also critical voices as they can have a negative impact on working life and the economy. These technologies and structures may be a threat to many professions and in the first step to lower-income jobs. Cybersecurity also became a serious concern for many companies and institutions. Nevertheless, one can also assume that automated work increases productivity and growth and creates new jobs (Oberzaucher, 2009).

Artificial intelligence is intelligence demonstrated by machines, unlike the natural intelligence displayed by humans and animals. The term is often used to describe machines that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem-solving" (Russel et al., 2009). Machine capabilities that are generally classified as AI include speech recognition and understanding, autonomously operating driving functions, intelligent routing in content delivery networks, military simulations, etc. (Allen, 2020). AI research traditionally has been divided into subfields, like robotics, machine learning, logic, or artificial neural networks. These AI fields mainly draw upon computer science, information engineering, mathematics,

psychology, linguistics. During the last decades advances in computer power, large amounts of data, and AI techniques have become an essential part of the technology industry, helping to solve many challenging problems in science and engineering. In addition, AI is applied in more and more areas of life. Given that, there are also concerns raised by people who doubt machines can act and decide like humans based on ethical and moral principles and the ability to empathize.

Sharing economy is an IT-facilitated peer-to-peer model for commercial or non-commercial sharing of underutilized goods and service capacity through an intermediary without transfer of ownership (Schlagwein et al., 2019). There are two main types of sharing economy enterprises: 1) Mostly private, non-commercial initiatives, by which goods and services are provided for free or sometimes for a modest subscription. This type is in the ethos of a sharing economy, which is not intended for any person to make an income, or a profit. 2) Commercial business models, in which a company provides (for a fee) a platform or application that suppliers and customers use to share goods or buy and sell services. While the term sharing economy is widely used, this type of economy is also referred as access economy as it suggests that "access" to goods and services may become more desirable than "ownership" of goods. This collaborative consumption model is increasingly applied in many different areas, like sharing mobility services (car sharing, ride sharing, and bike and scooter sharing), peer-to-peer accommodation (Airbnb), or travel advising. However, despite the many benefits for the users, there are also concerns about the treatment of workers as independent contractors and not employees of companies (e.g. Uber drivers) or the often careless handling of shared goods (like cars, bikes, or scooters).

Sustainability and global responsibility are closely linked with climate change as the number one risk to our planet and hence to our lives. Sustainability focusses on meeting the needs of the present generation without compromising the ability of future generations to meet their needs. The concept encourages framing not only business but also political decisions in terms of environmental, social, and human impact for the long-term. Thus, industry and public authorities increasingly commit themselves to reduce environmental pollution by cutting emissions, lowering energy usage, or sourcing more local and fair trade products. Anyhow, there is still no global commitment to social and environmental standards, and influential states even exit global climate agreements.

Due to the definition of megatrends, they all have a certain impact on the automotive business, too. The following chapter will have a look at related trends with a strong impact on automotive business, derived from some of these megatrends. The trends will be described in detail using the following structure:

- Definition,
- Current status,
- Expected future development and
- Consequences for automotive business.

The following trends, derived from the megatrends, will be described:

- Artificial Intelligence and Big Data
  “Digitalization” with its accelerating creation of a high quantity of data requires the specific capability to fast selection and processing of these “big data”. Algorithms using artificial intelligence are enablers for big data processing.
- Automated driving
  Digitalisation and artificial intelligence are strong drivers and enablers for automated driving. Artificial intelligence is necessary for situation awareness based on a huge amount of data from vehicle sensors and connectivity (V2X – Vehicle to X). Automated driving with its strongly expected positive effect on safety is a part of the megatrend “Global Responsibility”.
- Connected Mobility
  The interlinking of different systems and services both inside and outside a vehicle via internet and their connection to other life spheres is enabled by - and a part of - the megatrend “Digitalisation”.
- Shared Mobility
  The megatrend “Sharing Economy” describes the change from an ownership focussed economy to an economy focussed on usage. Products are paid per use and this use is temporary. Shared mobility is a part of the sharing economy, additionally pushed by the megatrend “Digitalisation”. In addition, it is also supported by the trend to “Sustainability and Global Responsibility”.
- Electrification
  The electrification of road transport is strongly driven by severe emission regulation as a reaction to the megatrend “Climate Change”. Emission regulations are following the megatrend “Sustainability and Global Responsibility”. Ongoing “Urbanisation” requires the reduction of overall local pollution and pushes the electrification of road transport additionally.

2.2 Artificial intelligence and big data

Definition

Artificial intelligence (AI), sometimes called machine intelligence, is ‘intelligence’ demonstrated by machines in contrast to natural intelligence shown by humans. Colloquially, the term "artificial intelligence" is used to describe machines/computers that mimic "cognitive" functions that humans associate with other human minds, such as "learning" and "problem-solving" (Russel et al., 2016).

Sub-elements of Artificial Intelligence with high significance for automated driving are Machine Learning and Deep Learning (see Figure 2.1)

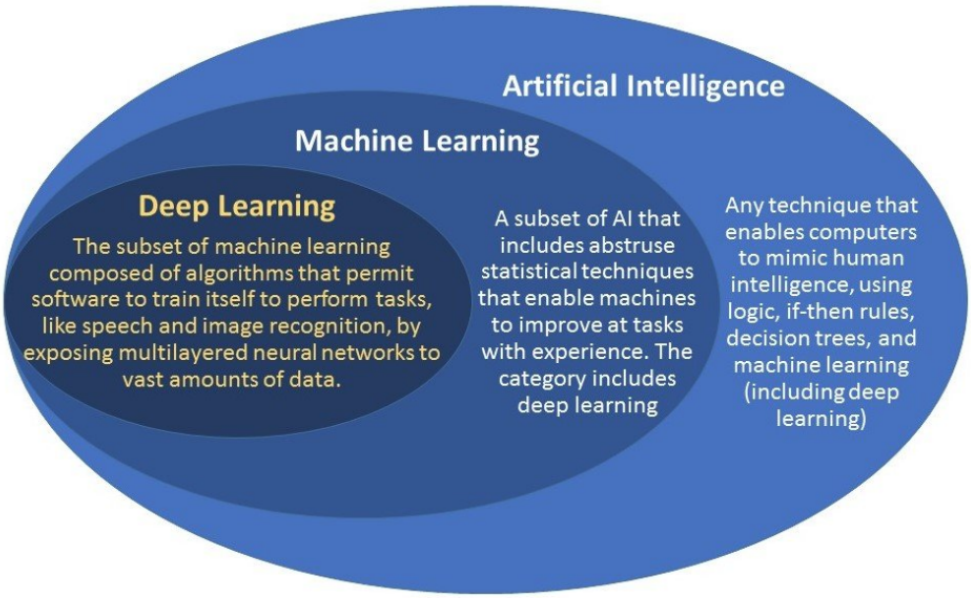


Figure 2.1: Artificial Intelligence, Machine Learning, and Deep Learning (Bhandarkar, 2018).

Big data are high-volume, high-velocity, and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision-making, and process automation (Gartner, 2019).

Current status

There are numerous applications making use of artificial intelligence and big data, e.g. image and speech recognition, consumer behaviour analytics and prediction, Industry 4.0, and modelling of complex systems.

In automated driving artificial intelligence is used to analyse the high amount of real-time data created by vehicle sensors (LiDAR, radar, camera, etc.) and external sources for scene and situation awareness as well as for behaviour prediction of other road users.

The amount of data to be processed has increased continuously over the last decades. The development of the last years and a projection until 2025 is shown in Figure 2.2 (note: 1 Zettabyte is equivalent to 10^{21} byte).

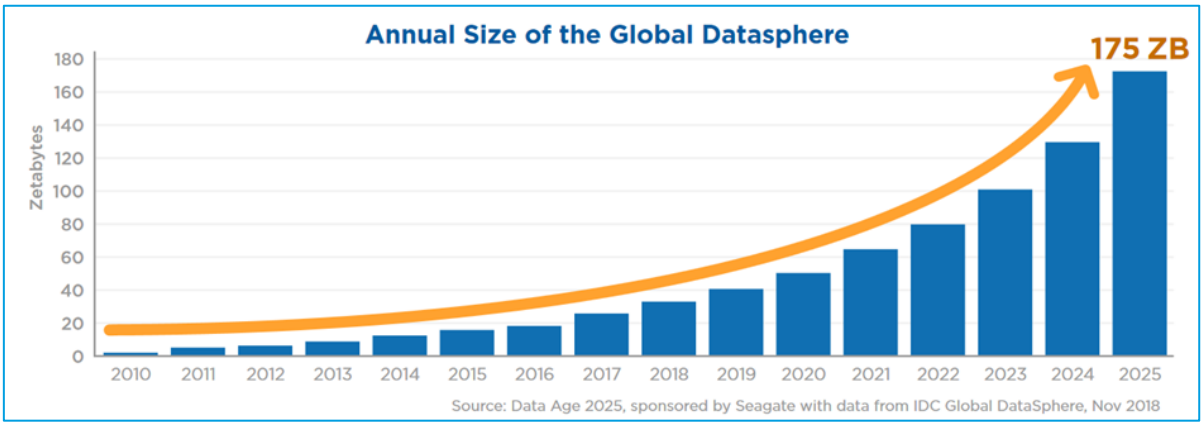


Figure 2.2: Annual Size of the Global Datasphere (Reinsel et al., 2018).

The usage of deep learning as a subset of artificial intelligence has grown strongly during the last years, too (see Figure 2.3).

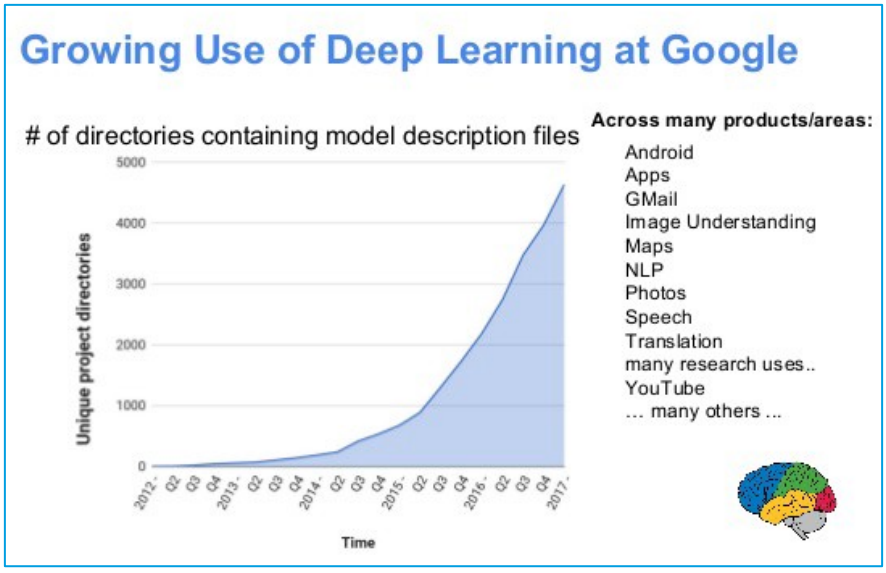


Figure 2.3: Growing Use of Deep Learning at Google (Bhandarkar, 2018).

Expected future development

The development of big data and artificial intelligence during the last years shows strong growth. The growth is exponential rather than linear. Figure 2.2 shows that the ongoing growth of the global data sphere is expected to be more than 25% per year (doubled in less than every three years).

Having a look at expectations for future artificial intelligence revenue, the predicted growth rate might be even higher. Figure 2.4 shows a prediction by the U.S. market intelligence consultant Tractica, expecting an annual global automotive market growth rate of more than 40%. Other

predictions show even stronger growth expectations, e.g., Variant Market Research expects annual growth of the total AI market of about 60% from 2015 to 2024 (Market Watch 2020).

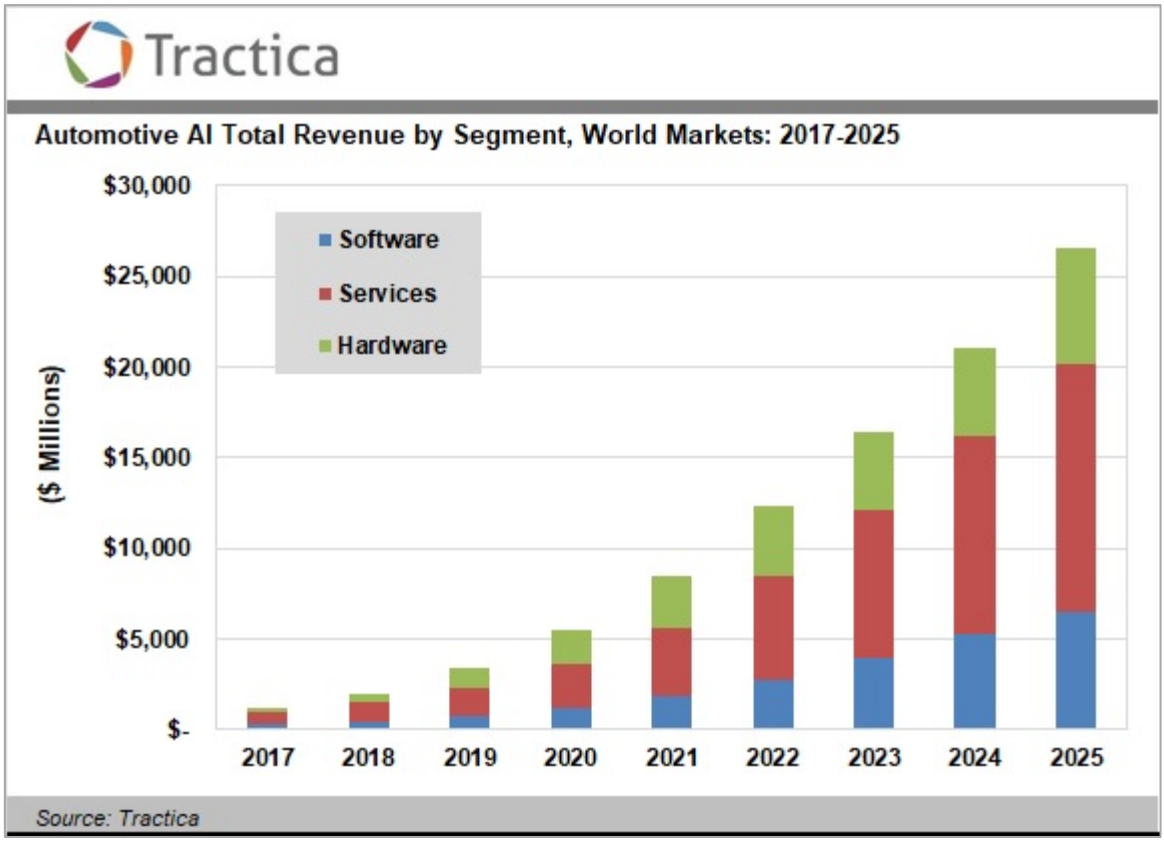


Figure 2.4: Artificial Intelligence Global Automotive Revenue Forecast 2017-2025 (Tractica, 2018).

Consequences for the automotive business (impact)

Artificial intelligence and its sub-elements machine learning and deep learning together with the ability to process so-called big data are key enablers for the realisation of automated driving functions. Especially in image and scene recognition, and in behaviour prediction, high-performance data processing and analytics are essential.

Artificial intelligence is evolving continuously, and experts expect an ongoing growth of performance and applications. An increasing number of AI skilled scientists and engineers are working on advancements and breakthroughs.

However: Will breakthroughs be reached during the next ten years, generating a performance much higher than today, allowing much more sophisticated applications? Or will “only” an evolutionary development of AI performance happen? What about societal concerns like data security, data privacy, and ethical aspects of AI? Will society build up sufficient trust in these new technologies or will the development and application of AI be restricted by societal and political concerns?

AI will develop, but the speed and the extent of the development until 2030 is still an open question. The stronger the development and the application of AI the better the prospects for automated driving. International tech giants and startups are leading this technology and the automotive industry is intensifying its contribution to AI development.

2.3 Automated Driving (AD)

Definition

An automated driving system (ADS) can be described as “The hardware and software that are collectively capable of performing the entire dynamic driving task (DDT) on a sustained basis, regardless of whether it is limited to a specific operational design domain (ODD); this term is used specifically to describe SAE level 3, 4, or 5 driving automation system” (SAE International, 2018).

Indicators for the spread of automated driving are the number of vehicles equipped with ADFs (automated driving functions), the number of automated driven vehicle kilometres, and the regional legalization.

Current status

For a long time after the invention of the automobile, no automation was implemented. That was followed by a phase where automation of vehicles only took place in auxiliary functions (like automatic transmission, ABS – Anti-lock Braking System, ESC – Electronic Stability Control) but not concerning the driving function itself. Related to the SAE level for automated driving, L0 automation (warning functions like blind-spot warning, lane departure warning) have been implemented in the last decade. L1 automation (like lane centering or adaptive cruise control) and L2 automation (like lane centering and adaptive cruise control) are currently available in premium cars. Genuine L3 systems are not yet on the market, rather some vehicles with L3 features with very limited ODD (e.g. on highways with only one-way traffic and good weather conditions). L4 with broader ODD is still far in the future.

Expected future development

There are many trend descriptions for automated driving. All of them expect future growth, but they differ – partly strongly – in the speed of the expected growth.

In a scenario analysis (see Figure 2.5), McKinsey expects a 15% market share of L4 vehicles in 2030 in a high disruption scenario (and a 55% market share of L3+ vehicles). On the other hand, in the low disruption scenario, the L3+ market share will be lower than 3% and the market share of L4 vehicles will be only marginal.

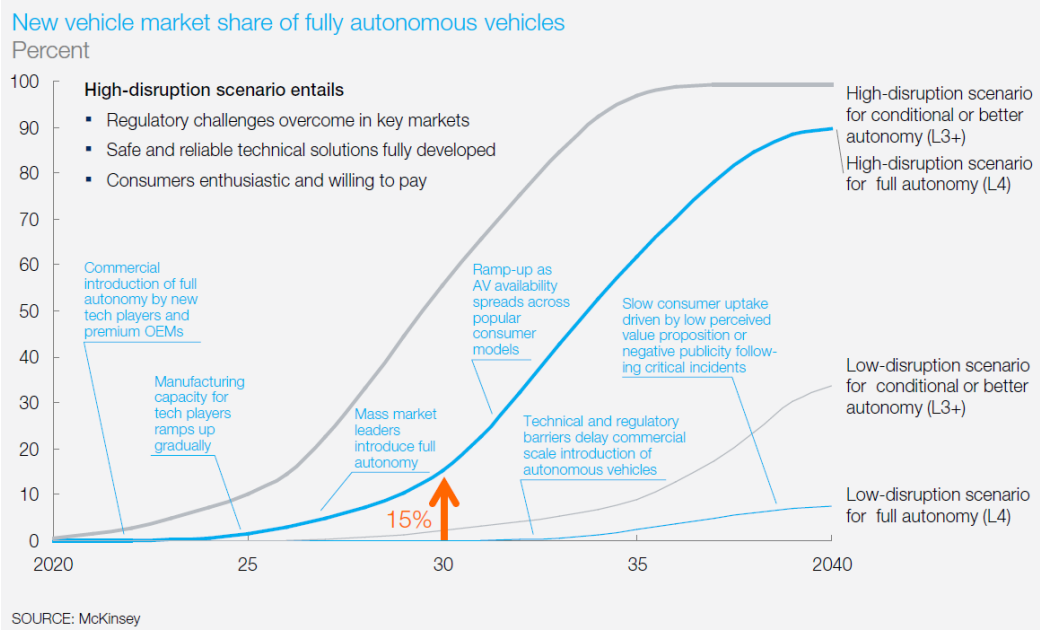


Figure 2.5: Automated vehicles sales scenarios (McKinsey, 2016).

IHS Markit prognoses show 33 million annual sales of autonomous vehicles (L4/5) globally in 2040, about 4 million annual sales in 2030, and 51,000 in 2021 (see Figure 2.6). The report has been issued in January 2018.

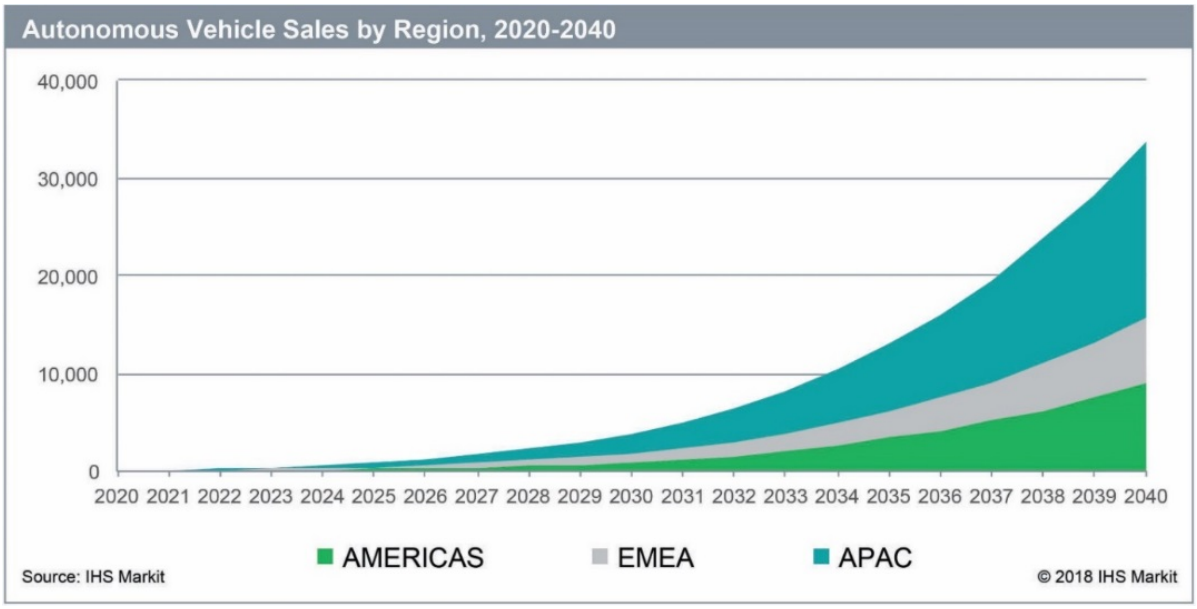


Figure 2.6: Autonomous vehicles sales prognosis (IHS Markit, 2018).

Strategy& (belonging to PwC) expects in its market outlook on autonomous vehicles different market shares of autonomous technologies in 2030. The highest share of about 25% of L4/5

vehicles is expected for Europe, the highest number with 7 million vehicles is expected in China (see Figure 2.7). The Strategy& market outlook was published in 2019.

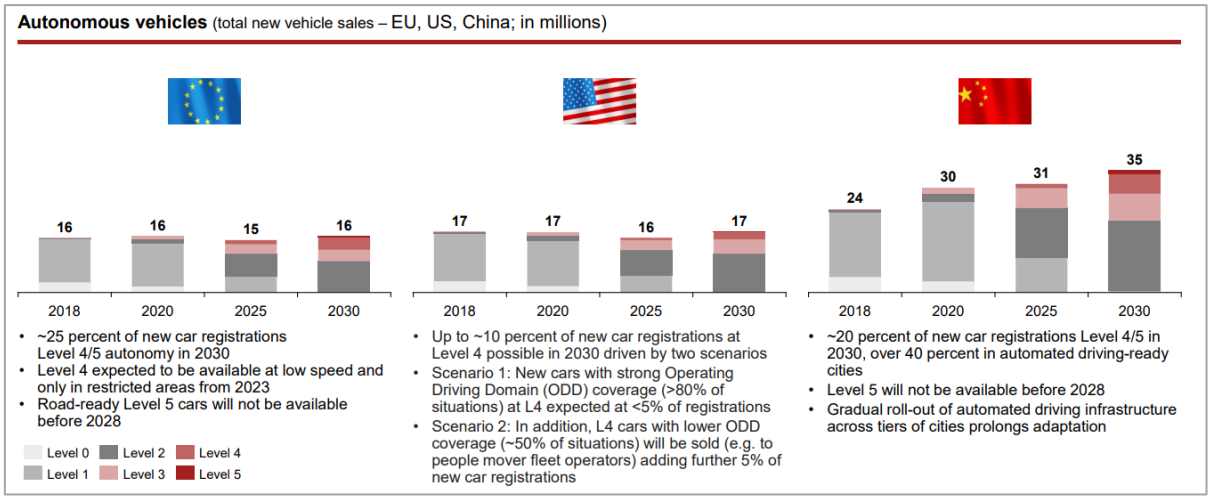


Figure 2.7: Market outlook for autonomous vehicles (Strategy&, 2019).

An aggregated overview of these three projections shows Table 2.1.

Table 2.1: Overview of trend prognosis for global AD vehicle sales[2].

Source	Global L3+ vehicle sales in 2030	Global L4+ vehicle sales in 2030
McKinsey, 2016 **High disruption scenario** **Low disruption scenario**	 44 million 2.4 million	 12 million < 1 million
IHS Markit, 2018		4 million
Strategy& (PwC), 2019	28 million	13.5 million

It is evident, that all analyses see the growth of automated vehicle sales. However, the expected speed of growth differs strongly.

Consequences for the automotive business (impact)

Experts expect growing customer's demand for automated cars in 2030. However, due to prognoses and scenarios, it is still not clear if it will be only limited to the relatively small segment of premium car customers and specific fleet customers or if it will already reach the mass volume segment. Nevertheless, ongoing growth after 2030 is broadly expected. Car manufacturers should prepare for this demand, even though the size of the market is difficult to predict.

[2] McKinsey publishes annual sales shares in percentage. Sales figures have been calculated by own assumption of 80 million total annual sales globally.

Besides, new mobility concepts and business models based on automated driving functions will rise. New market entrants like IT companies and startups are already trying to disrupt the automotive industry with new platforms, concepts, and business models. This is a fight for access to customers. OEMs losing this fight might be downgraded to a supplier of these new entrants.

2.4 Connected mobility

Definition

The term *connected mobility* is used to describe the interlinking of systems and services both inside and outside a vehicle via the internet, allowing a driver (and passengers) to benefit from solutions like keyless access systems, secure parking, warning sensors, and vehicle-to-vehicle or vehicle-to-infrastructure data transfer, etc. (Granath, 2020). Connected mobility is a huge field with an immense potential for applications. However, the connection of vehicles to each other (Car-2-Car communication), to traffic lights, congestion warning systems, and infrastructure (Car2X communication) is still in its infancy today.

Current status

Nowadays, most newly registered vehicles are equipped with advanced driving assistant systems (ADAS) and the integration of mobile devices in vehicles and their connection to the internet are well advanced (Schnurr et al., 2015). Car-2-Car communication is already available in new vehicles, and this trend is accelerating. Such communication enables highly automated and autonomous driving by improving the scene recognition capabilities of a vehicle system. The connectivity with the internet is also used for infotainment services (streaming music and videos or using social media) in the vehicle.

Many applications like Car-2-Car assistance systems or cruise control manage without the need for equivalent infrastructure. In urban traffic, however, intelligent vehicles alone are not seen as sufficient, as infrastructure must be included to keep traffic flowing (Schnurr et al., 2015). Traffic light assistants allow vehicles to communicate with traffic lights meaning that they can adjust their timings and speeds accordingly. Citywide networks of sensors may help drivers to identify empty parking spaces. To extend the line of sight during driving at high speed Car-2-Infrastructure connectivity will be important. It assures sufficient time left for any necessary handover of control to the human driver.

According to Market Research Future, the market for connected vehicles has risen by 45 percent in the past few years. The global market for connected mobility is set to grow by a compound annual growth rate of 19 percent by 2023 (Granath, 2020). Many cities already have examples of driverless transportation, like underground trains, or gain first experiences with small driverless shuttles.

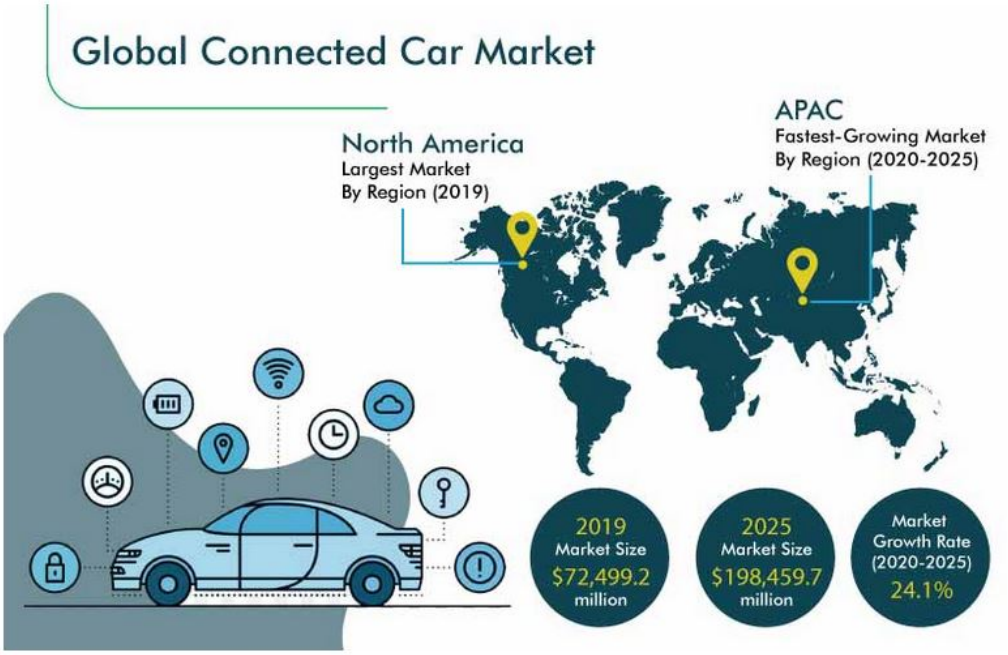


Figure 2.8: Global connected car market (P&S Intelligence, 2020).

P&S Intelligence reports that the global connected car market was valued at $72,499 million in 2019, and it is projected to advance with a compound average growth rate (CAGR) of 24.1% during the forecast period from 2020 to 2025. They defined as key growth factors the demand for an enhanced driving experience and the introduction of the internet of things (IoT) in the automotive industry.

Expected future development

By 2030, McKinsey expects a share of 45% of the global new car sales to be at level 3 connectivity or above (Figure 2.9). In the cited report, McKinsey refers to five different levels of vehicle connectivity (note: these levels are not equivalent to the SAE level of automation) that indicate the different possibilities of service consumptions due to the connected technology (Figure 2.10).

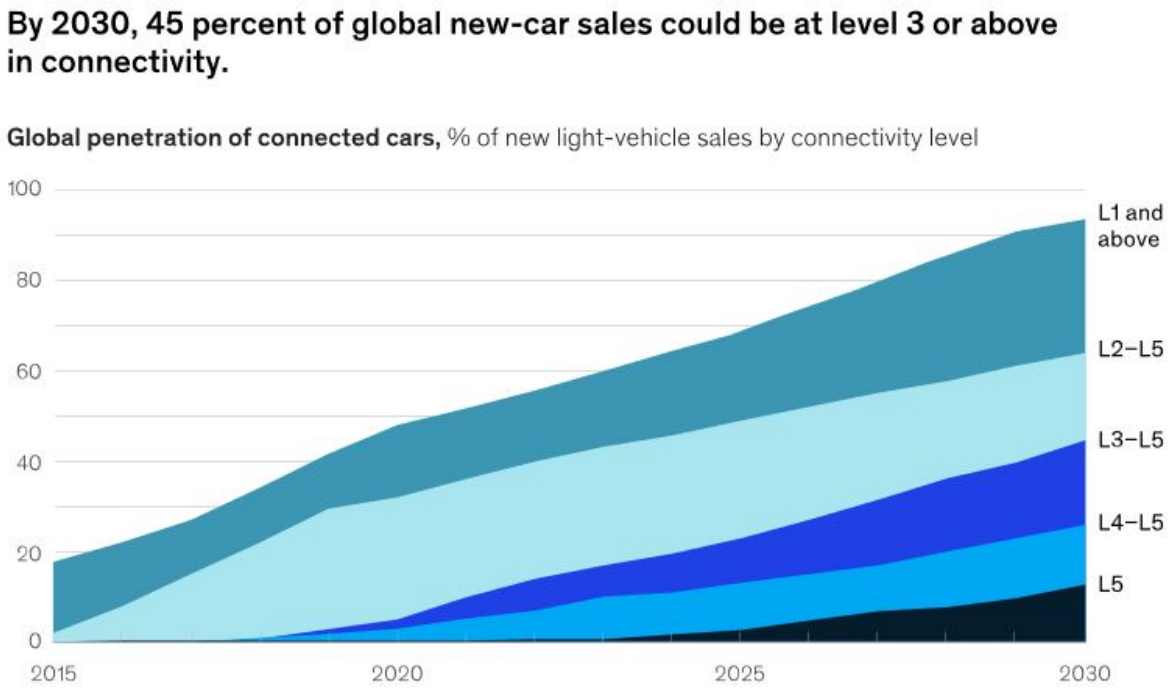


Figure 2.9: Global penetration of connected cars (Moeller et al., 2019).

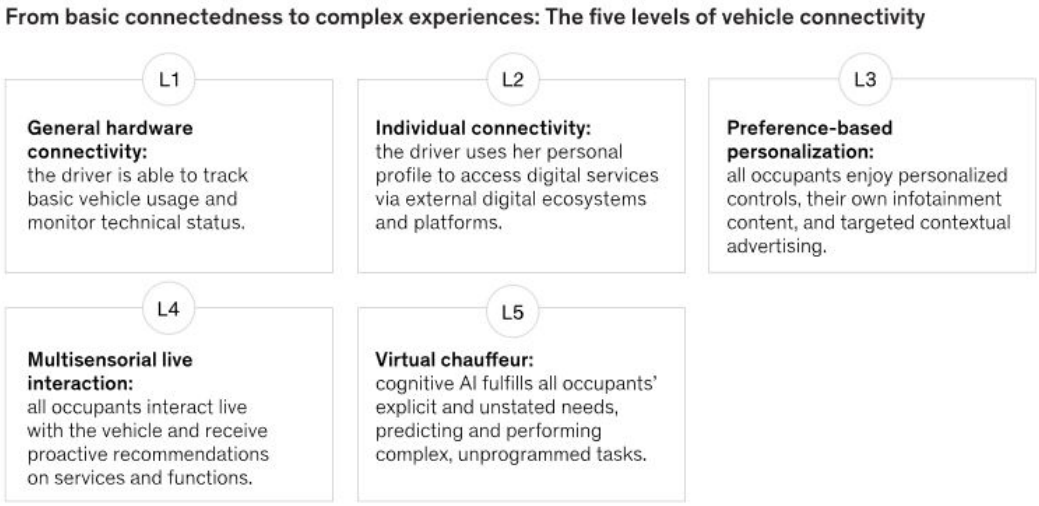


Figure 2.10: Levels of vehicle connectivity (Moeller et al., 2019).

However, there are concerns about the development of connected mobility and barriers to a successful implementation. Especially data security with the potential threat of cyber-attacks against self-driving vehicles is one of the most discussed hindrances. The technology inside and outside the vehicle should be highly tamper-proof and compartmentalized so that if one part fails or is hacked, the other systems remain unaffected (Granath, 2020). Another major hurdle constitutes

the still missing communication standards as well as a lack of harmonized legislation on a supranational level.

Consequences for the automotive business (impact)

The development and implementation of connected vehicles or solutions are not only a solo effort of the automotive industry but rather a collective endeavour of the automotive industry, infrastructure providers, public authorities (municipalities/governments), and the IT sector is needed to develop the full potential of connected mobility. Thus, the development is highly dependent on the technological progress, political support, cross-sector cooperation, and joint investments. The question is how willing the various stakeholders are to work together to bring about interconnected, standardized mobility solutions (Rabe, 2019).

2.5 Shared mobility

Definition

The umbrella term *shared mobility* is broadly used for transportation services and resources that are shared among users, either concurrently or one after another. This includes public transport, micro mobility (bike sharing, scooter sharing), automobile-based modes (car sharing, rides on-demand, i.e. ride hailing), and commute-based modes or ride sharing (car pooling and van pooling) (Shared-Use Mobility Center, 2020). Shared mobility services offer to the customer a cost-effective, sustainable, and convenient alternative to vehicle, bike, or scooter ownership and their options are likely to grow over the next decade. Shared mobility implies a shift from personal ownership of vehicles to shared use of vehicles (privately owned or by fleet owners). Mobility-as-a-Service concepts generally include shared mobility options.

Current status

Shared transportation has grown strongly during the last decade due to growing urbanization and environmental concerns that intensify the need for sustainable travel modes. Simultaneously, advances in digitalisation and connectivity technologies made asset sharing and thus data transfer easier and more efficient. This led OEMs, rental car companies, new mobility providers, and city-sponsored programs to introduce new solutions ranging from large physical networks to mobile applications designed to alter routes, fill empty seats and thus offer flexible on-demand transportation services (Shared-Use Mobility Center, 2020).

Especially cities and urban areas need to combine multiple modes of transport into integrated transport systems to reduce congestion and pollution and hence increase the quality of life (Moeller et al., 2019).

Due to the COVID-19 pandemic, many shared mobility services were suspended or work in ways that differ greatly from their standard operations since March 2020. However, shared mobility services are expected to continuously evolve and add multimodal options for different user scenarios mainly in (sub)urban environment (Moeller et al., 2019).

A consumer survey on shared mobility - carried out by McKinsey - indicates continued growth potential for shared mobility (see Figure 2.11).

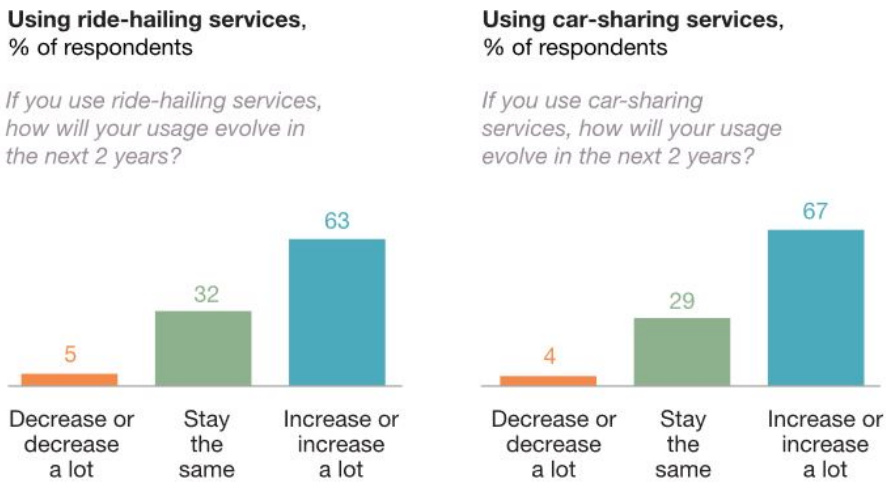


Figure 2.11: McKinsey consumer survey on shared mobility (Grosse-Ophoff, 2017).

Expected future development

The shared mobility market now exceeds $60 billion in value across the three largest markets: China, Europe, and the United States. In the next decade, when self-driving vehicles - Robo-Taxis and shuttles - become more common and leave the current pilot stage, an annual growth rate of 20 percent and above is expected through 2030.

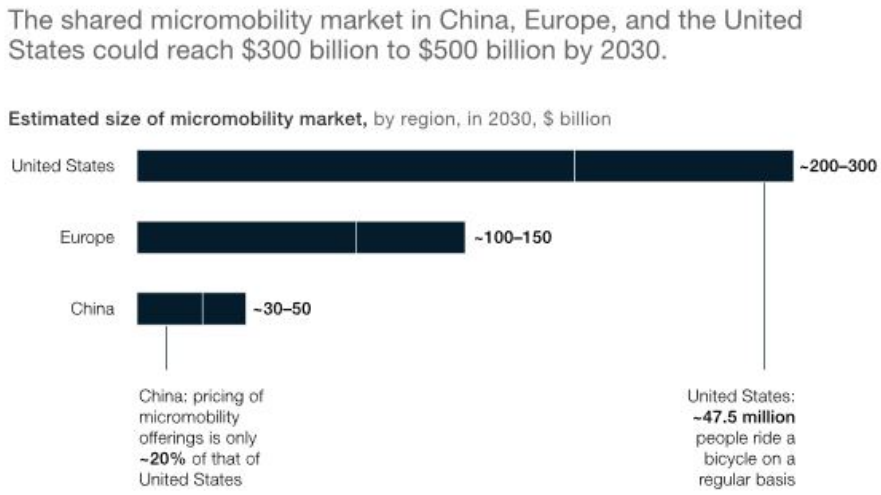


Figure 2.12: Shared micro mobility market by region, 2030 (Moeller et al., 2019).

Consequences for the automotive business (impact)

Automated driving in conjunction with shared mobility has the potential to increase strongly the viability and user base of shared transportation services in the future (Taiebat et al., 2018). The interest in shared automated vehicles (SAVs) increased in recent years due to the popularity of ride-hailing services, like Uber, Lyft. This interest might even more significantly increase in the future with higher levels of automation that enable the ride-hailing providers to offer their services without a human driver/ chauffeur and hence, at much lower operating costs.

Pilots with ride-hailing services and automated vehicles have already been launched. Uber, Waymo, and others have been testing AV ride services. Also, the companies EasyMile and Navya began testing several automated shuttle services around the globe. These services, however, still require a safety driver to closely monitor the system at all times.

Nevertheless, the impact that SAV services may have on travel behaviour, and the usage of other transportation modes remains uncertain. If the rate of shared mobility service users will grow significantly, some studies reveal that roadway capacity may be freed up due to more efficient operations and right-sizing of vehicles (Stocker et al., 2017). On the other hand, SAV services might cannibalize public transport by increasing the number of vehicles on urban roads.

If SAVs will be owned predominantly by fleet owners offering shared mobility services, fewer vehicles will be needed in the future. Then again, the highly used fleet will need to be renewed more often and more innovative vehicles might enter the market in shorter cycles.

Another and very important consequence of increased shared services refers to the change in the customer structure. The switch from using owned cars to shared car fleets changes the OEM business structure from B2C to B2B. That will probably lead to stronger buyer power and smaller OEM margins.

2.6 Electrification of road transport

Definition

Electrification of road transport means changing the power train of road vehicles from diesel or gasoline combustion engine to an electric engine, powered by a battery or a hydrogen fuel cell (BEV - Battery Electric Vehicle or FCEV - Fuel Cell Electric Vehicle). In general, so-called plug-in hybrid electric vehicles (PHEVs) with a combination of a combustion engine drive train and an electric drivetrain are also seen as electrified vehicles. Road transport includes transport by passenger cars, vans, trucks, and busses.

Current status

The electrification of road transport is currently strongly regulation-driven. To reduce CO_2 emissions of transport, the EU government and other governments are stipulating emission values referring to the OEMs´ fleet emissions. To comply with this regulation OEMs have to increase their sales of electric vehicles. To support this market dissemination, various countries are additionally subsidising the purchase of electric vehicles (EVs) as well as the build-up of a charging

infrastructure. The Chinese government also requires a specific share of EV sales of the total OEM sales in China.

The EV sales share in most countries is quite low (see Figure 2.13). The leading country is Norway due to its high financial subsidies, which make EVs already cheaper than cars with combustion engines. On the other hand, countries with a strong own automotive industry like Germany, South Korea, the U.S., France, and the UK show a sales share still low of less than 3% in 2019. The total cost of ownership is still higher for EVs and public charging infrastructure status is quite low.

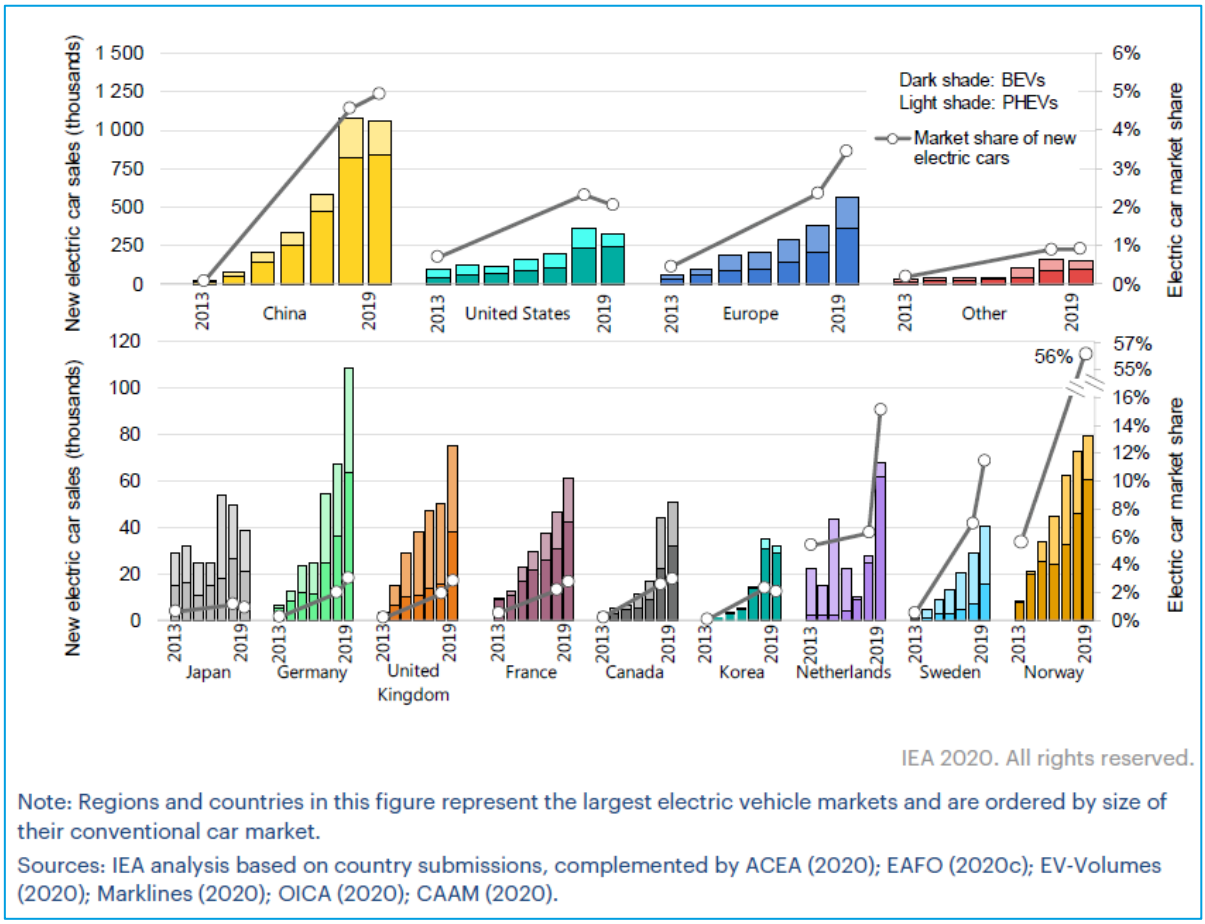
Interestingly, the corona pandemic related strong buying subsidy in Germany is currently boosting EV sales. The market share of EVs (BEVs and PHEVs) in the eight months from January to August 2020 was about 9% (KBA, 2020).

EV sales share in China was fairly high in 2019 with about 4%. The Chinese market is currently not only the globally biggest passenger car market but also the biggest EV market. Regulations e.g. related to car registrations in some cities (with strong advantages for EVs) and the electrification of big vehicle fleets (like taxi fleets) are pushing the sales figures. Starting in 2019, annually increasing EV sales quota for car manufacturers will push electric vehicle sales additionally.

The share of electrified vans and trucks is still quite low. Urban delivery transport shows already some applications of electric vans. Electric trucks´ share is still very low. The share of electric busses in Europe is also very low, but public transport providers have started to order electric buses. Currently, the majority of electric busses is operating in China, where the market share of electric busses was about 80% in 2017 and 2018 (Interact Analysis, 2018), driven by a strong regulation for fleet operators.

Even though there is no strong correlation between AD and electric mobility, future vehicles are often seen both as automated and electric. Especially future AD fleet vehicles - like so-called Robo-Taxis - could easily charge themselves if they would be equipped with an inductive charging system and are expected to need less maintenance work (because of fewer moving parts). Therefore, e-mobility could be an additional enabler or at least supporter for some specific AD-related business models.

On the other hand, the ongoing tightened emission regulation demands a high investment in research and development of new drive trains. For the automotive industry, this investment is competitive to the necessary strong investment in AD technologies.



Note: Regions and countries in this figure represent the largest electric vehicle markets and are ordered by size of their conventional car market.

Sources: IEA analysis based on country submissions, complemented by ACEA (2020); EAFO (2020c); EV-Volumes (2020); Marklines (2020); OICA (2020); CAAM (2020).

Figure 2.13: Numbers and shares of battery electric passenger cars from 2013 – 2019 (IEA, 2020).

Expected future development

There is a clear expert expectation for the future of the electric vehicle market: Growth, strongly driven by an ongoing tightening of CO_2 emission regulation. Electric vehicles are an essential part of the solution. Lowering the CO_2 emission of European passenger car vehicle fleets to 95 g/km until 2021 and additionally reducing them by 35% of the 2021 level until 2030, seems to be impossible without an increasing share of electric vehicles. In addition, the goal to improve air quality in European cities was followed by the regulation of NOx and particle emissions. Bans on old diesel vehicles on some inner-city streets or in some areas have been already decreed in 2018 and 2019.

Both goals, improved climate protection and improved urban air quality, encouraged a lot of countries and municipalities to announce plans for phasing out the registration of ICEVs in general or to ban ICEVs completely from city centres or wider urban regions. All analyses and reports on prognoses or projections of future EV sales are based on growth expectations but differ in the expected speed of growth. Depending on driving factors like regulations, cost, performance of battery technology, infrastructure development, and customer acceptance, future sales expectations are differing by 100% to 200%.

Bloomberg New Energy Finance develops annually EV outlooks up to 2040 (see Figure 2.14). The major findings of this graph are the following: Different institutions expect different future developments for the global market development of electric vehicles, and they increased their ten to twenty years´ forecast from year to year. Moreover, they all expect ongoing growth.

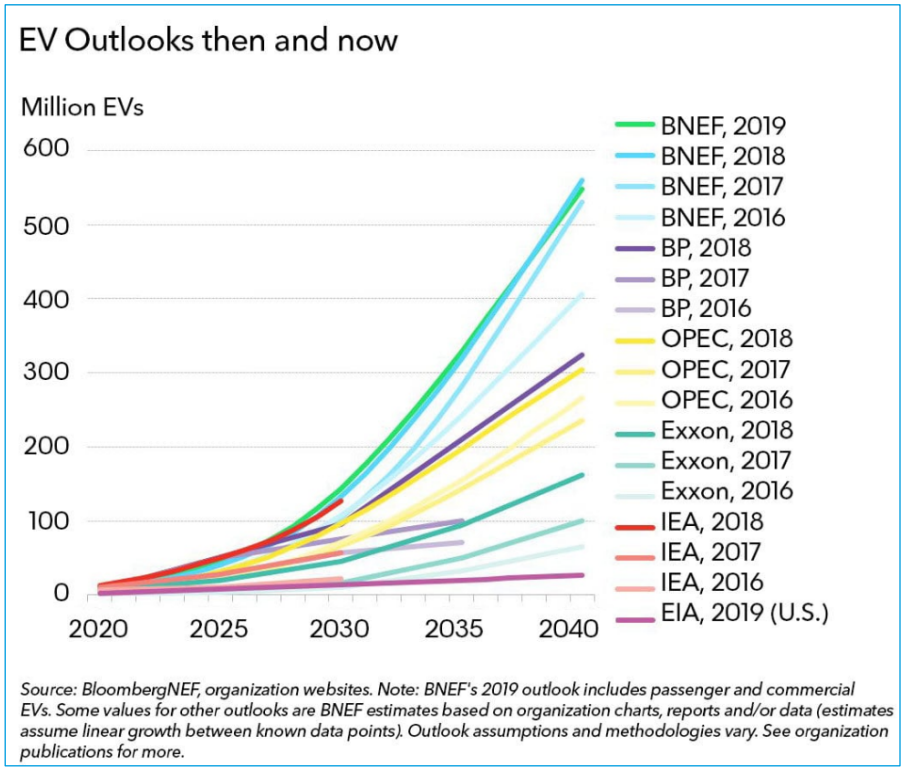


Figure 2.14: Different EV outlooks from BNEF and others (BNEF, 2019).

Reasons for the different outlooks are differing estimations and assumptions for the development and the effect of the driving forces.

The German Center of Automotive Management (CAM) carried out a scenario analysis for the future market dissemination of electric vehicles in different global regions. The results for Europe are shown in Figure 2.15.

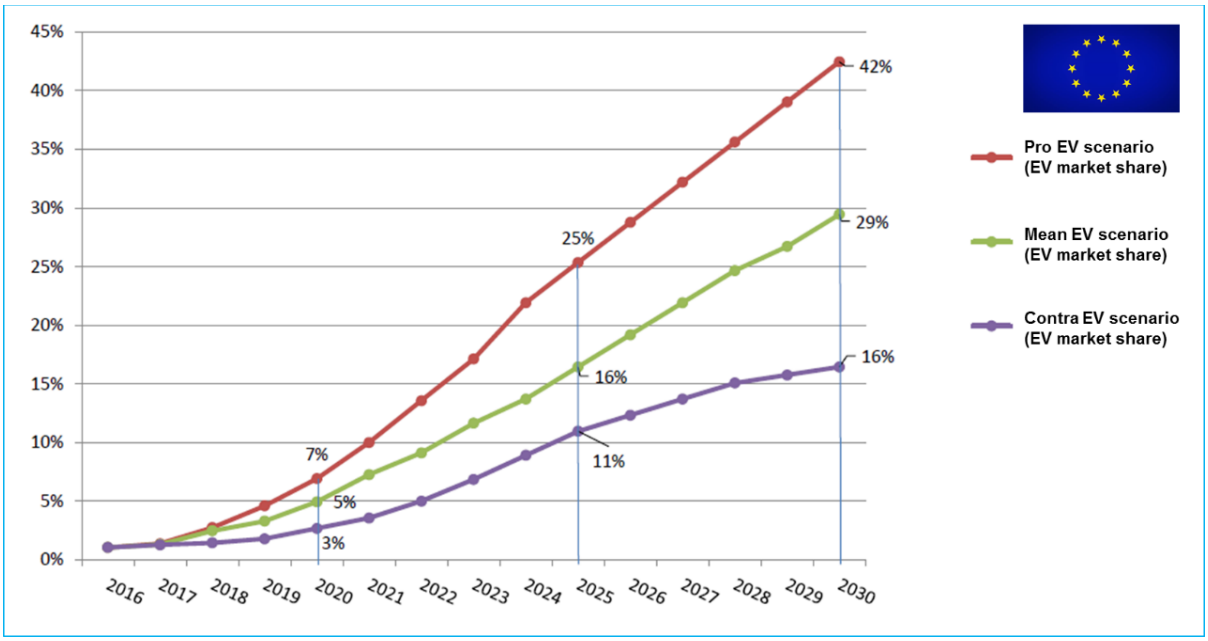


Figure 2.15: Market share scenarios for electric passenger cars and light commercial vehicles in the EU until 2030 (Bratzel et al., 2017).

For the different CAM scenarios, the framework conditions are explicitly mentioned. The Pro EV scenario e.g. is based on low battery cost (65 €/kWh), extensive charging infrastructure with EU-wide standards for easy billing and paying, broad EV product portfolios of all OEMs, big mobility-on-demand-fleets, strong CO_2 emission regulations (49 g/km), high fuel taxes for gasoline and diesel, restrictions for ICEVs in cities, etc.

Another source, the EV outlook done by Bloomberg NEF expects an EV market share of about 52% in 2030, which is an additional 10% higher than the CAM Pro EV scenario.

The CAM contra EV scenario is characterised by e.g. higher battery prices (120 €/kWh), economic gas-powered cars as an alternative to EV, mass segment vehicle portfolio rather small, range anxiety still relevant, charging infrastructure insufficient, not EU wide standardised, only slightly tightened CO_2 emission regulation (49 g/km), low restrictions for ICEV, effective exhaust aftertreatment for ICEVs reduces pollution, etc.

The differences in the driving forces lead to a differentiation of the 2030 EV market share from 16% to 42% in Europe (or from 2.4 million EVs to 6.2 million EVs in 2030).

Consequences for the automotive business (impact)

Experts agree on the growing importance of electric mobility with an increasing market share of EVs in the future. They do, however, not agree on the speed of growth and the extent of growth until 2030. The higher the growth rate is, the faster the automotive industry has to transfer its product portfolio from ICEVs to EVs. In addition, the faster the transfer will happen, the more the

automotive industry needs to invest in EV technologies (and e.g. battery factories). This investment will be in direct competition with investment in AD technologies. This is a key impact of vehicle electrification on the development of AD technologies.

2.7 Current AD-related business strategies of OEMs

Automotive original equipment manufacturers (OEMs) of course are observing the above-described trends and are integrating them in their future strategies. The following chapter gives an overview of current AD-related strategies of OEMs and some tech companies.

The automotive industry is expecting a fundamental change in its business environment with strong consequences for its business. In 2015, Mary Barra, Chief Executive Officer of GM already said, "I think there's going to be more change in the next five to ten years than there's been in the last 50" (Barra, 2015). Two years later, Dieter Zetsche, former CEO of Daimler, is cited with the following statement, "The all-important question is: how do we permanently succeed in driving disruptive changes ourselves and not being driven by digitization?" (Zetsche, 2017). Not as an answer to this question, but as a strategic statement, Herbert Diess, CEO of Volkswagen, said, "We will not become disrupted, we are the disruptor" (Diess, 2018).

They all expect that the traditional business model of the automotive industry (manufacturing, sales, and after-sales of passenger cars and commercial vehicles, complemented by financial services around these businesses) will increasingly come under pressure. For long-term prosperity, new business models with big growth potential should be developed to be brought into the market successfully.

To drive this change (instead of being driven) car manufacturers have to follow an ambidextrous approach: On the one hand, they strongly have to invest in new technologies and in new business models based on the key future trends like connectivity, automation, electrification, and sharing economy. As these markets are just developing and growing (but on a still low level) a positive return on investment will become very difficult to achieve during the next years. Therefore, car manufacturers have to go on with the exploitation of their traditional business models to generate the necessary profit to be able to do the necessary investments in new business models.

In the following, an overview is given about the AD-related aspects of the business model transformation. Three archetypes of AD-related business models are described and some car manufacturers and other players are allocated exemplarily to these archetypes.

AD-related archetype I: Product driven business models

Product driven business models are strongly based on the key product of the automotive industry, the car. In this traditional business model, currently, ADAS are sold as optional equipment to customers. L1 and L2 ADAS are already offered to customers by many car manufacturers, L3 systems are just coming on the market. Systems' sales are the key revenue driver, increasingly supplemented by offers for later updates. This business model will create a continuous revenue stream for car manufacturers and will achieve both profits for financing further AD-related

investments and reducing the manufacturing cost of AD-related components (like sensors) by economy of scale.

AD-related archetype II: Service driven business models

As traditional automotive services are mainly understood as financial services and after-sales services, future AD-related services have to be seen much broader. Instead of focusing the services on the car, future AD-related service will be dedicated much more to the customers themselves. Especially a broad range of mobility services (e.g. car sharing, ride sharing, ride hailing) can be strongly pushed by AD technologies. Beyond that, AD systems enable the driver - when the system is in self-driving mode - to use the driving time for other activities, e.g. to consume time-based, location-based, or other services. The development and implementation of these types of service-driven business models are challenging car manufacturers. It is a new type of business, very different from traditional business and it needs new skills, processes, customer relationships, and cooperation. In addition, big tech companies like Google appear in both forms, as new competitors as well as possible partners for these new mobility ecosystems.

AD-related archetype III: Data-driven business models

Automated vehicles with their big number of sensors are generating many data (e.g. on traffic situation, road conditions, road environment). In addition to that, drivers being exempt from the driving task as well as other passengers might also be a big source of data (e.g. via connected devices). Based on these data and additional connected services (e.g. from smart home, smart cities), business models, which are completely new and not yet existing up to now, can be created to deliver a total life sphere ecosystem to consumers. Some car manufacturers already started with related activities in this field, but tech companies are strongly ahead.

Status quo and outlook

Figure 2.16 is giving an overview of the three AD-related business model archetypes with some positioning examples of car manufacturers and some other companies (not exhaustive).

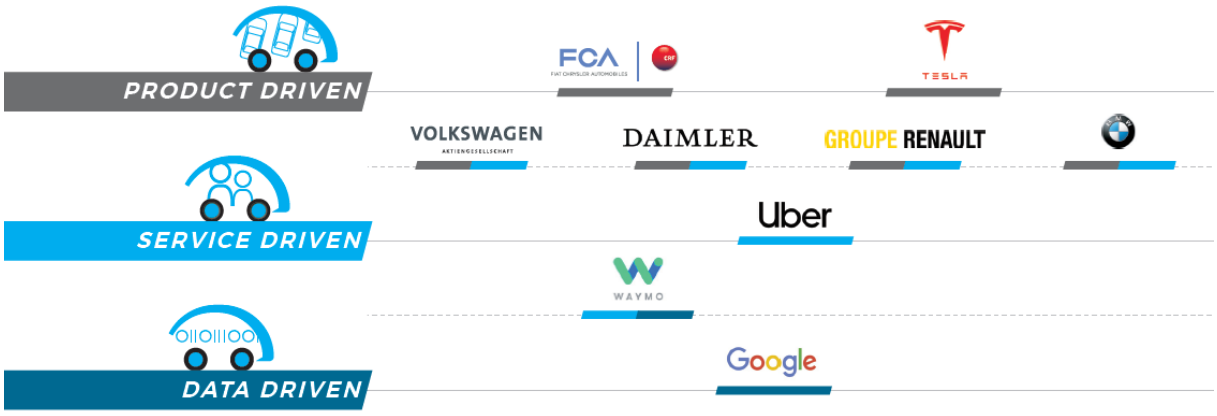


Figure 2.16: AD-related business model archetypes and exemplary allocation of automotive and other players (own graph, not exhaustive).

TESLA, offering an “auto-pilot” as optional equipment but still not engaged in mobility systems, and FCA, delivering AVs to the Waymo fleet, are both currently focussing on product-driven business models. Various car manufacturers like VW with its mobility services brand MOIA or Daimler and BMW with its YourNow joint ventures are already offering a bundle of mobility services that might be strongly boosted in the future by AD technologies. Renault at least is announcing comparable business models for the future. Mainly service driven is Uber, offering ride hailing services (and partly delivery services) in various countries. Alphabet Inc. with its subsidiaries Google and Waymo is one of the global leaders in data-driven business models. While Google´s business model is strongly data-driven, Waymo connects these data with AD-related mobility services.

Recently, more car manufacturers are discussing or even announcing their entry into further (AD-related) service-driven business models. Beyond pre-competitive cooperation in public-funded research projects like L3Pilot, new alliances and partnerships inside the automotive industry are built (e.g. Daimler/BMW, VW/Ford) as well as cross-sector cooperation (e.g. VW/Microsoft, VOLVO/Uber), to share their expertise and the huge investment costs for technology development and business ramp-up.

However, these activities are increasingly influenced by the current economic conditions for the automotive industry. Global trade conflicts, decreasing GDP growth, and decreasing passenger car markets (-5% globally from 2018 to 2019 and -9% in the Chinese Market) (VDA, 2020) have stressed the European automotive industry already in 2019. The current COVID-19 pandemic with its never seen steep decrease in sales for some single months (e.g. car sales in Western Europe have been reduced by 40% during the first half year of 2020 compared to 2019) (Automobilwoche, 2020) is a serious and strong additional challenge. Consequently, the automotive industry is intensively assessing its business segments to conserve their necessary financial liquidity and stability. Companies are placing back, reducing, or focusing their investments. As an example, Daimler announced to focus their SAE L4 and L5 automated driving technology stronger on the truck sector, where automation can reduce the cost for the drivers (Kaellenius, 2020). For

passenger cars, the activities will be stronger focused on SAE L3 functions. In addition, investments for mobility services has been adapted. Various other automotive companies are currently acting similarly. Opposite to that, there are no announcements of companies like Google, Waymo, or Amazon, related to reductions of their efforts. The risk that the European automotive industry loses the connection to these big tech companies is increasing.

2.8 From trends to scenarios

At a first glance, megatrends and their derived sub-trends provide a good orientation for future development. Artificial intelligence will evolve, and the number of applications will increase. This will boost autonomous driving technologies and connected mobility. An increasing sharing economy will boost shared mobility. In addition, tightened emission regulation driven by stronger climate protection pushes the dissemination of electric mobility. These are experts' mainstream expectations.

The quoted statements of automotive executives like Mary Barra, Dieter Zetsche, or Herbert Diess in the previous chapter demonstrate that the automotive industry is aware of these expectations and derives its strategies on this base. Nevertheless, the current (2020) strongly challenging situation for the automotive industry indicates, that trends do not necessarily happen continuously and linearly. In addition, it makes clear that mainstream expectations might also fail. In fact, there are also experts whose assessments of the future differ from mainstream expectations. Therefore, relevant questions related to so-called megatrends are questions like: Will these trends evolve slowly or fast, evolutionarily, or revolutionarily? Will there be breakthroughs or not, or might trends even break? All this depends on additional factors and driving forces.

Society is currently ambivalent regarding the acceptance of artificial intelligence and automated driving. The question is: Will that ambivalence remain, or will it change? What about the legislation: Will it be changed to allow AD with a handover of responsibility to the AD system or will it be hindered by societal concerns on safety and data privacy, ethical questions, or slow standardisation of testing and certification?

Considering all those, there is high uncertainty about the long-term future development related to the change speed of megatrends and the future status of additional driving forces. That means there is also a high uncertainty about how the long-term future environment of AD-related business models will look like.

To deal with this long-term uncertainty, a scenario approach has been applied in L3Pilot. This approach offers the opportunity to work with differentiated future developments instead of only one trend-based development. The applied scenario method and the results are described in the following chapters.

3 Business environment scenarios

3.1 Research question

Scenario development is a method to describe possible futures. To carry out a scenario process, a research question has to be defined first. The research question contains a regional scope, a time scope, and a subject scope. For the scenario development in L3Pilot, the following research question was defined:

"What could the European business environment for AD-related business models look like in 2030?"

Why has this question been raised?

Subject scope: Exploitation activities in L3Pilot shall specify, in which way the results of the L3Pilot project will be utilised later, e.g., how gained knowledge will be used, which developed technologies will be brought into the market, and which business models can be commercially sustainable? To cover all these aspects, the "business environment for AD-related business models" was defined as the subject scope. It focusses on all relevant environmental aspects for future AD-related business models.

Regional Scope: L3Pilot is a European Union co-funded research project. It aims at the demonstration of AD functions in various European countries, as one step to push automated driving technologies and applications in Europe. Even though the European automotive industry is acting globally, the focus on European society, market, and infrastructure is reflected in the defined regional scope "European".

Temporal Scope: The next decade is seen as a decade of big changes in the automotive industry.[3,4] Automated driving is besides digitalisation, electrification, connectivity, and sharing economy expected to be one of the strongest driving forces for this big change. To cover this decade and its possible changes completely, the year 2030 has been defined as the temporal scope.

3.2 Scenario method

As the future is uncertain, we have to be prepared for alternative futures. The longer the time horizon, the more uncertain it is. The scenario method offers a structured approach to develop alternative futures. In addition, the scenario method provides and structures a collaborative

[3] Marry Barra, CEO of General Motors: "I have no doubt that the automotive industry will change more in the next five to 10 years than it has in the last 50." (https://www.fleetowner.com/blog/gm-s-barra-next-decade-bring-big-automotive-changes, 2016)

[4] Dieter Zetsche, CEO of Daimler: "The German automobile industry will change more in the next ten years than it has in the last 100 years." (https://www.mobilitaet-von-morgen.de/6-dialog-en/changes-are-not-a-threat-but-an-opportunity?lang=en , 2017)

process, to elaborate scenarios in a participatory approach, involving different stakeholders with different perspectives as an important success factor.

An overview of the different steps of the applied scenario method[5] is shown in

Figure 3.1:

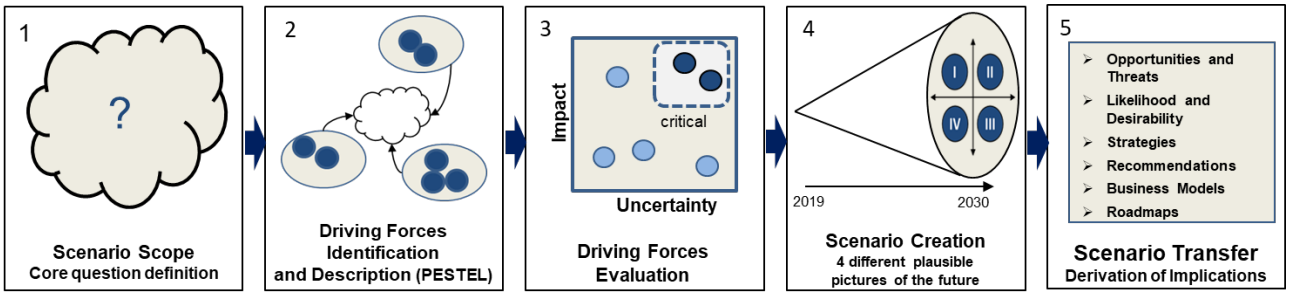


Figure 3.1: 5-steps scenario approach (own graph).

The first step is the definition of the focus of future analysis. This includes a temporal scope (year), a spatial scope (regional framework), and a content scope (subject context). It is often formulated as a question (so-called scenario core question), which provides the starting point for the next step.

The second step is the identification and description of the driving forces. Driving forces are influencing factors that have a significant impact on the core question. They are often structured by macro-environment areas, such as politics, economy, society, technology, ecology, and legislation (so-called PESTEL areas, by their first letters). The description of the driving forces includes a definition ("What does it mean?"), a description of the present ("What is the current status?"), and a description of alternative future options A and B. With these options A and B, two different and plausible future developments of the driving forces are described. Finally, explanations of possible reasons for the occurrence of the two future options A or B are given.

As the third step, all driving forces are assessed regarding their impact on the core question and the uncertainty of occurrence. The aim is to identify those driving forces that have both a high impact and a high degree of uncertainty. From a system dynamics point of view, these driving forces are critical driving forces.

As the fourth step, two of the critical driving forces are used to build a scenario cross, in which the four possible combinations (two driving forces which two options each) form the basis for four different plausible scenarios. Each of these four scenarios will then be enriched with all the remaining driving forces by deciding for each of the remaining driving force whether option A or option B will fit better to the scenario. This was done through a discussion in the WP1.4 team using the reasoning from the descriptions of the driving forces. These reasons connect the driving forces

[5] The term scenario method is a generic term and covers a lot of slightly differing methods with the same goal: Developing alternative futures as a basis for strategic planning. The method for the L3Pilot scenarios has been selected because it is participative, collaborative, efficient, and proved.

with each other. After the clear assignment of the driving forces´ options to each scenario, an embodiment or interpretation of the scenarios can be carried out. A combination of verbal description and visualization (graphics, photos, or videos) supports the communication and the understanding of the similarities and differences of the four scenarios.

The fifth step focusses on the derivation of implications. First, opportunities and threats are derived from the four plausible scenarios and their specific strengths are assessed for each scenario. Second, desirability and likelihood of every scenario are evaluated. Third, strategies and recommendations for action are created based on the opportunities, threats, desirability, and likelihood. Fourth, the consequences for business models and roadmaps are analysed.

For the development of strategies and actions, there are two different approaches to choose from. The first focusses on robust strategic actions, which are promising in all or at least the majority of the scenarios. This is often accompanied by specialized actions that promise success only in one or two scenarios. In that case, the development of the driving forces over time has to be observed and the strategies and actions should be continuously checked and adapted. This is a typical approach followed by enterprises, which have no or only minor direct influence on the business environment itself.

The second approach focusses on “Shaping the future”. Based on an evaluation of the desirability and likelihood of the four scenarios, strategies and measures can be developed that are designed to actively shape the future towards the most desired scenario. The stronger the assertive power of the institutions involved in scenario development, the greater the opportunity to actively shape the future.

As L3Pilot is a multi-stakeholder project joining forces from the automotive industry, academia but also public authorities and a user organization, it has a strong potential to influence future development. Therefore, the approach “Shaping the future” has been followed.

3.3 Scenario process

The scenario development was mainly done by a core team consisting of the following L3Pilot WP1.4 partners, representing different stakeholder groups:

- EICT (SME)
- FIA (User groups)
- RDW (Public authority)
- TNO (Research institute)
- VW (OEM)

The methodological lead was at EICT. For selected purposes, internal and external experts have been involved.

The whole process relied strongly on a participative approach with various workshops:

a. **Core team workshop in The Hague (step 1/2)**
   The core question (research question) and the first list of driving forces were created and discussed. Driving forces descriptions were distributed.

b. In between: Driving forces descriptions done by the core team, discussed and revised in telcos.

c. **Scenario WS @ General Assembly in Athens (step2/3)**
   The scenario approach in general and the drafts of the driving forces´ descriptions were presented. About 50-60 GA participants discussed and reviewed intensively the driving forces´ descriptions and evaluated the driving forces related to their impact on the core question and the uncertainty of occurrence (using the wisdom of the crowd).

d. **Core team workshop in Athens (step 4)**
   Based on the Uncertainty/Impact Matrix (U/I-Matrix), the scenario cross was developed in intensive discussions and the scenarios were enriched by allocating the options of the future status (A or B) of all other driving forces.

e. **Core team workshop in Berlin (step 4)**
   After the driving forces options´ allocation, the key elements of the scenario stories were elaborated. The scenario stories follow the idea of reporting a typical day of a person in the respective future. These descriptions were jointly conceived in the core team.

f. In between: Scenario stories were elaborated in distributed roles and reconciled with each other.

g. **Core team workshop in The Hague (iteration of step 2/3)**
   Three additional driving forces were created, discussed, and integrated into the scenarios (after an EICT internal review). Iterations are a part of the scenario method and can be carried out whenever necessary during the scenario process.

h. In between: Scenario visualisations created by EICT and reconciled with each other.

i. **Expert interviews (step 5)**
   In a series of personal and telephone interviews, project-internal and external experts have each been confronted with two of the four scenarios[6]. The experts were asked about their personal view on these scenarios, their view on desirability and likelihood of these scenarios, about the respective opportunities and threats for different stakeholders, as well as about possible strategies and actions to actively shape the future to reach the most desired one. The experts involved stem from different areas: automotive industry, mobility

[6] Due to complexity reduction for the interviews only two (out of four) scenarios were discussed with each expert during an interview. Generally, the opposite scenarios “AD Paradise” and “Slowly but Surely” or “Tech Push” and “Tantalus” were part of the expert evaluation.

services, academia, politics, public administration, regulation authorities, and user representatives.

The WP1.4 scenario core team aggregated the results of the expert interviews. In particular, they formulated in detail the opportunities and threats as well as the conclusions and recommendations based on their own perspective and the findings from the expert interviews.

The following chapter 3.4 describes the scenario process results in detail, starting with the elaborated driving forces and their evaluation. Next, the developed scenarios will be described, related opportunities and threats discussed, and conclusions and recommendations will be drawn.

The description of business models and future roadmaps, as well as the interdependency between them and the four business environment scenarios, will be part of the second deliverable of WP1.4, *D1.6 Deployment strategies, and business models for ADFs.*

3.4 Scenario creation and analysis

3.4.1 Driving forces

Driving Forces are the factors that have a strong impact on the key question. They originate from different environmental areas like society, technology, economy, ecology, politics, and legislation. The WP1.4 team elaborated in total 18 driving forces (out of the six environmental areas) using different sources like the trends described in chapter 2, previous national and international research projects, third-party trend reports, and own knowledge and experience. The description of the driving forces has been discussed and adjusted with the participants of the L3Pilot General Assembly 2018 in Athens and has been revised in Q1-2019 based on the General Assembly discussions.

*Table 3.1: List of driving forces and plausible future status options (Environmental areas: **P**olitics, **Eco**n**o**my, **S**ociety, **T**echnology, **Eco**l**o**gy, **L**egislation).*

No.	Driving Force	Status 2030 – Option A	Status 2030 – Option B
P1	**Governmental Support for AD**	Steadily increased	Remained constant
En1	**Availability of Infrastructure for AD**	High availability	Low availability
En2	**Customer Price of AD Functions**	Strongly decreased	Slowly decreased
En3	**Competition Structure of Digital Automotive Ecosystems**	Open and fragmented ecosystem	Strong oligopoly
S1	**Societal Acceptance of AD**	Significantly increased	Unchanged to 2019
S2	**Demand for Shared Mobility**	Significantly increased	Slightly increased
S3	**Environmental Behaviour**	Rise of green living	Business as usual
S4	**Personal Vehicle Ownership Share**	Sharp decrease	Small decrease
S5	**Willingness to pay for digital content**	Significantly increased	Unchanged to 2019
T1	**Application of Big Data Technologies**	Strongly increased	Slightly increased
T2	**Automated Driving Technology**	Disruptively increased	Evolutionarily increased
T3	**Application of Artificial Intelligence**	Disruptively increased	Evolutionarily increased
T4	**Application of AD Functions in Vehicles**	Broad application	Limited application
T5	**Electrification of Passenger Cars**	Strongly increased	Moderately increased
El1	**Pressure for CO_2-Emission Reduction**	Significantly increased	Moderately increased
L1	**Legislation for AD**	Harmonized AD friendly legislation	Fragmented and hesitant legislation
L2	**Regulation of access to city centers for private vehicles**	Strongly tightened	Moderately tightened
L3	**Data privacy legislation**	Unchanged to 2019	Stricter data privacy laws

Table 3.1 shows the list of the driving forces with plausible alternative options A and B for their status in 2030 compared to 2019.

The detailed description of all driving forces is documented in the Annex.

3.4.2 U/I-Matrix and critical driving forces

To identify critical driving forces that serve as a starting point for the scenario cross, all driving forces have to be evaluated concerning their impact on the key question “What could the European business environment for AD-related business models look like in 2030?” and their uncertainty of occurrence and projection. The participants of the L3Pilot General Assembly 2018 in Athens took part in this evaluation step (using the “wisdom of the crowd”). For the evaluation of impact, they rated the Top 5 impact factors from their point of view. For the evaluation of uncertainty, they had to state if they believe in option A, option B, or if they were uncertain about it. On this basis, the U/I-Matrix in Figure 3.2 was developed.

The left part of the matrix contains the driving forces with rather low uncertainty. The superscript letter expresses the mainstream expectation of the participants, e.g. $T2^{B}$ means that the majority of the participants expect an “evolutionarily increased automated driving technology” (driving force T2: “Automated drive technology”; option B: “Evolutionarily increased”). Only a minority expects a revolutionarily increased technology (Option A) or is explicitly uncertain about it.

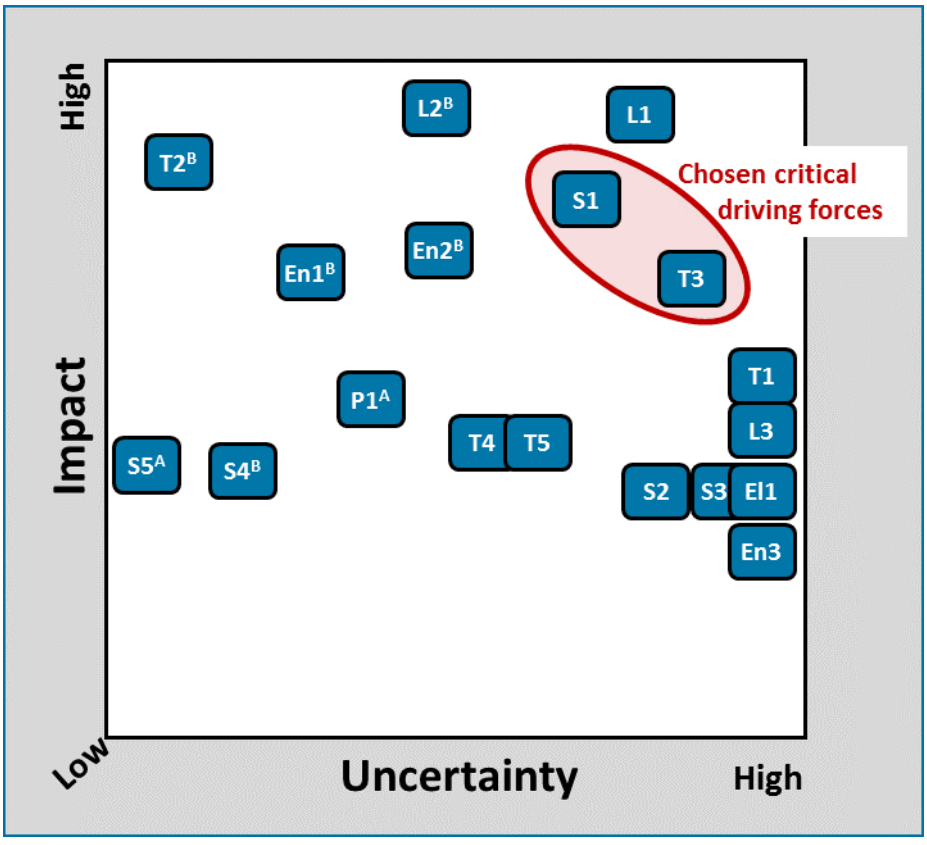


Figure 3.2: Uncertainty/Impact-Matrix and the chosen critical driving forces.

The right upper corner of the matrix contains the so-called critical driving forces with high impact and high uncertainty. Three critical driving forces of three different environmental areas have been identified:

- L1: Legislation for AD
- S1: Societal acceptance of AD
- T3: Application of artificial intelligence

This allows three different combinations of two driving forces for the scenario cross. All three combinations could have been chosen since they are relatively independent of each other. In this case, it was the responsibility of the core team to select two of the three critical driving forces. After an intensive discussion, the stress field between the key enabling technology for AD and related business models, on the one hand, and societal acceptance, on the other hand, was chosen as the scenario basis and will be used for the scenario cross. The final key argument for this was that the independence of these two driving forces has been rated as highest.

3.4.3 Scenario cross

The resulting scenario cross is shown in Figure 3.3. With two different options for each of the two critical driving forces, four different scenarios (I to IV) have been created and named.

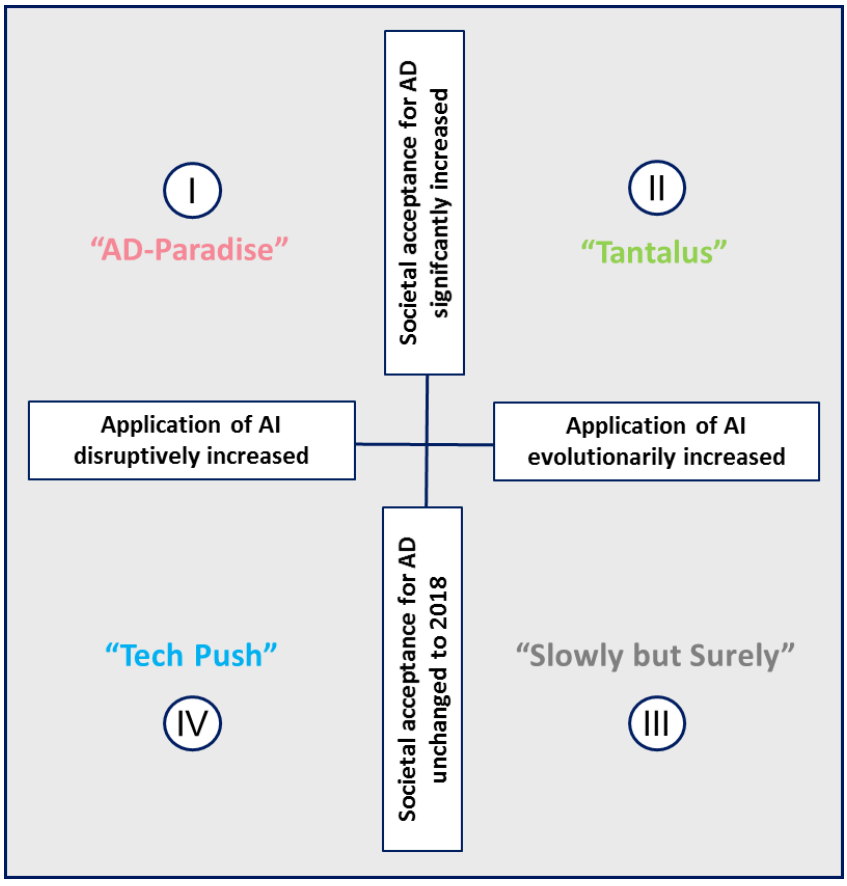


Figure 3.3: Scenario cross with four different scenarios (I to IV).

In this initial phase, the scenarios are defined by only these two driving forces. However, the immediate next step is the allocation of one of the options A or B of each of the remaining driving forces to all four scenarios. The result leads to a first understanding of the different scenarios.

Scenario I is seen as **“AD-Paradise”** because the developed technological capabilities are accompanied by a significant increase in societal acceptance. This is an ideal environment for AD-related business models.

Scenario II is characterized by a significantly increased societal acceptance, but the technological capabilities are only evolutionarily increased. People feel like the Greek mythology character **“Tantalus”,** whose desires are not fulfilled.

Scenario III shows a rather slow development of the AD business environment. Technological capabilities develop only evolutionarily, and societal acceptance is stagnating. There is a development, but only **“Slowly but Surely”**.

In Scenario IV, a **“Tech Push”** is in place, but societal acceptance hampers. The majority of potential customers is rather reluctant.

Table 3.2 shows the detailed allocation of the driving forces options to the four scenarios. The coloured blocks are showing the allocations.

The reasons for the occurrence of option A or option B, provided in the driving force descriptions (see Annex) are important for the allocation of the driving forces options to the scenarios. These reasons are documented in the more detailed driving forces descriptions (see Annex). They connect the driving forces options to each other because the reasons are often based on the occurrence of option A or B of other driving forces. The documentation of the reasons finally explains, why Option A or Option B of a driving force has been allocated to a scenario and can be found in the Annex: *Driving Forces Options´ Allocation to the Scenarios.*

Table 3.2: Driving forces options´ allocation to the four scenarios.

No.	Driving Force	Status 2030 – Option A	Status 2030 – Option B
P1	**Governmental Support for AD**	Steadily increased	Remained constant
En1	**Availability of Infrastructure for AD**	High availability	Low availability
En2	**Customer Price of AD Functions**	Strongly decreased	Slowly decreased
En3	**Competition Structure of Digital Automotive Ecosystems**	Open and fragmented ecosystem	Strong oligopoly
S1	**Societal Acceptance of AD**	Significantly increased	Unchanged to 2019
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L1	**Legislation for AD**	Harmonized AD friendly legislation	Fragmented and hesitant legislation
L2	**Regulation of access to city centers for private vehicles**	Strongly tightened	Moderately tightened
L3	**Data privacy legislation**	Unchanged to 2019	Stricter data privacy laws

■ AD-Paradise ■ Tantalus ■ Slowly but Surely ■ Tech Push

3.4.4 Scenario descriptions and visualizations

By allocating the driving forces´ options A or B, the four scenarios, *AD Paradise, Tantalus, Slowly but Surely, and Tech Push* are now defined via their key elements. To fully understand them and to enable a virtual diving into the scenarios, two additional formats have been created for each scenario: a one-pager story of a typical day of a person living in this scenario and a complementary illustration. Besides, an animated video clip has been produced to communicate the four future scenarios. It is available under the following link:
https://www.youtube.com/watch?v=xCFkLaYEpK8

Scenario Story I: AD Paradise

Eliza is in her mid-thirties, and she lives in a beautiful city. This morning she gets up rather late as she has been working quite long the day before. Her job in a “big data company” keeps her quite busy. Therefore, she always tries to find a good balance between work and family life. Fortunately, she can draw on the many possibilities offered by the new forms of mobility being established in recent years. “How exhausting it must have been in earlier times to get from A to B”, she thinks while booking travel services via her smartphone. With a few clicks on her smartphone, she has planned her way to work, the transfer of her kids to school & back home, and the business appointments for the day in the city. “Everything is so easy! You only have to choose one of the few big mobility service providers, and almost everything is sorted with only three clicks”, she thinks.

On the way to her office downtown, she uses an automated and electric shared ride-hailing car, because private cars no longer have access to the city centre. After a short “Hello” to the two other passengers, she writes some emails and opens her favourite premium news app. Wow! The EU government released a report, saying that from now on nearly all urban regions and the European transport corridors are AD-ready, thanks to the joint activities of all EU governments and the industry. This means that it will be getting easier to travel through Europe with an AD-L4 car. Since the extra cost for AD functions has been significantly decreasing, Eliza and her husband regularly rent a highly automated car for a weekend or holiday trip.

When getting to the headquarters of her company she leaves the automated shared ride-hailing car. At her office, she starts to prepare the sales presentation for this afternoon. As she finished it earlier than expected, she books a table in a trendy restaurant for lunch. To get there, she uses one of the electric shared two-wheelers which can be found everywhere in the city centre. After lunch and a successful business meeting, she again uses an automated ride-hailing service to return to the office. During the ride, she calls her kids: “Hey sweeties – how was school, and how about the new “City Pick up service with a teacher” – did you like it?” After discussing the pros and cons of travel to school accompanied by a teacher, she keeps smiling when thinking about the good old times.

Back at the office, she reports to her team about the meeting, checks the comments on the latest sales figures, and then prepares for the commute home. During the descent from the 70th floor to the ground level, she calls the automated shared ride hailing service via app to pick her up at the

exit. Thanks to the booked premium service “SingleRide”, she enjoys a video conference call with her brother and sister on her tablet while on the road.

Eliza arrives home and leaves the car in front of the door. The car automatically parks in a garage at the end of the street, waiting for the next request. With her family, she spends a relaxing evening, watching a documentary about the strong reduction in CO_2 emissions in Europe over the last few years, driven by technological advancements and changed behaviour of society. Eliza goes to bed. Just before falling asleep, she gets a wild thought: “Wouldn’t it be thrilling to drive a car without any automation? Only the vehicle and me, no one knows where the road leads us to …”

Figure 3.4: AD Paradise Scenario.

Scenario Story II: Tantalus

When the alarm clock beeps, Anna wakes up immediately. It's Thursday, one of her weekly working days. At the age of 64, she is still working for a big tech company as an engineer. Since she became grandma, she has been enjoying caring for her grandchildren two days a week. That is why she is working part-time for her company. Her grandchildren live in the neighbouring EU country just 40 km away, with the border crossing about half-way into the trip.

The TechCentre of her company is located in a big city about 30 km from her small home village. Although her office is situated in the private car ban-zone of the big city, she takes her own car for the most part of the trip. She really likes her carbon neutral car - even though she does not like driving. As an engineer, she is fascinated by the latest tech features the car provides. She likes especially the passive and active safety and automated driving functions, which enable automated driving on motorways as well as automated valet parking.

But every time she thinks about all the great features and starts to get excited, she almost immediately has to put a damper on her enthusiasm: What does all that help without proper infrastructure? On the rural roads she mainly uses, automated functions would need much more advanced technologies and better infrastructure support. On the one hand, there has been too little investment in AD support infrastructures like 5G, lane markings, more advanced maps, or standardised construction site markings. On the other hand, car manufacturers had to split their R&D budget during the last decade to develop technologies for electrification, connectivity, and automated driving, as well as for new mobility services. And as she drives to her grandchildren in the neighbouring country, the journey fatiguing her more and more, cross-border technical incompatibilities and fragmented legislation make things worse.

Anna remembers her own scepticism toward automated driving ten years ago. But in the meantime, she has had the opportunity to try out the first self-driving features in new cars, and she was impressed by how driving such a car was more comfortable and safer. That really opened up her eyes, and not only hers. On social media, an increasing number of people seem to be excited about the potential of automated driving. Last but not least, even the European AD sceptic countries are lowering their resistance to a harmonized AD friendly legislation.

She arrives at the peripheral Park&Ride hailing station. Thanks to the novel features of the mobility ecosystem she favours, her connected navigation to the ride hailing station - combined with her calendar entry “Work” - booked a seat in a ride-hailing car to her office. After leaving her car for automated valet parking (“Fascinating, how it works”) she enters the ride hailing car, greets the driver, and the two co-passengers. “Perhaps one day in the future big data algorithms will be powerful enough to find co-passengers in her social networks. “That would be great!” she thinks and starts listening to her favourite music via her premium music streaming service.

After an ordinary working day, she returns back home along the same route. While driving her own car, she thinks about her future: in 6 years from now, she will be 70 years old, and by then it would be really great to have both the advanced car technology and the accompanying infrastructure to

support highly automated driving. That would mean significantly less stress for her, and additionally, she could use the time being driven by the car to devote to her grandchildren.

And best of all, a high level of automation could maintain her mobility as she increases in age. She feels confident that this would be the key for herself to continue living in her beloved small village being driven on-demand to a supermarket, a hairdresser, a doctor, a physiotherapist and finally to stay closer to her children and grandchildren.

As she turned in for the night, she had to think of Tantalus, whom the gods punished by showing him everything he desired, while placing them just out of reach. No, she doesn´t deserve such a fate!

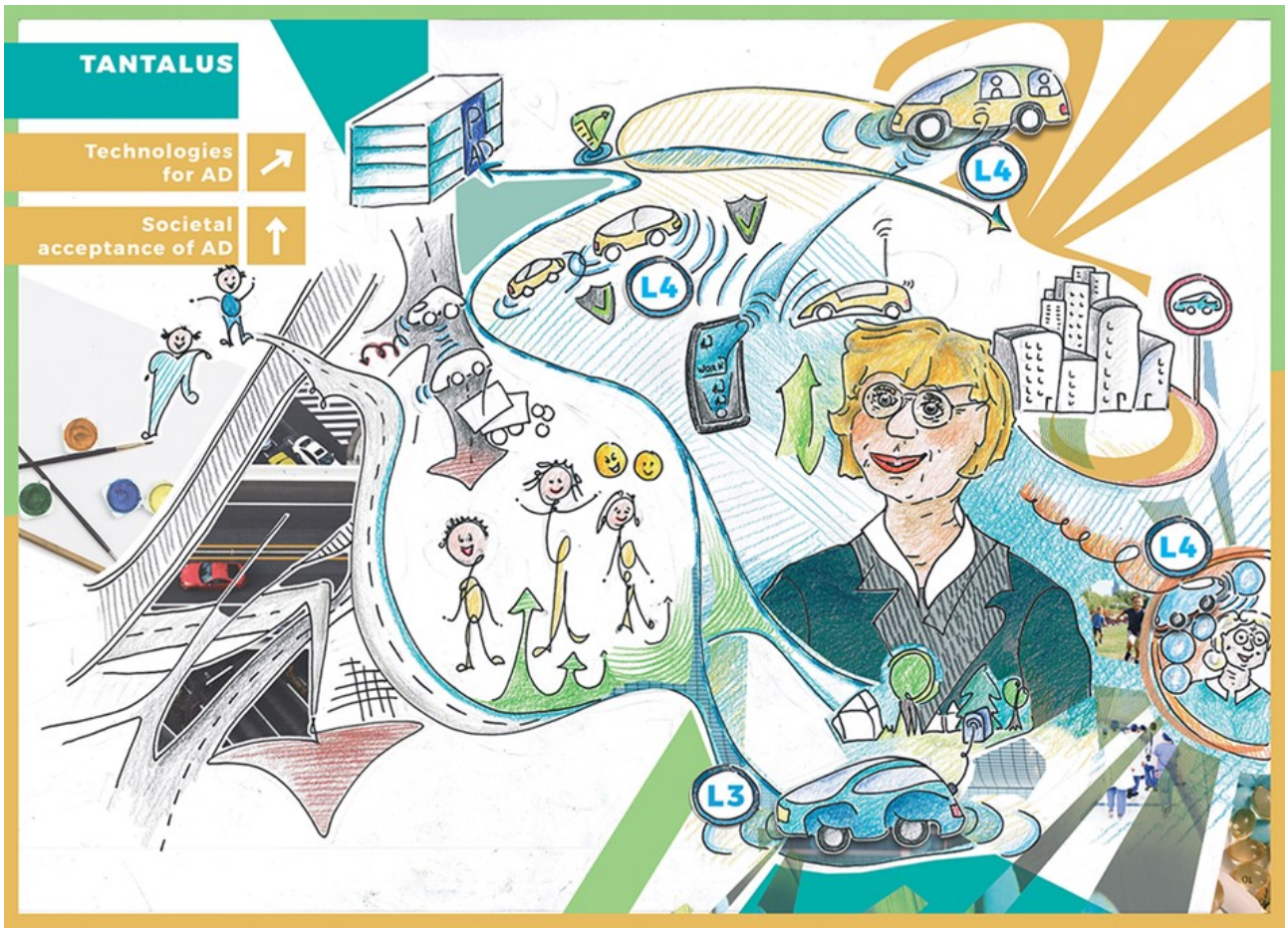

Figure 3.5: Tantalus Scenario.

Scenario Story III: Slowly but Surely

Abraham is divorced and in his late fifties. He lives in a green suburb some 15 kilometres from the capital. He has been working for the Ministry of Transport for more than twenty years. He commutes to the office every day, determined to present a harmonized automated driving-friendly regulation one day. Progress is made very slowly, as it is hard work to reach a consensus between more than 30 EU countries. But he is confident that eventually, technological developments in mobility will provide great benefits to society. In general, Abraham cherishes technology that has proven to work and make people's lives easier.

Like every morning, his classic mechanical alarm rings him up at 7:30 a.m. He enjoys his breakfast with a good cup of coffee while reading the daily news on his tablet. He regularly uses free news apps even though they are framed with advertisements. Afterwards, he checks his mails and agenda for the day. No need to drive to the office right now; just wait until traffic jams have dissolved. From experience, he knows that using public transportation can be as unreliable as daily traffic, so he sticks to using his own electric car for commuting. Fortunately, the city's passenger car ban still excludes electric vehicles, so his only concern is whether his charging app will be able to find one of the few park & charge spots close enough to his office.

Abraham is attached to his car, which he bought new just a year ago: his first electric vehicle is so silent and already equipped with some “intelligent driving features.” However, he has decided not to use these features because he does not know what to expect if they fail because of missing relevant infrastructure or some other reason: Will he manage to regain full control of the vehicle at any time and fast enough? And will he be held accountable if the car has an accident while using these features? The dealer did not instruct him on the features of an automated car. The manual contains lots of disclaimers for inappropriate use, and he is not a technical expert. As the legislation is not fully in place yet, why take any risk for his mainly short and well-known trips? To play it safe, he mainly sticks to manual driving, only occasionally using advanced driver assistance systems that are activated by default and have proven to work reliably, like blind-spot warning and emergency brake assist.

During the day, Abraham has a meeting elsewhere in the city centre, using his own car. Particularly, in urban traffic conditions, Abraham could imagine the benefits of automated driving very well. At the same time, he stays pragmatic and cautious: “Show me that it works and who is liable for accidents, and then I will somehow integrate it into my personal way of driving”.

But technology did not develop as quickly as Abraham expected ten years ago. Back in those days, he remembers his enthusiasm for the potential of artificial intelligence changing the world. However, these wishes never materialized the way he had dreamed of. Perhaps, this is also partly because the legislation is lagging behind technological development. After all, how can the development of artificial intelligence progress as long as access to all that vehicle data is not clearly regulated?

He feels sorry for his children to see so little progress has been made so far. At the same time, even compared to his previous car, this one is more sophisticated and comfortable. That is how it goes in real life: things will change, slowly but surely.

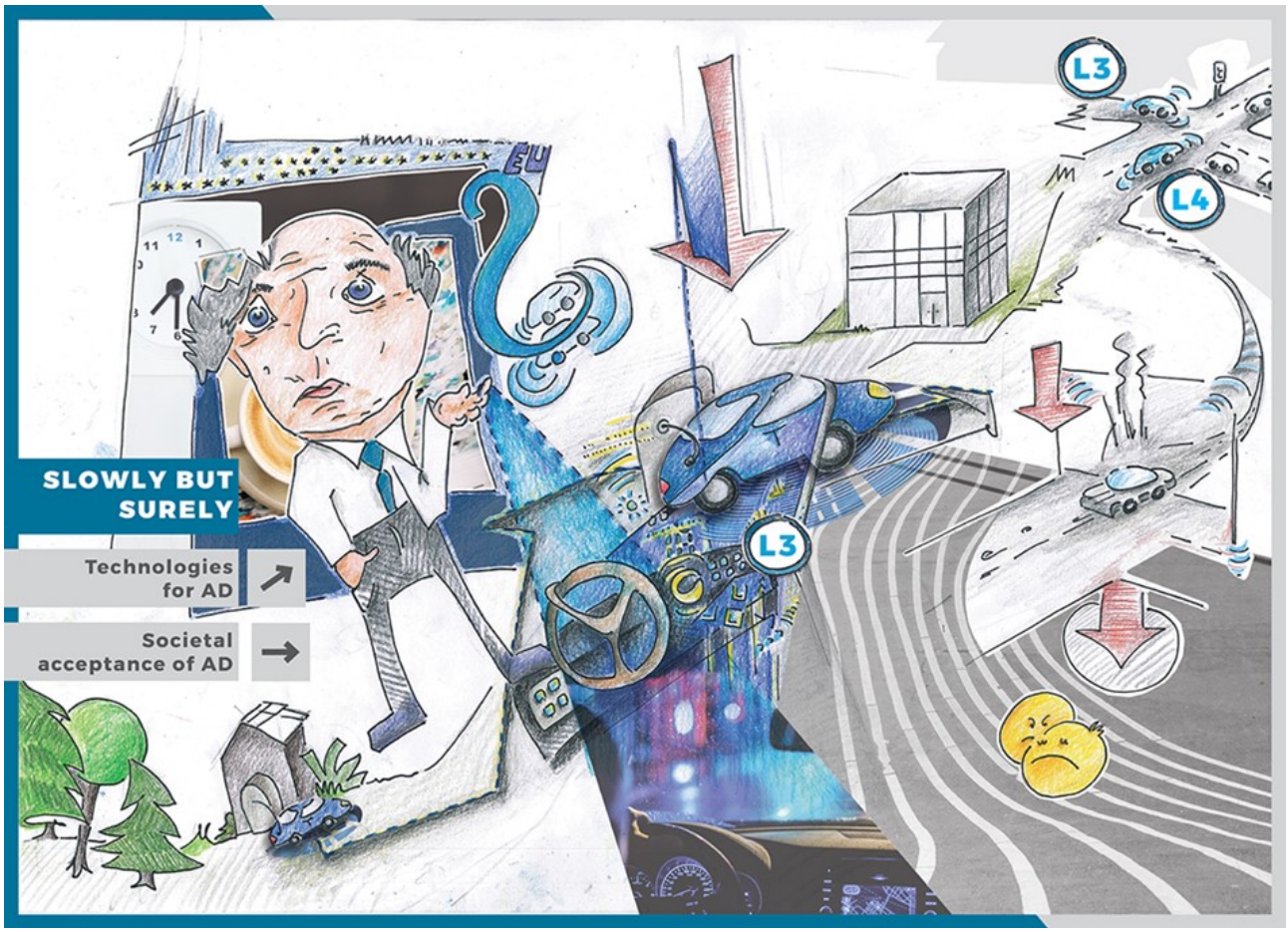

Figure 3.6: Slowly but Surely Scenario.

Scenario Story IV: Tech Push

Max is a real gadget freak. He is the first to call Uber, wear AirPods, and drive an electric scooter. His friends at the football club, just like his family, always laugh a bit as he enthusiastically talks about the latest technology, as his visionary ideas still seem a bit too far in the future for them. However, they are always curious about his tech adventures. Eventually, the widgets he already started using years ago gain popularity in the small village, where he lives with his young family. His colleagues at the well-known IT consulting company where he works are, however, much like Max.

In 2018, some 12 years ago, Max was still living in the capital. But some years later, his company got engaged in a smart mobility and energy pilot together with a big energy company and a European premium car manufacturer supported by the extensively financed future fund of the European Union. Since that time, he has been happy to use an automated electric vehicle of this OEM (as automated car features are still rather expensive, he would not have bought or leased one himself just yet). And now this car makes it possible for him to live further away from work. Their home is now in the village where his wife was born, where she works as a teacher - just like her father - at the elementary school. After all, he can use the time while being driven for a lot of working related activities in the car. However, in his small village, people do not see the main benefits of automated driving, as it requires infrastructure that is not available everywhere.

In the morning, he drives his kids to school and then heads to the motorway. That takes about 30 minutes, mainly through winding country roads. While he is on the motorway, the car takes over. He begins his daily routine. He is a bit hungry because he has not had breakfast yet. He always takes his time for this. After a quick shave, he tightens his tie and dials in for the video conference call. Some 20 minutes later, when his car requests him to take over again, he summarizes the action points and closes the call. It is a pity that despite the existing harmonized EU regulations, the neighbouring country's AD infrastructure is still poor because of insufficient investment. Due to the continuing hesitation of the customers, potential investors do not find the market interesting just yet. Therefore, he still has to drive for an hour by himself to the customer’s office. On those days when he travels to the HQ, he is usually very energetic, as he only needs manual driving for a short while along the way. Then he can even enjoy the luxury of writing code in the car.

The smart mobility and energy pilot is an extensive experiment where energy management of the company including the mobility modalities is managed by a central service. This means that huge amounts of different data are collected, but also that the service company installed the needed equipment with solar panels and batteries at his home. This way he has a chance to either charge the car or trade energy. It shows encouraging results: in the future, the hopefully decreasing prices for AD cars, combined with energy management, billable hours, and commercialisation of the gathered data may compensate for the extra cost of operating automated electric vehicles.

His family hardly experiences the benefits of automated driving. When travelling to school and the football club, Max still has to drive. As a geek, he really wants to show his family how great his car is. He proposes for the next summer holiday to travel to the Netherlands, 1800 kilometres. With the

automation switched on, they will be fresh when arriving at the target destination. In his mind, he is already selecting books to read on the road. But his wife favours flying. “A lot less hassle”, she says. “And how do you even know which roads are suitable for the car?” However, Max replies that at least they can bring more stuff with them and watch movies together. Next year, some more roads will be AD-ready.

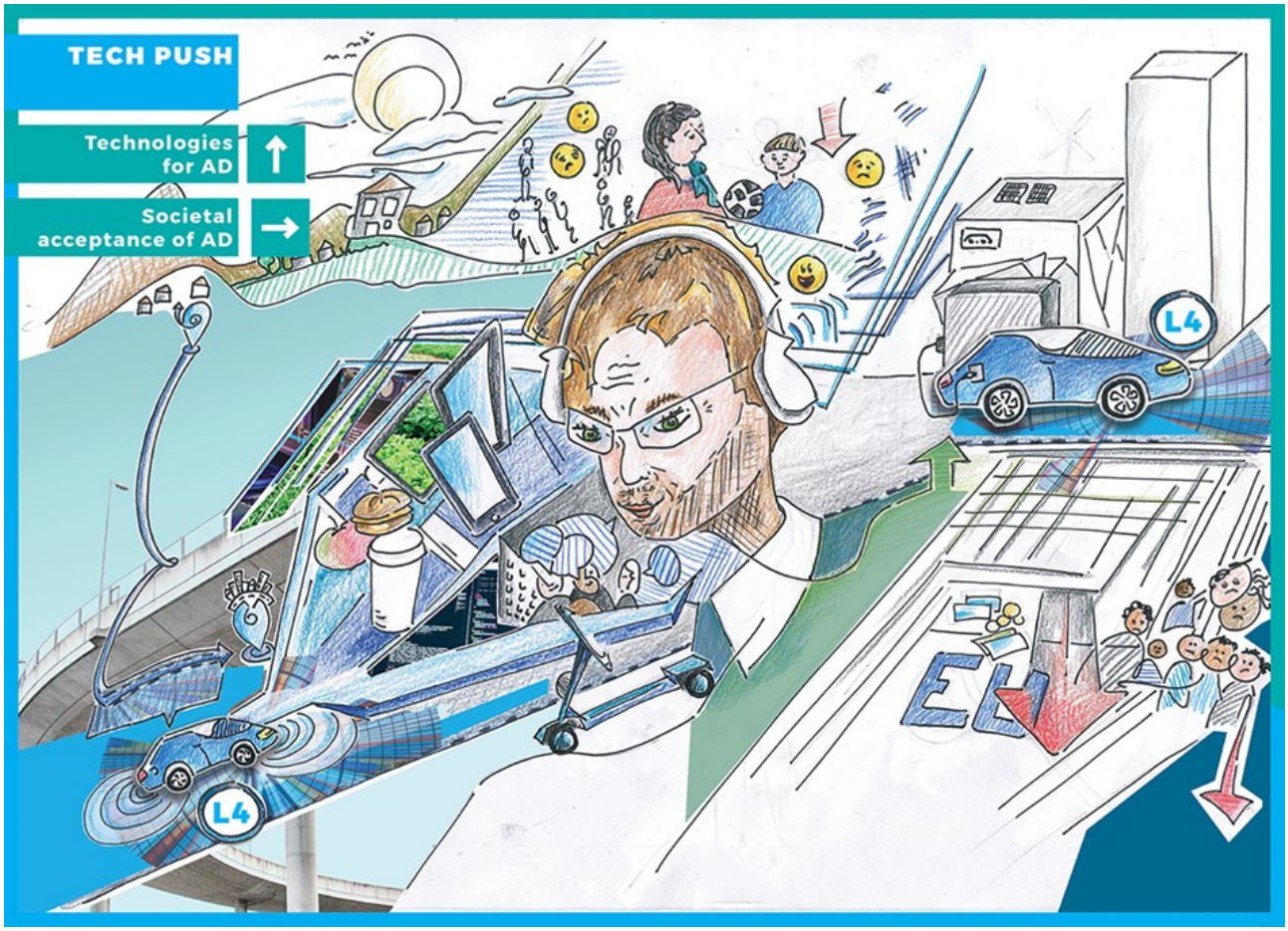

Figure 3.7: Tech Push Scenario.

3.4.5 Scenario specific opportunities and threats

The four elaborated business environment scenarios are quite different with regard to their framework conditions for AD-related business models. The answers to the questions, to what extent AD-related technologies are developed, or if the societal acceptance of AD has increased, complemented by the future status of other driving forces like e.g. political support, harmonization of legislation or investments in infrastructure can be decisive for the viability of specific future business models. As the combination of these factors is different and specific in the four scenarios, opportunities, and threats for AD-related business models will be scenario-specific, too. In addition, different stakeholders have different interests concerning AD-related business models: private enterprises focus on economic benefits, private customers want individual benefits, and society targets broader societal and environmental benefits.

In this chapter, opportunities, and threats for AD-related business models will be named, described, and evaluated related to every scenario. These opportunities and threats were composed from expert interviews, literature, and the expertise of the WP1.4 team members. A table that gives a comparative overview of the scenario-specific opportunities and threats completes the chapter.

3.4.5.1 Opportunities for private enterprises (OEMs, suppliers, tech companies)

O-1 Increasing demand for selling selected AD functions as optional equipment

This opportunity is strengthening the traditional business of the automotive industry (manufacturing and selling cars with standard equipment and optional equipment based on the customers' needs).

Key supporting factors are strong technological development, increased societal acceptance, availability of infrastructure, and legal harmonisation. In all scenarios, this opportunity exists, but in "Slowly but Surely" on a lower level. In the other three scenarios, this opportunity is strong. The scenario "AD Paradise" shows a sharp decrease in the personal vehicle ownership share. This limits the number of potential private customers, but their individual demand for extra equipment is seen as high.

O-2 Increasing demand for selling completely equipped L4 cars to private and fleet customers

This opportunity is strengthening the traditional business of the automotive industry (manufacturing and selling cars). Key supporting factors are strong technological development, increased societal acceptance, availability of infrastructure, and legal harmonisation. This opportunity is very strong in "AD Paradise", rather strong in "Tech Push" and partly strong in "Tantalus", related to the customer segments "Innovators" and "Early adopters".[7]

[7] The term "Early adopter" comes from diffusion research and refers to people who use the latest technical achievements or the latest variants of products or fashionable accessories. Early adopters are – after the actual "Innovators" - among the first to adopt new ideas.

O-3 Demand for cars with completely revolutionised interior

This opportunity is strengthening the traditional business of the automotive industry (manufacturing and selling cars). Interior design is one of its core competencies, even though a revolutionized interior (with a transformation from drivers driving position to a lounge-like interior design) will create completely new challenges, e.g. for occupant safety. Because of the strong development of L4 cars as private cars and as so-called Robo-Taxis and because of appropriate infrastructure, the demand is high in “AD Paradise”. It is low in “Tech Push” and negligible in “Tantalus” and “Slowly but Surely”.

O-4 Safety as a key feature of automated vehicles

This opportunity can support AD sales in general. Especially in the scenario “Slowly but Surely” the societal acceptance is still ambivalent. Marketing based on achieved safety standards can influence the societal acceptance in this scenario positively (for more findings on societal acceptance and means to influence the acceptance of the public see L3Pilot Deliverable D7.1 *Annual quantitative survey about user acceptance towards ADAS and vehicle automation*). In “AD Paradise”, people already see AD as safe. “Tantalus” and “Tech Push” are in between.

O-5 Increased societal acceptance of AD

Societal acceptance is a key condition for the broad dissemination of AVs and AD-based services. Societal acceptance influences strongly legislation and infrastructure investment as well as the readiness to use AD functions and the willingness to pay. Societal acceptance is strong in “AD Paradise” and “Tantalus” and still ambivalent in “Tech Push and Slowly but Surely”

O-6 Demand for operating AD-L4-Fleets

Ride hailing like today’s taxi services will face a strong boost by AD-L4 technologies because nowadays the driver is a strong cost factor. Offering ride-hailing services without a driver will reduce the cost significantly and increase the economic attractiveness strongly. That offers a business perspective for the operation of AD-L4 fleets (operation and maintenance), especially in the scenario “AD Paradise”, on a lower level in “Tech Push” and “Tantalus”.

O-7 Mobility as a Service (ride sharing, hailing, pooling)

In addition to O-6, another opportunity is to offer not only the fleet operation but also the complete mobility service as a one-stop-shop. They fit to the megatrends sharing economy and digitalisation and these trends are driving all four scenarios. AD will additionally foster the dissemination of MaaS. Therefore, this opportunity is strong in the scenario “AD Paradise”, strong in “Tech Push” and “Tantalus” and rather strong in “Slowly but Surely

O-8 Platforms for seamless multimodal mobility integration

In addition to O-7, the integration of the automated vehicle services into a seamless multimodal mobility service is a big opportunity in the scenario “AD Paradise”. There will be a demand for such an integrated solution, where daily mobility can be organised with only

some fingertips. Other scenarios show this opportunity as well, even with a lower level of automated driving.

O-9 In-car data-based services for drivers

In road transport, the majority of the cars is only occupied by one person, the driver, who is strongly engaged in the driving task. If the driver can hand over the driving task to an automated car, he/she is free to do other things he/she likes. This creates a big opportunity to offer additional service to the driver, e.g. location-based shopping, entertainment, education, or health and well-being services. This opportunity is very strong in the scenario “AD Paradise”, rather strong in the scenarios “Tech Push” and “Tantalus”.

O-10 Data based value-added services for the whole life sphere of people

In addition to O-9, the offered services can also reach beyond the driving time. Data generated by automated vehicles and from the driver's activities during automated driving may be integrated with data from other “smart devices” (e.g. related to home, office, and leisure) to completely new services for the whole life sphere. This seems to be an interesting opportunity in all scenarios, whereas the scenario “AD Paradise” offers the biggest contribution of AD-related data and “Slowly but Surely” the smallest.

O-11 New insurance demands

Automated driving creates for insurance companies simultaneously a big challenge and big opportunities in all scenarios. With the handover of the vehicle control from a human driver to an automated car, also the legal liability has to be shifted to the car. New insurance concepts have to be developed for all scenarios. Even in the scenario “Slowly but Surely”, where the advancements of AD are the slowest, new concepts for liability are needed to eliminate the concerns of potential AD users.

O-12 AD infrastructure

AD-related infrastructure goes from lane markings on road up to a high-speed 5G communication network and Big Data clouds. While the first is rather seen as a public duty, communication and data networks can create strong business opportunities for private companies, especially in the scenario “AD Paradise”, but also in “Tech Push” and “Tantalus”.

3.4.5.2 Opportunities for individual European citizens

O-13 Comfortable mobility

AD has the potential to increase mobility comfort. The driving task - stressful for many people especially in urban regions - is eliminated as well as searching a parking spot. Cars pick up passengers in front of the door and let them out close to their destination. People might arrive less stressed and more relaxed. This opportunity is very strong in “AD Paradise”, strong in “Tech Push” and less strong in “Tantalus”.

O-14 Free usage of "driving" time

Today a car driver has to be focussed strongly on the driving task, especially in urban traffic with its high density. Some of the scenarios offer the possibility to use the time while driving

for other activities instead of observing the traffic and driving the car. That is already possible with AD L3 under the condition of a readiness to overtake the control again within a limited time. But under L4 conditions it allows the driver to completely turn away from the driving task and use the time e.g. for work, entertainment, or even for sleeping. This opportunity is very strong in “AD Paradise”, strong in “Tech Push” and less strong in “Tantalus”.

O-15 Individual auto-mobility for children, elderly and disabled people

Children, disabled people, partly elderly people, and in general all people without a driving license have currently no access to individual auto-mobility. Without a driving license or without the capability of driving they are depending on relatives, friends, or other people if they want to use individual cars. Highly automated cars (L4) offers them the opportunity of independent access to this type of comfortable mobility. This is valid especially in “AD Paradise” and partly in “Tech Push”.

O-16 Cheaper individual mobility

With the strong market dissemination of AD technologies in the scenario “AD Paradise” combined with driverless ride hailing, individual auto-mobility will be rather cheaper than today. This offers participation in individual traffic also for more people than today. However, in the other scenarios, where dissemination is lower and drivers are still used, individual mobility will be more expensive than in “AD Paradise”.

3.4.5.3 Opportunities for European society

O-17 Increased traffic safety

AD has the potential to strongly increase traffic safety, as today the dominating factor for traffic accidents is human error. On the condition that the AD systems fulfil high reliability and safety standards, AVs are expected to cause significantly fewer accidents with less people injured or killed in traffic. This opportunity is very strong in “AD Paradise”. In “Tech Push” and “Tantalus”, where missing infrastructure leads to rather frequent take-overs, this opportunity is not that strong. Interestingly in “Slowly but Surely”, where technological advancements are proceeding not so fast, but where safety requirements are strong, a noticeable potential of increased safety is seen.

O-18 Increased global competitiveness of Europe related to AD technologies

One of the key targets for funding European AD-related research projects is to increase the competitiveness of the European industry in a global environment. The European automotive industry is not only competing with the global automotive industry but also with globally leading tech companies, especially from the U.S. and China. Even though European car manufacturers and suppliers are already acting globally, a strong home market is a very strong enabler for global competitiveness. Currently, the business environment for AD in Europe is lagging behind the U.S. and China. To increase the competitiveness, the pace of defining an AD friendly legal framework and of developing the technologies should be raised strongly. Only “AD Paradise” offers this opportunity and would lead to increased competitiveness, although industries in other regions are developing, too. “Tantalus” and

"Slowly but Surely" show developments that are too slow to keep up with international competitors and "Tech Push" would give at least the opportunity to maintain the current position in the competition.

O-19. Reduced CO_2 emission because of AV

AVs have the potential to reduce CO_2 emissions because of two key factors: smoother driving mode and connected driving. But this positive effect might be completely overcompensated by the increase of transport demand because of a higher attractiveness of AVs (e.g. Robo-Taxis as a comfortable, reliable, and economic means of transport, more and longer comfortable private or commute trips with the opportunity for alternative time usage). To avoid that overcompensation there is a strong need to reduce the vehicle kilometres although the passenger-km are likely to increase (e.g. by ride pooling). Where this does not work, electrification of AVs has a high priority. The opportunity to reduce CO_2 emissions through AD is strong in "AD paradise", rather strong in "Tech Push" and "Tantalus" and negligible in "Slowly but Surely".

O-20. Reduced space needed for parking

The appropriate use of public space is a subject of increased public discussion. Road traffic is occupying a lot of public space in cities (roads, parking spaces). Researchers expect a strong reduction of parking space in case of strong dissemination of AV. Fewer cars will be used and their daily "in-motion" share will be significantly higher. This opportunity will be strong in "AD Paradise", rather strong in "Tech Push" and "Tantalus" and negligible in "Slowly but Surely".

3.4.5.4 Threats for private enterprises (OEMs, suppliers, tech companies)

T-1 Missing infrastructure for AD (in general, rural, crossing borders)

AVs are depending on an appropriate infrastructure. Recognisable lane markings, traffic signs, and traffic lights as well as a highly available and reliable communication network (e.g. 5G), are crucial for the functioning of AV. Wherever that is missing, even partly, the benefits and the strong dissemination of AVs is threatened. This threat is very strong in "Slowly but Surely" where the slowness of the technological development is accompanied by the slowness of the infrastructure development; both factors are hindering each other. However, it is also strong in "Tantalus" and "Tech Push", where infrastructure only partly exists with gaps and especially cross-border incompatibilities. Only in "AD Paradise" this threat does not exist.

T-2 Missing international standardisation of technology and legislation

The automotive industry offers its products globally, at least in various global regions and many countries. People, especially in Europe, often cross borders with their cars. AVs have to fulfil high safety requirements and have requirements to infrastructure standards. Missing international standardisation and harmonisation of both, technology and legislation, is a big threat to the dissemination of AVs. In "Tantalus" and "Slowly but Surely" this threat is strong, in "Tech Push" rather strong.

T-3 Long amortisation periods for AD investments

The development of reliable AD technologies is key to OEMs being able to participate in future mobility markets, since customer acceptance and thus the demand for AVs and related services highly depends on trust in the safety and reliability of these systems. For the automotive industry, this means very high investments in R&D. The amortisation periods for these investments will be longer, the slower the dissemination speed of AVs. Given that customer acceptance but also favourable regulations for AD are still uncertain and doubts about self-driving vehicles still exist, there are serious threats for the broad application of AD and thus a return on investments. This threat is very strong in “Slowly but Surely”, strong in “Tech Push” since society is highly sceptical about AD. It is also strong in “Tantalus”, where a lack of harmonized regulations will lead to a long amortisation phase. In “AD Paradise”, this threat is not an issue.

T-4 People refuse ride pooling because they do not want to ride with strangers

Future mobility services like ride hailing and pooling, e.g. with Robo-Taxis are seen as successful business models for AD. Customers can enter and leave the Robo-Taxi wherever they want and share the ride with other passengers who want to go in the same direction. By pooling the rides, the service provides a cheap and flexible ride for the customers and reduces the number of vehicles and thus congestions on the roads. However, people might refuse ride pooling, as they do not want to ride with strangers and feel less safe in a Robo-Taxi, especially when there is no chauffeur in the vehicle. The feeling of insecurity is a big threat to mobility service providers. This holds true in “AD Paradise”, where people prefer single rides but is also an issue in “Tech Push” and “Tantalus”, where people are generally more sceptical about AD services or customers prefer ride pooling only with their peer groups.

T-5 People do not want to give up permanently driving control (especially with SAE L5)

AD is supposed to be a relief to the driver since the system takes over the driving tasks in defined conditions (SAE L3 and L4) or in all driving situations (SAE L5) and enables the driver to engage in other activities than driving. Nevertheless, driving is not only seen as a sometimes boring or complex and highly demanding task. People also enjoy driving a car on his/her own, deciding how and where to drive and what is also important, having control of the vehicle. As already discussed above, there are strong doubts about the safety and reliability of the system among a significant proportion of potential customers. Therefore, people may not want to permanently hand over driving control to the system. This threat is strong in “Slowly but Surely” as people are highly sceptical about the reliability of the system and less strong in “AD Paradise” where people appreciate comfortable AD-related mobility services. In “Tantalus” and “Tech Push” drivers always have the choice to take over driving control.

T-6 U.S. patents for business models by companies like Alphabet or Amazon

A key to succeeding in the global competition for the future mobility market is the generation of meaningful business models. IT giants and tech companies like Google and Amazon

already have strong leadership in this field and they are continuously strengthening their position by filing, for instance, a large number of mobility-related business model patents in the U.S.A. Additionally, this might limit the market expansion of European enterprises. Some experts consider these developments as a big threat to the entire automotive industry and state that it might be too late for the European OEMs to win this race. This concern particularly applies to the “AD paradise” scenario, as people are willing to use innovative mobility services. It has further also an impact in the “Tantalus” and “Tech Push” scenario, where the social acceptance is high (“Tantalus”) or the technological progress races ahead (“Tech Push”).

T-7 Tendency towards ecosystem monopoly

The development of digital automotive ecosystems is even today characterized by a strong cooperation phase of OEMs, Tier1 suppliers, and IT giants. Attractive start-ups are acquired from these ecosystems to integrate their technology and customer base (Holland-Letz, et.al., 2019). Tech companies like Google, Amazon but also mobility service providers like Uber or Lyft push the global market aiming at leading the future mobility market. There is a big threat for the automotive incumbents to lose this competition with the IT giants and miss the entry to one of the few leading mobility ecosystems or even to create an own one in the future. This threat is very strong in three scenarios, “AD Paradise”, “Tantalus”, and “Slowly but Surely”, where factors like consumer preferences, the economic power of few tech companies, and low regulation lead to a strong oligopoly of only very few ecosystems. It does not exist in “Tech Push” due to its open and fragmented ecosystem.

T-8 Technical reliability as a critical factor (in general and in critical weather conditions)

The acceptance of (highly) automated driving (SAE L3 and L4) requires not only interest in the technology but also trust in the reliable operation of the system. However, there are still strong doubts about what to do in case of a malfunction and the fear of losing control. The still unsolved problems of the reliable functioning of sensors in all critical weather situations might even increase this distrust. In addition, non-standardized ODDs can make it even more difficult for customers to understand the limitations. The threat is very strong in “Slowly but Surely” as there is little acceptance of AD technology among the society and technological solutions need time. It is weaker in “Tantalus” and especially in “Tech Push” and it has a negligible effect on user acceptance in “AD Paradise”.

T-9 Missing workforce skills

The technological progress of AD requires a highly qualified workforce. Particularly, big data analysts, computer scientists, and AI experts are needed who can run and evaluate advanced data analytics methods and tools, like predictive analytics, user behaviour models, etc. Further algorithms need to be generated and trained to develop AI applications for data processing and evaluation. The automotive industry faces strong competition for talents in that field with other industries. Given the increase of AI and big data applications for AD technologies, the automotive industry faces a big threat, which is very strong in “AD

Paradise" and "Tech Push" and less strong but also relevant in "Tantalus" and "Slowly but Surely".

T-10 Communication networks will not be able to cover the countries

The availability of digital communication to be used by AVs and road site units etc. (ITS-G5, LTE, 5G) will be restricted by extensive infrastructure needs. In addition, people are concerned about the necessary density of transmitters as they fear that radiation might affect their health. Thus, the required connectivity by a broad coverage with 5G and the implementation of common standards for ADFs might become a problem. This holds especially true for "Slowly but Surely", "Tech Push" and "Tantalus", as in all of these scenarios infrastructure investments leave something to be desired at least from the automotive industry perspective. In "AD Paradise", this is not an issue as the government and industry join forces to invest in infrastructure to push market growth.

3.4.5.5 Threats for individual European citizens

T-11 Potential loss of driving competency

If AVs will take over more and more complex driving tasks from the human driver (like with SAE L4), manual driving skills will become eroded. Thus, people lack manual driving experience and training and might easily become overstrained in critical situations when the system requests a takeover. This threat is very strong in "AD Paradise" and less strong in "Tantalus" and "Tech Push" as for the latter two scenarios only SAE L3 functions will be broadly available or missing infrastructure restrict the use of higher automation modes (SAE L4). In "Slowly but Surely" this threat does not exist.

T-12 Potential loss of data privacy and security

AD systems gather an immense amount of data to perform complex driving tasks. Data gathering not only includes vehicle-, driving- and environment-related data but also driver monitoring, like eye tracking, etc. These large amounts of partly highly sensitive private data need to be managed efficiently but at the same time be sufficiently protected against cyber threats. This threat to data privacy and security of people using AVs is strong in "AD Paradise" as a majority of people use AVs and related services and provide their personal data. It is less strong in "Tantalus", where AD technology is only slowly evolving, and in "Tech Push" as only a minority of technically-savvy users and early adopters are attracted by AD. In "Slowly but Surely" this is not an issue at all.

T-13 Dependency on a mobility ecosystem monopoly

The development of a mobility ecosystem monopoly or at least a strong oligopoly with only a few ecosystems leads from a customer perspective to lock-in and a high dependency on the provider consortium(s) and its solutions and applications. It further has implications on pricing due to less competition and may hinder innovation potential, as there are high barriers for new entrants to enter the ecosystem. There is a strong threat for individual customers due to the oligopoly structure in "AD Paradise", "Tantalus" and "Slowly but Surely". It does not exist

in “Tech Push”, since there is an open and fragmented mobility ecosystem, which is driven by new entrants that push the technological development and competition.

T-14 Reliability of personal mobility

The requirement for the reliability of personal mobility is high. People have to commute to work and want to arrive on time. They are planning private activities with a specific time, capacity, or baggage restrictions, among others. Many people are owning personal cars because they perceive this as a very available and reliable means of transport, even though sometimes traffic congestion challenges these attributes. The transition from personal cars with a total availability for the owner to a dependency of something like a Robo-Taxi fleet causes – despite the increased comfort if the system works – a specific threat to the potential users: What if no car will come when I will need it? People currently experience problems finding a taxi in the rush hour or to find a sharing car nearby when it is needed. This threat is negligible in “Slowly but Surely” and “Tech Push”, where people continue to rely on their own cars, but it is high in “AD Paradise” with its transformation to automated ride hailing fleets. In “Tantalus” this threat occurs specifically in city centres.

T-15 Potential stress by monitoring ADF

Automated driving functions at SAE L3 can take over driving tasks in defined conditions and operational design domains (ODD). If the AV leaves the ODD, the system requests a takeover from the driver within a limited time. While the system is driving, the driver is allowed to engage in other activities but must be able to take over control at any time. This may cause stress for the driver, as he/she needs to constantly monitor the ADF. This threat for the individual driver is strong in “Tantalus” and “Slowly but Surely” due to the only evolutionary increase in AD performance development and the focus on L3 functions, which are mainly available on the market. In “AD Paradise” and “Tech Push” this threat is less given since highly ADFs (SAE L4) do not need the attention of the driver. They can perform the driving tasks or abort the trip safely on its own if the driver will not take over.

T-16 Missing legal certainty

A harmonized legislation for AD, which covers the permission for AVs on public roads or at least in specific conditions as well as the regulation of liability is a key prerequisite for a broad application of the technology and acceptance by individual customers. Who will be held accountable if the AV has an accident, while using the ADFs, is a major concern for many people and might prevent them from using ADFs. This threat is particularly strong in “Slowly but Surely” and strong in “Tantalus”, where no common agreement could be reached on the supranational level. It is the opposite in “AD Paradise” and “Tech Push”, where joint actions by industry and government led to a harmonized AD friendly legislation.

3.4.5.6 Threats for European society

T-17 Loss of jobs because of AD / Need for new job profiles

About 5 million professional bus, coach, and freight drivers and one million taxi drivers are employed in Europe (ETF, 2020, and IRU, 2009), only naming two among various job profiles of professional drivers. AD is strongly threatening these jobs. On the other hand, logistic companies as well as public transport providers are already experiencing an increasing lack of professional drivers. Working conditions for professional drivers are seen as hard and the salaries seem to be not attractive enough. This threat creates a need for new job profiles: Long haul trucks with ADF for example might not need a driver in the future (at least not for the biggest part of the trip), but they might need a cargo manager, who organises all necessities around the transport – instead of driving. Public transport busses instead of a driver might need a host who cares for the passengers and supports them if needed (and an aging society might create more needs in the future). This threat is strong in “AD Paradise”, less strong in “Tech Push” and not relevant yet in “Tantalus” and “Slowly but Surely” because of missing technology.

T-18 Traffic increase by AVs (congestion, collapse, …)

L4 or L5 AVs have the big advantage to be able to pick up people right outside their front door and drop them off at their exact destination (or very near to it). This creates a significant increase in attractiveness. A quantitative mobility model developed by Deloitte shows as a result a significant increase of vehicle-kilometres in cities (+30%, even though the number of vehicles will be strongly reduced) (Deloitte, 2019). A research report from TNO shows comparable results (Snelder, et.al., 2019). This counteracts the effort of cities to reduce the amount of road traffic and to shift it to public transport. This threat is strong in “AD Paradise”, less strong in “Tech Push” and “Tantalus”. Only in “Slowly but Surely” it is negligible. Of course, there might be organisational and regulatory solutions to avoid the calculated traffic increase, but the threat exists.

T-19 Ethical critical decisions

In an accident situation, human drivers often do not have sufficient time to analyse the situation and figure out their possible options (whose life to save, whose life to risk) before they react. Very often, they react intuitively and that is in general accepted. An AV with its fast computing capabilities can calculate possible reactions and related consequences fast enough and might have the possibility to decide. The key question is, “Should we allow an AV to decide whose life should be risked?” The most given answer to this question is a clear ”No”. Instead, the target should be to risk as few as possible lives. Due to an analysis of the German Statistical Agency, about 92 % of all accidents are caused by human errors (DeStatis, 2019). AVs have the potential to reduce the number of accidents strongly, but algorithms for reacting in case of an accident have to be created – in a societally acceptable way. This threat is existing in every scenario.

T-20 Low market acceptance, low development speed

There was a strong hype related to AD over the last years. Announcements of enterprises

and amplification by media made people believe that we will see highly automated vehicles in widespread public use very soon. Recently, there are reports that schedules are postponed because of complexity higher than seen before. It makes people feel insecure related to the real performance of AD. This might lead to customer hesitation and low take-up rates for ADFs. It might additionally lower the development speed of OEM, automotive suppliers, and tech companies. This threat is very strong in “Slowly but Surely”, strong in “Tantalus”, rather strong in “Tech Push” and negligible in “AD Paradise”.

T-21 Decrease in established public transport

The increased attractiveness of AD in urban mobility (e.g. Robo-Taxis) is probably leading to increased road traffic (see also T-21). Partly this means a shift from established public transport to road traffic. This is not only counteracting the transport policies of cities but also reducing the revenue of public transport providers and increasing their need for subsidies. This threat is very strong in “AD Paradise”, rather strong in “Tantalus” and “Tech Push” and negligible in “Slowly but Surely”.

3.4.5.7 Overview of opportunities and threats and their effects in the four scenarios

Table 3.3: Overview of derived opportunities and their effects in the four scenarios.

Stakeholders	Opportunities		AD-Paradise	Tantalus	Slowly but Surely	TechPush
Private Enterprises	O-1	Increasing extras' sales in Europe (Assistance Sytems and AD functions)	++	++	+	++
	O-2	Increasing L4 car sales and L4 retro-fits for vehicles in Europe	+++	+	o	++
	O-3	Demand for cars with completely revolutionised interior	+++	0	0	+
	O-4	Safety as a key feature of automated vehicles	o	+	++	+
	O-5	Increasing societal acceptance of AD	+++	+++	+	+
	O-6	Demand for operating AD-L4-Fleets	+++	+	o	+
	O-7	Mobility as a Service (ride sharing, hailing, pooling, P2P)	+++	++	+	++
	O-8	Platform for seamless multimodal mobility integration	+++	++	++	++
	O-9	In-car data based services for drivers	+++	+	o	+
	O-10	Data based value added services for the whole life sphere of people	+++	++	+	++
	O-11	New insurance demands	+++	++	++	++
	O-12	AD infrastructure	+++	+	o	+
Individual European citizens	O-13	Comfortable mobility	+++	+	o	++
	O-14	Free usage of "driving" time	+++	+	o	++
	O-15	Individual auto-mobility for children, elderly and disabled people	+++	o	o	+
	O-16	Cheaper individual mobility	++	o	o	o
European Society	O-17	Increased traffic safety	+++	+	++	+
	O-18	Increased global competitiveness of Europe related to AD technologies	++	o	o	+
	O-19	Reduced CO_2 emission because of AV	++	+	o	+
	O-20	Reduced space needed for parking (new usage of public space)	++	+	o	+

Legend for opportunities: +++ very strong ++ strong + rather strong o neutral

Table 3.4: Overview of derived threats and their effects in the four scenarios.

Stakeholders	Threats		AD-Paradise	Tantalus	Slowly but Surely	TechPush
Private Enterprises	T-1	Missing infrastructure for AD (in general, rural, crossing borders,)	o	- -	- - -	- -
	T-2	Missing International standardisation of technology and legislation	o	- -	- -	-
	T-3	Long amortisation perlods for AD investments	o	- -	- - -	- -
	T-4	People refuse ride-pooling because they do not want to ride with strangers	- -	-	o	-
	T-5	People do not want to give up perma-nently driving control (esp. with L5)	-	-	---	--
	T-6	U.S. patents for business models by companies like Alphabet or Amazon	- - -	- -	-	- -
	T-7	Tendency to ecosystem monopoly	---	---	---	o
	T-8	Technical reliability as a critical factor (in general, in critical weather conditions)	o	--	---	-
	T-9	Missing workforce skills	---	--	--	---
	T-10	Communication networks will not be able to cover the countries	o	---	---	---
Individual European citizens	T-11	Potential loss of driving competency	- - -	-	o	-
	T-12	Potential loss of data privacy and security	--	-	o	-
	T-13	Dependency on a mobility ecosystem monopoly	--	--	--	o
	T-14	Reliability of personal mobility	- -	-	o	o
	T-15	Potential stress by monitoring ADF	-	- -	- -	-
	T-16	Missing legal certainty	o	--	---	o
European Society	T-17	Loss of jobs because of AD / Need for new job profiles	- -	o	o	-
	T-18	Traffic increase by AD vehicle (congestion, collapse, ...)	- - -	-	o	-
	T-19	Ethical critical decisions	- -	- -	- -	- -
	T-20	Low market acceptance, low development speed	o	- -	- - -	-
	T-21	Decrease of established public transport	- - -	-	o	-

Legend for threats: o neutral - rather strong -- strong --- very strong

3.4.6 Reflection of scenario-specific desirability and likelihood

During the elaboration of the four scenarios, the desirability of a scenario has not been in the scope of discussion. The selection of options A and B of every driving force was depending on plausibility, not on desirability. Especially in the case that representatives of different stakeholders are involved in a scenario process, an agreement on “plausible” future options is easier to achieve than on “desirable” future options because it reduces the influence of specific stakeholders’ interests. Taking the desirability out of the process of scenario elaboration and using it later for evaluating different scenarios increases the acceptance and feasibility of the scenario development.

The likelihood of occurrence of different plausible future developments has been partly reflected during the scenario development process. The Uncertainty/Impact-Matrix (Chapter 3.4.2) differentiates between rather uncertain driving forces on the one hand (where the participants of the L3Pilot General Assembly 2018 did not find a clear position on likelihood) and rather certain driving forces on the other hand (where a strong majority of the participants expected a specific future option to happen). However, depending on the followed scenario process, where the critical driving forces (with high impact AND high uncertainty) become the key differentiating factors of the four scenarios, a likelihood of occurrence for the scenarios cannot be derived out of the process itself.

Because of the above-mentioned reasons, an ex-post evaluation of the developed, described, and visualised scenarios is often used to reflect the desirability and likelihood of the scenarios. For that purpose, interviews with experts from different stakeholders have been used. The experts´ estimation of *desirability* and *likelihood of occurrence* – stated in the interviews – differ strongly, depending on their personal and professional perspective.

The expectation of the key effects of automated driving plays an important role. Some experts see a strong positive effect of AD technologies on comfort and safety and rate the desirability of “AD Paradise”, “Tech Push” and partly “Tantalus” as rather high. Other experts expect unwanted increased urban traffic by AD and therefore rate the desirability of “Slowly but Surely” higher.

Key findings of the reflection are:

- Experts’ diverging views on the likelihood of occurrence confirm the relevance of the scenario approach with thinking in alternative futures.
- Experts’ diverging views on desirability are a precursor of stakeholder conflicts to be resolved (see next chapter).

4 Recommendations and conclusions

4.1 Introduction

After having discussed the opportunities and threats for each business environment scenario as well as the desirability and likelihood, chapter 4 provides a short introduction into the approach “Shaping the future”, followed by recommendations for strategic action for the stakeholders involved, including an outline of major conflicting interests between the stakeholders. Finally, an analysis of the conflict lines and an outlook on how to solve them are provided.

4.2 The L3Pilot approach: Focus on “Shaping the future”

The concept of “Shaping the future” is following the idea: “Do not wait until the future happens, make it happen!” The more stakeholders are involved in such an approach, the more power is available to do this. L3Pilot is a multi-stakeholder project, where industry, academia, consumer organisations, and public authorities are involved. Altogether, they can accumulate the power needed for shaping the future. In addition, a strong connection to politics and administration increases the potential vigour.

However, this requires a consensus about the specific future that should be shaped. The discussion of the desirability of the scenarios (see chapter 3.4.6) indicates that this is not an easy exercise. Different stakeholders have different perspectives on future scenarios resulting in divergent evaluation.

Does it still make sense to pursue the “Shaping the future” approach or do the different perspectives prevent us from doing this? The answer is, “Shaping the future” is an appropriate approach, in so far as it considers all these arguments and perspectives and integrates them into a common future picture. The desired future is rather a “Best out of four futures” approach than choosing only one of the four scenarios.

This integration will be described in the next chapter, followed by the compilation of recommendations for action, differentiated according to the diverse stakeholders.

4.3 Recommendations

4.3.1 Shaping the future: What to consider

The basis of a “Shaping the future” approach is an integrated view that considers the key requirements of different stakeholders. The expert discussions about the different scenarios showed, that all scenarios have their pros and cons. The key challenge is to find a way to realize the pros and avoid the cons.

These pros and cons exist in all environmental areas and they are creating conflicts to be solved. Conflicts exist within the areas and between them. In the following, the pros and cons will be described, and the conflicts will be identified.

Society is ambivalent related to AD. Many people are enthusiastic about the advantages they expect from AD, covering the whole range from reduced stress of driving through reading, working, watching videos up to the ability of sleeping, and arriving relaxed. However, many people are concerned about the risks, having a feeling of being at the mercy of a **technology** they do not trust. Others are passionate drivers. They like driving and might be afraid to lose the joy of driving.

Technological innovation is one of the key concepts of the automotive industry to attract customers to buy their products and services. Technological innovation supports existing business models and enables new ones. New competitors of the automotive industry, especially in the area of mobility business, are big tech companies like Google, Amazon, or Tencent. They invest strongly in AD technologies, threatening the conventional business model of the automotive industry. Technology has been in the past and will be in the future an important factor to improve people´s life. On the other hand, during the last decades, **ecological** aspects became an increasingly important factor. Technology should not only cover the actual and short-term needs of society but also comply with long-term sustainability requirements. For example, a concept like Robo-Taxis might create a quantum leap in the attractiveness of urban mobility, because it has the potential to reduce the urban vehicle fleets and their needed parking space drastically. On the other hand, it also might change people's mobility behaviour from using public transport to individual Robo-Taxis, increasing energy use, and road congestion.

Economic wealth is an important driver for human activities. Earning a living through work is a key concept of societies and important to people. Creating attractive products, services, and business models by new AD technologies creates and secures jobs. On the other hand, it puts jobs at risk, too. Especially the jobs of professional drivers of taxis, buses, vans, and trucks are in danger. This type of impact – new technologies might supersede existing jobs – should be considered when discussing new AD-related business models.

Politics and Legislation play also an important role. The current legislation does not cover AD. The driver in general has still full responsibility for steering the vehicle and has to observe any ADAS function that is in active mode. There are only some exceptions in specific cases or field tests. Changing the responsibility and liability would be a paradigm shift and a balance needs to be found between the related opportunities and risks. In addition, politics and public authorities are responsible for the necessary AD infrastructure. Moreover, there is a strong need that an internationally harmonized and standardized infrastructure will be set up. This is crucial for Europe, but also important globally. The need to speed up implementation and come up with common standards should be reconciled.

All these aspects show that no one of the four scenarios as such is seen as a clearly most desired future. Although "AD Paradise" with its technological progress and high societal acceptance represents many desirable elements, it also contains some implicit or explicit drawbacks. The following section focusses on the recommendations for actions to shape the future as an integration of the desirables and an avoidance of the major drawbacks.

4.3.2 Shaping the future: What to do

This section is divided into three segments: First, general recommendations are provided, second, stakeholder specific recommendations are derived, and third, conflicts that need to be resolved are discussed. General recommendations are recommendations that make sense in every scenario. Stakeholder specific recommendations distinguish between recommendations for industry, for politics and public authorities, and academia. Finally, resulting key conflicts, which need to be solved will be derived and described. Table 4.1 shows an overview of the recommendations. In the following chapters, the recommendations will be described more in detail.

Table 4.1: Overview of recommendations.

General Recommendations
• AD requires **concerted action** from all involved parties.
• AD cannot be realised against the society, it has to be done **with and for the people**.
• AD should be seen in the **context of mobility systems**, not as a singular technology.
Stakeholder specific recommendations (partly in cooperation with other stakeholders)
Automotive industry players
• Develop AD technology achieving **safety, security, and reliability standards** and predictable behaviour.
• Foster the **development of standards** for AVs
• Create customer-oriented business models with a clear **customer value in use** and do it soon.
• Actively search for **partnerships** to realise the business models with more power and faster.
• Create **cross-border usability.**
• Communicate **clearly and honestly.**
• Create **positive experiences.**
• Embed AVs in **people´s life.**
Politics and public authorities
• Develop a **legal framework** on an international level.
• Allow appropriate **test fields.**
• Support **pre-competitive research** activities.
• Cities have to **manage the change.**
Academia
• Foster the **innovation process.**
• Take up the role of a **trustful holistic assessor** of AD.
Conflicts to solve
• Introduction of new attractive transport modes (like Robo-Taxis) **vs.** Avoidance of increased road traffic
• Introduction of new attractive transport modes (like Robo-Taxis) **vs.** Reduction of public transport
• Need for high investment for infrastructure **vs.** limited financial resources
• The high acquisition cost of AD functions for customers **vs.** dissemination speed of AD technologies
• The comfort of automated driving **vs.** stress and discomfort created by take-over requests
• Monetization of data **vs.** privacy of data

4.3.3 General recommendations

- **AD requires concerted action from all involved parties.**
  Automated Driving is a complex concept that can only be realized if vehicle manufacturers, technology suppliers, infrastructure providers, administrations, and legal authorities cooperate on a multi-national level to make it happen. Especially the development of technology, infrastructure, and regulations have to be well interlinked.
- **AD cannot be realised against the society, it has to be done with and for the people.**
  Currently, society is ambivalent about AD. Many people appreciate the opportunities and the potential benefits of AD, but there is also a large proportion of people that are concerned about it. Basically, they do not trust technology and mainly see the disadvantages and risks.
- **AD should be seen in the context of mobility systems, not as a singular technology.**
  AD at L4 and L5 has the potential to revolutionise especially the urban transportation systems. This defines additional requirements especially for AD-related business models, which need to cover integrated mobility solutions for the users.

4.3.4 Stakeholder specific recommendations

In the following paragraphs, stakeholder specific recommendations for the automotive industry but also politics and administrations, and academia are discussed. The recommendations are related to either single strategic actions of only one player or stakeholder group or collaborative action of multiple stakeholder groups.

Automotive industry players

- **Develop AD technology achieving safety, security, and reliability standards and predictable behaviour.**
  Trust is the keyword here. Trust is hard to gain but easy to lose. Not only technical failure rates need to be minimized, for reliability also the behaviour of the AVs has to be reasonable and predictable for the driver, who hands over driving to the AV. Functional safety and cyber-security need to fulfil emerging industry standards for AVs. The practical behaviour of an AV “in traffic” is the decisive factor for a customers’ assessment, whether they like and use AD or not.
- Foster the development of standards for AVs
- The already developed CoP (Code of Practise) for ADAS and CoP for AD in L3Pilot need to be followed by standards. Standards should be accepted not only in Europe but worldwide to avoid a tessellated landscape of automation.
- **Create customer-oriented business models with a clear customer value in use; and do it soon.**
  The conventional business model of the OEMs is selling cars to customers. In this business model, the sale of extra equipment (like ADAS today or AD functions in the future) plays an important role today and also in the future. In addition, service-related business models with and around AVs will grow significantly. Such business models require cooperative and coordinated activities from various stakeholders – even from different sectors – to generate a customer

value in use. It should be considered that in the U.S., already many service business models are protected by patents.

- **Actively search for partnerships to realise the business models with more power and faster**
  Beyond technological development, a strong and big ecosystem is of high relevance for service-related business models. Big tech companies already rely on comprehensive ecosystems and are running a large bundle of services in these ecosystems. OEMs should strongly question themselves whether they are strong enough to build their own ecosystem. Because of the economy of scale, not all OEMs can be successful with proprietary ecosystems for AD-related services.
- **Create cross-border usability.**
  Especially for the European Union with its open internal borders with many people crossing borders occasionally or even regularly, common standards for vehicles and infrastructure are of high importance. Of course, this requires the availability of a seamless infrastructure, too. To provide cross-border usability, car manufacturers, suppliers, infrastructure providers, and administrative bodies have to work together on a multi-national level.
- **Communicate clearly and honestly.**
  People who have been sceptical about AD up to now need credible and open communication that goes beyond what is legally required. This also includes a critical examination of the limitations and risks of technology. Use social media to also reach young people.
- **Create positive experiences.**
  The majority of people need to be convinced of the benefits of AD and that they are stronger than the drawbacks or risks. Own positive experiences play a big role in this context. However, this requires a high level of functionality, high safety, and a comfortable driving experience.
- **Embed AVs in humans' life.**
  AVs and human drivers will probably use roads together for a long time. The transition from completely human steered vehicles (today) to completely automated road traffic will last decades, as we have many other road users, like motorbikes, bicycles, pedestrians, etc. to take into account. AVs will probably behave differently from human drivers (e.g. they might always comply with traffic rules, also in situations where humans beings tend not to do so) and need a distinct way to communicate with human drivers (eye contact and gestures might not work). Therefore, AVs should be clearly recognisable as such (e.g. by specific 360-degree illumination). Their way to communicate with humans has to be intuitively comprehensible. Thus, a new etiquette between human drivers and AVs is needed.

Politics and administrations

- **Develop a legal framework on an international level.**
  To realize the benefits of AD, a paradigm change in road traffic legislation needs to be enacted: The shift of the responsibility from the driver to a technical system. This can only take place if the AD technology is sufficiently safe and reliable. Nevertheless, it should be considered, that

technology can reach a high level of safety and reliability, but will never be totally safe. Failure rates significantly lower than those for humans can be reached, but they never will be zero. Appropriate standards have to be defined for homologation (certification) and they should be valid internationally. Science can support these activities with its expert knowledge and from a neutral position.

- **Allow appropriate test fields.**
  One of the key challenges of AD is the complex interaction with the high diversity of road users in different situations and under various and even adverse weather conditions. Thus, a lot more testing is still necessary to ensure the safe and reliable functioning of the technology in all those conditions. The automated systems need to be tested and trained under specific safety constraints.
- **Support pre-competitive research activities.**
  Without broad and early standardisation, AD might fail, or at least it will lose a lot of time until market implementation. In order to avoid that different stakeholders develop their own unique and non-standardised solutions, common pre-competitive research and development activities are important. This includes industry players from the automotive industry and beyond, universities and other research institutes, and public authorities. Public-private research funding is already supporting that and needs to be continued.
- **Cities have to manage the change.**
  As AD has the potential to strongly change the traffic especially in urban regions (e.g. fleets of circulating Robo-Taxis instead of parked private cars), cities have to develop concepts for integrating strategically the new opportunities in their public and private urban transport systems to increase sustainability in all three dimensions (economic, ecological and social). They need to ensure they are not getting overwhelmed by the developments instead of controlling them. This also requires appropriate skills and competencies.

Academia

- **Foster the innovation process.**
  Universities and research institutes have experts with sound knowledge about AD-related specific technologies, processes, and human behaviour. Together with industrial partners, they can play a significant role in pushing innovations.
- **Take up the role of a trustful holistic assessor of AD**
  From a societal perspective, stakeholders with a specific interest in AD (e.g. economic or political) are easily considered biased in their communication about AD. Science institutes (when they are not directly involved in the technology development) can build up a position to neutrally inform society about the opportunities and risks of AD. However, this role requires in addition to their scientific expertise also strong communication skills.

4.3.5 Conflicts to solve

Overall, the above listed and described recommendations can be found in many publications about AD. They will probably find a rather high acceptance by different stakeholders and many people. However, it is not so easy to just follow them, as some are rather contradictory. The resulting conflicts need to be resolved to make AD a success. The key requirement for success can be formulated as “Make the benefits happen by avoiding the disadvantages as much as possible.”

- **Introduction of new attractive transport modes (like Robo-Taxis) vs. Avoidance of increased road traffic**
  New and attractive transportation modes lead generally to a shift of transportation shares from existing modes to the new mode. The concept of Robo-Taxis with its high attractiveness (door-to-door transport with lower costs than conventional taxis) surely will reduce the need for private cars but might also lead to an undesired shift from public transport, undesired at least from a municipality’s perspective. Consequently, road traffic and probably congestion will increase. That creates a conflict between Robo-Taxi fleet providers and their business model (aiming at a high transport share) and the municipality (aiming at sustainable and well-functioning transport systems). Municipalities can avoid the negative effects with strong regulations, but that might jeopardise the whole business model. Concepts to solve this conflict have to be developed and tested.
- **Introduction of new attractive transport modes (like Robo-Taxis) vs. Reduction of public transport**
  Following the same argumentation as above, the shift from public transport to Robo-Taxis would also lead to a reduction in the volume of public transport. This will likely increase the existing financial deficit of public transport in most cities. Especially in off-peak hours, when public transport schedules are less attractive and road traffic is mainly free of congestion and faster, public transport demand will decline. Municipalities have an interest in an attractive and viable urban transport system. Public transport and new modes like Robo-Taxis together with others (like micro-mobility modes) have to be integrated into efficient, effective, and viable concepts of urban transport systems. Concepts should be developed and demonstrated.
- **Need for high investment for infrastructure vs. limited financial resources**
  AD needs an appropriate infrastructure. High-speed and broadband communication infrastructure is a prerequisite for AD. The technology is already available (ITS-G5, LTE, 5G), but the network coverage in Europe is currently still low and needs high investments. Additional roadside infrastructure is needed because the infrastructure requirements of human drivers and AVs are different (e.g. in scene recognition at harsh weather conditions or construction sites). However, public investment for AD competes with other public spending and private investment requires the expectation of positive business cases. The mutual dependency of the different factors is complex: If there is no reliable infrastructure, the demand for AVs will remain low. This in turn will not give rise to innovative and viable business models. Without viable business models, public investments in AD infrastructure will remain low.

- **The high acquisition cost of AD functions for customers vs. dissemination speed of AD technologies**
  The conventional and original business model for car manufacturers is developing and selling cars to customers. This is still today the key business model, though with some adjustments. The business model also works with ADAS, which are sold in their market entry phase as extra equipment (at extra costs) and in later phases as standard equipment. Automation at SAE L3 and beyond can also be marketed via this business model. The above-discussed high requirements related to safety and reliability lead to significantly higher prices compared to existing ADAS systems. For example, Tesla offers its “Autopilot with full self-driving capability” for 7,500 € (with the additional remark that “prices are likely to increase over time with new feature releases”) (Tesla, 2020). The conventional dissemination of new technologies from upper price segments to lower price segments in conjunction with decreasing costs by economy of scale might also work for AD functions. However, it will slow down the dissemination speed significantly.
- **The comfort of automated driving vs. stress and discomfort created by take-over requests**
  A very interesting and highly relevant conflict occurs directly related to the comfort argument of AD, as one of the major advantages of AD is an increased comfort during the ride. Drivers do not solely need to concentrate on the driving task but are allowed to do different activities, from relaxing to working. However, especially at SAE L3, the potential take-over of the driving task at nearly any time might create high stress for drivers (depending on the personal disposition and capabilities), in a way that the increase of comfort might be countered by the fear of false reactions in such a stressful situation. This might discourage drivers from acquiring the technology.
- **Monetization of data vs. privacy of data**
  AD creates an immense amount of data. Hence, the monetization of data is a subject of many existing and emerging business models and will most likely include AD-related data in the future as well. The biggest barriers to these business models are questions of data ownership, data privacy, and data security. Data ownership related to AD data is a complex question and still under clarification. Data privacy and data security have to be safeguarded in a trustworthy way.

As a concluding recommendation, we would propose to build-up a multi-stakeholder dialogue, to discuss these conflicts and elaborate appropriate solutions for them. Solving these conflicts will give AD a strong push.

4.4 Impact, conclusions, and outlook

The overall objective of L3Pilot is to test and study the viability of automated driving as safe and efficient means of transportation and to explore new mobility service concepts to provide innovative and sustainable mobility solutions for all people. With the development of business environment scenarios for AD in 2030, WP1.4 *Exploitation and Innovation* makes a significant contribution to the overall project objective.

For L3Pilot three major impact areas are defined: knowledge impact, societal impact, and business impact. All impact areas address user acceptance, as it is the key to the success of AD systems on the market. However, the business impact area especially focusses on how to address customer requirements and thus develop user-centric deployment perspectives for AD.

With the development of the business environment scenarios, **WP 1.4 strongly contributes to the business impact of L3Pilot** and provides a solid knowledge base for industrial players as well as societal and political actors to jointly design innovative and sustainable future mobility systems and solutions. This knowledge base will be expanded by the generation and analyses of AD-related business models and the development of deployment perspectives for AD (which will be part of deliverable D1.6).

The following Table 4.2 shows in detail how the business environment scenarios for AD in 2030 may impact the deployment path of the European automotive industry. **One major pillar of the exploitable results is the provision of detailed and structured knowledge with regard to possible future developments for AD-related business** (trends and driving forces analysis, business environment scenarios, incl. their visualisation – all marked in grey). **The second pillar contains the development of a dialogue platform with decision-makers** from industry and policy but also experts in the field of automated driving. This dialogue will be continued with the generation and evaluation of viable and sustainable business models for automated driving.

Table 4.2: Business impact of business environment scenarios.

Exploitable results	Measures to maximize impact
• Analysing relevant **trends and driving forces** for future AD-related automotive business environment	• **How to handle the future:** Deriving opportunities and threats for different stakeholders in each scenario (based on project internal and external experts' evaluation) • **How to shape the future:** Providing recommendations for action to make the most desired future happen (based on project internal and external experts' evaluation)
• Developing four different **business environment scenarios 2030** for AD-related business models	
• Conducting **expert evaluation** of the scenarios	
• Providing **user-centric description and visualisation** (incl. a video) of each scenario	• **Presenting L3Pilot future scenarios** for AD (video) to the wider public via social media
• **Establishing a dialogue platform** with industry and policy (EUCAR, etc.)	• **Presenting and discussing business scenarios** with decision-makers (e.g. at EUCAR Conference 2019)
• **Generating business opportunities** for ADFs and related services in each scenario	• **Creating inputs for the description and evaluation** of future AD-related business models (BM) and the roles, different stakeholders will have in these BM (will be part of Deliverable D1.6)

The findings of the business scenario development show that the keys to successful market integration of AD are a broad user acceptance and viable business models, but also a well-developed infrastructure, and a harmonized legal framework on the international level. The scenarios are in line with most current debates about the future of automated driving.

However, **the development of these critical success factors is still highly uncertain**. **User acceptance** of new technologies is strongly influenced by experience but the majority of people do not have any experience with vehicle automation yet. Further, the very high investments for the **communication infrastructure for AD** may require an agreement between public and private investors to share expenses. Finally, a common **agreement on legal restrictions**, sustained by the nation states, to find a harmonized solution on the international level is still a big challenge.

In order to deal with this uncertain future development for automated driving, especially with its complex interdependencies between different stakeholders, **a scenario development approach has been applied in L3Pilot.** The method provides a structured approach to integrate various perspectives in a participatory way and to discuss and communicate different possible future developments. Even though the four business environment scenarios do not depict all conceivable futures, they nevertheless describe a wide framework that contains a variety of future options.

With the four different business environment scenarios, **a solid knowledge base has been offered for private and public decision-makers** to tackle the three big challenges mentioned above. However, the framework conditions for AD-related business are quite different in the four business scenarios. The results of the scenario analysis show that there is a **wide range of scenario-specific opportunities but also threats** that need to be taken into account for decision-making processes.

With these opportunities and threats, the **scenarios provide the scope for the development and evaluation of viable business models for automated driving**, which will be part of Deliverable D1.6 *Deployment strategies and business models for ADFs*. The findings of the scenario development process also indicate that a successful market implementation of the next level of ADFs does not only need to address the requirements and especially concerns of potential users. It also requires viable and sustainable business models, which sometimes have to deal with contradictory stakeholder interests from private and public sectors. With a *multi-stakeholder approach*, conflicts might be resolved or at least mitigated at an early stage of AD-related business model generation that will boost the market implementation.

For instance, AD-related mobility solutions for urban areas (e.g. Robo-Taxis) might lead to an increase in road traffic, and even cannibalizing public transport means. On the other hand, currently more and more urban initiatives from citizens and municipalities come up aiming at reducing the traffic in cities and developing concepts for alternative use of urban space. Both developments, newly AD-induced traffic versus alternative concepts for urban space, might give rise to **conflicts between public and private stakeholders**. Hence, new business models for AD need to take into account the interests of city authorities and possible restrictions regarding limited access to city centres for private or fleet vehicles in order to be successful. Again, a multi-stakeholder approach that involves both private companies and public authorities at an early stage of business model generation can push the market implementation of AD.

Following a *collaborative approach* and join forces not only from public and private decision-makers but also from different industries in order to shape the future for automated driving could

also be an option for the automotive industry with regard to its relations to the IT players. This is because the biggest challengers of the automotive sector in the field of automated driving are IT companies with a huge competitive advantage in data-driven businesses. The question is whether the OEMs are able to catch up and become serious competitors or if strategic cooperation with the tech companies is the only way to keep up with data-driven and AD-related business.

The second deliverable of WP1.4, *D1.6 Deployment strategies and business models for ADFs*, will take up the topic and discuss the challenges for the automotive industry but also its competitive advantages with regard to new competitors from the IT sector and the speed they bring into the competition. Against this background, viable business models for automated driving will be provided and evaluated. Further, D1.6 will elaborate on the business models' fit to the possible future business scenarios and derive strategies on how to prepare AD-related business for a still uncertain future.

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Annex 1: Driving forces and driving forces options´ allocation to the four scenarios

Driving force number and name: **P1 – Governmental Support for AD**

Specification of the driving force (What does it mean?):

- *Generally the government support for AD includes all measures to bring AD – technology to a high-level of readiness. To be concrete, the main support is characterized by two key – elements: Strong & effective funding programs & creation of legal frameworks.*

Status 2019

Governmental support is existing but these could be intensified

- *Several funding programs on national & European level are available but with limited budget & focus.*
- *Only a few countries have dealt with AD and introduced a legal framework for demonstrations (SAE 3).*

Status 2030 - Option A

Steadily increased

- *Funding programs for demonstrating the technology helped to push AD to come to market.*
- *Legislation on European & national level has been coordinated, so a common legal basis was built, in order to enable demonstrations even with SAE L4 vehicles.*

Reasons for occurrence of Option A

- *The governments have realized the importance of the topic as AD is not only a "game changing" topic for the automotive industry but also fundamental for the whole society.*

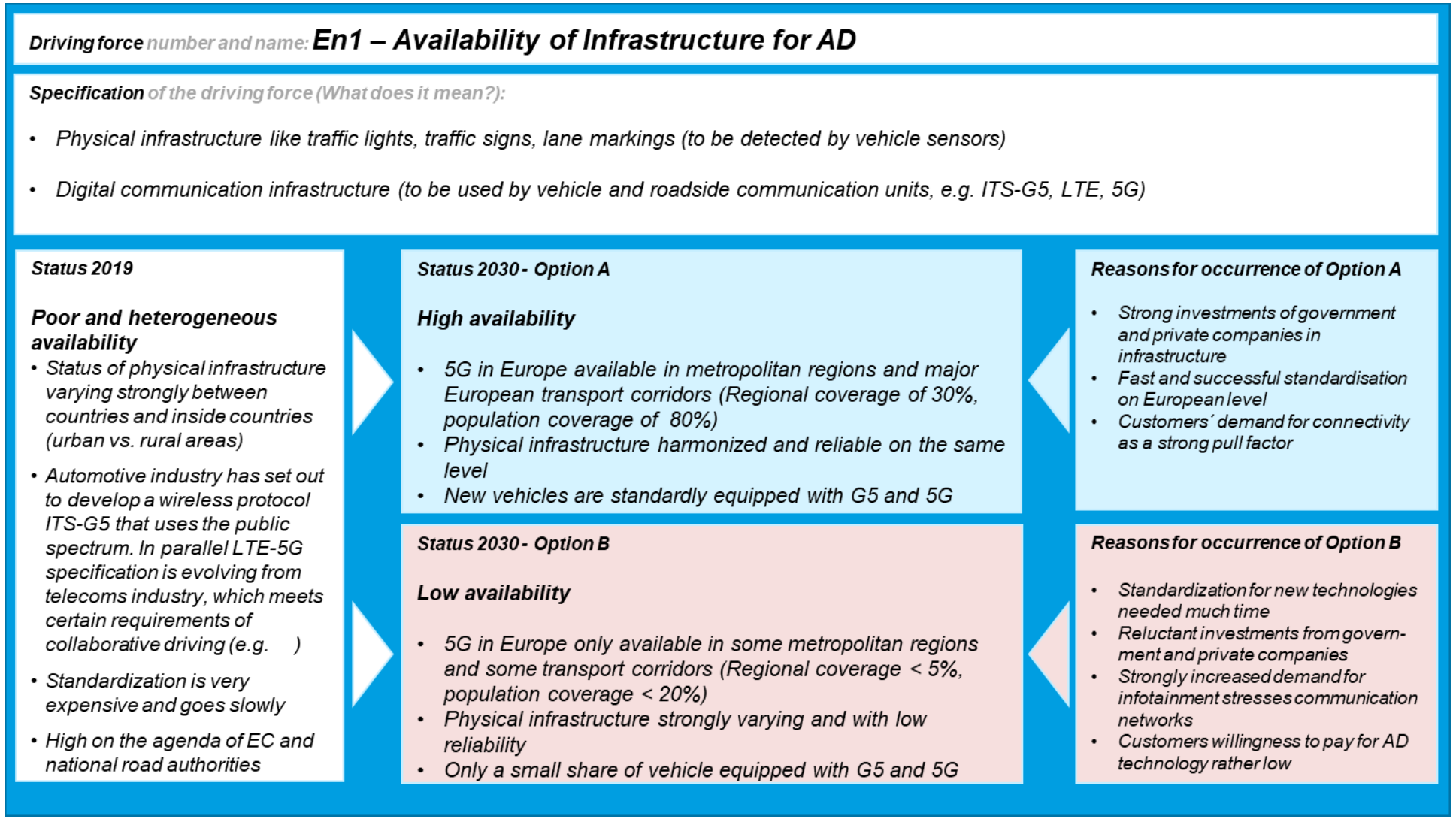
Status 2030 - Option B

Remained constant

- *All in all, the level of funding remained the same.*
- *The consultations at European level did not produce any result, so as a consequence different legal frameworks in the relevant countries have been introduced.*

Reasons for occurrence of Option B

- *Major technological breakthroughs have been made by the industry without the need of increased funding programs.*
- *A common understanding of the importance of AD could not been made by the countries.*


Driving force number and name: En1 – Availability of Infrastructure for AD
Specification of the driving force (What does it mean?):
• Physical infrastructure like traffic lights, traffic signs, lane markings (to be detected by vehicle sensors)
• Digital communication infrastructure (to be used by vehicle and roadside communication units, e.g. ITS-G5, LTE, 5G)
Status 2019
Poor and heterogeneous availability
• Status of physical infrastructure varying strongly between countries and inside countries (urban vs. rural areas)
• Automotive industry has set out to develop a wireless protocol ITS-G5 that uses the public spectrum. In parallel LTE-5G specification is evolving from telecoms industry, which meets certain requirements of collaborative driving (e.g.)
• Standardization is very expensive and goes slowly
• High on the agenda of EC and national road authorities
Status 2030 - Option A
High availability
• 5G in Europe available in metropolitan regions and major European transport corridors (Regional coverage of 30%, population coverage of 80%)
• Physical infrastructure harmonized and reliable on the same level
• New vehicles are standardly equipped with G5 and 5G
Status 2030 - Option B
Low availability
• 5G in Europe only available in some metropolitan regions and some transport corridors (Regional coverage < 5%, population coverage < 20%)
• Physical infrastructure strongly varying and with low reliability
• Only a small share of vehicle equipped with G5 and 5G
Reasons for occurrence of Option A
• Strong investments of government and private companies in infrastructure
• Fast and successful standardisation on European level
• Customers´ demand for connectivity as a strong pull factor
Reasons for occurrence of Option B
• Standardization for new technologies needed much time
• Reluctant investments from government and private companies
• Strongly increased demand for infotainment stresses communication networks
• Customers willingness to pay for AD technology rather low

Driving force number and name: **En2 – Customer Price of AD functions**

Specification of the driving force (What does it mean?):

- The customer price of AD functions are the extra costs that the buyer pays additionally to the price of a "normal" vehicle.
- The customer price of AD functions is driven by technological aspects, buying behavior of the customers, uptake rate and specific aspects of competition.

Status 2019

High costs for AD functions.

- Currently, the AD functions available are expensive. Reason for that, amongst other things, are missing economies of scale.
- In comparison, AD functions introduced into the market "long-time ago" are relatively inexpensive or sold without extra-charge (e.g. the Volkswagen "Front Assist").
- Competition has started but remains on a moderate level, but new players are entering the market.

Status 2030 - Option A

Strongly decreased

- AD functions on SAE level 4 are part of the basic equipment of the series-cars.

Reasons for occurrence of Option A

- Intense competition of OEMs & suppliers is leading to breakthrough technological innovations & fast integration into the series production (economies of scale).
- Low price sensitivity by the customer, so R&D costs could be compensated quickly.
- The legislature requires the installation of AD functions into the cars.

Status 2030 - Option B

Slowly decreased

- AD functions are offered mainly in the premium car segment of the OEMs at high extra price.
- AD Technology enters the market only slowly.

Reasons for occurrence of Option B

- Infrastructure is not ready for AD functions.
- The OEMs implement proprietary technology.
- A significant proportion of the customers avoid using AD functions due to social-culture restrictions.
- Costs for market introduction are higher than expected.

Driving force number and name: **En3 – Competition Structure of Digital Automotive Ecosystems**

Specification of the driving force (What does it mean?):

- Digital ecosystems are characterized by complementarity and interdependency because offers are built on the availability of other technologies
- Digital ecosystems are generated in co-evolution with customers and partners, using network effects that are even more effective the more users use a platform and might create a self-reinforcing effect.
- Competition structure means number, size, type and power of market players (e.g. incumbents like established OEMs, IT giants, but also new entrants and startups)

Status 2019

Manifold developments

- Digital automotive ecosystems are evolving, especially in mobility services.
- A first phase of diversification led already to a new phase of consolidation (e.g. merger of mobility services of Daimler and BMW)
- IT giants (like Amazon, Google, Apple) are also targeting mobility services as well as startups like Uber or Lyft
- Alliances between OEMs and IT giants are getting formed

Status 2030 - Option A

Open and fragmented ecosystem

- Car-related services are integrated with other travel, professional and lifestyle services
- Software components for separate functionalities are available from different vendors
- Customers can easily use solutions from different ecosystems in parallel

Reasons for occurrence of Option A

- Some big scandals related to data abuse of dominating digital platforms in other businesses led to a change in attitudes
- Governments has enforced open standards and controlled the market power of consortia
- A lot of customers prefer to split their data on different providers

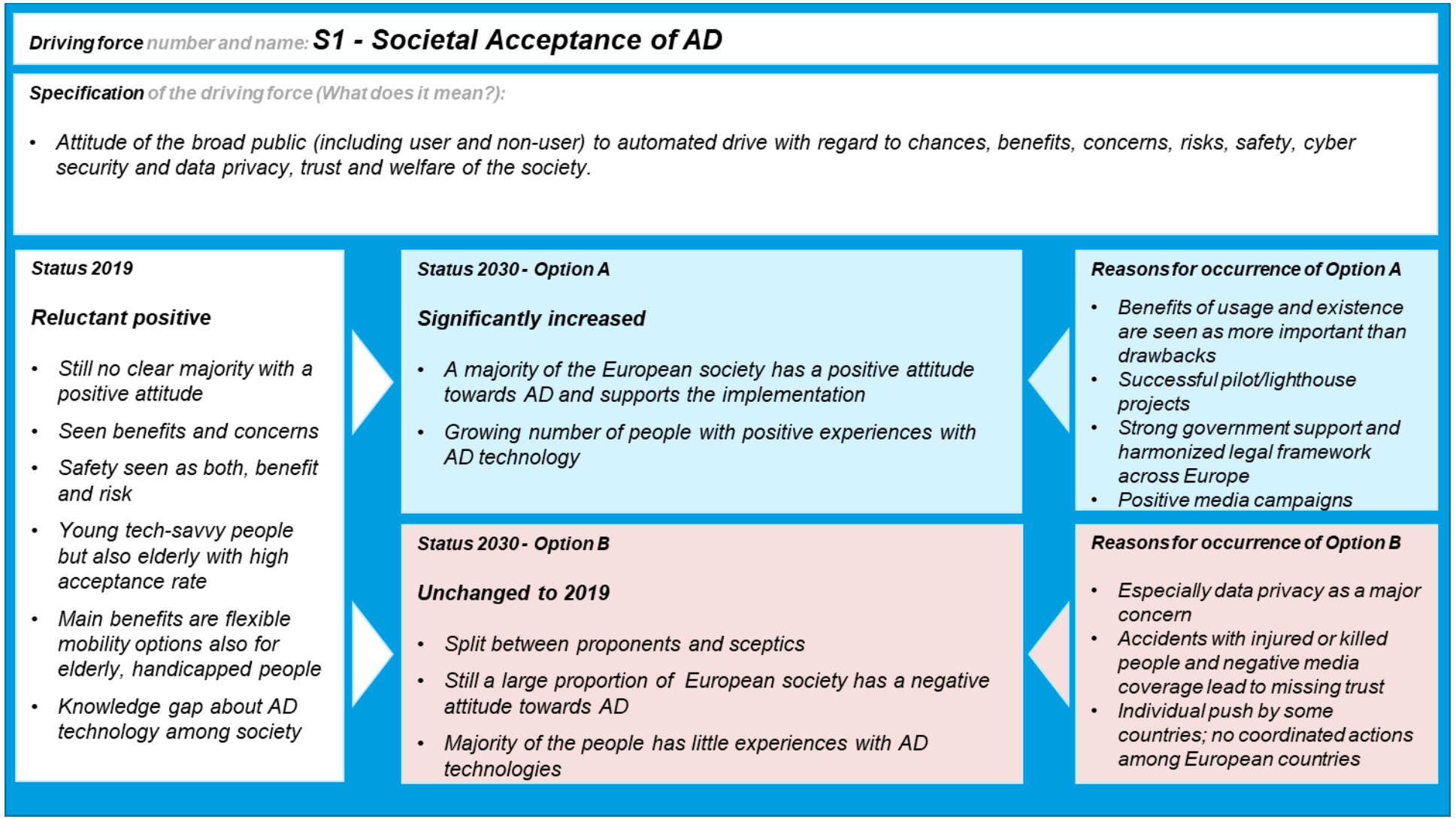
Status 2030 - Option B

Strong oligopoly

- Only a few (3) separated ecosystems consisting of integrated hard- and software standards dominate the market.
- Each of these ecosystems belongs to a consortium of OEMs, TIER 1 suppliers and IT giants. Attractive startups are acquired in an early growth phase.
- Customers are bound strongly to one ecosystem (like in 2019 Apple/Windows or Apple/Android)

Reasons for occurrence of Option B

- Fear of competition led to strong movement into alliances.
- Governments accepted the resulting market power of the consortia to ensure global competitiveness
- Users prefer stronger integration of services for their needs


Driving force number and name: S1 - Societal Acceptance of AD
Specification of the driving force (What does it mean?):
• Attitude of the broad public (including user and non-user) to automated drive with regard to chances, benefits, concerns, risks, safety, cyber security and data privacy, trust and welfare of the society.
Status 2019
Reluctant positive
• Still no clear majority with a positive attitude
• Seen benefits and concerns
• Safety seen as both, benefit and risk
• Young tech-savvy people but also elderly with high acceptance rate
• Main benefits are flexible mobility options also for elderly, handicapped people
• Knowledge gap about AD technology among society
Status 2030 - Option A
Significantly increased
• A majority of the European society has a positive attitude towards AD and supports the implementation
• Growing number of people with positive experiences with AD technology
Status 2030 - Option B
Unchanged to 2019
• Split between proponents and sceptics
• Still a large proportion of European society has a negative attitude towards AD
• Majority of the people has little experiences with AD technologies
Reasons for occurrence of Option A
• Benefits of usage and existence are seen as more important than drawbacks
• Successful pilot/lighthouse projects
• Strong government support and harmonized legal framework across Europe
• Positive media campaigns
Reasons for occurrence of Option B
• Especially data privacy as a major concern
• Accidents with injured or killed people and negative media coverage lead to missing trust
• Individual push by some countries; no coordinated actions among European countries

Driving force number and name: **S2 – Demand for Shared Mobility**

Specification of the driving force (What does it mean?):

Shared Mobility is an umbrella term that encompasses a variety of transportation modes including carsharing, bikesharing, peer-to-peer ridesharing, on-demand ride services, and other modes.
Shared mobility implies a shift from personal ownership of vehicles to shared use of vehicles (owned privately or by fleet owner).
Mobility-as-a-service concepts generally include shared mobility options.

Status 2019

Small but increasing demand in urban areas

- *Most people travel predominantly using one single mode (e.g. (own) car, public transport or bicycle)*
- *Demand for shared mobility services in urban areas is increasing. Mainly young, male and highly educated users*
- *Various providers of shared mobility services with own apps are on the market and many different shared mobility platforms are in development*
- *It is assumed that users prefer one single app and easy-to-use solution instead of multiple apps*
- *Some bicycle-sharing companies went bankrupt and left bicycles all-over the city*

Status 2030 - Option A

Significantly increased

- *Most people have a positive attitude towards sharing: suitable vehicles available, fewer vehicles needed, vehicles are renewed more quickly so more innovative, motorized or not, whatever the travelers (or logistics companies) need.*
- *A majority uses shared mobility options at least occasionally.*

Reasons for occurrence of Option A

- *Sharing is made easy and affordable by providers and with governmental support.*
- *Private vehicle ownership is expensive and a hassle (maintenance, congestion, parking problems)*
- *Shared vehicles make the transport system more efficient*
- *Governments enforce shared mobility in some cities*

Status 2030 - Option B

Slightly increased

- *Small share of population (and logistics companies) embraces sharing, the rest is happy to own and use their own vehicles*
- *There is no sense of urgency that sharing is the way forward*
- *Some sharing schemes cause annoyance (vehicles left in unsuitable places)*

Reasons for occurrence of Option B

- *Shared mobility providers are competing / don't work together to improve their services*
- *Not enough improvement in user friendliness (vehicles available, costs, payment methods)*
- *People just don't like sharing, or do not trust others enough*
- *Governments don't see enough reasons to support and promote sharing or find it too expensive*

Driving force number and name: **S3 – Environmental Behaviour**

Specification of the driving force (What does it mean?):

- *The status of environment strongly depends on human behaviour. Even though there is a strong awareness about environmental problems caused by human beings (like consumption of fossil fuels, harmful emissions, land usage, amount of waste) too little action is taken by society, industry and at the individual level to tackle these issues.*

Status 2019

High levels of concern and the need for action

- *Environmental issues notably climate change, air pollution and growing amount of waste are considered as most important across Europe*
- *Majority of people selectively behave as individuals in environmentally friendly ways (e.g. waste recycling but frequent flying)*
- *Young generation more eco-friendly; women with higher social responsibility than men*
- *Environment protection starts at the individual level where more needs to be done*

Status 2030 - Option A

Rise of green living

- *Strong increase of environmental awareness among all socio-demographic groups*
- *Majority of people across Europe assumes responsibility for environment quality and significantly change its behaviour (e.g. frequent use of public transport and EVs, using energy-efficient household equipment, ban plastic waste)*

Reasons for occurrence of Option A

- *Severe ecological disasters and visual evidence of global warming significantly affect people's live*
- *Harmonized strong political support at the national and European level to encourage environmentally-friendly behaviour (e.g. public transport)*
- *R&D investments and industry-driven campaigns to push green solutions*

Status 2030 - Option B

"Business as usual"

- *Strong environmental awareness across Europe but differences between socio-demographic groups and countries*
- *Behaviour of the majority (society and industry) related to environmental friendliness does not change significantly*

Reasons for occurrence of Option B

- *Occasional measures by national governments and the European Union*
- *Still weak environmental legislation for society and industry (e.g. reducing waste, emissions) in many European countries*

Driving force number and name: **S4 – Personal Vehicle Ownership Share**

Specification of the driving force (What does it mean?):

- *Vehicles can be privately owned (by people/household), company-owned or leased*
- *Personal vehicle ownership share is defined as the share of passenger cars which are at the full disposal of a private person (choice of brand, type, equipment; permanent personal availability)*

Status 2019

Mainly private owned cars

- *Personal car ownership is still important for majority of people (Private vehicle ownership > 90%)*
- *But the importance of ownership is decreasing, especially for the younger generation and in urban areas (due to e.g. increased higher education participation but also high cost of driving, less secure jobs, preference to communicate on-line while travelling, greater environmental awareness)*
- *Highest growth in vehicle ownership for elderly people*
- *Still very small share for shared vehicles (peer-to-peer or via sharing platform)*
- *Increase of urbanization*

Status 2030 - Option A

Sharp decrease

- *A lot of people no longer see a need to own their vehicle.*
- *There is a decrease of the personal vehicle ownership, with about 10-15%*
- *Instead, people use shared vehicles (motorised or not)*
- *Shift toward subscription and pay-per-use models*

Reasons for occurrence of Option A

- *Shared mobility options are cheaper and more user friendly than owning a private vehicle, and available in most places.*
- *Shared vehicles are newer, with more (automated) functions, and often electric – safer & eco-friendly; important aspects to many users*

Status 2030 - Option B

Small decrease

- *People still value owning their vehicles.*
- *There is a small decrease of the personal vehicle ownership rate, with about about 5%*
- *In some families, second or third car are the first to go, but there are also some single-car households that decide to get rid of their car.*

Reasons for occurrence of Option B

- *The privately owned vehicle is still a status symbol for many.*
- *The privately owned vehicle is more convenient than a shared vehicle and still affordable for many*
- *Automated (L3/L4) and electric vehicles become cheaper over time and people are eager to own one*

Driving force number and name: **S5 – Willingness to pay for digital content**

Specification of the driving force (What does it mean?):

- Consumers willingness to pay for digital content in general (e.g. music and video streaming, advertisement-free social networks with premium features, mobile local information focused on individual needs, etc.)
- Pay per use or temporal (daily, weekly, monthly, annual) subscriptions

Status 2019

Low willingness to pay in broad society

- Based on comprehensive amount of free web content many people do not want to pay anything extra
- In special segments there is some willingness to pay (e.g. Spotify has globally about 200 million users, nearly 50% of those pay for the premium access; Netflix has about 120 million paying subscribers globally)
- But: according to the International Federation of the Phonographic Industry, nearly 40% obtain music through copyright infringement

Status 2030 - Option A

Significantly increased

- More and more users accept to pay for high quality and advertisement free content
- Both, pay per use schemes and subscription models increased significantly

Reasons for occurrence of Option A

- Quality of paid content higher
- Consumers see additional value
- Copy right violations are controlled and monitored strongly
- Attractive pricing models

Status 2030 - Option B

Slightly increased

- The majority of the people consumes only free content, even though the advertisement has increased
- A smaller but slightly growing part or the consumers pays for premium content

Reasons for occurrence of Option B

- A big variety of free content is available
- Consumers' majority does not see a big additional value
- Possibilities for non-legal free consuming of content (e.g. music) still exist and are used

Driving force number and name: **T1 – Application of Big Data Technologies**

Specification of the driving force (What does it mean?):

- Big Data Technologies: Predictive analytics, user behavior analytics, or certain other advanced data analytics methods that extract value from huge amounts of data from various sources, that might be complex, unstructured, incoherent and/or volatile.
- Big Data concepts, tools and models are used to solve complex problems, connect and combine data to information and therefore create new methods and applications in various industry and business sectors

Status 2019

Reluctant positive

- Handling rapidly growing data sets is an important challenge
- Computation power rises, storage space gets cheaper, the number of data sources increases rapidly
- Gaining information from merging and analyzing different, dissimilar data sources becomes more and more relevant for various applications

Status 2030 - Option A

Strongly increased

- Big Data technologies will replace many of the now commonly used information sources and data storage concepts
- Data from all kinds of sources can be automatically linked and analyzed instantly, making Big Data both invisible and crucial in daily and business-focused life
- Due to computation power rising, input data quality is increasing, which simplifies data analysis.

Reasons for occurrence of Option A

- Big Data frameworks become powerful and easy-to-use, Cluster hardware becomes more affordable
- Data analyzing and data preparation / fusion can be automated without deep expert knowledge of the data
- Data becomes the basics to develop ML & AI concepts.

Status 2030 - Option B

Slightly increased

- Data analyzing is limited to the input data quality (manual data preparation requires expert knowledge)
- The complexity of models, projects, systems and/or management problems can lead to limited accuracy

Reasons for occurrence of Option B

- Big Data is a tool, limited to human knowledge, judgment and innovation
- The abilities of Big Data will not scale further due to the lack of structured and suitable input sources
- Questions related to ethical programming remain unanswered.

Driving force number and name: **T2 - Automated Driving Technology**

Specification of the driving force (What does it mean?):

- *Automated driving technology enables vehicles to sense the environment and navigate without human input by combining a variety of techniques to perceive their surrounding. These include sensors like radar, laser, gps, odometry and methods like computer vision & AI to achieve different levels of autonomy.*
- *Automated driving is a key technology contributing to increased safety, comfort and environmental protection in the context of mobility.*

Status 2019

Motorway assistance systems on an advanced level

- *Automated driving technology has been successfully deployed for autonomy levels up to L2 and have been prototyped for higher levels of automation.*
- *Performance still requires improvement for successful deployment in urban scenarios.*
- *First L3 functions are entering the market.*

Status 2030 - Option A

Disruptively increased

- *Empowered by the advancements in sensors, artificial intelligence and computational power, automated driving reaches a level of maturity that allows for safe deployment of high automation.*

Reasons for occurrence of Option A

- *Large investments into R&D for self-driving technology lead to major breakthroughs in sensors solving the major challenges of perception and localization*
- *Breakthrough research on AI, extremely successful in solving behavioral challenges of AD*

Status 2030 - Option B

Evolutionarily increased

- *Automated driving is progressively rolled out starting with lower levels of automation but systems will reach high automation only under strict conditions.*
- *Performance development is evolutionary but no breakthroughs*

Reasons for occurrence of Option B

- *Continuous research work shows success, but some limitations/restrictions still not overcame*
- *Validation and verification of AD systems, societal and other challenges*

Driving force number and name: **T3 - Application of Artificial Intelligence**

Specification of the driving force (What does it mean?):

- *Artificial intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience.*
- *Artificial intelligence is one of the pioneering drivers of the digital revolution in terms of its already existing and potential applications.*

Status 2019

Manifold applications on a basic / advanced level

- *Artificial intelligence already in a lot of applications like search engines, speech recognition, data and text mining, graphical recognition, gaming, robotics, automated drive, financial market´s analysis and prognosis, …*
- *Performance still far away from human intelligence*

Status 2030 - Option A

Disruptively increased

- *Artificial intelligence entered nearly all imaginable fields of application on the bases of disruptive performance increases*
- *In general still not on the level of human intelligence, artificial intelligence in combination with strongly increased computation power made a huge performance jump*

Reasons for occurrence of Option A

- *Moore´s law is still valid in 2030*
- *Breakthrough research work on AI, extremely successful*
- *AI leads in many applications to cost savings and is therefore subject also of strong industrial R&D investments*

Status 2030 - Option B

Evolutionarily increased

- *Artificial intelligence entered additional fields of applications*
- *Performance development is evolutionary but no breakthroughs*

Reasons for occurrence of Option B

- *Moore´s law comes to it´s boarders, development in IT performance retarded*
- *Continuous research work shows success, but some thresholds still not overcame*
- *Societal interests groups propagate against AI*

Driving force number and name: **T4 – Application of AD Functions in Vehicles**

Specification of the driving force (What does it mean?):

- The number of production vehicle types equipped with automated driving functions (SAE level 3-5) that are available on the market.
- The range of vehicle types with AD functions includes passenger cars as well as commercial vehicles and trucks.

Status 2019

Only few premium brands with L2 ADFs

- The number of currently available vehicles equipped with SAE L2 functions is limited to a handful of (premium) brand models (AUDI, BMW, Mercedes Benz, Tesla and other brands)
- Current legal restrictions do not allow OEMs to enable available L3 functions in the car and there are still some technical challenges to overcome

Status 2030 - Option A

Broad application of ADFs

- Strong increase in the number of models offering ADFs in the passenger car segment. L3 functions are available in all vehicles categories. More than 50% of all newly-registered cars are L3 vehicles.
- In addition all premium brands offer models equipped with L4 functions for motorway. New-vehicle market share of L4 vehicles is about 15%.
- Commercial vehicles and trucks are provided with L3 functions for motorway application

Status 2030 - Option B

Limited application of ADFs

- Moderate increase in the number of passenger cars with ADFs. L3 functions are only available in the premium car segment, whereas all premium brands offer various models. About 10% of the newly registered cars are equipped with L3 functions.
- Only a few premium brands offer L4 functions for motorway.
- First L3 functions are introduced for commercial vehicles and trucks for motorway application

Reasons for occurrence of Option A

- Strong investments in R&D by industry complemented by funding programs of the EU and member states
- Creation of harmonized legal framework for AD in Europe
- Broad media campaign leading to high user acceptance and demand for ADFs

Reasons for occurrence of Option B

- Main investments in R&D by industry.
- No common understanding of AD among European member states
- Some pioneering countries passed new regulations for AD in Europe
- High concerns among potential users wrt safety and data privacy of AD

Driving force number and name: **T5 – Electrification of Passenger Cars**

Specification of the driving force (What does it mean?):

- The term road vehicle in this context is strongly focused on passenger cars. The electrification of passenger cars will be accompanied/followed by the electrification of van, buses and trucks.
- Electrification in this context means vehicles powered by electric drive, like BEV (Battery Electric Vehicle), PHEV (Plug-in Hybrid Electric Vehicle) or FCEV (Fuel Cell Electric Vehicle)

Status 2019

Marginal share of all vehicles

- Electrification of passenger cars in Europe is still on a low level. (< 2,5% of annual sales).
- Electric passenger car stock in Europe: 1.1 Million (2018), 0.5% of total stock.
- Lighthouse country in Europe is Norway (45% between Jan. and June 2019). Reasons: extreme strong governmental support (Cost advantage and good infrastructure).
- European shares for buses, vans and trucks are even lower.

Status 2030 - Option A

Strongly increased

- Share of annual electric passenger car sales increased to about 40%
- Share of electric passenger cars in use at about 15%

Reasons for occurrence of Option A

- Battery cost down to 65 €/kWh
- Battery performance significantly increases
- EV more economic than ICEV
- EV in all segments and niches
- Strong electrification of fleets for mobility services
- Strong development of (also fast) charging infrastructure and interoperability;
- CO_2 emission regulation at 48 g/km
- Ban on ICE in city centers; Governmental support for EV

Status 2030 - Option B

Moderately increased

- Share of annual electric passenger car sales increased to about 15%
- Share of electric passenger cars in use at about 7%

Reasons for occurrence of Option B

- Battery cost still at 120 €/kWh
- Battery performance moderately increased
- ICEV mainly more economic than EV
- EV not covering all segments and niches
- Lack of charging infrastructure and interoperability
- CO_2 emission regulation at 90 g/km
- Nearly no bans for ICEV
- Low governmental support for EV

Driving force number and name: **EI1 - Pressure for CO_2-Emission Reduction**

Specification of the driving force (What does it mean?):

- The EU sets mandatory CO_2 emission targets, applying to new cars.
- The EU has recognised the important role of road transport in overall emissions reduction and sets progressively stricter CO_2 limits for passenger vehicles.

Status 2019

Moderate pressure to reduce CO_2 emissions

- Current limit 130 g CO_2/km will change to 95 g CO_2/km in 2020 (fleet average)
- NEDC has been superseded with more realistic WLTP
- Council has set the goal to reduce fleet emissions by 35% until 2030 (compared to 2020)
- EC plans to set a goal to for a contingent of zero-emission vehicles until 2030
- Differing positions on CO_2 emissions reduction among Member States
- ISA and CACC* have great potential to safe fuel and are part of General Safety Regulation debates

Status 2030 - Option A

Strongly increased

- A target of 50% for the reduction of CO_2 emissions is set, from "well to wheel"
- Stricter standards for fuel efficiency ratings are employed
- Credits and fines to incentivise zero- to low-emission vehicles are increased
- L3/L4 vehicles are seen as eco innovations and get a CO_2 bonus

Reasons for occurrence of Option A

- International agreements pressure European legislators to set ambitious goals for CO_2 reduction.
- Unified efforts of Member States to reduce CO_2 emissions
- Drivers enjoy the comfort and safety of ISA and CACC
- Traffic flow improves due to ISA and CACC

Status 2030 - Option B

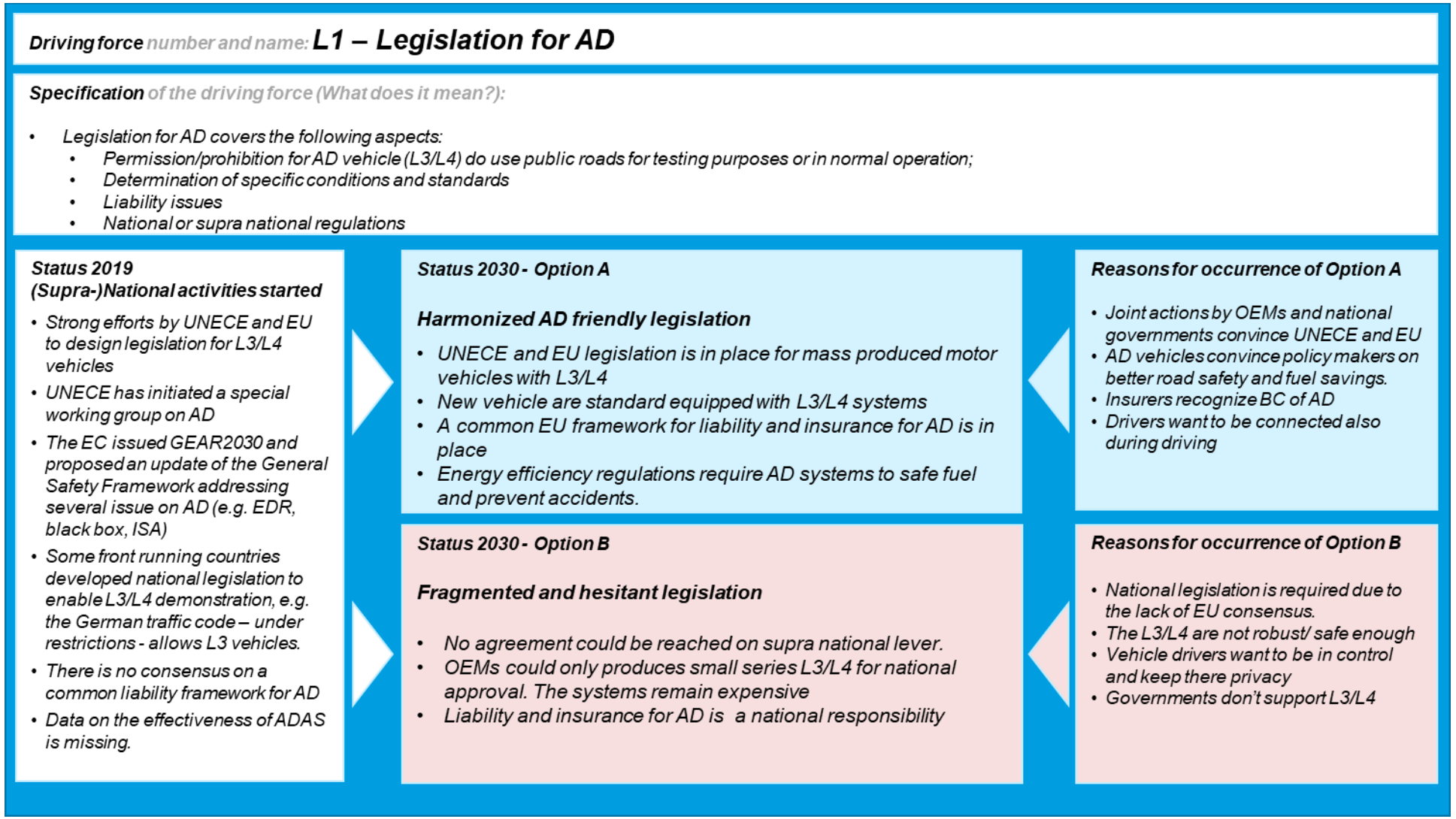
Moderately increased

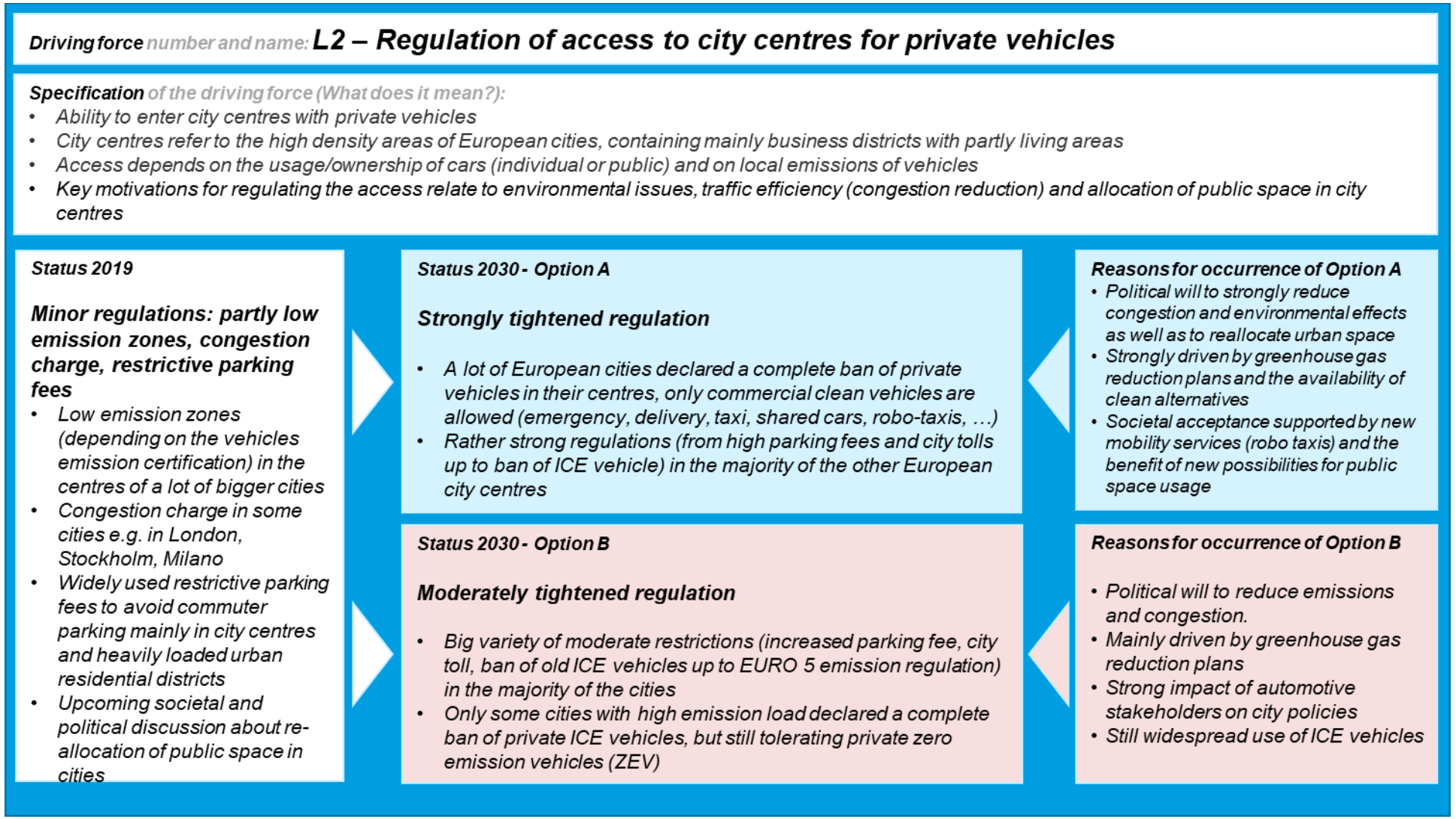
- The EU maintains the current goal of 35% for the reduction of CO_2 emissions until 2030
- Current WLTP standard remains in place
- Credits and fines to incentivise zero- to low-emission vehicles remain largely the same

Reasons for occurrence of Option B

- EU employs tentative commitment to internal climate agreements
- Fragmented efforts of Member States to reduce CO_2 emissions

*) ISA – Intelligent Speed Adaptation; CACC - Cooperative Adaptive Cruise Control


Driving force number and name: L1 – Legislation for AD
Specification of the driving force (What does it mean?):
• Legislation for AD covers the following aspects:
• Permission/prohibition for AD vehicle (L3/L4) do use public roads for testing purposes or in normal operation;
• Determination of specific conditions and standards
• Liability issues
• National or supra national regulations
Status 2019
(Supra-)National activities started
• Strong efforts by UNECE and EU to design legislation for L3/L4 vehicles
• UNECE has initiated a special working group on AD
• The EC issued GEAR2030 and proposed an update of the General Safety Framework addressing several issue on AD (e.g. EDR, black box, ISA)
• Some front running countries developed national legislation to enable L3/L4 demonstration, e.g. the German traffic code – under restrictions - allows L3 vehicles.
• There is no consensus on a common liability framework for AD
• Data on the effectiveness of ADAS is missing.
Status 2030 - Option A
Harmonized AD friendly legislation
• UNECE and EU legislation is in place for mass produced motor vehicles with L3/L4
• New vehicle are standard equipped with L3/L4 systems
• A common EU framework for liability and insurance for AD is in place
• Energy efficiency regulations require AD systems to safe fuel and prevent accidents.
Status 2030 - Option B
Fragmented and hesitant legislation
• No agreement could be reached on supra national lever.
• OEMs could only produces small series L3/L4 for national approval. The systems remain expensive
• Liability and insurance for AD is a national responsibility
Reasons for occurrence of Option A
• Joint actions by OEMs and national governments convince UNECE and EU
• AD vehicles convince policy makers on better road safety and fuel savings.
• Insurers recognize BC of AD
• Drivers want to be connected also during driving
Reasons for occurrence of Option B
• National legislation is required due to the lack of EU consensus.
• The L3/L4 are not robust/ safe enough
• Vehicle drivers want to be in control and keep there privacy
• Governments don't support L3/L4


Driving force number and name: L2 – Regulation of access to city centres for private vehicles
Specification of the driving force (What does it mean?):
• Ability to enter city centres with private vehicles
• City centres refer to the high density areas of European cities, containing mainly business districts with partly living areas
• Access depends on the usage/ownership of cars (individual or public) and on local emissions of vehicles
• Key motivations for regulating the access relate to environmental issues, traffic efficiency (congestion reduction) and allocation of public space in city centres
Status 2019
Minor regulations: partly low emission zones, congestion charge, restrictive parking fees
• Low emission zones (depending on the vehicles emission certification) in the centres of a lot of bigger cities
• Congestion charge in some cities e.g. in London, Stockholm, Milano
• Widely used restrictive parking fees to avoid commuter parking mainly in city centres and heavily loaded urban residential districts
• Upcoming societal and political discussion about re-allocation of public space in cities
Status 2030 - Option A
Strongly tightened regulation
• A lot of European cities declared a complete ban of private vehicles in their centres, only commercial clean vehicles are allowed (emergency, delivery, taxi, shared cars, robo-taxis, …)
• Rather strong regulations (from high parking fees and city tolls up to ban of ICE vehicle) in the majority of the other European city centres
Status 2030 - Option B
Moderately tightened regulation
• Big variety of moderate restrictions (increased parking fee, city toll, ban of old ICE vehicles up to EURO 5 emission regulation) in the majority of the cities
• Only some cities with high emission load declared a complete ban of private ICE vehicles, but still tolerating private zero emission vehicles (ZEV)
Reasons for occurrence of Option A
• Political will to strongly reduce congestion and environmental effects as well as to reallocate urban space
• Strongly driven by greenhouse gas reduction plans and the availability of clean alternatives
• Societal acceptance supported by new mobility services (robo taxis) and the benefit of new possibilities for public space usage
Reasons for occurrence of Option B
• Political will to reduce emissions and congestion.
• Mainly driven by greenhouse gas reduction plans
• Strong impact of automotive stakeholders on city policies
• Still widespread use of ICE vehicles

Driving force number and name: **L3 – Data privacy legislation**

Specification of the driving force (What does it mean?):

- Data privacy is understood as protection against abusive data processing, protection of the right to informational self-determination and protection of personal rights in data processing. Data privacy is often understood as a right that every human being may basically decide for himself whom and when which of his personal data should be accessible.
- Legislation for data privacy acts in the area of conflict between the protection of personal data and the safeguarding of the free movement of data for the benefit of the society and economy.

Status 2019

Ongoing discussions between too weak and too strong data privacy regulation

- New European General Data Protection Regulation in operation
- Data leakage events, including personal data, reach the news on a regular basis
- Ambivalent, consumers between value propositions and concerns (IT experts tend to rather high concerns)

Status 2030 - Option A

Unchanged to 2018

- No change in the legislation compared to 2018
- Ongoing leakage events, but on an societal acceptable level

Reasons for occurrence of Option A

- Existing regulation works well from the societal point of view.
- Service providers and customers benefit from possibilities for data flow enabled by existing regulations

Status 2030 - Option B

Stricter data privacy legislation

- Data privacy legislation has been renewed
- Restrictions for data processing and data usage much stronger
- Strong punishments and penalties safeguard their adherence

Reasons for occurrence of Option B

- Big data leakage scandals concerned people strongly
- Societal demand for more data privacy

L3Pilot-WP1.4: Business Environment Scenarios for AD related Business Models, Europe, 2030

Scenario I **"AD Paradise"**

No.	Driving Force	Status 2030 – Option A	Status 2030 – Option B	Reasons for option allocation
P1	**Governmental Support for AD**	**Steadily increased**	Remained constant	Increased societal acceptance pushed European governments to support
En1	**Availability of Infrastructure for AD**	**High availability**	Low availability	Government and industry invested strongly, pushed by the expectation of market growth (increasing societal acceptance)
En2	**Customer Price of AD Functions**	**Strongly decreased**	Slowly decreased	Economy of scope and scale, as well as fierce competition in interoperable components, reduced the prices strongly.
En3	**Competition Structure of Digital Automotive Ecosystems**	Open and fragmented ecosystem	**Strong oligopoly**	R&D power of oligopoly lead to technology push; Consumers liked the integrated systems approach of their specific ecosystem, despite lock-in
S1	**Societal Acceptance of AD**	**Significantly increased**	Unchanged to 2019	One of the critical Driving Forces: -> starting point for this scenario
S2	**Demand for Shared Mobility**	**Significantly increased**	Slightly increased	Strong technological development (AI, Big Data) improved the availability and efficiency of shared mobility and increased the demand
S3	**Environmental Behaviour**	**Rise of green living**	Business as usual	Strong technological development made green living easier; Transportation is much more efficient and reduced the personal footprint
S4	**Personal Vehicle Ownership Share**	**Sharp decrease**	Small decrease	Increased usage of efficient shared mobility services reduced the demand for personal vehicle ownership strongly
S5	**Willingness to pay for digital content**	**Significantly increased**	Unchanged to 2019	Attractive content offers a significant benefit for consumers which they rate as worth to pay for. More active usage of driving time increases in-car consuming of digital content.
T1	**Application of Big Data Technologies**	**Strongly increased**	Slightly increased	Strong AI development gave a push to big data technologies and their broad application in a lot of business areas
T2	**Automated Driving Technology**	**Disruptively increased**	Evolutionarily increased	Strong AI development worked as a booster for AD technology
T3	**Application of Artificial Intelligence**	**Disruptively increased**	Evolutionarily increased	One of the critical Driving Forces: -> starting point for this scenario
T4	**Application of AD Functions in Vehicles**	**Broad application of ADFs**	Limited application of ADFs	Societal and customer acceptance lead to a strong demand for AD functions in vehicles; Technology push enabled the fulfilment of the demand
T5	**Electrification of Passenger Cars**	**Strongly increased**	Moderately increased	EV are more economic than ICE cars in 2030; They become an integral part of the transforming mobility system with higher efficiency and sustainability
El1	**Pressure for CO_2-Emission Reduction**	**Significantly increased**	Moderately increased	The technology gave the option to reduce the CO_2 emissions more strongly and the EU used this to leverage emission reduction
L1	**Legislation for AD**	**Harmonized AD friendly legislation**	Fragmented and hesitant legislation	Societal demand, technology push and government support paved the way for a harmonized AD friendly legislation
L2	**Regulation of access to city centers for private vehicles**	**Strongly tightened regulation**	Moderately tightened regulation	Cities want to reduce strongly congestion and emissions. Automated clean fleets work as an alternative in urban mobility systems.
L3	**Data privacy legislation**	**Unchanged to 2019**	Stricter data privacy laws	Existing regulation works well from the societal point of view. Consumers and companies appreciate the relatively free movement of data for attractive services

L3Pilot-WP1.4: Business Environment Scenarios for AD related Business Models, Europe, 2030

Scenario II — **"Tantalus – People want it but can´t have it"**

No.	Driving Force	Status 2030 – Option A	Status 2030 – Option B	Reasons for option allocation
P1	**Governmental Support for AD**	**Steadily increased**	Remained constant	Increased societal acceptance pushed European governments to support
En1	**Availability of Infrastructure for AD**	High availability	**Low availability**	The development of higher AD functions still ongoing. European legislation was fragmented. Infrastructure investments were therefore rather reluctant.
En2	**Customer Price of AD Functions**	**Strongly decreased**	Slowly decreased	Technological development focused mainly on L3 functions. Economy of scope and scale, as well as fierce competition in interoperable components, reduced the prices.
En3	**Competition Structure of Digital Automotive Ecosystems**	Open and fragmented ecosystem	**Strong oligopoly**	R&D power of oligopoly lead to technology push; Consumers liked the integrated systems approach of their specific ecosystem, despite lock-in
S1	**Societal Acceptance of AD**	**Significantly increased**	Unchanged to 2019	One of the critical Driving Forces: -> starting point for this scenario
S2	**Demand for Shared Mobility**	**Significantly increased**	Slightly increased	People demanded a transportation transformation to reduce the negative effects (emission, congestion). Shared mobility was one of the attractive solutions, combining individual needs, comfort and effects.
S3	**Environmental Behaviour**	**Rise of green living**	Business as usual	Severe ecological disasters significantly affected people's live. People demanded a transportation transformation to reduce the negative effects.
S4	**Personal Vehicle Ownership Share**	Sharp decrease	**Small decrease**	Majority of people like ADFs and want to use the technology but they do not want to get rid of their personal vehicle
S5	**Willingness to pay for digital content**	**Significantly increased**	Unchanged to 2019	Attractive content offers a significant benefit for consumers which they rate as worth to pay for. Consumers are strongly interested in the possibilities of new technologies.
T1	**Application of Big Data Technologies**	Strongly increased	**Slightly increased**	AI development supported the application of Big Data technologies, but only slightly. Still no breakthrough. Proven deterministic algorithm behaviour is still required for road admission.
T2	**Automated Driving Technology**	Disruptively increased	**Evolutionarily increased**	Only evolutionary AI development was not strong enough for a disruptively increased AD technology
T3	**Application of Artificial Intelligence**	Disruptively increased	**Evolutionarily increased**	One of the critical Driving Forces: -> starting point for this scenario
T4	**Application of AD Functions in Vehicles**	**Broad application of ADFs**	Limited application of ADFs	Societal demand pulled the broad application of ADFs in cars, but because of the technical capabilities with a strong focus on L3 functions
T5	**Electrification of Passenger Cars**	**Strongly increased**	Moderately increased	EV are more economic than ICE cars in 2030; They became an integral part of the transforming mobility system with higher efficiency and sustainability
El1	**Pressure for CO_2-Emission Reduction**	**Significantly increased**	Moderately increased	The technology in electrification gave the option to reduce the CO_2 emis-sions more strongly and the EU used this to leverage emission reduction
L1	**Legislation for AD**	Harmonized AD friendly legislation	**Fragmented and hesitant legislation**	Even societal acceptance is high, common EU regulations sticked in the political agenda. Some countries were running forward, others are reluctant.
L2	**Regulation of access to city centers for private vehicles**	Strongly tightened regulation	**Moderately tightened regulation**	Cities want to reduce especially the emissions, but congestion as well. The access for clean vehicle is allowed as an incentive for accelerated electrification.
L3	**Data privacy legislation**	**Unchanged to 2019**	Stricter data privacy laws	Existing regulation works well from the societal point of view. Consumers and companies appreciate the relatively free movement of data for attractive services

L3Pilot-WP1.4: Business Environment Scenarios for AD related Business Models, Europe, 2030

Scenario III **"Slowly but surely"**

No.	Driving Force	Status 2030 – Option A	Status 2030 – Option B	Reasons for option allocation
P1	**Governmental Support for AD**	Steadily increased	**Remained constant**	Society was not demanding a strong governmental support, topic not with priority for governmental actions
En1	**Availability of Infrastructure for AD**	High availability	**Low availability**	Limited investments from government and industry; No clear common standards
En2	**Customer Price of AD Functions**	Strongly decreased	**Slowly decreased**	Effect of economy of scales not so strong because of limited demand;
En3	**Competition Structure of Digital Automotive Ecosystems**	Open and fragmented ecosystem	**Strong oligopoly**	No clear political strategy or need to rule the market; business potential and growth perspective for new entrants limited
S1	**Societal Acceptance of AD**	Significantly increased	**Unchanged to 2019**	One of the critical Driving Forces: -> starting point for this scenario
S2	**Demand for Shared Mobility**	Significantly increased	**Slightly increased**	Evolutionary technological development attracted more people for shared services, but the majority still favours traditional individual mobility
S3	**Environmental Behaviour**	Rise of green living	**Business as usual**	No strong push for people to change behaviour; majority saw green living as less comfortable or too expensive; GreenTech still not attractive enough
S4	**Personal Vehicle Ownership Share**	Sharp decrease	**Small decrease**	Mobility services offer for most people still not attractive enough; technological developments not strong enough for highly attractive services
S5	**Willingness to pay for digital content**	Significantly increased	**Unchanged to 2019**	A big variety of free content is available, though provided with a lot of advertisement. Consumers´ majority does not see a big additional value
T1	**Application of Big Data Technologies**	Strongly increased	**Slightly increased**	AI development supported the application of Big Data technologies, but only slightly. Still no breakthrough.
T2	**Automated Driving Technology**	Disruptively increased	**Evolutionarily increased**	Lack of demand held back investments. Only evolutionary AI development was not strong enough for a disruptively increased AD technology
T3	**Application of Artificial Intelligence**	Disruptively increased	**Evolutionarily increased**	One of the critical Driving Forces: -> starting point for this scenario
T4	**Application of AD Functions in Vehicles**	Broad application of ADFs	**Limited application of ADFs**	Societal demand was still limited, prices went down slowly, technology developed, but only evolutionarily
T5	**Electrification of Passenger Cars**	Strongly increased	**Moderately increased**	EV cost-attractive, but charging infrastructure and range restrictions and unchanged environmental behaviour lead to a only moderate increase.
EI1	**Pressure for CO_2-Emission Reduction**	Significantly increased	**Moderately increased**	The in 2018/19 negotiated regulation for 2030 is still seen as an acceptable compromise related to effectiveness and feasibility.
L1	**Legislation for AD**	Harmonized AD friendly legislation	**Fragmented and hesitant legislation**	Society is still undetermined related to AD; Some EU countries worked on the legislation, others are still waiting for more development
L2	**Regulation of access to city centers for private vehicles**	Strongly tightened regulation	**Moderately tightened regulation**	Cities want to reduce especially the emissions, but congestion as well. Leads to a strong shift to public transport and gives in some cities a favour to electric car users without leading to a breakthrough for EV
L3	**Data privacy legislation**	Unchanged to 2019	**Stricter data privacy laws**	Societal demand for more data privacy. Big data leakage scandals concern people strongly and make them aware of the risks of the new technologies.

L3Pilot-WP1.4: Business Environment Scenarios for AD related Business Models, Europe, 2030

Scenario IV **"Tech Push"**

No.	Driving Force	Status 2030 – Option A	Status 2030 – Option B	Reasons for option allocation
P1	**Governmental Support for AD**	**Steadily increased**	Remained constant	Governments saw clear benefits of AD and supported it to demonstrate the ecological, traffic and economic benefits to the society
En1	**Availability of Infrastructure for AD**	High availability	**Low availability**	Investments into infrastructure have been rather reluctant, because of the slow development of the overall demand for AD functions in vehicles
En2	**Customer Price of AD Functions**	Strongly decreased	**Slowly decreased**	Economy of scale lead to some price reduction, but increased cost for increased functionality of AD compensated that decrease partly.
En3	**Competition Structure of Digital Automotive Ecosystems**	**Open and fragmented ecosystem**	Strong oligopoly	Technological development was strongly driven by new entrants. Hope for future business potential growth gave the liquidity to these new entrants
S1	**Societal Acceptance of AD**	Significantly increased	**Unchanged to 2019**	One of the critical Driving Forces:-> starting point for this scenario
S2	**Demand for Shared Mobility**	**Significantly increased**	Slightly increased	Strong technological development (AI, Big Data) improved the availability and efficiency of shared mobility and increased the demand
S3	**Environmental Behaviour**	Rise of green living	**Business as usual**	People did not really change their behaviour; e.g. in transportation higher efficiencies have been compensated by more intensive usages
S4	**Personal Vehicle Ownership Share**	Sharp decrease	**Small decrease**	Shared mobility is rather used as an add-on to the personal vehicle than as a substitute. Majority likes multi-options but remain with their cars.
S5	**Willingness to pay for digital content**	Significantly increased	**Unchanged to 2019**	A big variety of free content is available, though provided with a lot of advertisement. Consumers´ majority does not see a big additional value
T1	**Application of Big Data Technologies**	**Strongly increased**	Slightly increased	Strong AI development gave a push to big data technologies and their broad application in a lot of business areas
T2	**Automated Driving Technology**	**Disruptively increased**	Evolutionarily increased	Strong AI development worked as a booster for AD technology
T3	**Application of Artificial Intelligence**	**Disruptively increased**	Evolutionarily increased	One of the critical Driving Forces: -> starting point for this scenario
T4	**Application of AD Functions in Vehicles**	Broad application of ADFs	**Limited application of ADFs**	Societal demand is still limited, prices went down slowly, OEM are customer focused
T5	**Electrification of Passenger Cars**	**Strongly increased**	Moderately increased	EV are more economic than ICE cars in 2030; They became an integral part of the transforming mobility system with higher efficiency and sustainability
El1	**Pressure for CO_2-Emission Reduction**	**Significantly increased**	Moderately increased	The technology in electrification gave the option to reduce the CO_2 emis-sions more strongly and the EU used this to leverage emission reduction
L1	**Legislation for AD**	**Harmonized AD friendly legislation**	Fragmented and hesitant legislation	Technology push and government support paved the way for a harmonized AD friendly legislation, to demonstrate the benefits to the society
L2	**Regulation of access to city centers for private vehicles**	Strongly tightened regulation	**Moderately tightened regulation**	Cities want to reduce especially the emissions, but congestion as well. The access for clean vehicle is allowed as an incentive for accelerated electrification.
L3	**Data privacy legislation**	**Unchanged to 2019**	Stricter data privacy laws	Existing regulation works well from the societal point of view. Consumers and companies appreciate the relatively free movement of data for attractive services