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HOW THE SHIFT TO NEW MOBILITY IS CHANGING THE EUROPEAN CITY

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Figure 3.1.1: **The spectrum of developments: trends and focal points**

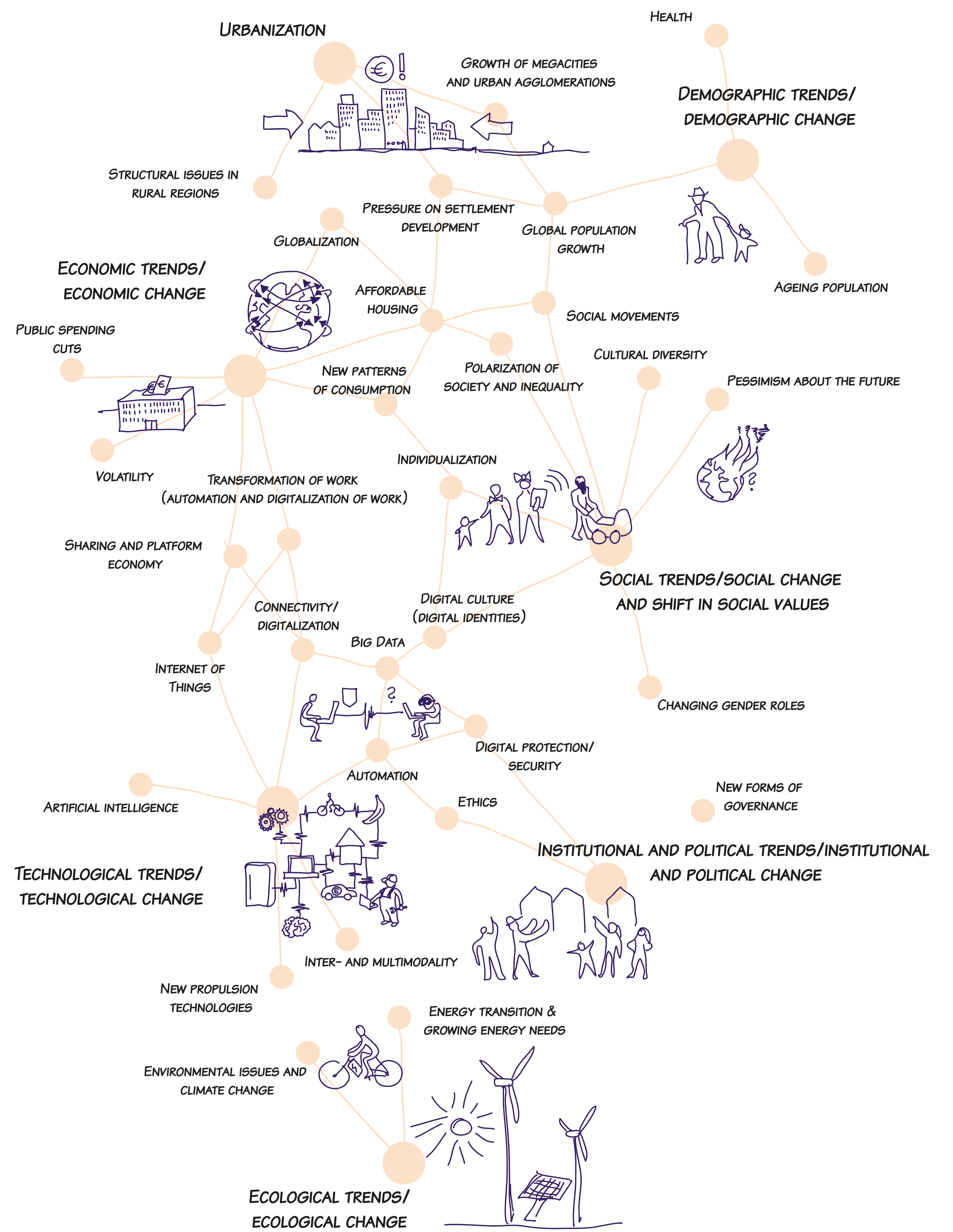
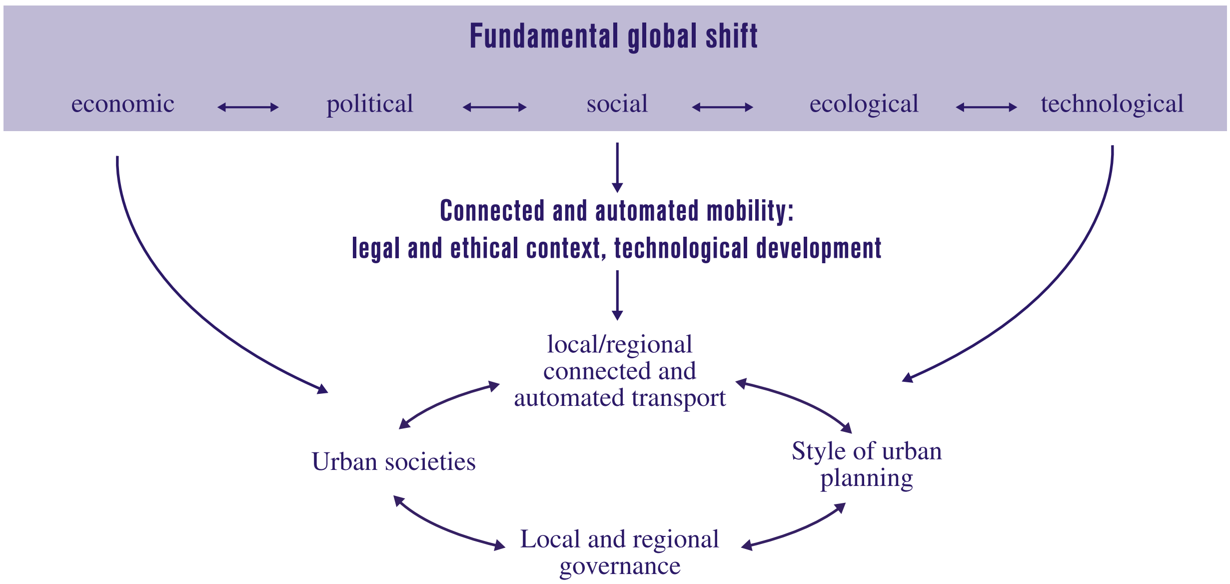


Illustration: Alexander Diem

3.1

SOCIAL CHANGE AS A DEVELOPMENT FRAMEWORK FOR MOBILITY

Figure 3.1.2: **Interplay between different dimensions of social change**



Source: AVENUE21

Modern society is in the midst of a rapid, intense and extensive transformation. One of the main reasons for this change is the increasing pace of globalization, which is notably responsible for intensifying trade relations, driving capital markets and thus economic competition between nation states, but also facilitating cultural exchange. A key element that makes it all possible is the ability to communicate globally via the Web 2.0 (see Chap. 3.1.1). The second driver of the social transformation we are currently witnessing is the increasing digitalization/digital transformation taking place within the wider context of a large-scale and multifaceted technological revolution. This change not only affects current and future job markets, it also facilitates and promotes additional forms of technological change and has a significant impact on day-to-day practices (see Chap. 3.1.2).

While these two aspects of social change are driven by the economy and technology, the ongoing ecological transformation mostly stems from the consequences of (1) the intensive exploitation of raw materials on a global scale as well as (2) damage to the environment at a local level, both factors in which transport plays a key role (see Chap. 3.1.3). The phenomenon of urbanization – the growth of towns and cities – represents a fourth significant shift (WBGU 2016): even if demographic changes resulting from population growth are mainly impacting Asia and Africa, the shifting population dynamics towards the agglomeration of large cities make these phenomena relevant to Europe, too (see Chap. 3.1.4).

The fifth aspect of social change examined here concerns the new way in which policy and planning decisions are made in a process that includes additional actors ("governance"; see Chap. 3.1.5). Lastly, we examine how the discussed trends are impacting (European) societies socio-economically, socio-demographically, socio-culturally and socio-spatially (Dangschat 2019; see Chap. 3.1.6).

3.1.1 GLOBALIZATION

Globalization is by no means a new phenomenon. Indeed, some analysts claim its origins can be traced all the way back to the global trade relationships that existed in the Greek and Roman empires, or during the Hanseatic League (Jeute 2017). Since the end of the 1960s, however, the term "globalization" has come to mean the renewed intensification of trade relationships, the opening up of capital markets (e.g. with the signing of the Bretton Woods Agreement), the dismantling of import restrictions (tariffs, industrial standards, restrictions on direct foreign investment), the expansion of international air transport (Open Skies Treaty) and, above all, the development and expansion of the internet. The rise of Japan and South Korea, as well as the development of numerous emerging markets in Latin America and Asia, and, more recently, the decision by (ex-)communist states to open up their economies, have led to the intensification of competition between manufacturing regions and of trade relations within the triad of Europe, East and South-East Asia and North America, which has also resulted in goods being produced in different parts of the world and a shift in economic power structures from those countries considered part of the "First World" to emerging markets (the BRICs and Asian Tigers; Ohmae 1985, Beck 1997).

The advent of the internet, and in particular the interactivity that came with Web 2.0, has not only enabled global real-time communication; increasingly we are also seeing the transfer of information between computers and with digitally connected devices using defined algorithms (e.g. on financial markets, in trade relations and, currently, even manufacturing). The proliferation of manufacturing and trade relationships has brought nation states and companies together in the throes of competition between different economic orders, welfare state models, approaches to policy, moral concepts and everyday practices.

For the automotive industry, the development of CAVs and their implementation, this global competition has major ramifications (Porter/Heppelmann 2014). In addition to the growing competition between car manufacturers due to new players entering the market (first Japan, then Korea, China and India), parts suppliers (Bosch, Continental), media businesses (Samsung) and IT companies (Waymo, IBM, NVIDIA, Aurora), as well as mobility service providers (Uber, Lyft), are now increasingly also becoming involved in the manufacturing process for "next-generation" vehicles (Bormann et al. 2018). Moreover, the major export markets are now in fast-growing economies, which have different business models, government regulations and demands.

Public authorities control developments at various levels of transport policy, e.g. by regulating business models (such as via partnerships with foreign investors) and also by funding research. Further regulatory options can have a direct or indirect effect on the future of CAVs, for instance the setting of emission limits or the stipulation of requirements that need to be met for the authorization of highly and fully automated vehicles (see Chap. 3.1.4). The populations of different countries around the globe also differ when it comes to their basic affinity for new technology and their acceptance of highly and fully automated vehicles (Ernst & Young 2013, Eimler/Geisler 2015, Fraedrich/Lenz 2015a, b, Detecton Consulting 2016, Fraedrich et al. 2016, Deloitte Development 2017a, b).

3.1.2 DIGITAL TRANSFORMATION AND TECHNOLOGICAL CHANGE

The term "digitalization" actually means the conversion of analogue measurement and control parameters into discrete (staggered) values so that they can be processed by a computer. However, in common parlance, "digitalization" is understood as the introduction and increased use of digital transmission technology in the economy, in public life and in everyday activities. "Digital transformation", "digital revolution" and the "Fourth Industrial Revolution" are also used to describe a process that has been gaining widespread momentum (Giffinger et al. 2018). Within this context, we are seeing not only more but new kinds of data and data processing technologies (Big Data).

As part of the broader phenomenon of digital transformation, there is plenty of discussion on Industry 4.0, the Internet of Things (IoT), artificial intelligence (AI) and augmented reality (AR). Industry 4.0 is understood as the extensive digitalization of industrial production, with systems connected using state-of-the-art information and communication technology; human-machine interfaces are being redefined. The technical foundation for these developments is provided by intelligent and digitally connected systems, which are to be implemented to make largely autonomous production possible: in Industry 4.0, humans, machines, facilities, logistics and products communicate and cooperate directly with each other (Bauernhansl et al. 2014).

The IoT involves a number of vastly different end devices being linked up and connected via the web – in addition to laptops and smartphones, this includes household devices, household technology (Smart Home), wearable devices and, in the future, CAVs, which former German transport minister Alexander Dobrindt dubbed a "third space" (alongside the home and the workplace) in 2017. The IoT is primarily driven by enhancements and new developments in the field of information and communication technology (Chui et al. 2010).

The IoT is also a major factor when it comes to connected driving as such technologies allow personalized on-trip data to be generated and subsequently capitalized upon. The data, which are mainly generated through connected driving, play a part in managing traffic flows in a way that makes them safer and more efficient, and enable the provision of more effective mobility services (see Chap. 3.3). Data-based business models are also made possible. These data could also have a regulatory effect, for example if the use of certain transport routes and public spaces are priced based on the respective level of use (by the public sector) or based on current demand (by the mobility provider; POLIS 2018: 5).

The significance of artificial intelligence within this context is considerable: if management and control mechanisms for CAT are to be implemented efficiently and effectively, self-learning computer networks and end devices are going to be crucial. Humans could soon be communicating and cooperating with artificially intelligent machines on our roads too. However, questions are increasingly being raised concerning technology-driven surveillance, personal freedoms and the processing of data collected in public space, i.e. on roads (Boeglin 2015, Mitteregger 2019).

Augmented reality (AR) is understood as the use of computer-based technology to enhance our perception of the real world. This information is able to engage all the human senses. However, AR is often understood solely as the visualization of information, i.e. enhancing images or videos with additional computer-generated information or virtual objects that are either superimposed or projected. Some innovative vehicle models already feature this technology: being able to replace the real world with a virtual one while driving is one of the selling points. In addition to the wide range of applications in gaming, AR can also be used, for example, in discussions on future urban development options, which include the presentation, design and management of prospective CAT together with the appropriate traffic infrastructure (Car Trottle 2017).

Alongside technological developments taking place as part of the digital transformation, other developments happening in the field of storage and sensor technology are making it possible for CAVs to adequately and effectively perceive information, process it in real time and decide how to drive (Soteropoulos et al. 2019).

3.1.3 ECOLOGICAL CHANGE

This consists, on the one hand, of climate change, which is most apparent in the warming of the Earth's atmosphere and the subsequent consequences this will have on the sea levels, air and water currents and thus ultimately the weather (drought, heavy rain and flooding, mudflows, thawing permafrost and higher temperatures, particularly in urban areas). On the other, ecological change comprises the extensive exploitation of natural (and, above all, non-renewable) resources (WBGU 2016). These impacts are the result of human civilization, its pursuit of growth, economic systems and unsustainable lifestyles (Brundtland 1987: 1).

With the aim of keeping global temperature rise to below 2°C, just under 200 countries signed an agreement at the 21st UN Climate Change Conference held in Paris in 2015 to limit their emissions of harmful greenhouse gases (particularly carbon dioxide – CO_2 – and nitrogen oxides – NO_x). At a subsequent conference held in Katowice in 2018, delegates agreed to uniform standards to measure and compare national and regional developments. However, most countries had failed to abide by previous thresholds, with road transport in particular responsible for a continued rise in greenhouse gas emissions (EEA 2017).

In spite of all the technological progress, efforts to make the necessary cuts to emissions have thus far failed, especially in the transport sector: between 1990 and 2014, Germany's emissions dropped from 1,248 to 902 million tonnes of CO_2 equivalent (-25.4%), whereas the transport industry has managed to reduce its CO_2 equivalent by just 1.9% over the same period (from 163 to 160 million tonnes of CO_2 equivalent; BMUB 2016: 8). The target of reducing the industry's emissions by 40–42% by 2030 will allegedly be achieved – according to the "Climate action and mobility" policy embedded in the German government's Climate Action Plan (BMUB 2016: 49–56) – through the promotion of alternative drive systems, public transport, rail travel, cycling and walking, i.e. through an alternative modal split, but also via a digitalization strategy and an increased share of "clean energy". However, the strategy fails to mention how the necessary changes, not only in terms of policy and administrative approach, but also the required behavioural shift among the population, can be achieved.

The reasons behind the transport sector's inability to reach emission targets are lock-in and rebound effects resulting from a widespread dependency on cars. And although engine efficiency is improving, this progress is being effectively cancelled out by ever-larger, heavier vehicles with an ever-increasing engine capacity, the very vehicles that are experiencing growing demand: in 2017, 15.2% of Germany's newly registered vehicles were SUVs, an increase of 22.5% compared to the previous year (Federal Motor Transport Authority 2018). Furthermore, on average, drivers are travelling longer distances and driving at higher speeds (for Austria, see Tomschy et al. 2016: 97). Lastly, there is simply a lack of political will to implement the regulations necessary to fully phase out combustion engines running on fossil fuels (Canzler 2015).

Battery-powered electronic vehicles, as well as the automation and connectivity processes, require greater amounts of increasingly scarce natural resources (e.g. silicon, cobalt, rare earths) that are frequently mined under appalling conditions. What is more, extracting and recycling these materials entails a considerable environmental cost. The electronic vehicle modules in which they are used are also often manufactured under dire, unacceptable working conditions.

3.1.4 URBANIZATION

The demographic and economic developments taking place in emerging economies are also being accompanied by a high level of urbanization, particularly in Asia and Africa. Although, in 2007, the news that the share of the global population living in urban areas had reached 50% was met with enthusiasm by the UN (UN 2008), and despite declarations from the OECD (2015) and the German Advisory Council on Global Change (WBGU 2011) that we are currently living in “the metropolitan century”, the truth is that, in addition to spectacular skylines and technological innovations, urbanization brings many challenges, such as increasing socio-economic polarization, a widening divide between urban and rural areas, the loss of traditional values, higher energy consumption and greater emissions.

In Europe, urbanization is not so much a quantitative but a qualitative process. The continent may be on course to see its already impressive level of urbanization (74%) grow further (UN 2018), but this is tending to result in a shift from small towns to large cities and from rural areas to urban agglomerations.

This transformation goes hand in hand with, on the one hand, issues of how to manage infrastructure under- and overload, and on the other, a sharp rise in living costs within inner cities (especially private but also commercial rent costs), which leads to households occupied by lower- and middle-income families being pushed out to the economic and regional periphery (i.e. gentrification). Urban living also brings about a more rapid change in values and a growing cultural diversity that can lead to certain residents feeling overwhelmed (Dangschat 2015a). The urban lifestyles that accompany such shifts are also largely unsustainable, despite all the hopes currently being pinned on the growth of car sharing in major cities (Gossen 2012).

It is thought that such large urban areas have the necessary conditions to help productively shape the mobility transformation. This is what the A-S-I strategy stands for:

- *avoid*: travel as little as possible and avoid forms of travel that harm the environment
- *shift*: generally moving from a mobility model centred on motorized transport and towards a multimodality that promotes other options (e.g. ecomobility through the use of public transport, cycling and walking)
- *improve*: enhancing a wide range of aspects as part of a general improvement of public space and thus quality of life.

The (often wide) range of for-profit free-floating car-sharing services springing up in large cities is often seen as part of this transition, and in recent years these businesses have contributed to a drop in car registration figures in cities and a slight decrease in the number of private cars on the road. However, the number of (short) journeys has increased (VCÖ 2017). Car sharing is thus in direct competition with active mobility or even public transport. A car-sharing system based on CAVs would mean even greater expectations for profitability (i.e. more providers), lower costs and increased convenience; in other words, it would lead to more spontaneous journeys and unnecessary travel.

3.1.5 FROM GOVERNMENT TO GOVERNANCE

Public administrations first faced criticism for their lack of efficiency back in the 1990s. At the time, the private sector ramped up the pressure to establish an approach called New Public Management, which aimed to replace the bureaucratic, centralized and hierarchical management style with a target-driven, transparent and decentralized model. Instead of imposing rigid rules, managers should increasingly focus on the result, which was to be achieved through cost accounting (instead of governmental accounting), product focus, performance comparisons and contract management. “Responsibility centres” and “flat hierarchies” were introduced with the aim of driving internal and external competition, and increasing individual responsibility (Jann et al. 2006).

Criticism has not only come from the business community: since the 1990s, the general public have shown increasing frustration with the way state services are run. Many felt their voices were not being heard, especially when it came to local and city-wide planning. This resulted in a growing demand for participation and “co-creation” (Sinning 2008), a process also frequently referred to as “the shift from government to governance” (Heeg/Rosol 2007: 504; Bröchler/Lauth 2014).

In political science discussions, but also debates in the fields of organizational sociology and business management, the term “governance” is often also used to signify a departure from structures that are primarily centred on imperative supervision (“command and control”). Rather, drawing on elements that focus on individual responsibility, the managed organizations, units or actors should take an active role in tackling the tasks and/or challenges at hand.

In addition, the term “governance” also includes models of cooperation involving multiple actors. In political contexts, the concept has also come into use both in addition to and as a substitute for “government” and expresses the idea that within the respective entity, management and controlling activities should not just be carried out by the state as the “first sector”, but also by the “second sector” (i.e. the market) and the “third sector” (i.e. non-profit organizations, voluntary associations, special interest groups; Heeg/Rosol 2007: 504; Hamedinger 2013: 62). Private sector and civil society actors are thus recognized as resources and instruments that work alongside local policymakers and administrators to intervene where necessary. Consequently, a shift is occurring not only regarding the specific actors involved in such decisions, but also in terms of their authority, responsibilities, competencies and their ability to exercise power. As the number of actors and interests involved in policy and planning decision processes continues to increase, so too does the complexity of institutions and control structures, and thus the need for communication and coordination. Given the rising diversity of actors, and their competing interests, as well as the growing complexity of processes, the future direction of policy and planning management will be key.

This is why, when developing scenarios (see Chap. 5.2), our research team ideally aimed to centre their case studies on three different types of policy and planning management. During this process, the three key sectors – the market, state actors and the non-profit sector – were each focused on separately. Based on the respective characteristics of the market, state and the non-profit sector, our team examine how governance and power relations are shifting in policy and planning management processes and thus how they could have a major impact on the use of CAVs.

It remains unclear how "politics" will approach the challenges of CAT. The experts, however, are in agreement about the importance of engaging with the subject and potential challenges as early as possible (Fagnant/Kockelman 2015), not least to (largely) avoid returning to an urban-planning model based on cars (Jones 2017). On the one hand, it is expected that the EU and the majority of nation states will set different priorities with regard to policy and planning decisions compared to regional and local actors. While the former place greater emphasis on competition (Kauffmann/Rosenfeld 2012), local and regional areas are where the consequences of transport policy play out, and these issues will thus have a bigger role in local decision makers' planning and further policy choices.

3.1.6 SOCIAL CHANGE

As we considered aspects of urbanization, we touched upon certain elements of social change, in particular changes in values and shifting lifestyles and mobility choices. Social change is understood to encompass three aspects:

- *Socio-economic change*
  This concept mainly refers to inequalities in income, which have started to grow again markedly in recent years, and in wealth (Bach 2013, Castells-Quintana et al. 2015). It also refers to shifting social policies that differ both internationally and within nation states, together with labour market risk that varies from region to region.

- *Socio-demographic change*
  This term has long been understood to refer to the growing number of childless and small households (*Versingelung* or increase in one-person households; Hradil 1995) and the ageing of modern societies resulting from growing life expectancy and lower fertility rates (Wehrhahn 2016). In recent years, issues such as migration, refugees and integration have become relevant too.

- *Sociocultural change*
  This concept is largely understood as a change in values (as well as a pluralization of values), a shift away from traditional ties (individualization) and an increased re-embedding in communities of shared values (social milieus) expressed in an increased proliferation of different lifestyles (Dangschat 2014).

Due to different preferences and constraints influencing a choice of residential location, time spent in public space, mobility, etc., these categories bring about largely heterogeneous patterns of distribution (segregation) and behaviours. It can thus be assumed that socio-spatial restructuring constitutes a fourth dimension of social change. This final aspect is particularly significant as many statements on the introduction and acceptance of CAT are made at the national level and without reference to any particular spatial dimension (transport networks, settlement structures, supply and demand profiles, availability).

With regard to a shift in values, the above-mentioned aspects of social change are not uniform, but in fact tend to be polarizing, with new social battle lines being drawn ("Distinction"; Bourdieu 1987) and existing divisions (xenophobia) exacerbated. While younger generations, who are usually better qualified and more tech-savvy, tend to feel positive about the future, a growing section of society is more insecure and anxious. This is particularly true for those groups who are the "modernization losers", having missed the opportunity to partake in economic development ("lift effect"; Beck 2013) or having not been able to keep step with evolving values. The middle classes, in particular, and now gradually the elite too are affected by these new anxieties (Zweck et al. 2015).

Moreover, the advent of Web 2.0 has significantly changed our communication habits, how we manage our time day to day and, ultimately, completely reshaped and revolutionized our relationships with one another. This example uniquely illustrates how technological developments can cut both ways. Smartphones and tablets might well be necessary for the development of new business models as well as make it possible for us to establish social connections with "others" in a pragmatic way (by exchanging or sharing information, time and basic commodities) and allow social innovation. For example, it is thanks to Web 2.0 that the sharing economy was able to get off the ground; crowdfunding and the application of collective intelligence would also be impossible without this technology (Dangschat 2015b).

Yet, on the other hand, the internet also allows "fake news" to be spread at lightning speed, abusive comments to be hurled from anonymous users, our democracies to be undermined (*Disruptive Democracy*; Bloom/Sancino 2019) as well as myriad forms of cybercrime and hacking. Moreover, "smart algorithms" allow discussions and democratic elections to be manipulated through the deployment of social bots.

Some parts of the population in Germany, and particularly in Austria, are expressing serious misgivings about this technology, leading not least to widespread scepticism concerning CAM (Fraedrich/Lenz 2015a, b). This trend can also be seen in the high level of importance (concerning both positive and negative trends) experts attributed to data during the survey we conducted (see Chap. 3.4).

As briefly outlined above, the manifold and, in part, fundamental social change currently taking place will significantly shape the future of mobility. There are some persistent elements that operate as lock-in effects, innovative elements that amplify existing rebound effects or create new ones, and disruptive elements that are exacerbating the anxieties currently felt by swathes of the population. Given the existing landscape, the question of whether and how CAM could help not only solve the current problems of (urban) mobility but also strengthen social cohesion remains, for now at least, uncertain (see Chap. 4.3). In any case, the challenge posed by rapid technological development taking place against the backdrop of social change means that there is a pressing need for policy and planning authorities, along with businesses and civil society, to face up to these issues. It is also important for them to consider how much cities and towns wish to simply adapt to CAVs or CAM or whether they should only permit those business and mobility models that will help achieve objectives outlined as part of sustainable transport and urban development plans (Rupprecht et al. 2018).

3.2

THE EUROPEAN CITY: AN ANALYTICAL FRAMEWORK AND MODEL FOR POLICY/PLANNING DECISIONS

When we use the term "European city" in our research, we do so in full knowledge that the concept, and its associated attributes, have also been the subject of criticism, especially in recent years (Rietdorf 2001, Hassenpflug 2002, Häußermann 2005, Kazepov 2005, Brake 2011, Siebel 2015). On the one hand, a growing connectivity via social media and the globalization of commodity chains, financial transactions and (urban) cultures, as well as increasing regional and transnational links between social milieus, are leading some to question whether it is still possible to make a clear distinction between "city" and "rural space" (Saunders 1987). On the other hand – ultimately due to urban growth in emerging economies – the 21st century has been declared the "century of the cities" by the German Advisory Council on Global Change (WBGU 2016, The Urban Task Force 2003, Läpple 2005, Dangschat 2010).

Beyond this, the image of the European city is one of an "urbanity" that is characterized by functional and architectural diversity, overall cohesion, planned public space, and endless experiences and encounters. Scholars active in the cultural and social sciences, as well as the humanities, however, see the city as a place that is home to a bourgeois way of life, self-organizing, a division of labour and social diversity, tolerance, (civilized) otherness and distance.

Max Weber (1921) developed the concept of the "occidental city" to set the concept of the European city apart from the "oriental city". Weber considered the city to be an economic and social hub that was shaped by the market. Simmel (1903) considered the city to be home to the money economy and an increasingly rational way of living. Today the European city is either contrasted with the "American city" (Bagnasco/Le Galès 2000, Kaelble 2001, Le Galès 2002, Giersig 2005, Häußermann/Haila 2005) or, from a post-colonial perspective, considered as part of the Global North and thus compared with the cities of the Global South (Gugler 2004, Grant/Nijman 2006, Robinson 2006, Simon 2006, Haferburg/Oßenbrügge 2009, Diez/Scholvin 2017).

Despite ongoing uncertainty as to whether the "characteristic features" of the European city, such as local government, the influence of active residents and the erosion of the dichotomy between the public and the private, are still relevant to current developments (Sennett 1983, Siebel 2015), by the same token, it can be argued that the ability to respond flexibly to ongoing processes is also a key feature of the European city (Sennett 2018, BBSR 2010).

Our analysis of the impacts of CAM on the European city centres on how urban society, urban planning and urban policy are responding to changing economic, ecological, social and architectural objectives. This subsequently means that the European city must be understood as multidimensional and considered from an interdisciplinary perspective.

One significant aspect regarding policy and planning in the European city is the relatively high level of autonomy enjoyed by city policymakers and planners as part of the subsidiarity principle. This sees the responsibilities of national government devolved to the regional/local level and financially covered through the provision of transfer payments by the state (Siebel 2004). However, binding cities to states in this manner also makes them susceptible to welfare state restructuring during which responsibilities are transferred to those "lower down" without the relevant funding being secured (Jessop 1992, Brenner 2004). Against this backdrop, the European city also became the "entrepreneurial city" (Harvey 1989, Häußermann 2001). Klaus von Dohnanyi, a former mayor of Hamburg, was the first mayor of a German city to refer to his jurisdiction as an *Unternehmen* or "enterprise" (Dohnanyi 1983, Dangschat 1992).

The current relevance and significance of financial autonomy can also be seen with regard to the potential fiscal impacts of CAT, which were examined as part of the Vienna project (Soteropoulos et al. 2018b; see also Chap. 4.3). Parallel to the outlined urban development trends, we can examine European city transport and mobility planning since the Second World War by dividing developments into three different stages (see Chaps. 3.2.1 to 3.2.3 as well as Figs. 3.2.4 and 3.2.5).

3.2.1 DESTRUCTION AND REBUILDING – STAGE 1

Large-scale destruction during World War II paved the way for a departure from the industrial, workers' cities of the past that were characterized by high-density housing, hardship and a struggle for survival. Light, air and sunshine would be the order of the day, resulting in the concept – based on the Athens Charter, a largely for-

Figure 3.2.1: **Dimensions of the European city**

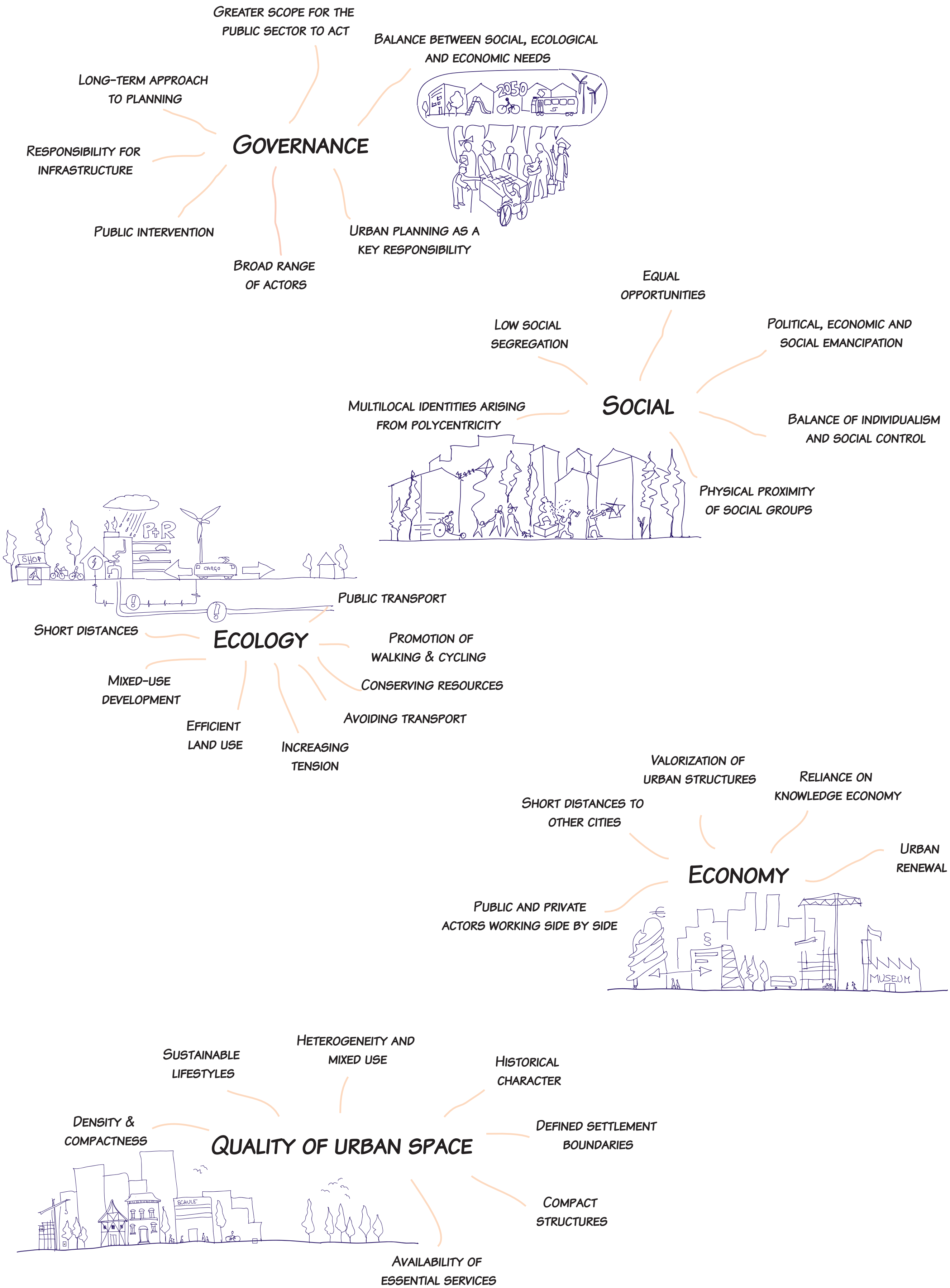


Illustration: Alexander Diem

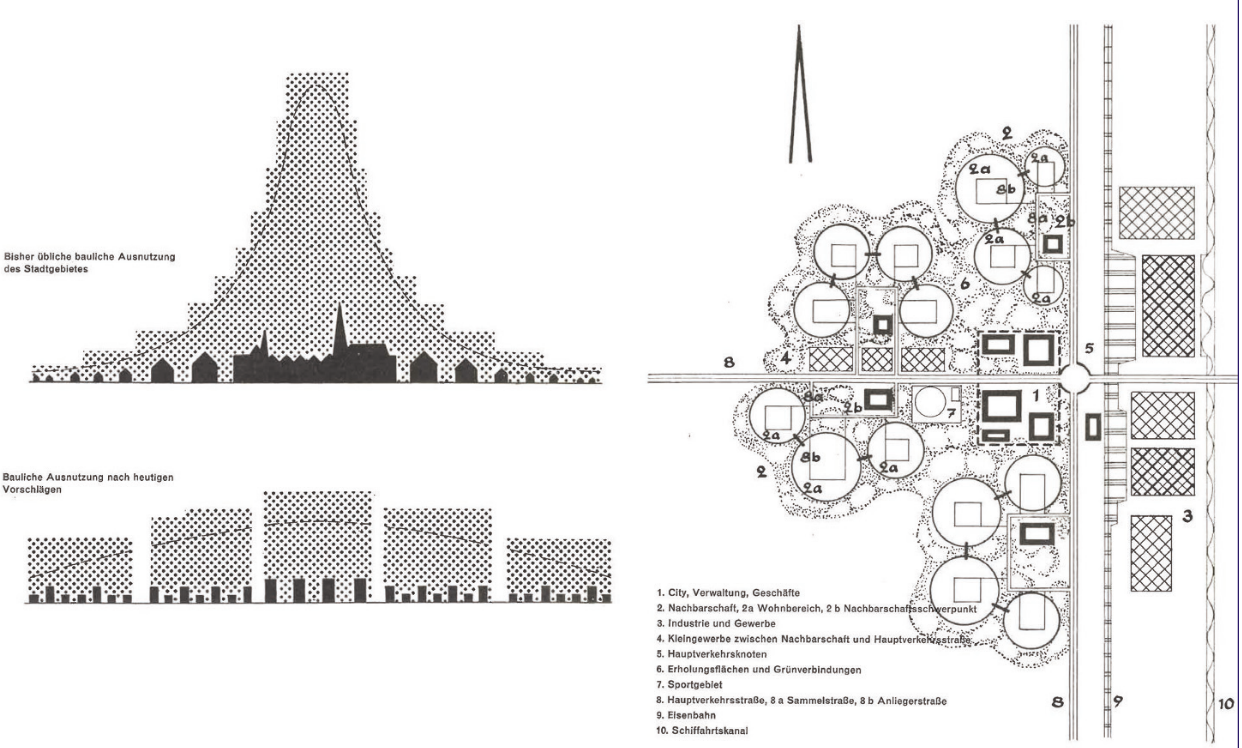
gotten pamphlet created during a meeting of members of the CIAM (Congrès Internationaux d'Architecture Moderne) under the leadership of Swiss architect Le Corbusier – of *Die aufgelockerte und gegliederte Stadt* (the articulated and relaxed city, Göderitz et al. 1957; see Fig. 3.2.2). In addition to the damage caused by the conflict, the new focus on functional separation that emerged from the proverbial and literal ashes contributed to the further "destruction" of the traditional European city, i.e. its urban planning structures, ideas of urbanity and social cohesion.

The post-war period also saw rapid growth in car-based mobility. First mass-produced by Henry Ford, who created the "universal car" or Model T, which was to be affordable for factory workers, the car was later used to political ends by the Third Reich in the form of "Volkswagen" (the people's car). Now, in peacetime, the private vehicle was being talked up as a symbol of the economic miracle and an embodiment of Europe's road to recovery. The conditions were such that governments were willing to create vast amounts of space for cars and to develop cities with automobiles in mind based on the *autogerechte Stadt* (car-friendly city) proposed by Hans Bernhard Reichow, who also developed a corresponding conceptual urban design plan in 1959, albeit one which also took different modes of transport into consideration. In the years that followed, the notion of a car-friendly city grew to extremes. Cars needed to be able to travel largely unimpeded, and so any hindrances, such as buildings, pedestrian crossings or even tram lines, were removed. Corridors were created for urban motorways together with extensive traffic junctions, with urban cityscapes having to make way.

This urban planning model for the reconstruction and expansion of settlement structures came to define western European cities, but also cities in socialist-led countries, for roughly five decades (Goldzamt 1973). Large housing estates were created next to office blocks, shopping centres were built alongside universities and other institutes of education, all separated by a green belt and connected via car-friendly roads. The use of cars, which rose considerably from the end of the 1960s, also provided the basis for suburbanization: the movement of young, upwardly mobile families and household-based services, and then, later, offices and light industry, to peri-urban areas (Friedrichs 1978, Brake et al. 2001).

In the late 1960s and early 1970s, views started to change. In 1965, German psychoanalyst Alexander Mitscherlich published a book titled *Unwirtlichkeit der Städte* (The Inhospitality of Our Cities) in which he criticized Germany's urban planning and renewal strategies, which were centered purely on functionalistic principles. The Deutsche Städtetag (German Association of Towns and Cities) headed by the then Mayor of Munich, Hans-Jochen Vogel, eventually called for German cities to be saved immediately (DStT 1971), and the Club of Rome published a report on *The Limits to Growth* in 1972. However, the oil crisis finally made clear that a rethink of how resources were used was desperately needed, all of which led to a fresh approach and return to the values and characteristics of the European city.

Figure 3.2.2: **The articulated and relaxed city**



Source: Göderitz (1957) © Wasmuth & Zohlen Verlag, Berlin

Figure 3.2.3: **Friedrich-Engels-Platz in Leipzig following its reconstruction in 1971**

A car-friendly city created by segregating the modes of transport: separated, low-conflict spaces for pedestrians, cars and trams, as well as a spacious design of the entire traffic area

Source: German Federal Archives

3.2.2 CAUTIOUS URBAN RENEWAL – STAGE 2

The second stage of post-war urban development saw the start – partly triggered by huge protests – of policymakers replacing their previous strategy of urban redevelopment with one centred on "cautious urban renewal". Although this approach initially consisted solely of structural decisions, i.e. whether a building was "worthy of preservation", the passing of the Urban Development Promotion Act in 1971 made it mandatory for residents to be involved in redevelopment projects. At the end of the 1970s, during the redevelopment of Berlin's Kreuzberg district, "12 principles of urban renewal" were developed (Hämer 1990) that were adopted by district representatives before going on to become a model for the whole of Berlin in 1984 (thanks to International Building Exhibitions (IBA)) and, ultimately, urban regeneration across the entire nation.

Pursued alongside state regulations (such as tenant protections, building refurbishment and housing subsidies, and tax deductions for privately owned housing) and the architectural transformation of public space by bringing in traffic calming measures, this "cautious urban renewal" approach encouraged an increased demand for inner-city living, which in large cities, such as Munich, Hamburg and Düsseldorf, led to a process of gentrification that has been ongoing since the late 1970s (Dangschat 1988). Transport development was now boosted by the rapid expansion of public transport (esp. rail); however, this took place without first reducing the space afforded to cars.

3.2.3 THE LIVEABLE CITY – STAGE 3

The second stage, which tried to incorporate more balance into urban planning, made way for a third stage that was characterized by renewal, improvement of public space, greater quality of life by reducing emissions (not just greenhouse gases but also noise) and encouragement of – and demand for from certain social groups – active mobility by promoting walking, cycling and travel by scooter (Jones 2017). Schemes to improve the local living environment and calm traffic were introduced at the federal and state level that were later combined to form a broader concept as part of the "Socially Integrative City" scheme adopted by German federal and state governments. This scheme placed integrated planning approaches that aimed to promote vibrant neighbourhoods and social cohesion centre stage.[1] Increasing ecological and (urban) climate issues and challenges, as well as a growing interest, among certain parts of the urban population, in eating sustainably and ethically, healthy living, well-being and a high quality of life (LOHAS = Lifestyles of Health and Sustainability) added increased momentum and zeal to achieve sustainable urban development targets that continue to this day.

Policymakers and planners responded to this shift by redesigning and revolutionizing public space, introducing traffic calming measures and expanding cycling lanes as well as removing parking spaces. House builders had to adhere to a growing number of restrictions that stipulated the construction of low-energy, accessible homes, and mobility concepts were also developed that revolved around residents eschewing private cars and thus reducing mobility costs. At the same time, efforts were once again

Figure 3.2.4: **Stages of transport and mobility planning and policy in the European city**

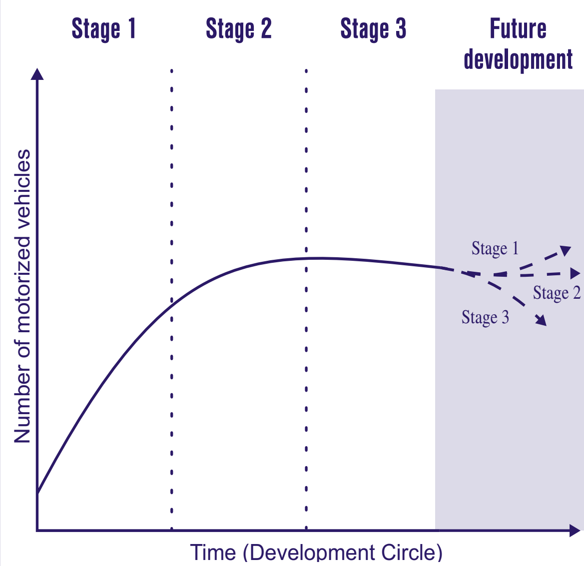
	STAGE 1 Accommodating traffic growth	STAGE 2 Encouraging modal shift	STAGE 3 Promoting liveable cities
CHARACTERISTICS ACCORDING TO JONES	• Rapid growth in car ownership (among the wealthy) • Focus on the vehicle and infrastructure • Economic growth becomes the objective • Lack of investment in walking and cycling	• Negative social and environmental effects become apparent • Regulatory approaches and public influence • Improvement of public transport • Parking management, restricted access	• Focus on liveable spaces and sustainable forms of mobility • Aim to increase the quality and liveability of urban areas • Stricter controls and socio-science approaches • Reclaiming public space • Car ownership starts to decline
PLANNING PARADIGMS	• The articulated and relaxed city (Göderitz 1957) • Car-friendly city (Reichow 1959) • Traffic in Towns (Buchanan 1963) • Athens Charter (CIAM 1933)	• 12 principles of cautious urban renewal (Hämer 1990) • IBA Berlin (1984) • Traffic-calming measures in residential areas: large-scale trials (DE), woonerf concept (NL)	• Association of German cities and towns, 2018 • SUMP (Sustainable Urban Mobility Plans) • Guidelines for Urban Road Design (RASt) • Leipzig Charter, 2007

Source: Charactaristics according to Jones (2017)

stepped up to encourage social diversity when housing initial occupants, and neighbourhood management systems were introduced in so-called “problem” areas.

In terms of transport and mobility planning, increased focus was given to the shift from motorized private transport (MPT) to public transport, cycling and walking (ecomobility). The expansion of multimodal traffic concepts became the focus of urban and mobility development. Moreover, recent years have seen the advent of connectivity between various modes of transport thanks to apps and digital platforms that offer a wide range of transport options, a comprehensive ticketing system, calculation of costs and additional information (MaaS). The current objective of transport and mobility policy is to help achieve a largely car-free multimodality in cities. However, at the same time, we can observe a rise in delivery vehicles in cities, which can be attributed to the increasingly influential role played by digital commerce.

Figure 3.2.5: **Development of transport and mobility planning paradigms**



Source: AVENUE21 based on Jones (2017)

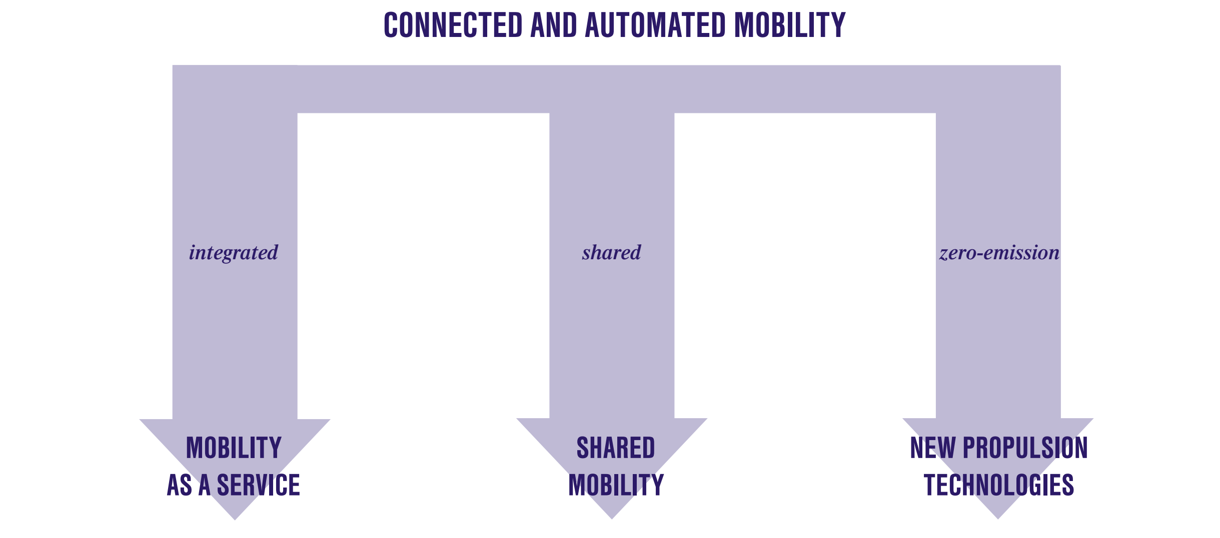
3.2.4 THE INFLUENCE OF CONNECTED AND AUTOMATED VEHICLES ON TRANSPORT AND MOBILITY POLICY

We now turn to the question of how the introduction of CAT will influence transport and mobility policy in the European city. CAT is generally perceived as a positive development (STRIA 2019), but such evaluations rarely discuss which (urban) development measures, regulations and monitoring systems will be required for its successful implementation. This in turn raises the question of whether CAT is in line with and helps achieve the objectives of current developments in urban and mobility planning as set out in Stage 3, and whether, given CAT’s need for separate and ample space, and individual and often protected lanes, it will make new traffic structures necessary (Rupprecht et al. 2018). Lastly, it is assumed that CAVs will result in an increase in traffic volume and therefore feared that the European city could be redesigned to accommodate CAVs (return to Stage 1; Jones 2017, Dangschat 2018, Rupprecht et al. 2018). Figure 3.2.4 illustrates that future governance will heavily influence how transport and mobility planning is adapted in the years to come, as will the objectives that are chosen within this context (see scenarios in Chap. 5).

1 At the European level, the Leipzig Charter, which was instigated by Germany, saw the creation of a Europe-wide model for sustainable development; the charter has become binding for European urban development (BMVBS 2007). The objectives outlined in this charter contrast markedly with the guidelines issued in the Athens Charter.

3.3 NEW MOBILITY: DEVELOPMENTS, OPPORTUNITIES AND RISKS[1]

Figure 3.3.1: **Cornerstones of connected and automated mobility based on the objective of creating a more climate-friendly transport policy**



Source: AVENUE21

Megatrends are an effective way to narrow down the potential future pathways urban planners and policy-makers may take[2] and to provide useful indicators for cutting-edge research (WBGU 2011). The current megatrends – and their impact on (automated) mobility – are discussed in more detail in Chapter 3.1. Amidst the current push to create a more environmentally friendly transport policy (Chap. 1), simply automating vehicles does not go far enough given the increasingly urgent need for action as we face up to the reality of climate change. What will be crucial is whether automated vehicles can be developed that are low emission (or emission-free) and whether they will be embedded within an integrated Mobility as a Service concept as shared mobility (Lennert/Schönduwe 2017). We will thus examine the MaaS concept, as well as key elements such as shared mobility and new propulsion technologies, against the backdrop of automated driving, and discuss the future development pathways these technologies may take.

3.3.1 MOBILITY AS A SERVICE

Mobility as a Service (MaaS) is a concept whereby public and private transport services (as well as different forms of mobility, including automated vehicles) are combined with a single digital access portal (a platform or an app) in order to offer mobility solutions that are tailored to meet people's individual needs (EPOMM 2017; Jittrapirom et al. 2017: 14). Connected and automated vehicles aid the development of MaaS by continually blurring the lines between classic public transport and MPT thanks to the automation of vehicles, resulting in increasingly flexible and independent movement (Lenz/Fraedrich 2015: 189; Bruns et al. 2018: 12). The technological development of CAVs opens new possibilities for the development of business models, which could enable new suppliers to gain entry to the market. Due to ongoing automation and connectivity, it is possible that disruptive developments will take place in the mobility sector and that existing services will undergo further transformation in the years to come (Gertz/Dörnemann 2016: 5). Key components of a MaaS solution are (Jittrapirom et al. 2017: 16; Lund 2017):

- *MaaS operators/integrators*
  These actors sell a comprehensive service to the end consumer, handle activities such as customer management and carry out marketing strategies. MaaS services can be either private or public, or a mix of both. These mixed models are called PPP (public–private partnership) or PPPP (public–private–people partnership). The latter can typically also be expanded to include peer-to-peer sharing and social dimensions (Aapaoja et al. 2017: 9–11). The challenges of using MaaS in

practice often arise during the search for a suitable operator structure: on the one hand, businesses solely offering a platform have no control over, and no responsibility for, the individual services. On the other, public transport operators and private mobility providers have an interest in promoting their own mobility services (Smith et al. 2017: 8).

- *Cooperation between various mobility providers*
  Cooperation between various mobility providers (such as car and bike-sharing as well as public transport and taxi companies) in a horizontal integration model is vital for a successful system (Joschunat et al. 2016: 70; Li/Voege 2017). To enable door-to-door mobility, the aim should be to create a pool of supply-based services (public transport operating on an interval timetable) and demand-based services (e.g. bike sharing, connected and automated ride and car sharing; Lund 2017). Most notably with regard to the first and last mile, automated vehicles are seen to offer huge potential as a shuttle system to carry travellers to public transport hubs in urban and rural areas (BMVIT 2016c, Ohnemus/Perl 2016). As there is now a bigger choice of transport options and mobility services, MaaS operators are better placed to meet customers' various needs and preferences (Goulding/Karmagianni 2018: 2).

- *Mobility platforms (information and communication technology)*
  The core components, such as information on alternative forms of mobility and bookings as well as payment and billing for used mobility services, are all managed on one platform (vertical integration; Joschunat et al. 2016: 70). According to Sochor et al. (2017: 193–196), the scope of vertical integration can be divided into different levels: Level 0 (no integration), Level 1 (integration of information), Level 2 (integration of booking and payment), Level 3 (integration of the service offer) and Level 4 (integration of societal goals, incentives).

At present, MaaS approaches are being implemented internationally in different contexts[3]: in 2014, a mobility app was tested in 70 households in Gothenburg as part of the "Go:Smart/UbiGo" pilot; the "UbiGo app"[4] was also trialled in Stockholm in 2018. An important finding that resulted from the first pilot project in Gothenburg was that MaaS can lead to a change in mobility behaviour and to higher user satisfaction (https://ubigo.me/). The "Whim app" (https://whimapp.com/) was introduced in Helsinki in 2016, Austria has become familiar with a functionally and modally integrated MaaS system thanks to the countrywide "SMILE – einfach mobil" project (2012–2015), and residents of Vienna have had access to the "WienMobil" app since 2017.

A growing percentage of the population is now taking advantage of multimodal mobility, i.e. individuals are using different forms of transport to get from A to B (Busch-Geertsema et al. 2016: 757). Smartphones and apps are being used to find out the best way (e.g. the fastest or most convenient route) to complete a journey – on foot, by bike, public transport, car sharing, etc. – and this is particularly true in urban areas and among younger members of the population (BMVIT 2019). The (technological) development of platforms (individualization of services, customization options, e.g. to suit an individual's personal routine) as well as the integration of

Figure 3.3.2: **MaaS – opportunities, risks and obstacles**

OPPORTUNITIES	• Creation of competitive, sustainable alternatives to private cars and a reduction of MPT use (see Lund 2017, Holmberg et al. 2016) • Improved efficiency of existing mobility services and public transport, including in less densely populated areas (Gertz/Dörnemann 2016, Hoadley 2017, Bösch et al. 2018) • Development of an inclusive mobility system as MaaS can be adapted to personal needs (personalization of service; Hoadley 2017)
RISKS	• Exclusion of the less tech-savvy by digitalizing transport services ("digital gap"; Hoadley 2017) as well as those who cannot afford to access such services (mobility poverty) by introducing business models, i.e. private operator structures (Pangbourne et al. 2019) • Socio-spatial inequalities that arise when commercially designed operator structures lead to MaaS being offered exclusively in densely populated urban areas and not in less densely populated locations (Alberts et al. 2016) • Rebound effects, e.g. when an imbalance of transport modes occurs (Eckhardt et al. 2018), resulting in those previously unable to use motorized vehicles being granted access (Datson 2016, Durand et al. 2018)
OBSTACLES	• Casual use of the term "MaaS" – the objective of MaaS must be to achieve MaaS Levels 3 and 4 (Harms et al. 2018) • Even greater uncertainty about the effects of MaaS at the individual (mobility behaviour, everyday integration) and social (e.g. social and ecological sustainability; Durand et al. 2018) levels • MaaS will pose significant challenges for governance structures, e.g. lack of provisions for MaaS in public strategies, the availability of data (Big Data) resulting in power being transferred to private actors, the risk of innovations being outsourced to the private sector (Pangbourne et al. 2019)

additional services make it possible to reach new target groups. What is noticeable is that previous socio-ecological ideals are increasingly being superseded by customers' pragmatic attitudes to mobility: flexible service provisions appeal to highly mobile individuals with a multitude of choices who want to ensure they have several travel options at their disposal (Maertins 2006).

The level of demand for MaaS depends on a number of factors (Harms et al. 2018: 23–24):

- *Mobility behaviour*
  Studies show that car owners[5] who use their vehicles very often (on four or more days per week) and never or rarely use public transport are the least inclined to use MaaS (Ho et al. 2017). Experience with (intermodal) public transport, however, increases the likelihood of an individual using MaaS as well as other forms of transport.

- *Route characteristics*
  MaaS holds unique potential when it comes to leisure travel and journeys to irregular, unknown destinations: integrating additional information and making it accessible to the user (Harms et al. 2018: 23).

- *Digital skills*
  Young, tech-savvy adults tend to use MaaS more compared to older generations or those less familiar with technology (Kamargianni et al. 2018).

- *Socio-demographics*
  Households with two or more small children show less interest in MaaS than other households (Haahtela/Viitamo 2017; Ho et al. 2017). Given the fact that social structures crucially influence mobility and how it can be accessed, it is important that any future MaaS research not only analyses individuals but also considers familial structures (Haahtela/Viitamo 2017).

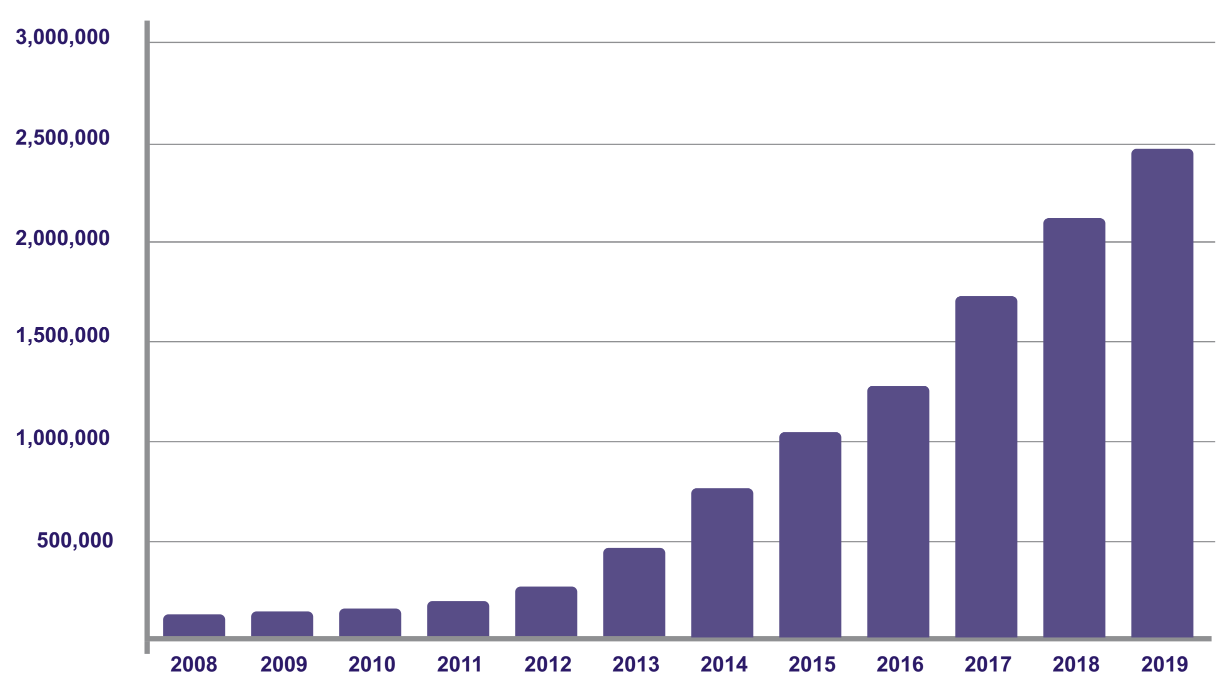
- *Aspects of (mobility) culture*
  How much a society is "service-orientated" plays a particularly important role (Haahtela/Viitamo 2017).

These points show that within a society, several different factors are at play, which determine the level of accessibility of MaaS services. Against this backdrop, MaaS services need to be introduced in a way that targets specific groups and avoids replicating existing social inequalities (e.g. the "digital divide"; Durand et al. 2018).

3.3.2 SHARED MOBILITY

Shared mobility is just one part of the sharing economy and concerns the shared use of mobility services (BMVIT 2016c: 12). Shared mobility is a part ownership-based, part public mobility model and grants users access to various means of transport without the need for ownership (Kollosche/Schwedes 2016: 26).

Figure 3.3.3: **Registered car sharing users in Germany**



Source: AVENUE21 based on Bundesverband CarSharing (2019), accessed via Statista

As shared mobility increases the number of passengers on a journey and in a specific vehicle, it is considered vital in helping to realize the climate-friendly and resource-efficient mobility model of the future. Within the context of automated vehicles too, shared use will be a vital prerequisite to significantly reducing the number of private cars, enabling more efficient use of the existing infrastructure and allowing an improved quality of life through the recovery and repurposing of space dedicated to roads (BMVIT 2016c: 60; see Chap. 4.3).

Shared mobility services are usually booked and invoiced via an app and/or an internet platform. In recent years, the mobility sector has seen the addition of a large number of sharing services with different organizational structures and motives (Scholl et al. 2013; BMVIT 2016c), e.g. commercial (Business-to-Consumer – B2C, Business-to-Business – B2B), non-commercial (Consumer-to-Consumer – C2C) and public (Government-to-Consumer – G2C). Currently, shared mobility services are primarily offered via two different systems: they are either station-based or free floating. The growing appeal of shared mobility can mainly be attributed to free-floating systems, which, thanks to CAVs that can travel the few metres back to the pick-up location, could be set to become more significant both in absolute and in relative terms (Shaheen/Chan 2016: 577).

However, shared mobility continues to be used in a socially selective manner: customers are more likely to be male and tend to be younger on average than the rest of the population; users also have a comparatively higher level of education and a higher income (Böhler et al. 2007, Kopp et al. 2015, Riegler et al. 2016, Hülsmann et al. 2018).

Sociocultural factors favouring shared mobility are:

- A shift in values characterized by the fading symbolic value of property (Botsman 2013, Owyang et al. 2014, Priddat 2015).
- Sharing is associated with modern values, a higher level of freedom as well as greater flexibility and independence (Harms 2003).
- Growing general awareness of the ecological consequences of individual actions, although the “green image” (Steding et al. 2004, Gossen 2012, Lindloff et al. 2014) is now becoming less important.
- Everyday compatibility and pragmatic arguments are gaining ground (Loose 2010, Lindloff et al. 2014; e.g. convenience, flexibility, loan points can be easily reached, service is simple and straightforward to use, costs less).

Mainly two forms of shared mobility are relevant within the context of CAT: car sharing and ride sharing. In both examples, connected and automated vehicles offer the potential to create systems that are more affordable and efficient (Bösch et al. 2018: 82). The following looks at both services in detail.

Figure 3.3.4: **Shared mobility – opportunities, risks and obstacles**

OPPORTUNITIES	• Data analysis of how the rising level of automation has affected mobility behaviour and, subsequently, the scope to optimize services (Freese/Schönberg 2014) • Savings and more efficient use of resources achieved through connected and automated vehicles (Bösch et al. 2018) • Expansion of shared mobility services by diversifying the types of vehicles available (e.g. e-cars; BMVIT 2016c) • Using instead of owning: a shift in attitudes tends to lead to further growth of shared and connected forms of mobility (BMVIT 2016c) driven by information and communication technologies, digitalization and cultural processes of change (Alberts et al. 2016)
RISKS	• Lack of oversight of the sharing services on offer, lack of connectivity and integration (if the service is not embedded within a MaaS system), substantial effort required from users (BMVIT 2016c) • Relocation challenges in free-floating systems: vehicles are stuck in “cold spots” that are unattractive to users, idle periods are not profitable for operators (Weikl/Bogenberger 2013) • New forms of shared mobility (e.g. e-scooters) trigger conflicts regarding use in public space (Riegler 2018)
OBSTACLES	• Everyday mobility shaped by routine (Scheiner 2009) • Anxieties and concerns about “others” keep demand low for the shared use of driverless small vehicles (Salonen/Haavisto 2019) • Accessibility (distance to the vehicle) and availability of vehicles – connecting and automating the systems could counteract this (BMVIT 2016c) • Organizational aspects and corporate strategies impede the development of an integrated information and communication platform (MaaS; BMVIT 2016c) • Partial lack of predictability and security resulting from the high degree of flexibility offered by shared mobility (Vogel et al. 2014)

Commercial car sharing (B2C) is already well established in Europe's major cities. In recent years, free-floating systems in particular have reached a growing number of major cities where the respective networks have gradually been expanded and the modes of transport on offer have been diversified through the addition of bike sharing, e-moped sharing and e-scooter sharing. Although (car) sharing is seeing substantial growth,[6] the number of car-sharing users as a share of the total population remains rather low (see Fig. 3.3.3).

Austria is one of the countries where user figures remain low but the trend is heading upwards: of Austria's approx. 3.9 million private households, only around 100,000 use car sharing (BMVIT 2016a in VCÖ 2018b). A study published by PwC in 2018 predicts that by 2030 more than one in three kilometres driven in Europe will be completed using some form of shared mobility. The number of private cars that could be replaced by car sharing depends on the respective system, the overall conditions within the transport system in the various cities and the aspects concerning (mobility) culture. Scenarios and prognoses thus calculate vastly different figures with regard to the potential reduction in greenhouse emissions. For example, in a study for the city of Munich, the authors estimate that one free-floating car sharing vehicle could replace 3.6 private cars (Schreier et al. 2015); in a study on another German city, Bremen, they predict that each station-based car-sharing vehicle could replace 16 private cars (Schreier et al. 2018). Generally speaking, the large-scale operators believe the future of car sharing lies in automation and the use of electric mobility. For instance, there are plans for the entire Car2Go fleet to be fully autonomous and electric by 2030 (Stüber 2018).

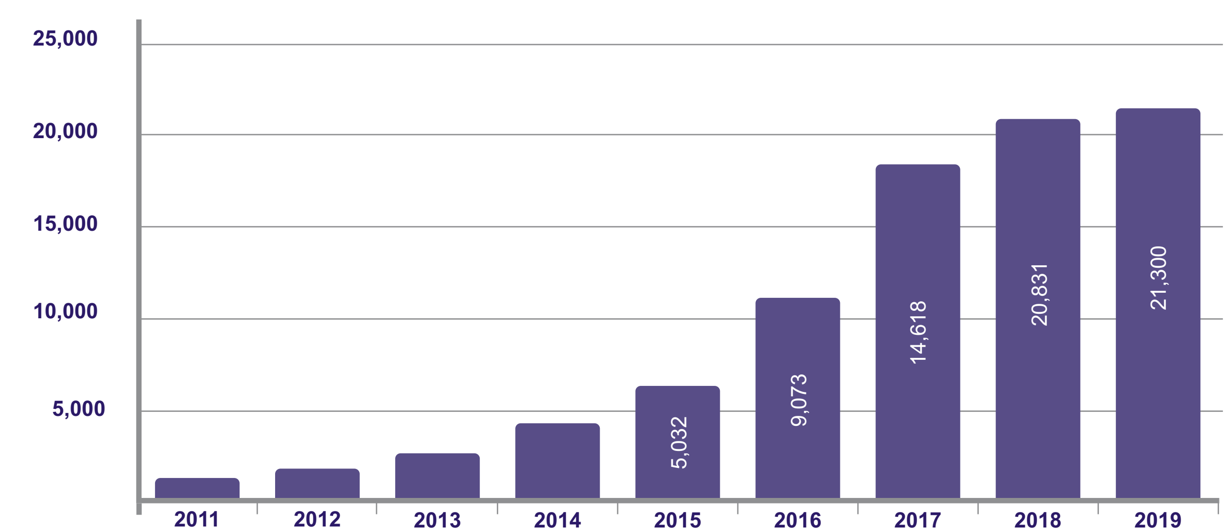
In addition to sharing the actual mode of transportation ("good sharing"), there are other forms of sharing where a vehicle is used simultaneously by different individuals: depending on the providers, the services on offer range from ride pooling (carriers, rental and taxi companies that are obligated to ensure continuous service), ride sharing (e.g. Blabla Car) and ride selling or ride hailing (commercial platform operators, e.g. Uber; cf. Sommer 2016). At present, there are a number of barriers particularly with regard to (C2C) ride sharing from the user's perspective (accessibility, safety, proximity to strangers; Nielsen et al. 2015). To that effect, connected and automated ride sharing could present a huge opportunity to increase usage by enabling a higher level of flexibility (Bruns et al. 2018: 22).

3.3.3 NEW PROPULSION TECHNOLOGIES

As resources are set to become even more scarce and we face the evident threat of climate change, it is vital to also discuss CAVs within the context of alternative fuels and new propulsion technologies.[7] A growing number of alternative solutions are being developed to compete with fossil fuels (Kollosche/Schwedes 2016: 19–20). These are:

- battery-powered electricity (generated by renewables),
- electric motors powered directly (via cables or induction),
- different generations of biofuels,
- fuel cell cars powered by hydrogen (see UBA 2015 for more on the advantages and disadvantages of different vehicle generations).

Figure 3.3.5: **Number of e-cars in Austria**



Source: AVENUE21, Statistics Austria (2019b)

To be able to use these new types of fuel, new propulsion systems need to be designed and produced. Which adapted propulsion systems and respective fuels will prevail on the market depends on their level of efficiency (e.g. cost effectiveness, environmental compatibility and practical applicability; Kollosche/Schwedes 2016: 19–20):

- *Battery Electric Vehicles (BEV)*: electric motor with a battery, can be recharged from the grid; limited distances of 200–400 km.
- *Fuel cell vehicles* generate the necessary power with the aid of a fuel cell, which powers an electric motor; hydrogen is used as fuel; no grid connection required; average distances of 400–600 km.
- *Fuel cell hybrid electric vehicles*: hydrogen is converted into electrical energy in the fuel cells; vehicles thus feature both fuel cells and a battery.
- *Hybrid vehicles*: a combination of a classic combustion engine and an electric motor; no need to connect to the grid (with the exception of plug-in hybrid electric vehicles – PHEV).

Politicians at both national and international levels consider electromobility to be key to decarbonizing transport (BMVIT n.d.; European Commission 2018). Although the number of registered electric vehicles has been rising gradually, overall the transition to electric models has been slow (AustriaTech 2018). If alternative fuels and propulsion technologies are to achieve substantial market penetration, they will first need to find a certain level of (growing) acceptance among end consumers. But as the registration figures show, there is quite a high degree of scepticism. This is because, on the one hand, the public are not fully aware of the advantages of these technologies, while the focus is often placed on the constraints that currently exist (high purchasing costs, limited range, poor network of charging stations; Bobeth/Matthies 2016). However, these arguments are also often used to justify emotionally driven reservations. And even though the range of such vehicles would suffice for the majority of journeys (Kollosche/Schwedes 2016: 19–20), these are the arguments made time and time again. On the other hand, users sometimes consciously choose to ignore the fact that their (fossil fuel-based) mobility and the resulting emissions are contributing to climate change.

However, in sharing systems, electric vehicles are met with a significantly higher level of acceptance and appear to have greater appeal: they are seen to be more environmentally friendly and almost just as practical as conventional vehicles (Hülsmann et al. 2018: 120). Car sharing thus plays a vital role in breaking down psychological barriers to e-mobility and in allowing low-threshold contact points (Hülsmann et al. 2018: 120). There are now e-car sharing providers in almost every Austrian federal state (e:mobil 2018), although community-based (stationary) e-car sharing has mostly been established in rural areas (partly through targeted “klimaaktiv mobil” funding; klimaaktiv 2017).

One particular political target – that of increasing the number of e-vehicles – requires a significantly more radical expansion of the charging infrastructure in residential buildings, as well as of renewable energies and network capacity. In addition to boosting the availability of charging stations, it will also be important to improve charging times in order to increase public acceptance of e-mobility. It is thus crucial that the time spent waiting for a vehicle to charge can be made more enjoyable; here there is still a significant lack of suitable solutions (Ebert et al. 2012).

With this in mind, the task at hand is also to increasingly utilize the synergies between electromobility and automated driving. The process of automation will thus be able to break down some of the obstacles that prevent individuals from using electromobility (e.g. users’ fear of not being able to travel far, access to charging infrastructure, management of charging time). Connected and automated vehicles are able to manage these aspects au-

Figure 3.3.6: **New propulsion technologies – opportunities, risks and obstacles**

OPPORTUNITIES	• Low-threshold access to new propulsion technologies enabled by shared mobility (VCÖ 2018b; Hülsmann et al. 2018) • Increased quality of life in cities thanks to fewer emissions (pollutants and noise pollution; VCÖ 2011)
RISKS	• Path dependency resulting from the current focus on e-mobility (Fischedick/Grunwald 2017) • User scepticism towards new propulsion technologies (Kollosche/Schwedes 2016) • Concerns about road safety (e.g. alternative propulsion systems producing low noise levels; Ingenieur.de 2018)
OBSTACLES	• Industrial strategies put forth by policymakers that restrict the further development of technologies to help produce alternative fuels and propulsion systems (Kollosche/Schwedes 2016) • E-mobility and its expansion are tied to infrastructure development (charging stations) and the standardization of charging plugs and access schemes, communication protocols and solutions for billing systems (e.g. Ebert et al. 2012)

tonomously based on real-time journey demand (Chen et al. 2016). In order to take advantage of the technological synergies available, RWTH Aachen is currently running a project (UNICARagil, www.unicaragil.de) to develop a modular and scalable vehicle concept for electric-powered automated vehicles that can be adjusted flexibly to suit a wide range of applications in logistics and passenger transportation.

In conclusion, it is clear that any further examination of the potential CAVs hold to help bring about a shift in mobility must also consider the three trends mentioned here – MaaS, shared mobility and new propulsion technologies. For this reason, we actively included the three factors when developing our scenarios (see Chap. 5).

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1 Vanessa Sodl (a researcher in Transportation System Planning, TU Wien) played a considerable role in helping compile this report and her knowledge, in particular on MaaS and new propulsion technologies, was invaluable to our work.

2 However, megatrends represent, at best, general frameworks that take effect on a global scale and are thus in no way deterministic development trajectories.

3 Even if the concept of MaaS integration is only comprehensively embedded in a handful of projects.

4 The app combines public transport, car sharing, car hire and taxis in one intermodal mobility service. Each household selects a flexible monthly subscription and the account is shared by all members of the household.

5 In 2017, there were 371 private cars per 1,000 inhabitants in Vienna (the figure stood at around 500 private cars per 1,000 inhabitants in other Austrian federal state capitals due to less effective public transport systems). The figure was 349 in Munich and 346 in Hamburg, with a slightly higher number for Berlin (384). In Europe's developed cities, 300 private cars per 1,000 inhabitants has become somewhat of a benchmark that symbolizes a considerably lower private car stock (ORF 2018).

6 In recent years, however, the trend seems to have reversed somewhat, which can also be seen in the merging of different providers.

7 Yet it is assumed that any changes are likely to be in small, gradual steps, which means that the combustion engine will still be the dominant form of propulsion until the year 2040 (Bukold 2015: 3). On the other hand, political decisions, such as those made in Norway, France and also China, indicate that this shift could take place at a faster pace in at least some regions.

3.4

EXPERTS' IMPACT ASSESSMENT OF CONNECTED AND AUTOMATED MOBILITY[1]

3.4.1 SURVEY AIM AND METHODOLOGY

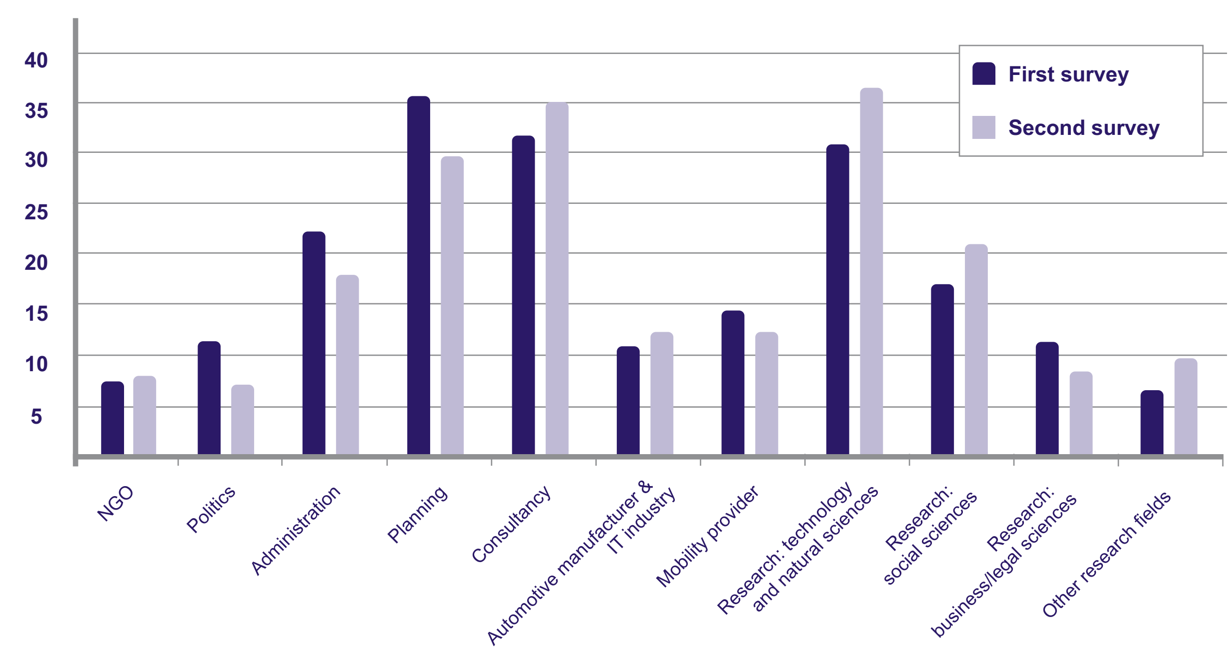
In the autumn of 2017 and the winter of 2018/2019, experts from a broad range of fields that included urban development, mobility planning and technology development were invited to participate in two online surveys as part of the AVENUE21 project. The aim of both surveys was to ascertain the existing level of knowledge within a range of academic, planning and business settings concerning the link between connected and automated road vehicles and the development of European urban regions – an area which, according to Fraedrich et al. (2018), is still under-researched. Within the project as a whole, these two surveys would also support the concurrent creation of scenarios (Chap. 5).

Data were collected using standardized electronic surveys; a total of approx. 980 individuals were approached and invited to take part. When selecting a list of prospective experts, our team made sure to choose specialists with a broad range of expertise. We contacted individuals who are conducting research in different academic fields (technology, social sciences, business or legal sciences) or working for mobility service providers as well as experts involved in development and public administration, land-use planning, consultancy or politics. When conducting both surveys, we contacted specialists both in German-speaking countries (i.e. using a German questionnaire) and in the rest of Europe (predominantly from the Netherlands and the United Kingdom, who received an English questionnaire). The majority of respondents for both surveys were from German-speaking countries.[2]

We received over 200 responses to the surveys, i.e. our response rate was above 20% (first survey: 211, second survey: 216). Although this may be a relatively high number for a survey of this kind, given the non-response rate of just below 80%, we should expect some of the results to be distorted.

As this project examines the issue of CAT and the impact it has on the European city (in terms of impacts on governance, architecture and urban development as well as urban society), the urban and transport planning professions are comparatively overrepresented in these surveys, while those specialists who work more specifically with technological systems tend to be underrepresented.

Figure 3.4.1: **Membership of specific stakeholder groups as specified by respondents (in percent*)**



* As respondents were able to select multiple answers, the percentage values add up to more than 100%
Source: AVENUE21

The respondents' answers regarding their professional field (see Fig. 3.4.1) indicate that a particularly high number of professionals from the fields of "planning", "consultancy" and "technology or natural sciences research" (each accounting for between 30% and 37% of participants) took part. In contrast to the first survey, professionals active in the field of technology or natural sciences research interestingly formed the largest group of participants in the second survey.

3.4.2 FIRST SURVEY: STAKEHOLDERS AND THEIR EVALUATION OF THE RISKS AND OPPORTUNITIES OF CONNECTED AND AUTOMATED TRANSPORT

The first survey was conducted in autumn 2017 and aimed to:

- ascertain the participating experts' level of knowledge and their respective sources,
- obtain a nuanced picture of different CAM use cases, and
- find out how urban and mobility planners evaluated the opportunities and risks frequently mentioned in the general discourse.

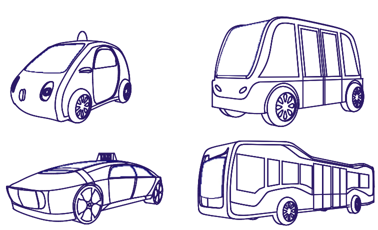
First, participants were asked where they access information about the subject and/or how much first-hand experience they have with CAT. Just below 75% of the experts surveyed responded that they source information from the (specialist) media. Moreover, around 60% of those surveyed stated that they had already undertaken in-depth scientific research or been actively involved in planning or research activities. A considerably smaller group stated that they were involved in specific tests using CAVs (approx. 27%) or already had first-hand experience with CAVs (approx. 29%). Those in the latter three groups were also asked to specify which specific CAV use cases they had experienced (see Table 3.4.1).

When asked about the relevance of CAVs for their respective professional field, 68% of the participants believed CAVs had a high or very high potential to help develop innovative products or planning strategies. Respondents also believed that working with CAVs offered a high or very high potential to elevate the status of their own institution (approx. 38%) and to develop solutions that better meet the demands of customers. 78% of respondents felt that CAVs posed no threat to their professional field.

With regard to previous experience with CAVs, by far the most frequently encountered vehicles were automated shuttle buses (approx. 74%), which were well ahead of Level 4 cars (approx. 40%). At present, other use cases appear to play a less important role. A majority of respondents think that the different use cases will have a positive impact on their professional field: 61% of participants stated that automated shuttles would offer solutions to challenges and unresolved issues in their professional field (Figure 3.4.1).

All participants were asked to state how likely they thought automated modes of transport were to replace traditional forms of mobility. Respondents believed that

Table 3.4.1: **Respondents' first-hand experience and need (broken down by use case)**



	Which connected and automated vehicle applications have you experienced first-hand? (n = 149)			Which connected and automated vehicle applications do you expect to make a positive contribution within the context of your profession? (n = 193)		
	Responses N	Responses %	% of cases*	Responses N	Responses %	% of cases*
SHUTTLE	110	29.7	73.8	118	17.6	61.1
PUBLIC TRANSPORT	47	12.7	31.5	112	16.7	58.0
CAR SHARING	41	11.1	27.5	102	15.2	52.8
RIDE SHARING	37	10.0	24.8	86	12.8	44.6
LEVEL 5[3]	28	7.6	18.8	78	11.6	40.4
LEVEL 4[4]	59	15.9	39.6	62	9.3	32.1
FREIGHT TRANSPORT	33	8.9	22.1	62	9.3	32.1
OTHER USE CASE	15	4.1	10.1	7	1.0	3.6

* Multiple responses were possible, resulting in values > 100
Source: AVENUE21

connected and automated sharing services had the highest potential for crowding out other transport options. 97.6% of those surveyed expect that this use case will displace one of the existing forms of transport, closely followed by connected and automated private cars (96.2%) and driverless public transport (93.4%). Respondents thought fully automated freight transport would have a considerably lower impact (49.3%; see Fig. 3.4.2).

When the question was reversed, experts presume that traditional public transport will be most heavily impacted by the displacement effect (93.4% of experts believe that at least one of the automated forms of mobility mentioned in the survey will displace traditional public transport), followed by conventional private cars (89.6% of respondents). Each of these high figures underscores the often-cited argument that a core characteristic of automation will be the blurring of boundaries between individual and public transport ("hybridization", Lenz/Fraedrich 2015: 185).

Although considerably fewer specialists expect that cycling (61.1%) and walking (56.4%) will become less relevant, they do think that even these active forms of mobility are highly likely to be displaced by CAT, which stands in direct contrast to the objectives of the existing transport policy, i.e. to encourage active mobility.

One other relevant point is the high potential CAVs have for displacing traditional forms of transport (see Fig. 3.4.2). Here respondents gave a considerably higher rating for fully automated freight transport compared to conventional private cars (42.7%). This means that the process of automation will not only affect people's transport habits, it also raises the question of which journeys could be completely delegated to machines.

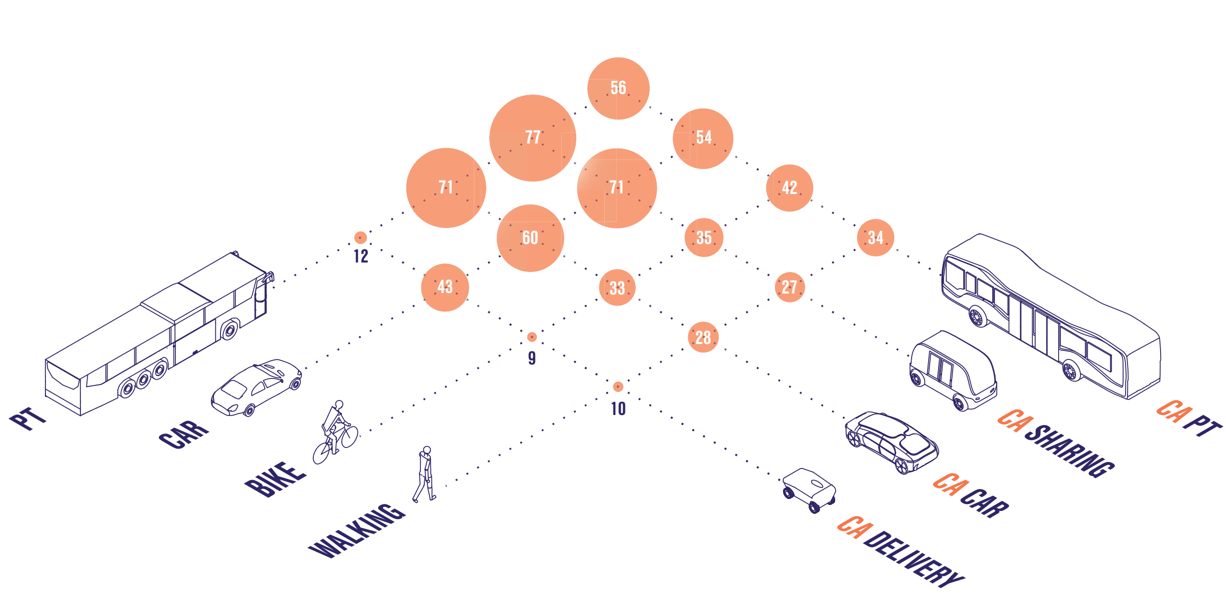
To find out how respondents view frequently raised arguments on the potential impacts of CAVs, these claims were presented as possible advantages and disadvantages – shown here in two separate tables (Tables 3.4.2 and 3.4.3) – for participants to evaluate.

The 14 advantages presented in the survey were grouped based on a factor analysis, a statistical method used to group variables that correlate to one another (see Table 3.4.2, Backhaus et al. 2019). Using this method, we were able to ascertain two factors. The first factor combines structural policy and social aspects (with an explained variance of 28%). The second groups together those aspects that are more economically relevant (explained variance: 21%). If the individual statements are listed based on their average level of approval, the economically relevant advantages are almost always given higher approval ratings than the structural policy and socially relevant factors.

The structural policy and socially relevant benefits tend to receive less approval (see Table. 3.4.2): the mean value of responses even falls within the category of "slight rejection" (< 4.0) for the final two statements. The respondents thus tend to believe that CAT will not lead to a stabilization of rural areas or the freeing up of intra-urban areas. This last finding stands in striking contrast to the results of a number of studies and to urban planning actors' core judgement that CAT will allow intra-urban traffic areas to be freed up so that they can be repurposed (see Chaps. 1, 4.1 and 4.3).

Respondents consider the link between CAT and the production and utilization of digital data generated during operation to be particularly relevant (see Table 3.4.2). Among the advantages listed in the survey, the

Figure 3.4.2: **Potential of individual connected and automated vehicle use cases to displace other modes of transport in per cent**



Source: AVENUE21

statement "Increasing automation and networking of transport will lead to the collection of larger volumes of additional data to be used for efficient control of transport" was calculated with an arithmetic mean[5] of 5.33 as the second most approved benefit.

However, respondents also considered the potential associated risks and counterproductive developments to be considerable (see Table 3.4.3). If we list the disadvantages according to their respective approval ratings, three of the four most strongly weighted disadvantages concern data security:

- 91% agree with the statement that "Connected and automated transport will lead to large volumes of additional data being collected and used by third parties" (with an arithmetic mean of 6.00 – one of the highest values in our data set).
- 78% state that "Connected and automated transport will lead to large volumes of additional data being collected and used for continuous monitoring" (with an arithmetic mean of 5.44).
- 72% agree with the statement that "Connected and automated transport will lead to transport becoming a security risk due to hacking" (with an arithmetic mean of 5.13).

The impacts CAV will have structurally and in terms of social policy – be they negative or positive – are considered by respondents to be of little importance. Participants seemed to offer little approval of the statements concerning urban sprawl, the waning significance of brick-and-mortar retail, the risk posed to certain professions and the basic provision of spatial mobility (see Table 3.4.3). Moreover, respondents assume that the

Table 3.4.2: **Expert assessment of the opportunities arising from the introduction of connected and automated transport**

INCREASING AUTOMATION AND NETWORKING OF TRANSPORT WILL LEAD TO …		STRUCTURAL POLICY AND SOCIAL FACTOR	ECONOMICALLY RELEVANT FACTOR
	Mean values	Factor loading	
... new solutions in the logistics sector.	5.67	0.199	0.639
... large volumes of additional data being collected and used for efficient control of transport.	5.33	0.160	0.734
… an increase in transport safety.	5.31	0.428	0.518
... strengthened intermodality through services provided over the last passenger transport mile.	5.25	0.690	0.297
... increased mobility comfort.	5.18	0.325	0.582
... increased sharing services.	4.89	0.542	0.354
... an increase in the performance capability of the transport network.	4.79	0.274	0.576
... public transport services becoming more cost-efficient.	4.71	0.567	0.494
... boosting of the economy.	4.52	0.049	0.523
... public transport services being expanded.	4.5	0.557	0.375
… creation of socially inclusive mobility services.	4.42	0.671	0.340
... decarbonization of the mobility system.	4.03	0.605	0.277
... stabilization of rural areas.	3.87	0.771	-0.011
... freeing up of intra-urban areas.	3.82	0.790	0.143
Factors: mean value[6]		4.44	5.26
Factors: explained variance		28%	21%

1 = disagree, 7 = totally agree
Source: AVENUE21

number of motor vehicles on roads will not fall but rise in the coming years.

Their responses suggest a belief that this increase will also not be short term: with a mean value of 3.06, participants reject the statement "An increase in traffic volumes due to automated driving is an effect of the transition phase" (see Fig. 3.4.3). At the same time, with a mean value of 5.26, respondents clearly agree with the statement "Higher traffic volumes should be counterbalanced through legislation".

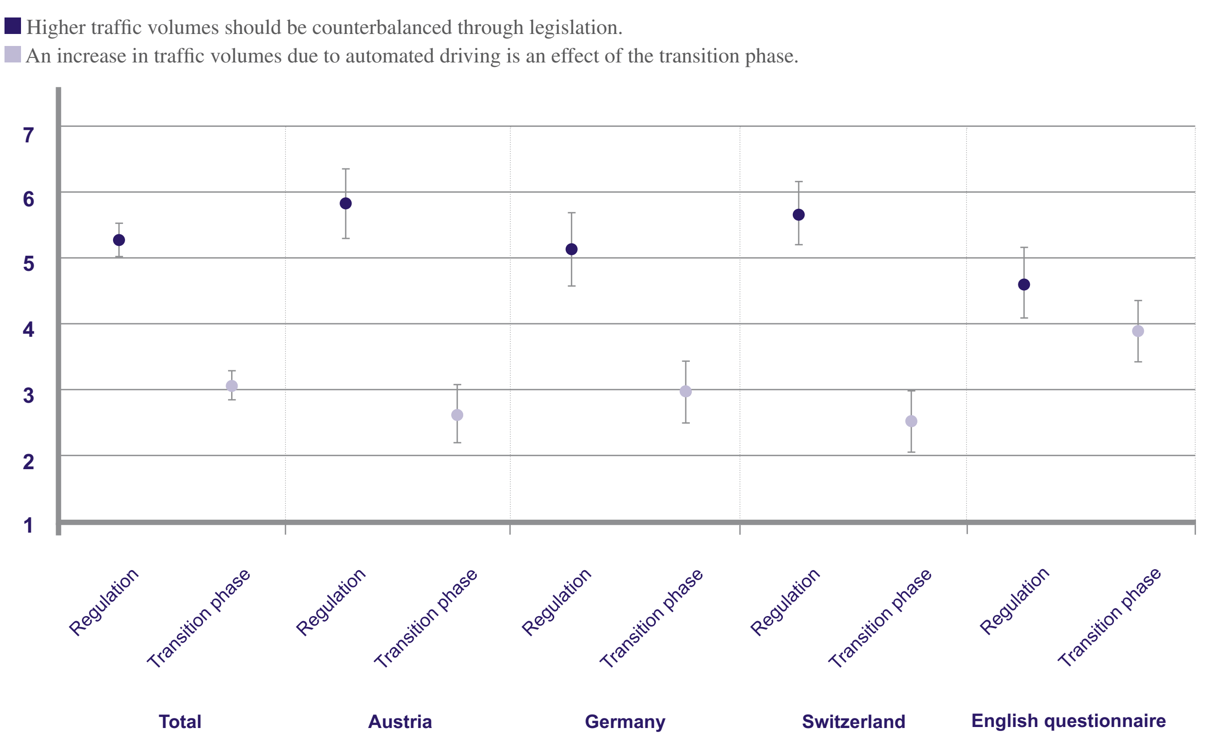
It is notable that the respondents from German-speaking countries were far more clearly in agreement with these statements than those responding to the English survey. While the average approval figures for the German survey are significantly different for these two questions, for the English survey, the mean approval values stood at 4.62 (regulation) and 3.9 (increase temporary) and were thus so close that the differences are not significant at a CI of 95%.

Table 3.4.3: **Expert assessment of the risks and impacts involved in the introduction of connected and automated transport**

CONNECTED AND AUTOMATED TRANSPORT WILL LEAD TO ...	MEAN VALUES
... large volumes of additional data being collected and used by third parties.	6.00
... large volumes of additional data being collected and used for continuous monitoring.	5.44
… increased motor vehicle traffic volumes.	5.26
... transport becoming a security risk due to hacking.	5.13
... increasing urban sprawl as peripheral locations will become increasingly attractive.	4.89
... production and delivery chains being completely overhauled.	4.73
... the decreased significance of offline retail trade compared to e-commerce.	4.69
... a threat to jobs that, at first glance, do not have any direct connection to vehicle steering.	4.53
... privatization threatening the basic provision of spatial mobility.	4.08

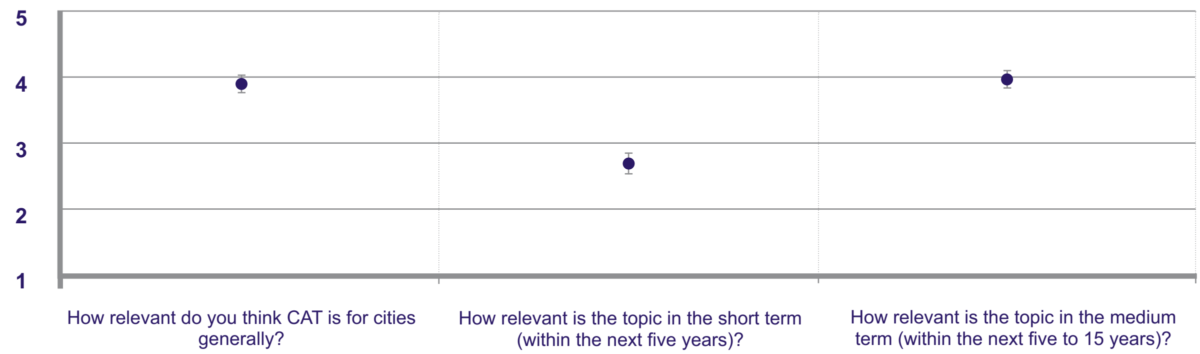
1 = disagree, 7 = totally agree
Source: AVENUE21

Figure 3.4.3: **Experts' opinion on rising traffic volumes and relevant regulation**



Mean values and 95% confidence intervals; 1 = disagree, 7 = totally agree
Source: AVENUE21

Figure 3.4.4: **Experts' opinion on the overall relevance of the subject from the perspective of urban planning**



Mean values and 95% confidence intervals; 1 = not relevant, 5 = extremely relevant
Source: AVENUE21

3.4.3 SECOND SURVEY: STAKEHOLDERS AND SCOPE FOR ACTION IN TOWNS AND CITIES DURING THE INTRODUCTION OF CONNECTED AND AUTOMATED VEHICLES

We carried out a second survey in the winter of 2018/2019. 216 experts agreed to take part, 98 of whom had already participated in the first survey.

The second survey focused on:

- potential actions and planning options in urban regions,
- how stakeholders' professional backgrounds influenced their evaluations,
- potential for cooperation and conflict, and
- examples of measures that could influence the effects of CAT.

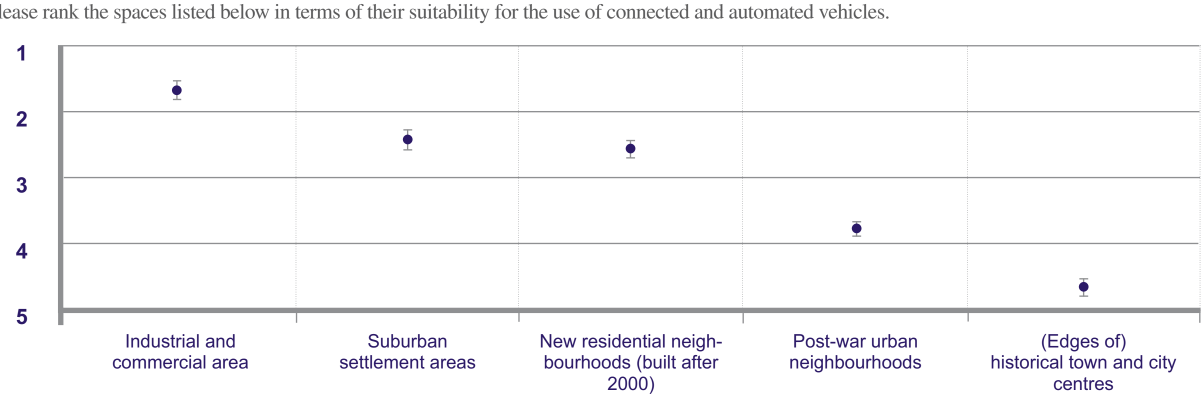
Participants were thus asked to judge how relevant CAT would be over certain periods of time. Here it became evident that the respondents only considered the topic to be of any real importance within the medium term (see Fig. 3.4.4); in their view, CAT is unlikely to be relevant over the coming five years.

Furthermore, participants were asked to evaluate the suitability of a range of settlement structures for the use of CAVs (see Fig. 3.4.5). Industrial and commercial areas were believed to be most suitable, with suburban settlement areas coming second, closely followed by new residential neighbourhoods. However, the mean ranks of both settlement types are so close in value that it cannot be determined (at a statistical certainty of 95%) which of the two should be ranked second and which third. What is clearer, however, is the ranking of the remaining types of settlement: post-war urban neighbourhoods are clearly ranked fourth and (edges of) historical town and city centres undoubtedly come in last. The evaluation given by experts in this survey evidently mirrors AVENUE21's analysis on automated drivability (see Chap. 4.4).

Subsequently, a series of questions were posed which aimed to ascertain the potential for conflict between urban areas and various stakeholders based on their diverging interests (see Fig. 3.4.6). The potential for conflict between urban areas and international market

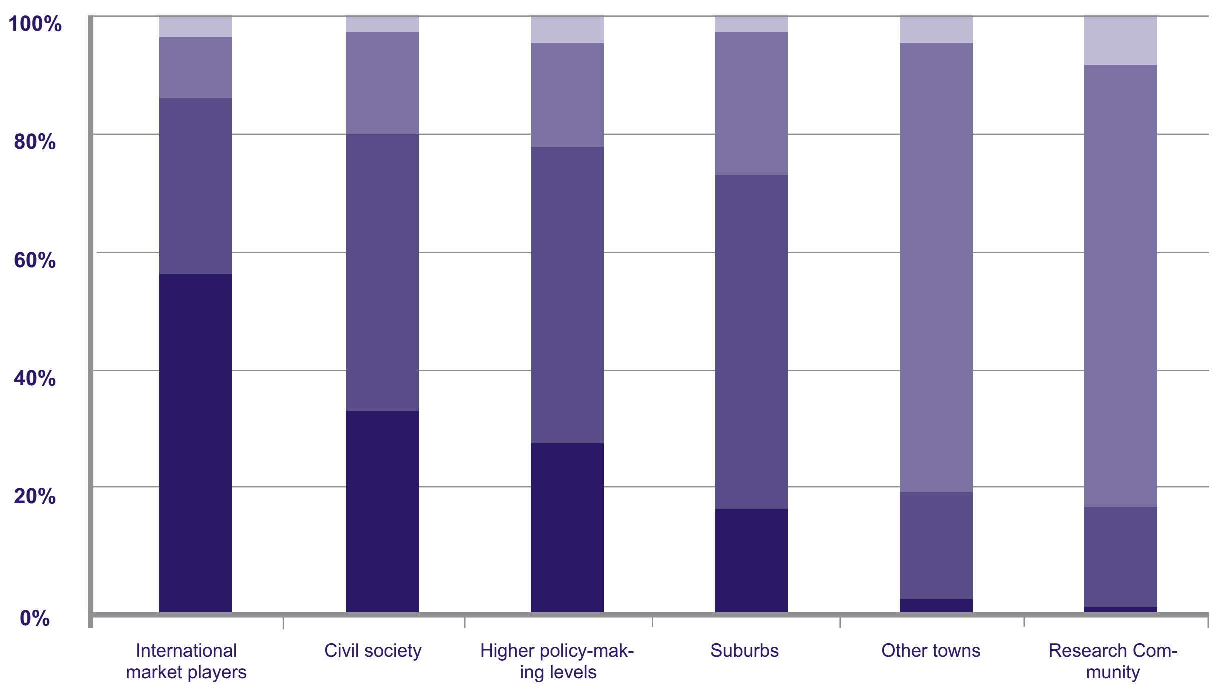
Figure 3.4.5: **Expert opinion on the suitability of a range of settlement types for the use of connected and automated vehicles**

Please rank the spaces listed below in terms of their suitability for the use of connected and automated vehicles.



Mean ranks and 95% confidence intervals; 1 = best suited, 5 = worst suited
Source: AVENUE21

Figure 3.4.6: **Expert opinion on the potential for conflict between selected actors and European towns and cities**
How big to you consider the potential for conflict to be between towns and cities and the stakeholder groups listed below when it comes to (further) developing and introducing connected and automated vehicles?

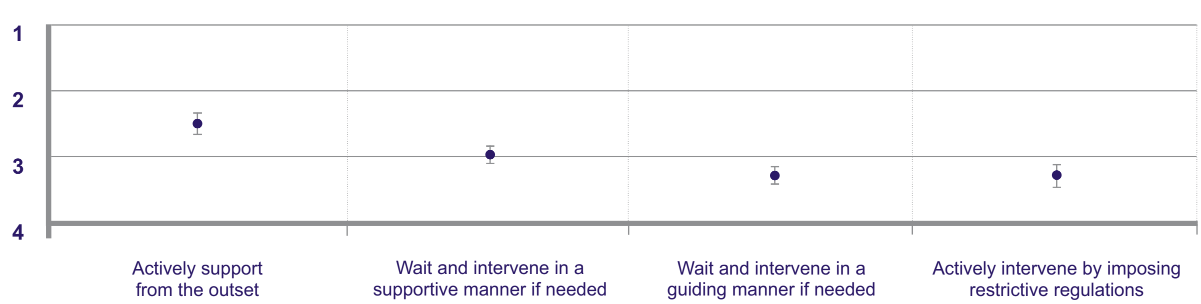


Source: AVENUE21

players was considered to be the highest at just under 60%. A slightly lower percentage believed there was the likelihood of conflict between cities and towns and civil society, higher policymaking levels and the rural-urban fringe (between approx. 20% and approx. 30%). A majority (around 75%) of respondents feel there is no or only a minimal potential for conflict between the urban areas themselves as well as between cities and towns and researchers.

One aim of the second survey was to gather data on experts' opinions regarding which of the many approaches towns and cities should take to respond to the introduction of CAVs (see Fig. 3.4.7). Respondents were offered a range of answers, each linking a time component (taking action from the start vs. waiting to see how things start to develop) with a type of action (encouraging CAT vs. CAT regulation). The results shown below illustrate that experts feel it is more important to support CAT than to regulate the technology: the statement "Providing active support from the outset during introduction" is seen as the most important, followed by "Awaiting the first developments and intervening in a supporting manner, if needed". Respondents named "Await the first developments and intervene in a guiding manner, if necessary" and "Actively intervene in the introduction process by

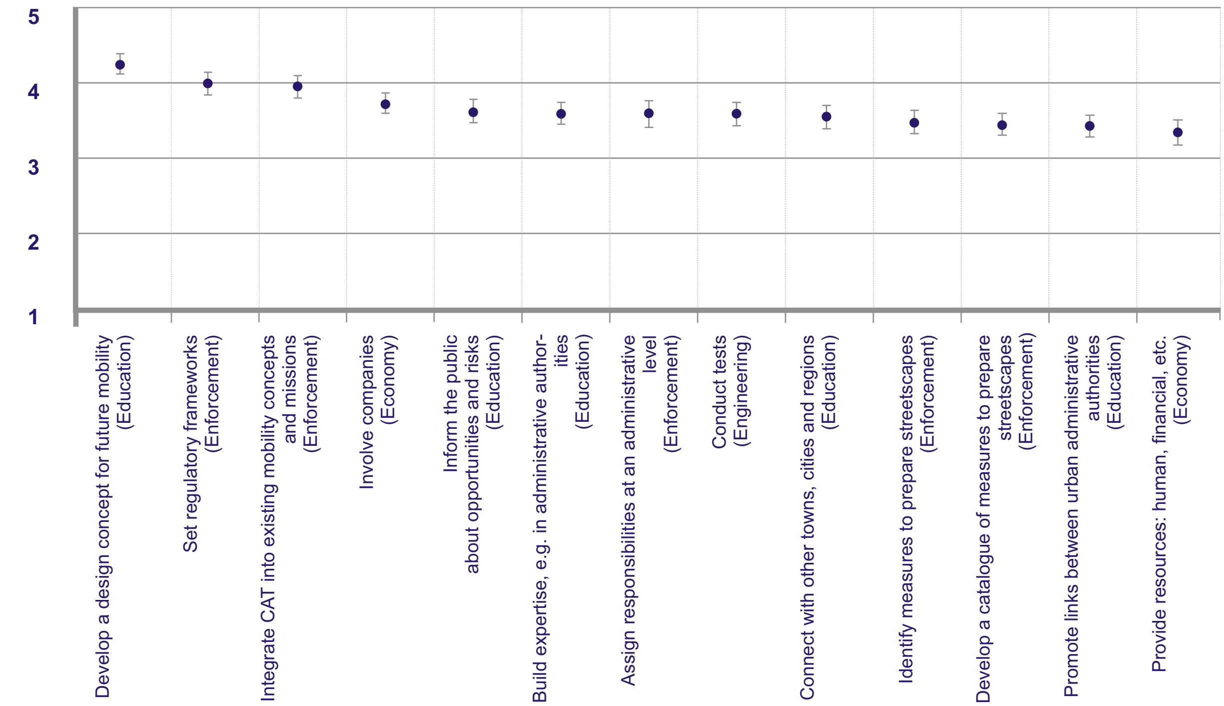
Figure 3.4.7: **Expert opinion on how European cities should approach the introduction of CAT**
European towns and cities have different ways of responding to connected and automated vehicles. Please rank the following answers in order of importance.



Mean ranks and 95% confidence interval; 1 = most important, 4 = least important
Source: AVENUE21

Figure 3.4.8: **Expert opinion on the need for measures that cities and towns can take to prepare for the introduction of connected and automated transport**

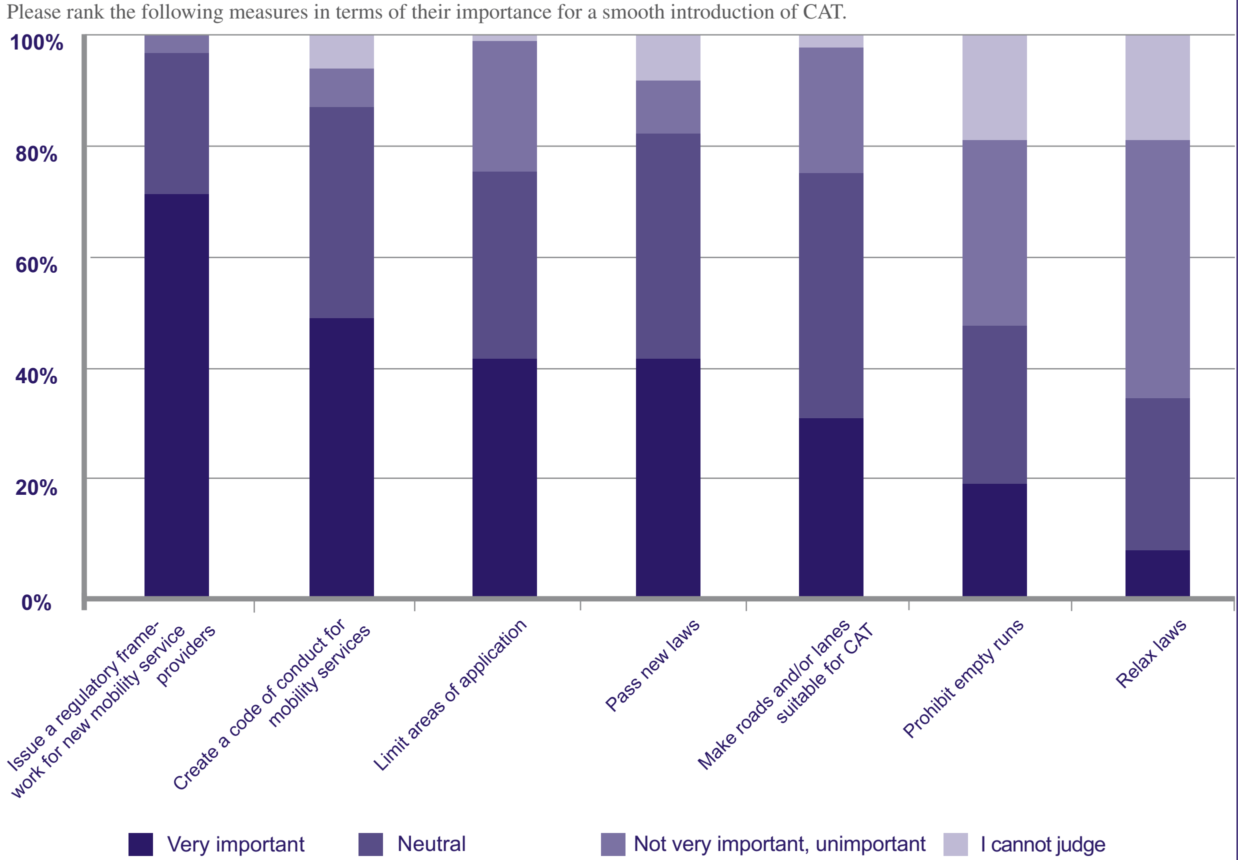
How urgent do you think the following steps are when preparing for the introduction of connected and automated transport?



Mean values and 95% confidence interval; 1 = not urgent, 5 = very urgent
Source: AVENUE21

Figure 3.4.9: **Expert opinion on the necessary framework conditions for measures to govern the introduction of connected and automated transport**

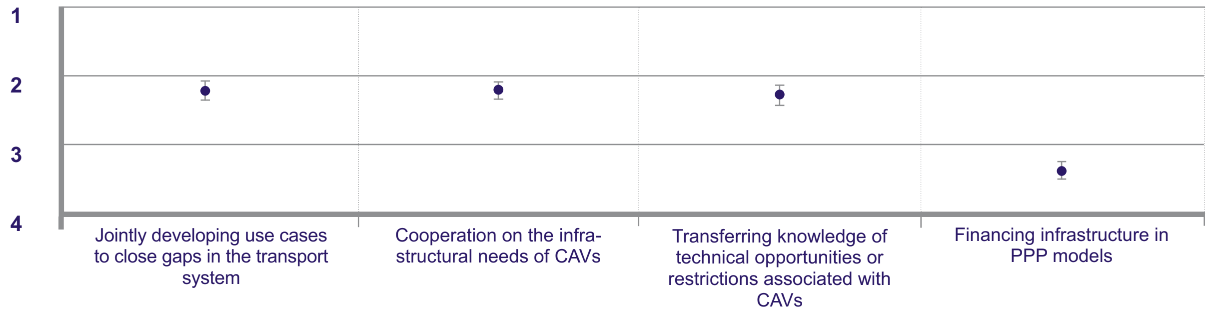
Please rank the following measures in terms of their importance for a smooth introduction of CAT.



Source: AVENUE21

Figure 3.4.10: **Expert opinion on the opportunities available to market players to support the introduction of connected and automated vehicles**

Which of the following opportunities do you think are best suited for market players to support towns and cities as they introduce connected and automated vehicles?



Mean ranks and 95% confidence interval; 1 = most important, 4 = least important
Source: AVENUE21

imposing restrictive regulation" as the third- and fourth-best options, with an almost equal level of approval.

Furthermore, respondents were asked to state which of the measures available to towns and cities they deemed necessary (see Fig. 3.4.8). "Developing a vision for future mobility", "Setting of regulatory frameworks" and "Integrating CAT into existing mobility visions and/or missions" were considered to be particularly urgent (mean values of 4.2 or around 4); however, it should be noted that the mean values for the remaining items were all within a range of 3.4 to 3.75 and thus were almost identical.

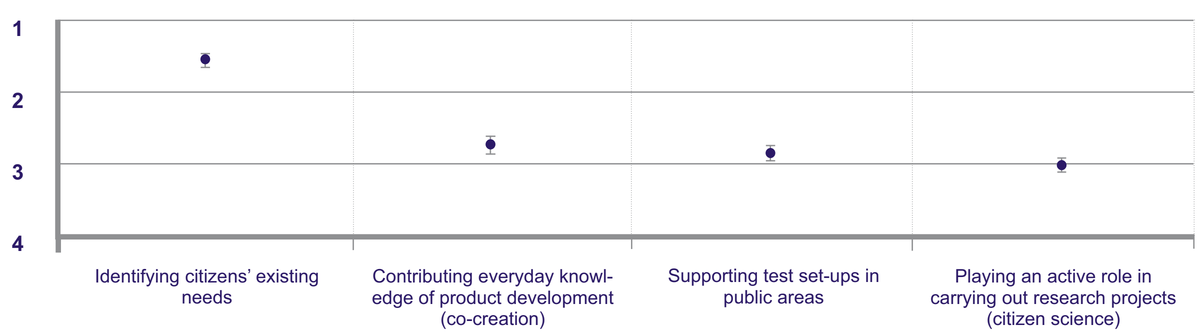
This sheds light on a dilemma currently facing urban and mobility planners: the first survey confirmed that the issue of CAVs was highly relevant for professional groups involved in the broader field of urban and mobility planning; meanwhile, the second survey indicated that CAVs will be an urban development issue that will be highly relevant over the medium term (Figure 3.4.4). However, there does not appear to be consensus concerning the necessary measures that towns and cities should adopt (see Fig. 3.4.8). It is evident that negotiations will need to take place, but there are little to no clues as to how this should happen.

If towns and cities wish to manage the introduction of CAT, they can select measures from a range of different areas. The experts were asked how important they considered the areas of economy (e.g. financial incentives, pricing measures, fiscal policy), enforcement (e.g. statutory measures, regulatory policy), education (e.g. measures to raise awareness, communication, information) and engineering (e.g. technical execution of planning, road technology and supply-side measures) to be for the support and facilitation of CAT (see Fig. 3.4.8). Here the results show that the experts we surveyed considered economic measures (two aspects) as relatively neutral, with an arithmetic mean of 3.22 on a scale of 1 (not urgent) to 5 (very urgent). The measures that fall into the enforcement (mean value of 4.2: five aspects), engineering (mean value of 3.96: one aspect) and education (mean value 3.81: one aspect) categories were, however, seen to be (slightly) important.

In the next step, respondents were asked to assess the necessary frameworks for specific measures regarding the introduction of CAT (see Fig. 3.4.9). Respondents considered the most important to be "Draw up policies and principles for new mobility service providers" (approx. 70%), followed by the creation of a code of conduct for mobility service providers (just under 50%).

Figure 3.4.11: **Expert opinion on the opportunities available to civil society to support the introduction of connected and automated vehicles**

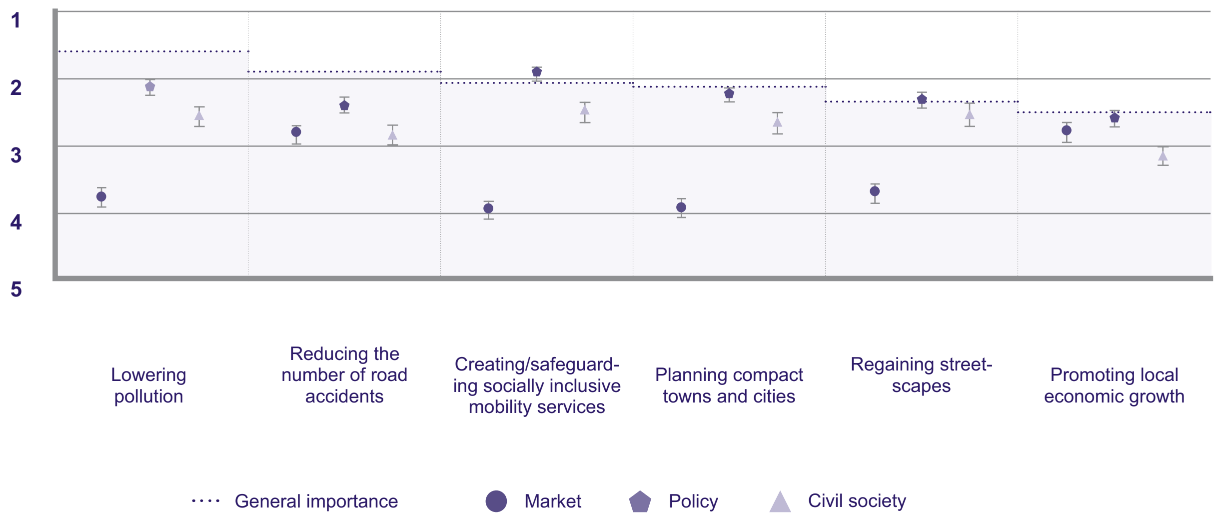
Which of the opportunities listed below are best suited for civil society stakeholder groups to be actively involved in introducing connected and automated vehicles?



Mean ranks and 95% confidence interval; 1 = most important, 4 = least important
Source: AVENUE21

Figure 3.4.12: **Expert opinion on the importance of urban development objectives and the suitability of the three scenarios**

How important do you consider the goals listed below to be to urban development?
How well suited are the various scenarios to helping to achieve the listed urban development goals?



Urban development goals: 1 = extremely important, 5 = extremely unimportant; suitability: 1 = scenario is very well suited, 5 = scenario is not well suited at all
Source: AVENUE21

Prohibiting empty runs and relaxing laws were considered to be slightly less important. However, a proportionally high number of respondents (just under 20%) stated that they did not feel able to judge the importance of the measure.

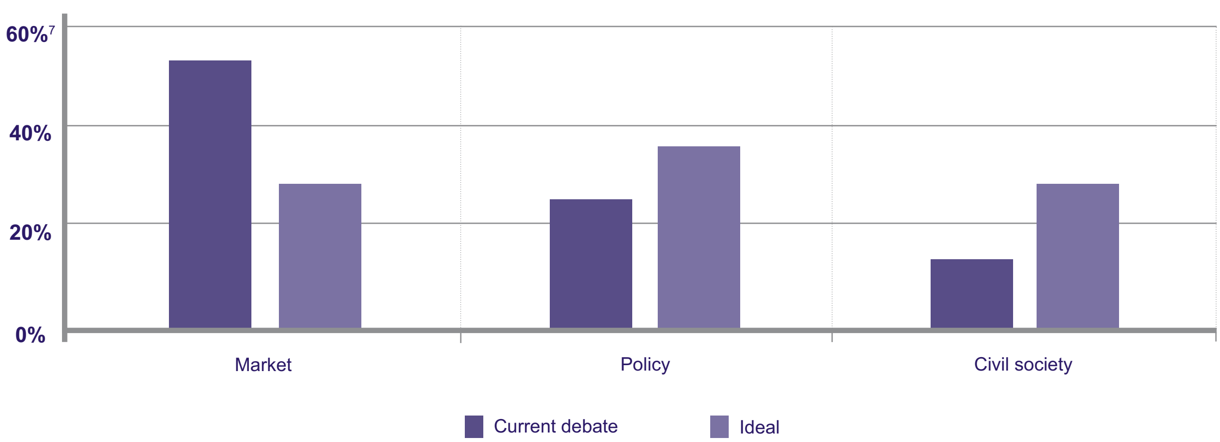
Moreover, participants were asked for their opinion on how towns and cities could be supported in their efforts to implement CAVs by market players (see Fig. 3.4.10) and civil society stakeholder groups (see Fig. 3.4.11).

Here respondents were presented with a series of possible measures and asked to rank them from "most important" to "least important" depending on their suitability. If we compare those measures experts ranked in the middle of the list with regard to the steps the market can adopt to support towns and cities during the introduction of CAT (see Fig. 3.4.10), respondents appear to be in agreement that "Financing infrastructure in PPP models" is the least important of the suggested possibilities. With regard to the other suggested measures ("Jointly developing use cases to close gaps in the transport system", "Working together on the infrastructural needs for CAVs" and "Transferring knowledge of technical opportunities and restrictions with CAVs"), respondents appear to show no clear preference when it comes to selecting the measures they consider most suitable.

A similar picture emerged when respondents were asked about the possibilities available to civil society stakeholders to support towns and cities (see Fig. 3.4.11). Here respondents are largely in agreement that the best

Figure 3.4.13: **Expert opinion on the percentage of actors involved in the current discourse on the introduction of connected and automated transport and the ideal level of participation**

■ To what extent do market, policy and civil society stakeholders influence today's debate on CAT, in your opinion?
■ If it were up to you, to what degree should each stakeholder steer the introduction of connected and automated vehicles?



Source: AVENUE21

way for civil society to be involved is to support towns and cities in their efforts to introduce CAVs by drawing attention to the existing mobility needs of residents based on their everyday experiences. However, with regard to the other statements ("Contributing everyday knowledge of product development", "Supporting test set-ups in public areas" and "Playing an active role in carrying out research projects"), the respondents are almost always divided on the ranking of importance.

During the AVENUE21 project, three scenarios were developed outlining the possible future effects the integration of CAT will have on European towns and cities if this introduction is primarily influenced by three different stakeholders (the market, policy, civil society; see Chap. 5). It was thus one of the aims of the second survey to underpin the scenarios developed by our research team with expert opinion. Respondents were therefore also asked how suitable they considered the three scenarios to be to achieving frequently stated urban development objectives (see Fig. 3.4.12). All the objectives listed in the survey were generally considered to be relevant. Respondents felt the most important goal was to alleviate the burden on the local and global environment and climate, followed by reducing the number of road accidents and fatalities. The aim of promoting local economic growth/location policies, on the other hand, was deemed the least important. When different scenarios were compared, the market-driven approach was almost always given the worst score or was always judged to be less important than the two other scenarios. It only ranked ahead of the civil society-driven scenario with regard to the goal of promoting local economic growth and received a similar score when it came to reducing road accidents and fatalities. Of the three scenarios, the policy-led scenario was consistently given the best ranking. This illustrates that European experts are undoubtedly sceptical about the free market's ability to effectively manage the introduction of CAT, and instead believe primarily in the capacity of policymakers and planning authorities and/or the towns or cities to develop solutions.

In order to better evaluate how relevant these scenarios are to the real world, respondents were asked to state which stakeholder groups are most involved in the current debate on CAT (see Fig. 3.4.13). Respondents stated that the market has a powerful influence (over 50%), and ranked quite far ahead of policy (approx. 25%) and civil society stakeholders (approx. 15%). If the desired balance of power and involvement were in place, market, policy and civil society stakeholders would have a relatively equal say in how CAVs were introduced, with policymakers having slightly more control (approx. 37%) than the market and civil society (approx. 30% each). There is therefore a clear mismatch between the current discourse and the positive impact each actor is seen to potentially be able to bring to the table.

3.4.4 SUMMARY

The aim of conducting these two surveys was to ascertain the opinions of experts involved in a range of professions linked to urban and mobility planning with regard to CAVs in general and current urban development goals in particular. It was the opinion of the over 300 specialists who participated in the two surveys that a debate on the issue of CAVs should and must take place, not only in their respective professional fields but also more generally within the wider context of urban development. One key outcome of the surveys is that the results paint a nuanced picture that oscillates between scepticism and hope. For example, the 211 respondents who participated in the first wave believe (see Table 3.4.2) that CAT will result in:

Figure 3.4.14: **The surveys reveal a new urban mobility paradigm**

A NEW MOBILITY PARADIGM ...

WHICH MODE OF TRANSPORT SHOULD I CHOOSE FOR MY JOURNEY?

▼

SHOULD I DRIVE MYSELF OR LEAVE IT TO A MACHINE?

... IN SOME AREAS WITHIN URBAN REGIONS

Source: AVENUE21

- new solutions in the logistics sector,
- large volumes of additional data being collected and used for efficient control of transport,
- improved road safety,
- strengthened intermodality through services provided over the last passenger transport mile, and
- increased mobility comfort.

However, they appear less convinced that CAT will enable

- intra-urban areas to be freed up,
- rural areas to be stabilized,
- the mobility system to be decarbonized, and
- socially inclusive mobility services to be created.

Data generated as a result of connected and automated processes are viewed with notable ambivalence; the greatest scepticism is shown towards the following risks and consequences of CAT (see Table 3.4.3):

- collected data will be used by third parties,
- collected data will be used for continuous monitoring, and
- transport could become a security risk due to hacking.

According to the survey, another problem (see Table 3.4.3) is the fact that CAVs will lead to the volume of traffic increasing instead of decreasing (a number of other scenario-based studies have also reached the same conclusion; see Chap. 4.3). As it is assumed that an increase in traffic will not simply be a temporary effect, respondents in the first survey expect that regulation will be necessary to avoid the expected growth in vehicle numbers (see Fig. 3.4.3). Respondents who participated in the first survey suspect that CAVs and the new business models based on this nascent technology are highly likely to replace other services (see Fig. 3.4.2). This was viewed

- as clearly having a positive impact because sharing services based on connected and automated mobility will reduce the volume of traditional private cars (71%),
- as equally positive because public transport services based on connected and automated mobility will replace traditional public transport (56%) and traditional private cars (54%),
- as moderately positive because a traditional private car will be replaced by a “smarter” version (60%), which, however, will also lead to continued use of motor vehicles as a form of transport.

Another factor considered problematic (although this was a concern for far fewer respondents) is that CAVs may dampen enthusiasm for active forms of mobility, which are currently being heavily promoted in European cities. The biggest competition arises from

- connected and automated public transport (42% likelihood of displacing cycling and 34% chance of replacing walking),
- connected and automated sharing (35% or 27%), and
- connected and automated private cars (33% or 28%).

When we asked respondents for their opinion on the possibility of other services being crowded out, the two key takeaways were:

- the service “hybridization” theory and thus the blurring of the boundaries between individual and public transport; there is evidence to support this argument but it is potentially too short-sighted as
- the shift will ultimately not only impact the choice of transport but will also present travellers with a new option: whether to complete the journey themselves or to delegate this task to a machine.

In the second survey, the main emphasis was placed on aspects that concerned the management and evaluation of the scenarios developed as part of the project. The 216 participants consider that the debate on CAT is mainly led by companies and/or the market (see Fig. 3.4.13), but believe that policymakers should play the leading role. They consider the most pressing need for action to be with regard to cities and/or policymakers and planning authorities (see Fig. 3.4.8), who they suggest should

- develop a concept for future CAT-based mobility,
- set regulatory frameworks,
- integrate CAT into existing mobility concepts,
- more heavily involve businesses, and
- inform the public about the opportunities and risks.

The experts we surveyed were not in agreement about the possible courses of action that can be taken by local/ regional policymakers and town and city planning authorities. The two key views, which received an almost equal level of support in the survey, contradict each other (see Fig. 3.4.7): the restrictive regulation of CAVs and the proactive encouragement of their implementation both received almost the same level of approval.

Among the options given to steer CAT implementation, respondents felt that a set of policies and principles and/ or a code of conduct for "new" mobility service providers were the most important. A general relaxing of laws or the prohibition of empty CAV runs, a measure frequently cited in the literature (Fagnant/Kockelman 2015), were seen to be less relevant (see Fig. 3.4.9).

Respondents feel the strengths of private sector companies would best serve cities if these actors are involved in cooperative projects (defining applications, infrastructure needs, allowing knowledge transfer), while they clearly reject the idea of involving market actors in infrastructure development and the financing of such measures through PPP models (see Fig. 3.4.10). Consequently, the experts believe the biggest potential for conflict to be between cities and international corporations, followed by conflict with civil society (see Fig. 3.4.6).

The experts are of the opinion that cities could benefit if civil society's needs and everyday knowledge are taken into consideration during the introduction of CAVs (see Fig. 3.4.11). The idea of civil society actors playing an active role as part of "citizen science" concepts was least popular among the experts.

Alongside issues that relate directly to transport, respondents were also asked to give their verdict on the importance of urban development goals (see Fig. 3.4.12). Here they believe it is vital to:

- reduce the environmental impact,
- bring down the number of road accidents,
- plan a compact city, and
- safeguard socially inclusive mobility services.

Moreover, respondents were also given a brief outline of the three scenarios developed as part of this project and asked to give their verdict on which of the scenarios would most likely meet the six outlined urban development goals. With regard to each goal, the policy-driven scenario was determined to have the most positive impact, followed by a civil-society driven approach. Respondents were only convinced the market-driven approach would be more successful than the civil society-based concept when it came to encouraging economic growth, but even in this regard, the experts still believed the policy-driven approach would be most effective.

The survey respondents still place a substantial amount of trust in the public authorities. However, it is clear that

- it is necessary to address the social challenges that will arise through the introduction of CAT in good time;
- policymakers and planning authorities and/ or towns and cities should act consistently – whether they should take a proactive or reactive approach remains subject to debate;
- it remains unclear which measures should be applied as part of this approach, and
- CAT is far from likely to meet the highly optimistic expectations.

When and how policymakers and urban planners should exert a controlling influence will be decisive in determining whether the positive impacts will outweigh the negative, and whether those unwanted impacts can be avoided altogether.

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1 Julia Dorner played a vital role in designing and carrying out not only the two surveys but also their statistical analysis and the interpretation of the results.

2 First survey: 149 fully completed German questionnaires, 62 English questionnaires.
Second survey: 181 fully completed German questionnaires, 35 English questionnaires.

3/4 No automated Level 5 driving systems existed (in accordance with SAE J3016) at the time the survey was conducted. Nonetheless, 28 of those surveyed stated that they had experience with Level 5 vehicles.

5 It is frequently debated whether Likert scales (i.e. ordinal scales) can be calculated as a metric (interval) scale. Due to the fact that parametric analysis methods have been proven effective at preventing various violations of the statistical criteria (see, for instance, Norman 2010) and, at the same time, open up considerably more possibilities for analysis, we decided to use Likert scales and Likert items on a metric scale.

6 Despite the seemingly obvious loading for the economic factor, one item ("Increasing automation and networking of transport will lead to boosting of the economy") was not included in the economic factor based on a reliability analysis.

7 An additional category ("other") was mentioned but only some participants filled this section in, resulting in percentage values that added up to less than 100%. Those most frequently named in this category were researchers.

Figure 3.5.1: **Population density in the studied regions in 2011, inhabitants per km²**

Image: AVENUE21; source: Eurostat 2011

Figure 3.5.2: **Population density in Europe in 2014 on a 10 x 10 kilometre grid**

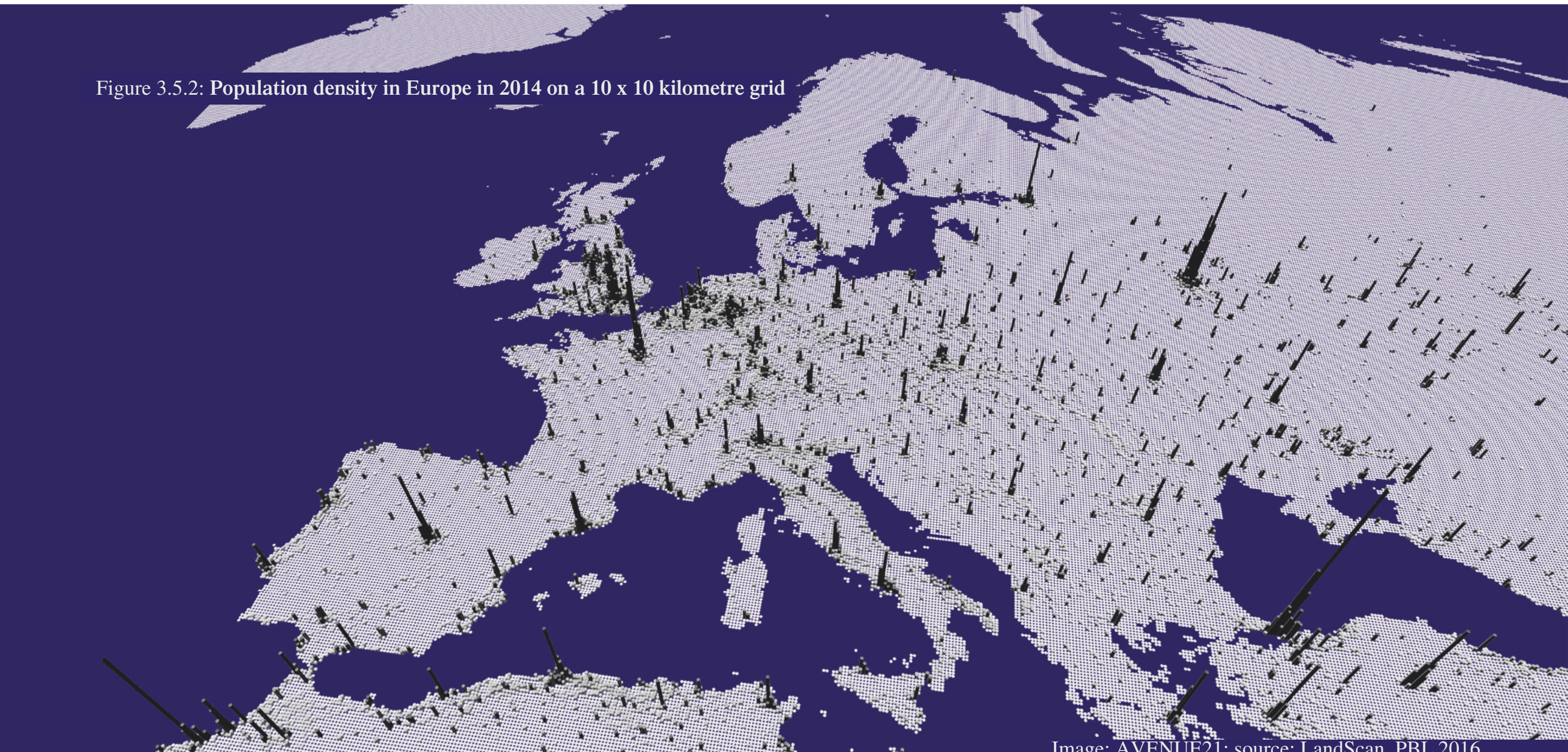


Image: AVENUE21; source: LandScan, PBL 2016

3.5

DEVELOPMENT OF TRANSPORT AND SETTLEMENT POLICY: LONDON, RANDSTAD, VIENNA

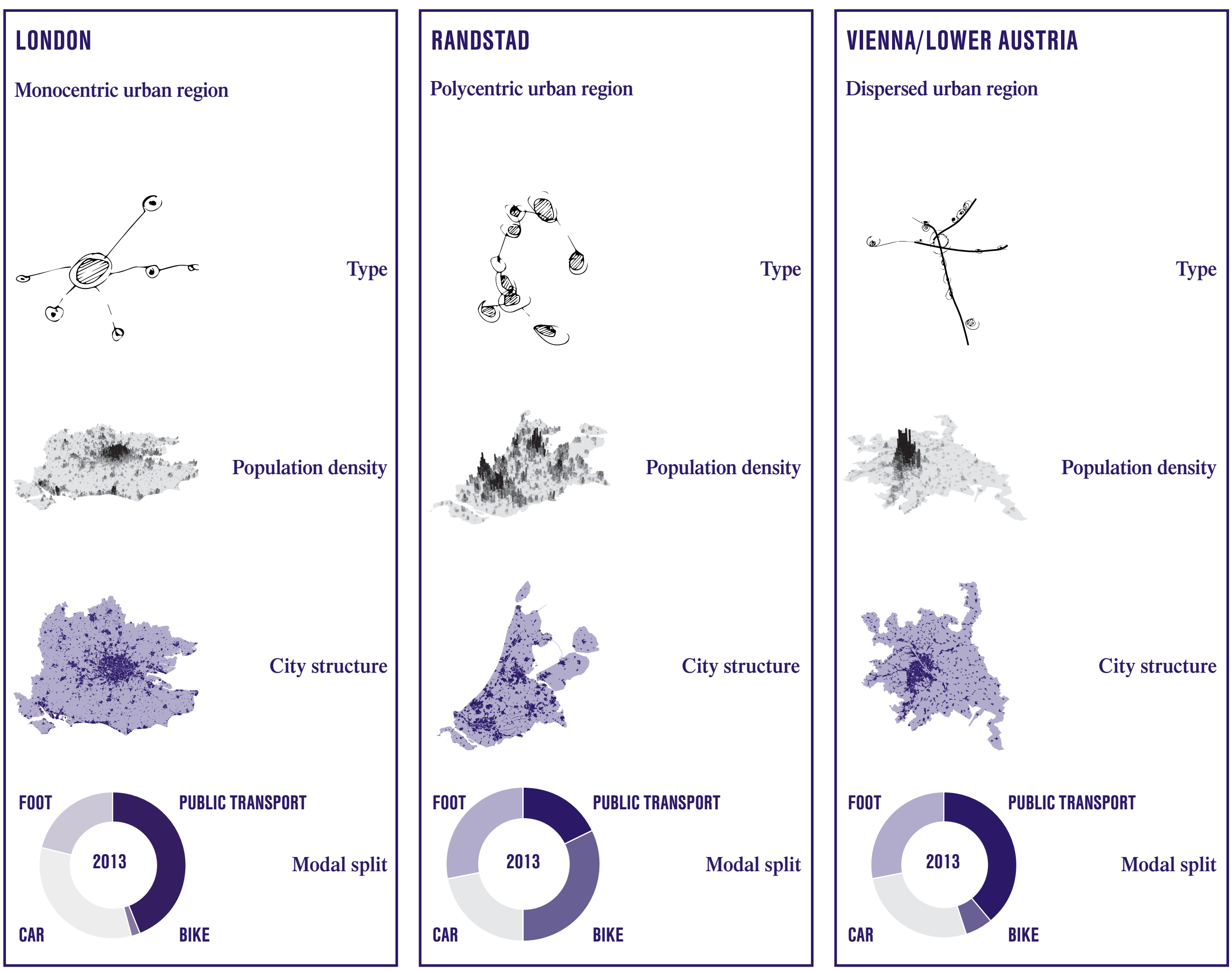
To provide case studies that cover the full spectrum of the "European city" and the effects that CAT could have in these areas, we selected three regions for analysis: the region of Greater London, the region of Randstad in the Netherlands and Vienna/Lower Austria. By analysing these regions, we hope not only to focus attention on the circumstances and urban challenges specific to each area but also to highlight the key role context plays with regard to the implementation of CAT and to suggest various options for policy and planning action. What the future holds for these regions depends not just on the spatial conditions and infrastructures, but, crucially, on the approach – now and in years to come – that will be adopted by policymakers and planning authorities (see Chaps. 3.2 and 4.6).

Analysing these specific towns and cities thus allows us to illustrate the wide range of possible future applications of CAT in respect of existing spatial structures, urban planning concepts and perceived challenges. In Chapter 4.5, we expand our research to also examine pioneering schemes globally.

3.5.1 METHODOLOGY AND SELECTION

This analysis focuses on the ways in which governance, mobility and urban development interact in selected localities/local contexts. The cities or regions analysed here (London, Randstad and Vienna) were selected based on a theory-led approach. The criteria for selec-

Figure 3.5.3: **Overview of the analysed regions**



Source: AVENUE21, Eurostat (2017)

tion were primarily settlement structure requirements and the type of urban region, mobility cultures and infrastructures as well as planning and governance systems, which differ considerably in the three regions under analysis. Furthermore, the selected cities/regions are all in Europe and are characterized by dynamic economic and demographic development. Figure 3.5.4 compares the regions' transport and mobility policy measures, drawing upon the urban transport policy development path set out by Jones (2017) and mentioned here in Chapter 3.2.

Moreover, the cities as well as the urban regions are each considered a prime example of their respective settlement structure. In terms of transport infrastructure, it is significant that the city of Vienna is based on a predominantly concentric city model, the urban region of Randstad is mainly characterized by polycentric links (a linear city surrounding a "Green Heart") and London as well as its urban region (surrounded by a "green belt") has good transport links between the all-powerful centre and its surrounding satellite towns.

Figure 3.5.4: **Overview of transport and mobility policy in the three selected regions**

	STAGE 1 Accommodating traffic growth	STAGE 2 Encouraging modal shift	STAGE 3 Promoting liveable cities
GREATER LONDON	• Plan to build four concentric ring roads and radial roads • Dismantling of the tram system • Construction of urban expressways • One-way roads and parking spaces	• "Homes before Roads" initiative • Zones and day tickets on public transport • Construction of the Jubilee Line • Limiting transport costs and uniform zone system on public transport • Construction of the Docklands Light Railway and Thameslink • Planning of the Thameslink network	• Expansion of the public transport network (esp. improvement of stations and door-to-door services) • Introduction of the "Oyster Card" • Promotion of walking and cycling (cycle lanes, "Cycle Superhighways") • "Healthy Streets": a new narrative for London
RANDSTAD	• Merging different rail operators to form one national provider • Provision of a widespread motorway network across the whole of the country • First national long-term spatial development strategy • New policy instruments adapted to political, geographic and social realities (Randstad, "Green Heart")	• Nationwide ticketing and pricing system for public transport • Priority for public transport at traffic lights • "Stop de Kindermoord" ("stop killing children") protests in Eindhoven (1973) • "Straßenspieltag" – temporary road closures so children can play outside (1986) • Policy to encourage less car use and more journeys by public transport • Restrictive policies to limit distance travelled using vehicles • "Compact city" as a planning model	• Structural model for infrastructure and regional development • "Randstad 2040" strategy • "OV-chipkaart" • "OV-fiets": linking cycling and train travel • Encouragement of multimodal transport, improved mobility hubs and transport information • Decentralization of national policy – greater focus on regions • PPP models for infrastructural improvements • Implementation of pricing model for roads based on kilometres travelled
VIENNA/LOWER AUSTRIA	• Closure of some tram lines that were replaced by municipal bus services • Number of kilometres passengers could travel by tram reduced by a third • Radial concentric growth	• Introduction of VOR, a transport authority for the eastern region (1984) • Increase in public transport mileage and network lines (e.g. underground expansion) • Use of low-floor trams • Linear-shaped city expansion along settlement axes	• STEP 2025: boost ecomobility, lower MPT as a percentage of modal split to 20% by 2025 • Construction of U2, U5 underground lines; expansion of urban railway • €365 ticket for public transport, "WienMobil" app to improve inter- and multimodality • Encourage walking and cycling (e.g. creation of pedestrian zones and shared spaces, mobility agencies)

Sources: Greater London: Jones (2017); Randstad: Reid (2017), OECD (2014), MOT (2017), Alpkokin (2012); Vienna/Lower Austria: Schubert (1985), Békési (2005), City of Vienna (2017)

Based on these various conditions, the cities and regions set different priorities with regard to transport and settlement development. Figure 3.5.5 gives an example of the key themes addressed in each respective area.

Figure 3.5.5: **Key areas for urban and mobility planning in the selected regions**

GREATER LONDON
• Transport connections to overflow cities (last-mile solutions)
• Decentralization of the region – more polycentric approach
RANDSTAD
• Inter- and multimodality (with a high percentage of cyclists)
• Settlement development along multimodal transport hubs
VIENNA/LOWER AUSTRIA
• Creating links between the city and surrounding region
• Improving public transport

Source: AVENUE21

If we compare the European regions chosen, we see, on the one hand, quite substantial differences resulting from each country's and region's respective historical development and unique settlement characteristics (see Figs. 3.5.4 and 3.5.5). On the other hand, some similarities can also be seen. The impressive transport and communication links between the metropolises and their surrounding regions, all of which transcend the boundaries of each city, defy the term "European city" (see Chap. 3.2). This element requires new management models that do not end at the city's boundary lines but encompass interregional links and emphasize the relevance of specific key (international) hubs (SUMP; Backhaus et al. 2019, Wefering et al. 2014). Connected and automated transport will create and allow for new links and thus have a substantial impact on the spatial and transport situation as well as the character of the European city. We will thus provide an overview of select issues affecting urban and mobility planning in the three regions and explore current CAT projects in the regions in more detail. In doing so, it becomes clear that the way in which CAVs are examined should depend on the context and that the potential and opportunities for desirable changes can be brought about if CAT is purposefully developed and managed. This approach to (future) CAT development and management will by no means redefine urban planning, but will instead take its place within historically evolving spatial development strategies.

Figure 3.5.6: **Polycentric links in Randstad**

Source: AVENUE21

3.5.2 RANDSTAD

Randstad is a conurbation that is primarily characterized by a highly functional integration of urban zones and a polycentric settlement structure, which is also present in large parts of Europe (European Union 2011: 4). Polycentric urban structures are also one spatial development strategy deployed on the continent explicitly to bring about territorial cohesion (Hall/Pain 2006).

THE PATH TO AN INTEGRATED MOBILITY SYSTEM

The polycentric structure of the Randstad region, which consists of four large urban centres – Amsterdam, Rotterdam, The Hague and Utrecht – not only defines the settlement structure and development, but has long impacted the transport and mobility system. For many years, the transport planning model in the region was primarily shaped by the local interests of the individual cities, and this was particularly true of public transport. As recently as 2007, the OECD reported that Randstad does not have an integrated public transport system but fragmented systems and networks run by individual cities in the region (OECD 2007: 107). At the end of the last decade, however, increased efforts were made to develop an integrated mobility system in the Netherlands and thus in Randstad too. Policy papers such as "Mobiliteitaanpak" (2008) and the "Structural model for infrastructure and spatial planning" (2012) thus outlined the development of a coherent, integrated mobility system as a key transport and mobility objective. This was to be developed at the national level together with subnational authorities with the aim of ensuring national and regional mobility systems are more closely interlinked and more effectively aligned with one another. The various modes of transport should be better connected and the primary focus should be the promotion of multimodal transport and multimodal transport hubs (Ministerie van Infrastructuur en Milieu 2015: 10).

An important step towards the development of a coherent, integrated mobility system and, in particular, better linkage between public transport systems in the Randstad region came in the shape of the "OV-chipkaart", a scheme initiated by the Dutch government back in 2010 but only introduced nationwide (and beyond into Belgium and Germany) in 2012 (Ministry of Transport, Public Works and Water Management 2010: 5). The "OV-chipkaart" is a chip card that enables a single electronic payment system for the entire Dutch public transport system, i.e. it applies to all national, regional and local transport authorities as well as their respective fare schemes (Roland Berger 2016: 31).

INTER- AND MULTIMODALITY AS WELL AS IMPROVEMENT OF TRANSPORT HUBS

Further initiatives designed to develop an integrated mobility system are focused primarily on connecting public transport and/or rail services with cycling, a mode of transport far more frequently used in the Netherlands than in other European countries. One example of such an initiative is the growing construction and improvement of bike parking racks and storage areas at train stations (Godefrooij 2012: 40). A nationwide bike-lending scheme – "OV-fiets" – was also introduced back in 2003 and has since been taken over by the Dutch railway operator. The scheme offers many stations, whose numbers have grown considerably in recent years – especially at train stations and particularly in the Randstad region – and is expressly designed to offer a solution for the final section of a train journey (Ministerie van Verkeer en Waterstaat 2009: 48).

The Randstad region is characterized by a very dense railway network with a high number of stations, and this factor has also received a growing level of attention throughout the course of settlement development projects (Stead/Meijers 2015: 12). For instance, as part of the 2040 policy plan for the northern part of Randstad ("Structuurvisie Noord-Holland 2040"), a "transit-oriented development" has been outlined that aims to increase use of the surrounding areas and/or catchment areas of train stations for settlement development as well as other urban functions (Deltametropol 2013: 228). This will be achieved through spatial measures and schemes as part of a coordinated location policy (Provincie Noord-Holland 2015: 46). In the Randstad region, transport hubs are usually more than just transit points; they are also places where urban activities take place, and travellers arrive, live and work (Deltametropol 2013: 85).

Curtis and Scheuer (2016) summarize the unique features of this planning approach as follows: "However, during the decade since, it has become clearer that the dichotomy of public transport versus car does not need to be regarded in competition. Instead, it can be viewed as an opportunity to work towards intelligent solutions of task-sharing and mutual support between these modes, and for walking and cycling and the growing range of hybrid forms of transport that do not neatly fit the traditional categories of collective and individual such as shared cars and bicycles, online ride-sharing or user-responsive public transport services. This type of thinking around multimodal accessibility, rather than single-mode market shares can be understood as the most significant contribution to global practice in integrated transport and land use planning to emerge from the Randstad and its unique interplay of settlement patterns and transport networks" (Curtis/Scheurer 2016: 287).

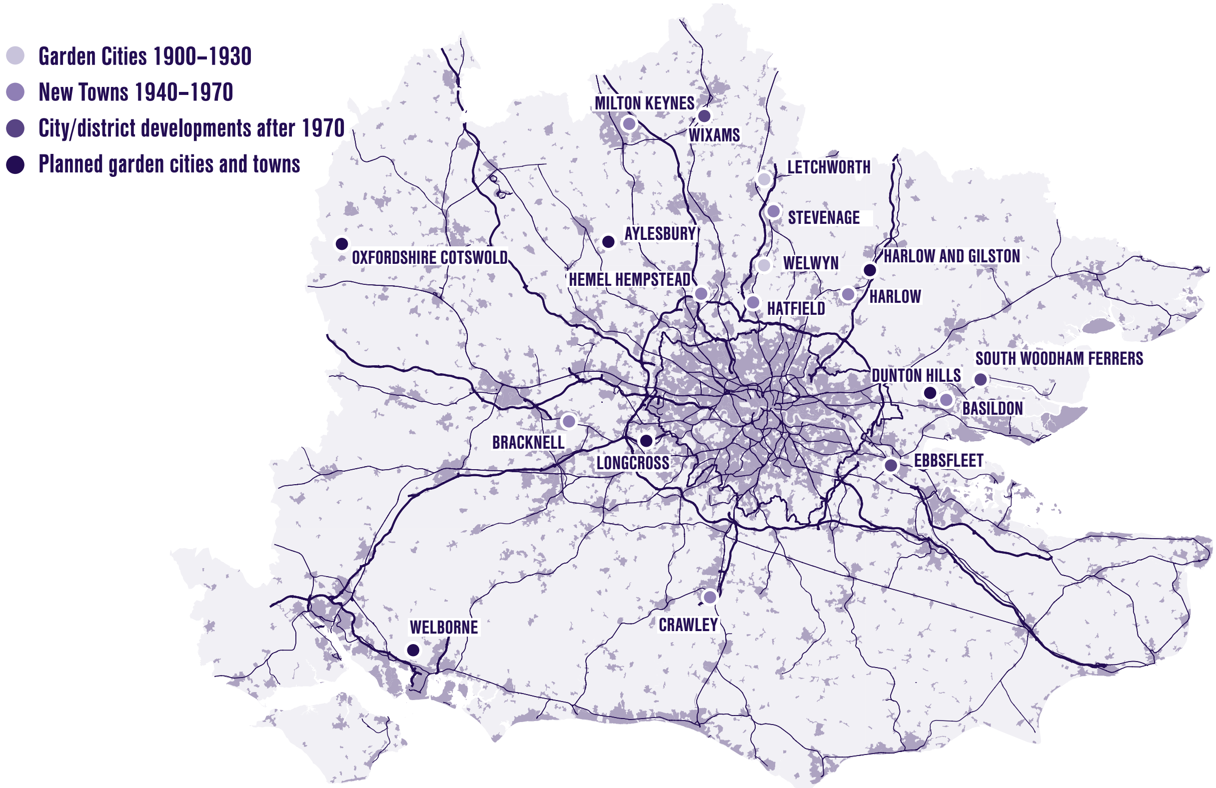
CONNECTED AND AUTOMATED TRANSPORT IN THE NETHERLANDS AND RANDSTAD REGION

Within the context of the development of CAVs, it is important to consider the key objective of an integrated mobility system in the Randstad region and examine how this new technology could create opportunities to further integrate transport systems (to develop one single service) and thus also lead to greater connectivity within the region itself and, based on these developments, thus consider the possibilities CAT may offer with regard to linking up urban peripheries or peri-urban landscapes in the region.

According to a number of international comparisons, the Netherlands have some of the best test and development conditions for CAVs (KPMG 2018, Welch/Behrmann 2018). The activities in the Netherlands are based both on tests involving vehicles and the development of infrastructure (e.g. the expansion of high-speed mobile data transmission) as well as on the proactive design of policy strategies ("Declaration of Amsterdam 2016"). Another relevant example is the "WEpods" project. As part of this project, two self-driving e-shuttles (EasyMile EZ10) have been in place since 2015 in Gelderland, the province bordering Randstad to the east, and in the towns of Ede and Wageningen, and were explicitly tested as potential last-mile solutions, i.e. possible ways to complete the last mile either from or to a train station. These could represent a very cost-effective form of public transport – available around the clock and on demand – especially in areas with low demand, and also effectively help boost public transport integration (Scheltes 2018, Fig. 3.5.3).

When the tests were initiated, even Melanie Schultz van Haegen, Dutch Minister of Infrastructure and the Environment at the time, emphasized the potential CAVs held for creating a more flexible and integrated public transport system: “With the WEpod, we are entering a completely new stage of the voyage of discovery that the Netherlands embarked on with the aim of making transport more flexible, safer and cleaner” (Wageningen University & Research 2016).

Figure 3.5.7: **Garden cities and new towns in south-east England since the early 20th century**



Source: AVENUE21

3.5.3 GREATER LONDON

For more than a century, the growth of London has been intricately linked to developments in mobility and technology. Over the years, a series of satellite towns were built around the city's green belt, initially based on rail transport and, later, on personal mobility. Like other European regions that are witnessing the ongoing march of urbanization, the rapidly growing British capital faces considerable challenges in terms of settlement and transport development. However, London's stringent, historically developed, top-down planning approach to managing growth is unique.

THE HISTORY OF ENGLISH GARDEN CITIES AND NEW TOWNS

Even during the planning and development of London's first new towns at the start of the 20th century, the transport system that existed in the area surrounding the capital played a crucial role. Newly created towns such as Letchworth and Welwyn Garden City in the north of London were developed in 1903 and 1920 respectively and designed based on the concept of the garden city.

They were built along railway lines and planners made the town centres accessible on foot or by bike. These garden cities were designed to be small enough that pedestrians and cyclists could easily reach any point within the town in just 15 minutes; the railway provided access to the capital (Schmitz 2001: 48–49).

By the mid-20th century, the New Towns Act was passed, which allowed the construction of more new towns around London. Unlike the first developments built to accommodate the overspill of population from London, these new towns were designed purely to suit personal car mobility. A prime example of one of these developments is Milton Keynes situated to the north-west of London: it was the last new town to be built and was created in 1976.

THE CONCEPT TODAY

Even now some are pushing for new garden cities to be built around the capital (and in other parts of the UK) to ease the pressure on local services. In 2014, the Department for Communities and Local Government announced that a new garden city would be built in Ebbsfleet to the east of London to accommodate 15,000 residents (Department for Communities and Local Government 2015). In 2016, the department published guidelines whereby councils could submit an application to be chosen as a site for a new garden city. Subsequently, it was announced in early 2017 that a total of three new garden towns and 14 new garden villages would be built across the whole of England, with several of the new developments planned for areas close to London (Department for Communities and Local Government 2017 and Fig. 3.5.7).

The most pressing challenges facing London's urban planners and developers are the rapidly growing population in the region and the need to control this growth through decentralization. London's long-term urban development strategy has two pillars: on the one hand, the decentralization of growth ("Building the Polycentric City"; NLA 2017), and residents' health and well-being ("Healthy Streets for London"; TfL 2017) on the other.

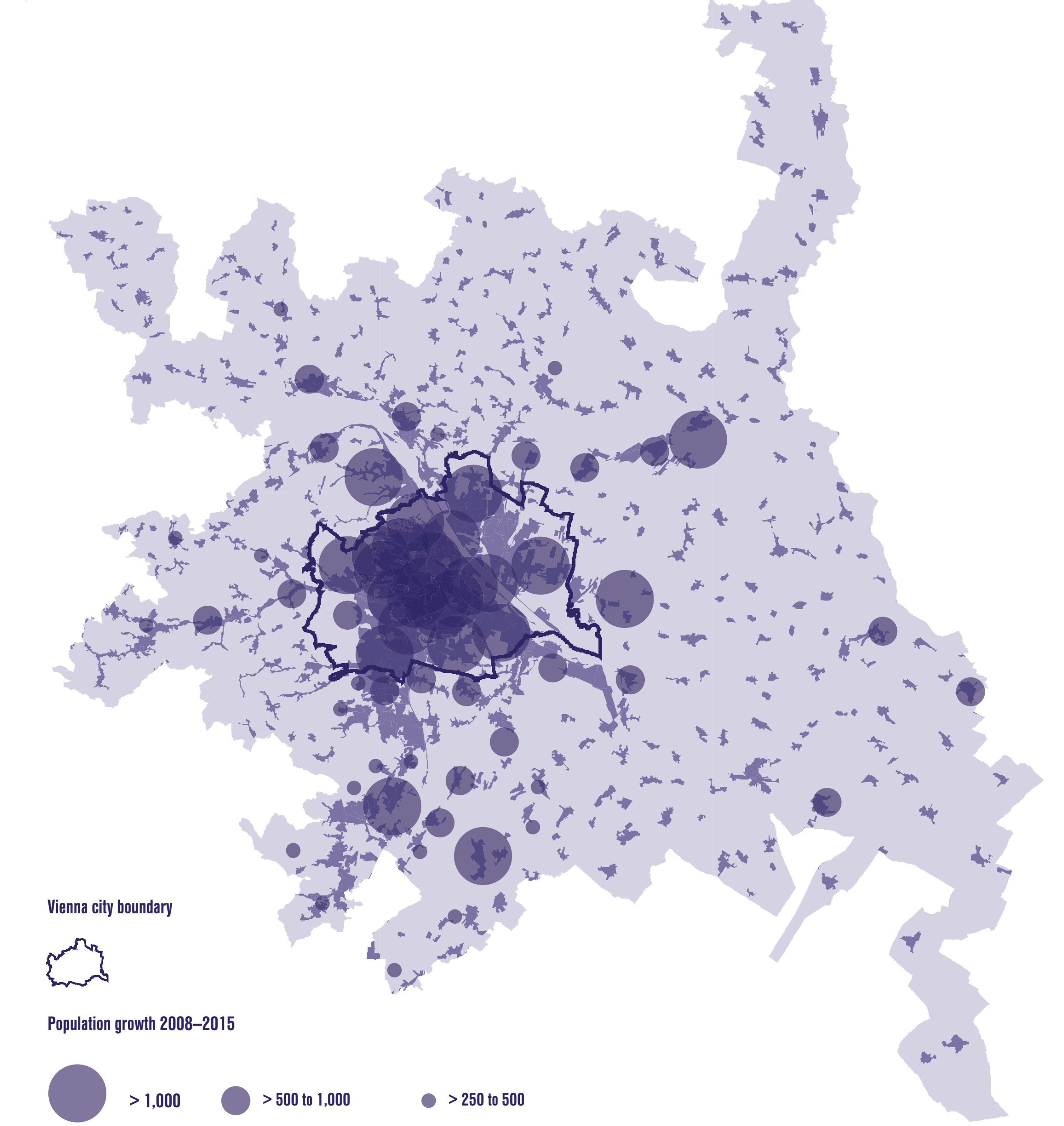
Policy papers on the future development of transport and mobility in London and the Greater London region – such as the "London Infrastructure Plan 2050" – stress that settlement expansion (outside of London) and thus plans to build new overspill towns should be concentrated around existing, expanded or new transport corridors and stations (especially railway lines; Mayor of London 2014: 45). While no planning progress has been made on the garden villages of Longcross and Dunton Hills or the garden towns of Aylesbury and Harlow-Gilston besides choosing a location, initial development plans are already in place for the garden city of Ebbsfleet, especially in terms of transport and mobility.

TRANSPORT LINKS GENERATED THROUGH CONNECTED AND AUTOMATED VEHICLES IN CITY DISTRICTS AND ALONG "CONNECTED CORRIDORS"

Within this context, it thus comes as no surprise that Milton Keynes, i.e. a new town designed solely around personalized mobility, has hosted a series of CAT trials: initially it was part of the "LUTZ Pathfinder" research project and it is currently involved in the "UK Autodrive" research project, which is testing automated pods as part of the "Transport Systems Catapult" initiative (TSC 2017). As part of this, considerable funds, primarily provided by the Department for Transport, have been invested in research on these "Low-Speed Autonomous Transport Systems – L-SATS" which are explicitly seen as potential solutions for the last mile of urban mobility (TSC 2014: 2). The town of Milton Keynes is also convinced of the potential of CAT and plans to use it. As early as 2011, the city wrote in its transport strategy ("A Transport Vision and Strategy for Milton Keynes") that in terms of its public transport services, personalized public transport, such as automated pods, would be ideal in the long term for the city's grid road layout (Milton Keynes Council 2011: 42–43). Moreover, in 2015, the town refused to grant permission for the construction of a tram system. When stating its reasons, it made reference not only to cost but to the use of pods as a public transport system (Smith 2015). This shows that plans currently being drawn up for many new garden cities – depending on the outcome of the tests in Milton Keynes – could already be designed to accommodate a public transport system that includes these more cost-effective pods.

If we turn back to Ebbsfleet Garden City, a site which is close to the A2 major road – and connected to a national and international (Eurostar) high-speed rail link – another aspect becomes relevant to debates concerning CAM: the use of CAVs on motorways. The Department for Transport, for instance, considers "the creation of connected corridors – initially to test, and then deploy, the technology – as a cornerstone of the UK [in the context of connected and autonomous vehicles]" (Hanson 2015: 4). One such test corridor is already in place on the A2/M2 motorway between London and Dover (Hanson 2015: 5). In collaboration with the government company in charge of the country's major roads and motorways (Highways England), the connection possibilities between vehicles as well as between vehicles and the infrastructure are being tested here against the backdrop of CAM (TRL Limited 2016: 1). There are also plans to carry out test runs involving CAVs – both here and on other stretches of motorway – in a subsequent stage.

Figure 3.5.8: **Development dynamics in the Vienna/Lower Austria region**



Source: AVENUE21

3.5.4 VIENNA/LOWER AUSTRIA

Vienna is the epitome of a traditional European city that has long been influenced by a concentric design (Schubert 1985: 521). Since the late 1960s, the city has grown far beyond its established boundaries, becoming a dispersed urban region. Most notably in recent years, the population within Vienna and in its surrounding area has also grown considerably. This has further increased connectedness and integration within the overall metropolitan region. Administrative boundaries may exist but now have an ever-diminishing impact on everyday dealings and functional relationships (MA 18 2014: 88); however, they continue to be very present in governance and administrative structures. This poses particular challenges for management, especially in terms of spatial planning, transport planning and location development. This can particularly be seen in the city/region's public transport system.

NECESSARY ACTION TO TACKLE THE CHALLENGES FACING THE METROPOLITAN REGION

As part of the current city development plan ("STEP 2025"), efforts are being made to harness the growth dynamic to benefit the population. Within this framework, a regional model with regional development axes was developed that focused heavily on regional links within the metropolitan region of Vienna (Vienna and parts of Burgenland and Lower Austria) and the Centrope region (which also includes western Hungary, western Slovakia and southern Czechia) as well as links within the metropolitan region (MA 18 2014: 91).

This model and the regional development axes aimed to ensure that population growth and suburbanization – processes that span administrative boundaries – went hand in hand with a managed settlement plan that was based on development and public transport axes (Dangschat/Hamedinger 2009: 108; Scheuvens et al. 2016). However, in future, this regional model for the entire metropolitan region will need to be given greater consideration within the various public authorities. A key factor here are city-regional governance structures that complement the administrative structures of public authorities, which have evolved over time and are usually designed to represent local interests, by giving a voice to various city-regional interests, such as the city-regional model. Such structures could make it possible to tap existing potential for cooperation more effectively, especially in areas such as regional planning, transport planning and location development (MA 18 2014: 91).

THE IMPORTANCE OF SETTLEMENT AND TRANSPORT DEVELOPMENT IN THE METROPOLITAN REGION

One element that is crucial here is the interlinking of settlement and transport development. However, it will not only be a matter of conducting coordinated settlement development along public transport axes. Instead, it will be necessary to also improve public transport services on a city-regional scale: while public transport has always played a vital role within the Austrian capital's urban transport system and accounts for one of the highest modal splits across Europe's capital cities (39% in 2016), if we compare these figures with those for the city-region and surrounding areas, i.e. among commuters, we see a considerably lower modal split share of 21% (City of Vienna 2014: 103). In the future, however, urban development plans and mobility and transport services across the entire metropolitan region – irrespective of administrative boundaries and various competencies – will need to be considered as an integrated system. This will require, first and foremost, effective regional cooperation at various transport and settlement policy levels as well as concepts for a controlled settlement development along public transport axes, in peripheral urban locations as well as in the surrounding area.

CONNECTED, AUTOMATED AND PUBLIC TRANSPORT

Public transport has long played a key role within Vienna's mobility system, and the service has become even more vital, especially in recent years. In particular since the city's 2005 development plan (Dangschat/Hamedinger 2009: 104) and the subsequent 2025 concept, public transport has ultimately been seen as the backbone of the mobility system, and there is a belief that it needs to be bolstered further and made more attractive. By adopting the existing strategy plan for urban transport – the 2003 "Transport Master Plan" – Vienna has decided to continue with the more offensive public transport policy that was launched in the 1990s. This stipulates that public transport should make up 40% of the modal split by 2020 (in 2001 it stood at 34%) while the share of MPT should be reduced to 25% by 2020 (2001: 36%; Stadt Wien 2006: 41). If we examine the most recent developments regarding modal split in Vienna (from 2003 to today), there is indeed a clear increase in public transport use as a percentage of modal split, its share rising by 10% to 39% (as of 2015). Like London, Budapest, Prague, Helsinki, Tallinn, Bucharest and Warsaw, Vienna has one of the highest levels of public transport use as a share of modal split across Europe's capitals (Nabielek et al. 2016: 26).

In order to see whether the addition of CAVs could improve existing public transport in peripheral urban and suburban areas (Gertz/Dörnemann 2016: 22), two automated shuttles have been undergoing trial runs in aspern Seestadt, a new urban development project in the northeast of Vienna, since the summer of 2019. The automated shuttles run along a two-kilometre route connecting areas in the south-west of Seestadt that are currently only moderately served by public transport with the terminus of one of the underground lines. The aim here is to find out just how much automated shuttles can be integrated into the service provided by the public transport authority, as well as to analyse their effectiveness as a link in the intermodal mobility chain. The project is also embedded within Seestadt's transport and road concept, which focuses on increasing the appeal of more environmentally friendly forms of mobility and striking a greater balance between them. Subsequent trials can be arranged to gain insight into the potential that may lie in supplementing public rail transport with flexible, needs-oriented, automated shuttles, especially within the city region.