

DIPLOMARBEIT

# Scenarios in urban public transport 2050: accommodating for passenger's basic needs in the design of vehicles

ausgeführt zum Zwecke der Erlangung des akademischen Grades einer Diplom-  
Ingenieurin  
unter der Leitung

**Univ. Prof. Dipl.-Ing. Dr.-Ing. Martin Berger**

E280-05  
Institut für Raumplanung  
Forschungsbereich Verkehrssystemplanung

eingereicht an der Technischen Universität Wien  
Fakultät für Architektur und Raumplanung

von

**Sophie Hofbauer, BSc**

11714912

Wien, am 13.10.2022

Unterschrift



## Kurzfassung

Die folgende Masterarbeit befasst sich mit den Auswirkungen von gesellschaftlichen Megatrends auf das individuelle Mobilitätsverhalten im öffentlichen Personennahverkehr in urbanen Zentren sowie den dazugehörigen Ballungsräumen. Die These dahinter ist, dass das Streben nach einem ständigen Wachstum der Kapazitäten (und mehr Fahrgästen begrenzt) nicht wirtschaftlich ist. Dementsprechend müssen Verkehrsspitzen gebrochen werden und eine Umverteilung der Auslastung stattfinden.

Um zu sehen, wie das tägliche Leben und insbesondere die Arbeitswelt mittel- bis langfristig im Jahr 2050 aussehen werden und was die Bedürfnisse von Fahrgästen sind, wurden zahlreiche Entwicklungen betrachtet. Diese wurden nach ihrer Bedeutung für die Mobilität und den Einfluss auf das individuelle Verhalten eingeordnet. Diese Einordnung, gefolgt von einer Bewertung mittels einer Cross-Impact-Analyse, bildet die Grundlage für die narrativen Szenarien.

Das Ergebnis der Arbeit sind drei konkrete Szenarien, worin die Anforderungen, als auch Herausforderungen für die Zukunft für verschiedene Stakeholder (Fahrgäste, Fahrzeughersteller, Betreibergesellschaften, Politik) beschrieben sind.

Aus dem individuellen Verhalten und den Bedürfnissen der Fahrgäste aus den Szenarien wurden grundlegende Aspekte für das zukünftige Design und den Betrieb von schienengebundenen Fahrzeugen abgeleitet. Die Antwort liefern zum einem die Digitalisierung und die Information über Wege und Wegezwecke der Fahrgäste für die Ausgestaltung des Angebots und zum anderen menschliche Grundbedürfnisse wie Barrierefreiheit und Komfort, die im Design der Fahrzeuge berücksichtigt werden sollen.

Diese Ableitungen und möglichen Auswirkungen sollen eine Grundlage für Siemens Mobility bieten, die für unternehmensinterne Strategien herangezogen werden können. Somit kann in wünschenswerte Richtungen gelenkt und potenzielle Störfaktoren vermieden werden.



## Abstract

The following master thesis deals with the effects of societal megatrends on individual mobility behavior in public transport in urban centers as well as the associated metropolitan areas. The thesis underlying thesis is that the pursuit of constant growth and more passengers is limited and, above all, not economical. Accordingly, traffic peaks must be broken and a redistribution of the passenger load must take place.

In order to determine what daily life and, in particular, the working world will look like in the medium to long term in 2050 and what the needs of passengers' will be, numerous developments were considered. These were classified according to their importance for mobility and the influence on individual behavior. This classification, followed by an assessment using a cross-impact analysis, forms the basis for the narrative scenarios.

The result of the work are three scenarios, in which the requirements, but also challenges for the future are described for different stakeholders. Based on the individual behavior and passengers' needs from the scenarios, fundamental aspects for the future design and operation of rail-bound vehicles were derived. The answer is provided, on the one hand, by digitization and information about passengers' routes and journey purposes for the design of the service and, on the other hand, by basic human needs such as accessibility and comfort, which are to be taken into account in the design of the vehicles.

These derivations and possible effects should provide a basis for Siemens Mobility that can be used for internal company strategies. In this way, desirable directions can be steered and potential disruptive factors can be counteracted.



## Eidesstaatliche Erklärung

Hiermit versichere ich an Eides statt, dass ich die vorliegende Diplomarbeit ohne fremde Hilfe und ohne Benutzung anderer als der angegebenen Quellen und Hilfsmittel angefertigt und die den benutzten Quellen wörtlich oder inhaltlich entnommenen Stellen als solche kenntlich gemacht habe.

Diese Arbeit wurde in gleicher oder ähnlicher Form noch bei keiner anderen Prüferin/ keinem anderen Prüfer als Prüfungsleistung eingereicht.

Wien, am 13.10.2022

Unterschrift





# Table of Contents

Kurzfassung .....	I
Abstract .....	III
Eidesstaatliche Erklärung .....	V
Danksagung .....	IX
Glossary .....	X
1. Introduction.....	1
Definitions .....	3
2. Review of Literature .....	7
2.1 Megatrends .....	7
Technology .....	7
Demographic .....	11
Urbanization .....	14
Climate change .....	17
Work 2050 .....	19
Mobility .....	23
(Unpredictable) events.....	26
Conclusio Megatrends.....	27
2.2 Recent developments and ideas .....	28
3. Methods .....	32
3.1 Key factors .....	35
Key factor 1: human aspect (demand side).....	37
Key factor 2: work life (demand side) .....	42
Key factor 3: (public) transport market.....	46
Key factor 4: (transport) policy.....	53
3.2 Scenarios .....	60
Acting retrogressively (negative scenario) .....	64
Somewhere in between (trend-scenario) .....	67
Together towards a prospering future (positive scenario) .....	70
3.3 Comparison .....	73
What does this mean for transport? .....	73
3.4 People’s needs.....	75
Conclusio people’s needs .....	79

4. Conclusio .....	81
What are the individual mobility needs of passengers and what are the resulting customer demands on public transport? .....	81
How can vehicle manufacturers respond? .....	82
How can operators respond? .....	82
5. Discussion .....	84
Planning considerations on the scenarios .....	84
Methodological reflection .....	84
Outlook .....	85
Table of Figures .....	86
References .....	87
Appendix.....	102
Appendix 01: Students Survey.....	102
Appendix 02: Cross-Impact-Matrix arguments .....	103
Appendix 03: Consistency .....	107

## Danksagung

Hiermit bedanke ich mich bei meinen Betreuern Martin Berger, vor allem für den akademischen Input und bei Benjamin Albrecht, insbesondere für den breiten Einblick in tagesaktuelle und zukünftige Fragestellungen im öffentlichen Verkehr.

Ein großer Dank gilt all meinen Liebsten für die Unterstützung während meines gesamten Studiums, insbesondere im Masterstudium. Und all den wunderbaren Menschen die ich im Zuge dessen kennenlernen durfte.

## Glossary

AI	Artificial Intelligence
AR	Augmented Reality
BMK	Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation, and Technology (Vienna, Austria)
CAVs	Connected autonomous vehicles
CX	Customer Experience
GDP	Gross domestic product
IoT	Internet of Things
MaaS	Mobility as a Service
MTR	Mass Transit Railway (Hong Kong, China)
OECD	Organization for Economic Co-operation and Development
PX	Passenger Experience
TfL	Transport for London (London, United Kingdom)
UN	United Nations

# 1. Introduction

The last few years have been characterized by growth in society as a whole. The economy, the real estate market, even so the transportation sector have largely been defined by increasing values such as higher ridership, larger route networks, maximizing profit, etc. That this will not always be possible was already known before the Covid-19 pandemic, and the first transport operators noticed that digitalization and changing working conditions have an impact on mobility behavior. For example, people no longer commute from home to the office five times a week, rather spend single days at the home office. As well as the growth of gig economy, which has created low-cost alternatives to public transport with services such as *Uber* or similar.

The 2020 pandemic and associated lockdowns, which called for a radical shift to home office, accelerated this process significantly. Public transport has experienced substantial losses in ridership due to several (partial) lockdowns and sanitation measures. A full recovery or reaching the same ridership levels as before the pandemic is currently not foreseeable (as of May 2021). On the one hand, the pandemic is not over yet; on the other hand, this radical upheaval has significantly changed the behavioral patterns of individuals. In order to be able to plan an attractive offer and create incentives in the future, it is relevant for transport operators, vehicle manufacturers and, moreover, for cities and municipalities to know in which direction mobility behavior will develop and what the needs of passengers will be, since work trips account for around 25 % of all trips made (Scheer et al., 2020, p. 54). Therefore, the following work takes a closer look at the influence of the working world on commuting patterns.

## Objective

This thesis aims to investigate which social trends within the working world influence mobility behavior in cities and metropolitan areas and which developments can therefore be expected in medium to long term (2050). The aim is to identify global trends and to know their impact on the public transport sector and the requirements passengers have on vehicles.

The result of the work will be three concrete scenarios, from which measures for the future of public transport are possible to be derived. These effects are to provide an insight for Siemens Mobility, which can be used for internal company strategies. Thus, desirable directions can be steered and potential disruptive factors can be counteracted.

The aim is therefore to be able to answer the following points when the work is completed:

- How do trends in the world of work in 2050 affect mobility behavior and are individual mobility needs of passengers influenced by this?
- Development of scenarios based on social trends.
- What are the resulting customer demands on the (interior) design of public transport?

The following table should picture the limitations of the thesis:

modes of transport	spatial delimitations	timeframe	geographical context	trip purpose	perspective
public transport	urban areas	2050	western world	work/commute	(mainly) passengers view
rail-bound					

## Research question

In the face of changing public transport usage patterns, are there alternative / additional relevant criteria apart from maximizing passenger numbers (maximizing transport capacity) for designing a public transport system?

## Hypothesis

H0: In the future, it will not be possible to measure the success of transport operators on the number of passengers, since people's individual mobility needs are changing due to social developments. Above all changes, the rapid change in the world of work needs to be considered. Therefore, people will develop other requirements on the design of public transport.

## Applied methods

The first step of this thesis is to define relevant terms for the ongoing thesis. Afterwards, a literature review should give a brief overview of relevant [megatrends](#) for future transport planning. Moreover, [recent developments](#) within the sector, which build a foundation for future actions, will be introduced.

The main methodical approach for the result is the scenario method. Interviews and a student survey were used to reduce the number of megatrends to four key factors. Then, narrative scenarios have been created to imagine life in 2050. Therefore, a simplified methodological approach after Gausemeier has been used. In the end, passengers' needs have been deduced. A more detailed description for the used approaches can be found in the beginning of every chapter, in particular the more extensive scenario method can be found in the corresponding [chapter](#). After the scenarios, the findings about passengers' needs and their requirements for future vehicles will be explained.

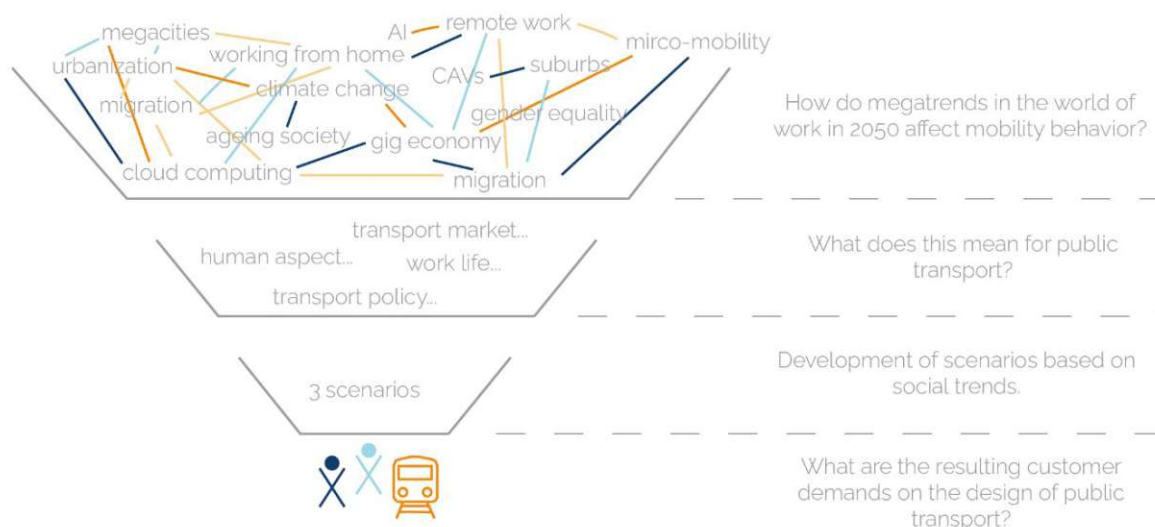


Figure 1 This diagram should illustrate how the extensive topic of megatrends will be brought step by step to the level of individuals.

## State of the art

As mentioned in the introduction, ridership in some places was already declining prior to Covid-19. For example, the *U.S. Federal Department of Transportation* observed a 7.5 % decline within ridership between 2014 and 2018, regardless of city size (O'Toole, 2018). Reasons for this include the relocation of corporate offices outside of major downtowns or the growth of transportation network companies such as *Uber* and *Lyft*, which was also noted in Toronto. The decline in ridership was seen despite the economic growth. The increase in active mobility in inner-city areas (15-minute city, superblock, etc.) also had an impact on public transportation (Haider, 2016).

A similar phenomenon was observed in London in 2018. *Transport of London* saw a 2 % decrease in subway ridership in just one year. Changes in mobility behavior here are due to permanent substitutes such as *Netflix* instead of cinema or *Deliveroo* instead of eating out at local restaurants. Further, the article also addresses individual events such as terrorist attacks that cause short-term cuts in public transportation use (Bulman, 2018). In other metropolitan areas, such as Mumbai, entire subway networks are currently being built and these transportation systems are still in their infancy (Ahmed et al., 2020, p. 1968).

A 2021 SLR (systematic literature review) systematic search for urban mobility scenarios of the future projected for 2030 revealed that 52 scenarios were published in the most popular scientific databases. Primary findings from these papers describe a shift to shared mobility. The forecasts for electric and autonomous vehicles vary; the sudden breakthrough of these technologies by 2030 is hardly expected, but a rather steady transformation can be imagined. However, it is already foreseeable that autonomous vehicles will have a far-reaching impact on public transport 2030 (Miskolczi et al., 2021, pp. 9–10).

## Definitions

Before writing about trends and megatrends in work life and society and how they affect mobility behaviors some terms like *trend* and respectively *megatrend* need to be defined and moreover, a brief introduction about what influences mobility patterns of individual will be given. Only then is it possible to understand future developments.

### Mobility patterns

Factors and circumstances, which are influencing mobility behavior and travel patterns of individuals and how they are choosing their mode of transport can be distinguished between five categories, according to researchers from the University of Delaware. First, there are more general influential factors along socio-economic groups like gender, ethnicity, household income, age, education, employment and family status, ownership structures etc. Secondly, there are factors regarding the transit level of service, such as network coverage (does not matter if public transport, bicycle, road or walkway), usability and affordability of public transport, comfort, operating hours etc. Moreover, there are urban design factors, which vary very often in local and regional contexts like land-use patterns, social infrastructure, population density, parking availability etc. and factors of accessibility. Last, there are the distinct characteristics of certain trips, including the purpose (work, school, health etc.), distance, origin and destination information (Racca and Ratledge, 2003, pp. 2–5).

### Megatrend

According to John Naisbitt, who was one of the early future scientists, shaped this term which was published in his book *Megatrends* in 1982: megatrends can be defined as global and profoundly transformation processes which have long time effects in economics, technology, politics, society and ecology and complex interactions between the different fields. They develop slowly over decades and can be influenced by short- and medium-termed trends and influence or increase each other (Naisbitt, 1982, p. 22).

*Zukunftsinstitut*, a German futurology and trend research institute says that megatrends last at least some decades and are not only transforming different parts of life, they reshape entire societies. Further, every trend sooner or later develops an anti-trend and is some kind of disruptive (*Zukunftsinstitut GmbH*).

A lot of futurists and institutions (background in consulting, futurology or are (non) governmental institutions) have defined a number, most between ten and twenty, of megatrends which they think will shape the future. There must be noticed that megatrends occur differently depending on regions and time. Some institutions either define the different megatrends more in depth, others put them together to clusters. For example, resource scarcity is often a side effect of climate change (Artuso and Guijt, 2020, p. 39). There is common sense about some topics like climate change, urbanization, digitalization and new technologies, demographic shifts, a transformation of the health sector as well as in work life, thus rendering them as uncontroversial megatrends. Some institutions mention occasions such as shifts in global economic/political power, cybercrime, fake news, human data as good or weapon, spirituality, microbiomes or synthetic biology (EYQ, 2020, pp. 66–69), which are definitely part of the future and will lead to changes, but not (yet) to an extent which would define a megatrend.

To answer the questions of this thesis the most relevant megatrends will be explained and discussed in the following chapters. Of course, none of these trends can be considered on its own, because they are impact each other, although in this work the focus lies on those megatrends which are expected to have a high linkage to mobility and commuting.

On the following pages will often appear the terms Covid-19 and the pandemic, even though the pandemic is not the main aspect of this thesis. The pandemic forced a lot of industries to think different and has transformed life within just a few days, triggered a lot of happenings and showed, how fast changes can be made.

### Average daily commute

In order to find answers to the questions on how commuting behaviors will occur in 2050, it is important to understand current patterns in commuting and also in work life and which challenges this causes for transport operators. Therefore, taking a look at what current commuting patterns are in different cities is necessary.

*Moovit*, a provider for MaaS, has collected commuting data across the world, from smaller towns to megacities. The results vary widely between different cities and countries. For example, in Canada people's average commutes ranges from about 47 minutes in Montreal to 84 minutes in Ottawa, where else average commutes in Spain are mostly between 25 minutes in Granada and 45 minutes in Madrid. In Europe, most commutes are less than 1 hour compared to North and also South America, where they are often 1 hour and more. *Moovit* also gathered data on how many percentages of people usually commute longer than 2 hours per day by public transport. In big metropolitan areas of the United States like Miami, Los Angeles, New York or Seattle, over 30 percent of the people spend more than 2 hours a day on public transport. In comparison, major cities in Europe like Madrid, Athens, Berlin, Paris or London have a share of riders between 20 and 26 percent, who spent that much time on public transport (*Moovit App Global Ltd.*).

Moreover, over the last decades rising housing prices and better infrastructure (bigger highways, faster trains etc.) got more people to move further away from their jobs, which also lead to a greater urban sprawl. In spite of this process, commuting time did not rise that much, only the commuting distances and kilometers travelled by people.

Longer commutes, both in time and distance, which lead to higher transport volumes which further leads to an increase in CO<sub>2</sub> -emissions and air pollution are the results of mistakes in land use planning.



In cities with mixed land-use patterns, where residential areas and jobs are located close to each other, fewer kilometers are travelled. Whereas in sprawled areas people have to take long commutes because of limited accessibility and therefore high numbers in traffic do not state anything about life quality and well-being. Due to that it is not the current status to measure success of transport operators per traffic volume (ITF, 2021).

## Revenue

To understand public transport and on which fundamental it is built, the following chapter should give a brief overview of how operators and networks are funded. To give an example, *Transport of London* is financed about 70 percent by passenger fares. This shows that mass transit relies on daily commuters, and that more hybrid working models inhibit people from buying multiple-day passes and therefore, a certain percentage of income was missing during the pandemic – which operators relied on in previous years. For *TfL* fares-income declined from £ 4,751m in 2019/20 to £ 1,600m in 2020/21, nevertheless, basic offers are essential. In previous years grants from central and local governments made about one third of their funding (Transport for London, 2021, p. 87).

One part of the income of passenger fares is tourism. With special offers like multiple day passes with discounts for attractions or discounts at off-peak-time (Union Internationale des Transports Publics, 2020, p. 2). Tourism is tried to be spread across the day. Tourists as an addition on weekends and in vacation-season, when locals commute less, are a great addition for public transport, otherwise, when they use public transportation during the rush hours, they can cause additional congestion in the network (Albalade and Bel, 2009, p. 8).

Apart from tourists, as already mentioned, the main source of income are citizens, who use public transit in their town. Some households suffer from mobility poverty; however, average mobility budgets are quite high e.g. the average German household spent € 233 per month for private vehicles and around € 33 on buses, railways and taxis in 2018 (Statistisches Bundesamt, 2021).

The problem of encouraging people to spend more on public transport is, that the true costs of taking a car are invisible and it often seems cheaper to take the own vehicle. Drivers do not have to pay air pollution or social cost and health care from accidents or long term issues because of bad air quality. Further, infrastructure such as highways and bridges are highly governmentally-funded. Therefore, funding is a tool of governments which could be used more wisely, e.g. when substituting a car transit route from a suburb to the city center, when there is a train line with the same route, which is also funded by them, they are making their own competition, respectively losing money twice.

One of the only operators who running its metro system profitable and self-financed worldwide is *Mass Transit Railway (MTR)* in Hongkong, China. When they expand their network, they force real-estate-developers with lots near the lines to pay a certain percentage per year to *MTR* because they are the ones who benefit from the new metro as the value of their properties rises. Fares there are relatively low due to this so called *Rail plus property* system. Operators know that this model only works because of their privileged situation in Hongkong, where they have such a young metro network. Nevertheless, implementing such a system is not as easy given the fact that there are different land policies in every country (Keegan, 2019).

In most European and North American cases it is not possible to run public transport profitable, because cities have already existing rail and metro networks and due their age, they are often expensive to maintain and renovate. Operators and governments know that they cannot run services

without losing money, otherwise areas of low density would not be served anymore. Moreover, they learned from historical mistakes of Margaret Thachter's transport privatization invitations and the loss of service quality. To run public transport in the future, newly build urban areas can be more profitable, when there are mixed land-uses with higher building density to fit more people in less space.

It is about time to move away from wanting to make mass transit profitable and more about to run it efficient and economic. Additionally, it is important to see the true costs of it and the value for livable cities without congestions. Further cities benefit from a good transport network because it helps to attract stronger pools of employees and therefore economic output and capital rises (Jaffe, 2015).

*Key findings:* Running public transport with a good quality of service and cost efficient is a major challenge for operators and cities governments, but if external costs of individual transport are considered and governments thus spend their grants more sustainably there is a chance to run public transport more profitably.

## 2. Review of Literature

The focus of the following literature review is based on internet research and grey literature rather than on academic literature, which is quite rare, due to the unpredictable scientific proof of the future and everything published is just an approximation. In order to understand those expectations and approaches, scientific research from the past can help to understand several (new) phenomena and support those ideas.

As mentioned in the abstract, the idea is to give a global overview on how mobility patterns and commuting habits will change in urbanized areas over the next 30 years and how the public transport sector can adapt to that. Due to the lack of literature and data in English language as well as the impossibility to adopt a one-fits-all approach, the global perspective got narrowed down to western countries, with a similar state of development and cultural understanding.

To underline the perspective of the western world it was tried to give examples from cities and countries in different areas and with different sizes to mark out differences between societies, geographical areas, work sectors and the individual challenges each city faces. Of course this gives only a glimpse idea of future challenges for cities because the requirements in mobility are influenced by many sectors like housing, health, work life, environment e.g. Further, the demarcation of the western, educated, industrialized, rich and demographic countries blurs sometimes due to data, literature and specific phenomena.

### 2.1 Megatrends

The following chapter should give a brief overview about existing megatrends and predictions about their development over the next 30 years. Research and data availability varies widely. Moreover, the focus during this trend research was built up on two main questions: which mobility needs does trend xy entail and further, what consequences will this phenomenon have for mass transit. At the end of every trend, the key findings summarize it up.

Origin or respectively, the driving forces for some of the following megatrends are developments in the technology sector. Only through those processes changes are even possible, e.g. without online shopping high streets would not change nor would it be possible to work from home if employees could not access the companies server in their homes. So digitalization changed the way of living and all parts from private life to work life are affected.

#### Technology

Historically, society as a whole and therefore, work life transformed with new inventions. Through milestones like the steam engine radical social changes happened. Whole industries disappeared and others evolved. The phenome is still the same today, although the speed of shifts and changes accelerated. As technology is changing faster than ever, jobs and how they are performed are transforming radically. Especially the manufacturing sector is subjected to major transitions: This phenomenon is often called *industry 4.0*. Through technologies like artificial intelligence (AI), machine learning (MI), augmented reality (AR), blockchain and the internet of things (IoT) devices get connected even more and collected data can be used for e.g. predictive maintenance, improving decision making processes or self-optimization. Due to that, whole industries need to be rethought and in particular blue-collar jobs are at risk of getting automated.

Jason Bloomberg, an author of Forbes magazine gathered, some definition for the term digitalization, one of them from two researchers from University of North Carolina School of Media and Journalism J. Scott Brennen, Doctoral Candidate in Communication, and Daniel Kreiss, Associate Professor, says that digitalization means the reconstruction of many parts in social life around communicating digital and media infrastructure (Bloomberg, 2018).

According to *Gartner's Glossary* "Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business" (Gartner Glossary). Building on it, futurist Tristan Horx estimates that the word *digitalization* will sooner or later disappear, because everything is digital and it is self-understood (Horx, 06:30–06:52).

### Digitalization

A report of the digitalization and the American workforce focuses on how digitalization impacts people's lives and defines automatization of work processes as a main part of transition. The level of digitalization develops differently and varies across geographical areas. Nevertheless, it is certain that adopting new skills is necessary for bringing digitalization to the next level, therefore, digital education is more important than ever and further, not only high-skilled groups need this education, especially underrepresented groups must be picked up from the industries. The degree and pace of digitalization vary widely across occupations and industries (Muro et al., 2017, p. 3).

Through different paces and access to digital environments a gap occurs, which is called "digital divide". This term already showed up in the 1990s when computers did increasingly percolate the daily life. Which means people either do not have means of infrastructure like a laptop or internet access etc. neither they have the digital proficiency and skills to use these tools. Sometimes this is not even the users fault because governments fail in seeing the necessity of education and building up a broadband/internet strategy and therefore not providing enough capacities. An example for digital division in society is home schooling, which came during the pandemic. Especially families with lower household budgets had no or just one laptop at home and so only one of two kids could attend online classes. Another example are parents who are not working with computers and do not have digital skills, they are not able to help younger children to access classes. Further a well working internet infrastructure is a basic requirement for prospering economics (Chakravorti, 2021).

Dörner and Edelman from *McKinsey* defined the word digital across elements and described working in a digital world as a constant improvement as a cycle and thinking about using new capabilities to improve or optimize existing processes. Data in a digitalized surrounding can help therefore to analyze information better and have connected devices make faster decisions (Dörner and Edelman, 2015, pp. 2–3).

Virtual consulting with specialists in medicine, finance or administration procedures, online education or online shopping are results from digitalization which are already full under way in everyday life and are constantly improving and reducing the amount of trips (in passenger mobility). The examples mentioned are just first steps, what is coming is unclear and experts agree it is hard to predict how people work in 2050, but soft skills, digital skills as well as the willingness to change will be more important than ever (G20 Employment Working Group, 2017, p. 20).

*Key findings:* Digitalization is already ongoing, but there are still a lot of unrealized opportunities and industries are starting to wake up as the competition and pressure is getting higher. Especially,

emergency markets are stepping up quickly and pushing digitalization to a next level. What is certain is, that a lot of current jobs will disappear and new ones will emerge. Further, digitalization makes it necessary for people to constantly improve their skills and lifelong learning will be a requirement in order to get good jobs.

### Cloud computing

The fundament to move towards more digital businesses is grounded in cloud computing. IT-solutions are delivered via internet solutions, which are scalable and elastic (Gartner Glossary). Most industries are based on cloud computing from telecommunication to agriculture, in Europe around 40 percent of companies are using this technology, whereby in leading countries like Sweden and Norway over 70 % of the enterprises are using cloud-based technologies (Eurostat, 2022). Some clients rely on basic services and communication tools like web mailing services or video conferencing, others put their whole services like supply chains, big data analytics and customer processes in the hands of cloud computing. However, not only businesses, but also in private life many services people use are based on cloud computing e.g. *Office 365 Outlook* is based on *Microsoft Azure*, *Netflix* and *Lyft* are hosted on *Amazon Web Services*. So boycotting buying products via *Amazon* does not mean people are not using it. It is hard to get numbers on how many people are using cloud-computing global in some way, but as there around 3.6 billion people using social media in 2020, there are at least 3.6 billion cloud-based services users. Till 2025 this number is estimated to increase to about 4.41 billion by 2025 (Statista Research Department, 2022).

To give an example: A person decides to open an online business and is not sure about how successful the business idea will be. Everything the person needs is a web-enabled device, he or she never needs to invest and build up a technical infrastructure, because hardware and software can be accessed via platform providers. Depending on the demand, the person can access flexibly access how much performance in terms of data storage, processing power etc. is needed. The payment is calculated after performance, so no big investments have to be done prior and in general, the fixed costs are relatively low. To make this example more tangible: There is high demand of people who want to get home after a big event. A usual taxi provider would get a lot of phone calls and would not have the capacity to answer them and match drivers and customers. *Uber* can simply increase their infrastructure resources via their cloud and can therefore connect drivers and customers automatically and efficient through AI (Subramanian, 2019).

Despite all those advantages, for having the chance to quickly upraise capacities and constantly providing those services, there are resources like electricity and water for cooling the servers needed. In the US, around 1.8 % of the overall electricity are used for cloud computing and data centers (Francis, 2021). Moreover, data sovereignty and especially processing the information is a controversial issue and users are dependent on the providers and it is nearly impossible to switch between providers without making losses (Omankwu et al., 2016, p. 92).

Depending on which service is needed, cloud computing can be distinguished between different functions e.g. platform as a service, infrastructure as a service, function as a service or software as a service. AI, cryptocurrencies, blockchain, IoT etc. happens over those clouds (Foutty and Bawa, 2018). There are only a few big operators on the market, who provide those on-demand cloud computing services e.g. *Amazon Web Services* (holds amongst one third of the market), *Microsoft Azure*, *Google Cloud Platform*, *Alibaba Cloud*, *IBM Cloud* (Richter, 2022). So data is stored on their platforms. Therefore, those providers are in the possession of the collected data respectively have certain rights

over it and e.g. can analyze it. To underpin this developments with numbers: The computing-cloud on a global level is worth around \$ 445.3 bn in 2021 and has an expected compound annual growth rate around 16.3 % until 2026 (Markets and Markets, 2021).

The effects for businesses are – at least in the industry – well known: inexpensive access to computing capacity, the chance for quick innovation boosts, reaching global markets etc. The impacts on society, on the other hand, are relatively unknown. There is not much research about how labor markets change and how it will impact society.

*Key findings:* The opportunity of using computer system resources on-demand and performance oriented payment makes it possible for anybody with relatively low starting capital to set up a business anywhere in the world. As the effects in business and future developments are relatively known, it is not clear how it will affect society and there has not been a big discussion yet. What is certain is, that human capital will get less stationary as it is already today, because via those services it can be accessed from all over the world. Therefore, working from home or remotely will increase.

### Automation

By implementing automation and AI, machines will replace (low skilled) human labor and therefore, companies will improve quality and speed of work as well as increase efficiency, raise safety, reduce costs and produce less energy-intensively and therefore, global productivity will increase. As a consequence, a lot of blue-color-workers potentially lose their job and especially low skilled workers have a higher risk for automation. Despite that, there will be a huge shortage of skilled workers like technicians, data scientists or engineers to serve those machines and develop new technologies (Pfeifer, 2022). Moreover, sectors with social interactions like education, health or public service have a lower risk of automation in the near future (OECD, 2019, p. 13). Although those sectors will be supported through task-oriented ai-functions e.g. in medicine radiographs get scanned by AI and diagnoses can build up on huge amounts of data. Therefore, doctors and other specialists can focus more on individual needs of patients (Autor et al., 2022).

On the one hand AI takes jobs but on the other hand it also creates a lot more new ones. There is a common sense about the fact that AI makes work life generally better and might give humans the chance to focus on tasks which enhance creativity, empathy or critical thinking. Although, with further implantation of AI and self-learning machines, it needs to be ensured that the goals of AI are aligned with those of humanity, otherwise there are huge risks for society e.g. AI-enabled weapons (Marr, 2022).

*Key findings:* As AI is still in its early days of development and daily life's are already determined by algorithms, developments in the upcoming years will completely change the world of work as it is known today. In the first step, changes in manufactural labor will lead to different (human) traffic loads of factories locations because less blue-color-workers are commuting to those areas.

## Demographic

According to statistics of the *United Nations* it is estimated that the population will grow from about 7.7 billion today up to 9.7 billion in 2050. The fertility rate, which was about 2.5 births per woman in 2019, will further decline to 2.2 in 2050. The reason for that is increasing life expectancy which will rise from 72.6 up to 77.1 years. In poorer countries, however, life expectancy is 7.4 years behind the average (United Nations, Department of Economic and Social Affairs, 2019, pp. 28–30).

As the working-age population grows in some parts of the world, in other parts the amount of elderly people is rising. In Europe and North America one of four people will be over 65 years old in 2050. Also the number of individuals who are over 80 years old will triple (United Nations, Department of Economic and Social Affairs, 2019, p. 18).

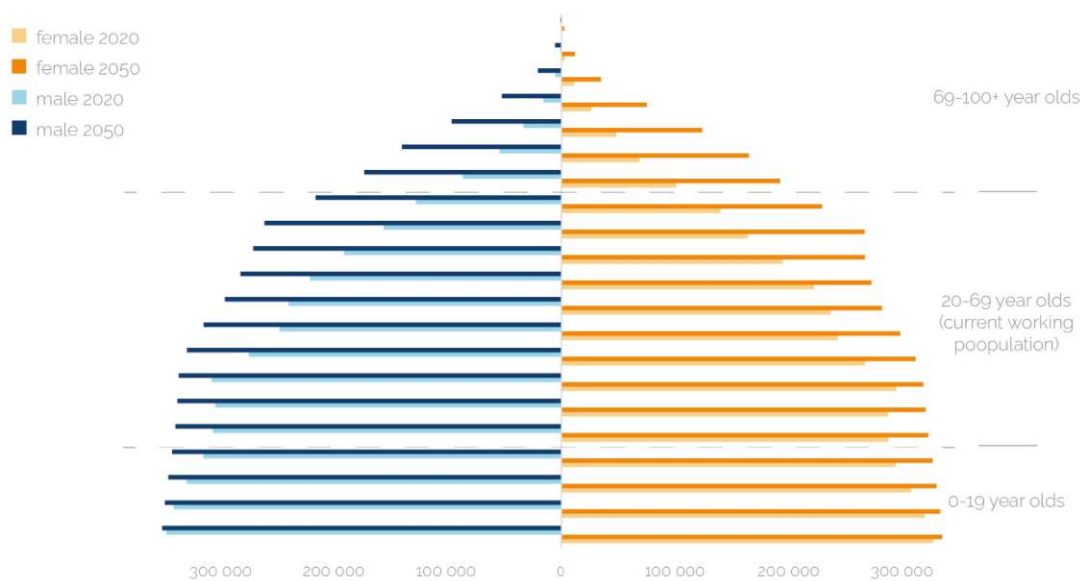


Figure 2 Distribution of age groups in 2020 and 2050 worldwide. The steps are in 5-year-age-groups (y-axis) and the numbers on x-axis are in thousands. It can be seen clearly, that the amount of elderly increases a lot.<sup>1</sup>

## Ageing society

*Silver society* or *best agers* describes a new stage of life in developed societies where people are healthier than ever in history. This group of elderly people (65+) is actively looking for a new duty in life like travelling, going back to university, joining clubs or volunteering, writing a book e.g., because after retirement or while they are working less hours, they have time and financial resources to unfold themselves. Further they are fit and healthy due to a conscious lifestyle which includes a balanced diet, movement, maintenance of high cognitive function also factors like a balanced work-life-relation and better health systems are responsible for that (Gutman and Drexler, 2015, p. 16).

What follows are multiple questions, which is not cleared yet and depends on the developments of the health system and in biology is: how much help and care will those people need? And from which age on? Does an 80 year old person need the same help as the average person needs now? Or will a person of this age be as fit as an average 60 year old person nowadays and will still use the public transport and be active? Or will there be a change in the opposite direction? Especially lower income groups, which are not caring lifelong for their mental and physical health, because of several reasons like working double shifts, having not enough money for a healthy diet e.g. are threatened that their

<sup>1</sup> United Nations, Department of Economic and Social Affairs, Population Division (2019b).

health condition is worse than now, because of diseases of affluence like diabetes or obesity. Further, people of a lower socioeconomic group often do not have savings on their bank account and getting small retirement payments, which will force them to still go work with a high age (UNFPA and HelpAge International, 2012, pp. 29–30).

Another reason for that matter is that retirement age is constantly being raised according to the rising life expectancy at the same time pension forms have not significantly adapted to the new trend, so it is clear that people will need to stay longer in their jobs. Not only the government side undergoes an adoption process: companies also must implement age-friendly working cultures and flexible time models – impartial from socioeconomic groups (Ehnes, 2012, p. 19).

*Key findings:* What is clear is, that people 65+ will be the biggest population group in 2050 and a lot of them will be mobile, either because they have to be, in order to work and avoid old-age-poverty or they can choose their journeys and enjoy their new freedom and unfold themselves. A part of them will also stay at home due to health issues and will be remitted to care.

### Migration

It is natural that more people on the planet means more migration and there are several causes for that. One main reason will be climate change which is expected to lead to extreme weather conditions. Those are further responsible for hunger crises due to crop failures, further reasons for fleeing are war, political insecurities or prosecution. Currently there are about 64 million people fleeing. This number is expected to rise up to 1 billion until 2050 (Bassetti, 2019).

On the other hand, there is migration of humans who simply are looking for better opportunities in all fields of life and e.g. move to cities where they can find better job opportunities. Labor markets will be affected by migration of both kinds or rather be depending on that, especially markets in Europe or North America where aging society and a low fertility rate (prognose 1.78 North America, 1.72 Europe; 2.1 births per woman are needed to maintain population size) will lead to a decline in working age population (Ruiz et al., 2020, pp. 46–47). A study from the *Center of Global Development* shows that the European Union and the United Kingdom will need around 44 million new workers by 2050, which will mostly be migrants from Africa (depends on the level of automation in work), to carry the consequences of the ageing society (Kenny and Yang, 2021, p. 19).

*Key findings:* Migration will either voluntarily or involuntarily impact housing- and labor markets. The direct impacts on everyday mobility will be rather low – except the growth of cities and therefore the potential in ridership. Still, policy makers will face challenges like supporting inclusive societies and providing affordable housing and mobility in order to prevent disadvantaged districts and areas.

### Average household size

It is known that the average household size has shrunk over the last decades. While ancestors lived with multiple generations under one roof, people tend to have smaller families or even live on their own nowadays. Especially in wealthier states like France, Luxembourg, Germany, Austria, Norway etc. already one third of the households have only one member (United Nations, Department of Economic and Social Affairs, Population Division, 2019a, pp. 4–5).

Global predictions on percentages of single-person-households are hard to find apart from data from Europe or Northern America, as it is a relatively young phenomenon for Asian countries – except for South Korea and Japan (about 30 % single-person-households). This can be seen in the percentages of one-person-households (Yeung and Cheung, 2015, p. 1101). The main reasons for one-person-



households in Western societies are a lot of middle class young professionals, which choose this form of living as a lifestyle as well as widowed elderly people. In Asian societies a lot of migrant workers with low education who cannot afford housing in the cities live in one-person-households in the metropolitan areas (Yeung and Cheung, 2015, p. 1108). In economically rising areas and advanced societies as e.g. Japan like mentioned above it is quite common to live alone – especially for people over the age of 65.

Are smaller households leading to more mobility? In families or households with more members, people benefiting from synergy effects like grocery shopping – one of x persons is responsible for this task and not everyone needs to take on this way. Whereas in a single household the person has to go and get the groceries. Further, many single-person-households belong to generation 65+, where the chances of being immobile are higher. As there is no household member who can take care, they need to purchase health services e.g. and another (unknown) person has to do an extra journey. On the other hand, single-person-households may be more flexible in moving apartments because they are less dependent on other persons, which leads to an increase in labor market mobility (Deloitte, 2015).

*Key findings:* What is clear is that one-person-households will increase and so will mobility. This is mainly due to more errands like shopping (does not matter if groceries get delivered or in person) and due to the fact that living alone means having less/no social interactions at home which may also lead to more leisure activities to meet friends and family.

### Gender equality

Gender differences in the use of public transportation and travel behavior are the result of certain roles in labor markets and in family structures, because women are often responsible for unpaid care duties (children, elderly people) in households. Worldwide, there are still only about 50 % of women participating in the labor market, whereas around 80 % of men from the working-age population are working. This is because of a high amount of tasks in the informal sector, which are typically carried out by women. As a consequence, women who work either part-time, irregular hours or not at all (for a certain amount of time), earn lower wages which leads to lower pensions and therefore, to have a higher risk of old-age-poverty (Dabla-Norris and Kochhar, 2019, p. 8).

Regarding transportation the combination of a lot of care tasks leads to a high(er) amount of trips per day e.g. taking kids from and to school before going to work and running errands afterwards, which results in complex trip-chains. These trips are often made by mass transit because women often simply have no other choice, due to their lower income and facilities in the surrounding areas. Therefore, women are using public transport more frequently, but for shorter distances than men (Namgung and Akar, 2014, p. 136). This creates a certain irony, because men are dominating the transportation sector as planners and decision makers and therefore, the design is made by men for men, who mostly take more simple trips such as going straight to work and home afterwards. Whereas for women, who take more complex trips, the way public transport is designed does not fit their needs (Zhen, 2021). The shorter commute of female persons often leads to a limited choice of jobs which ends in a circle and therefore, promotion perspectives are rather low (Hutt, 2019).

With rising education, supporting programs for female entrepreneurs, better parity for maternity and paternity leave, affordable and high-quality childcare etc. women are participating more on the job market and therefore, their income and wealth increases as well, which will also change financial markets (Dabla-Norris and Kochhar, 2019, pp. 10–11). Especially, countries, where equality is still low and there is a lot of room for improvement, will profit more on an economical level than leading

economic countries, because equality is resulting in a higher GDP, which reduces (old-age) poverty and other social issues. In the European Union, where especially eastern countries are affected, it is expected that gender equality leads to an average increase from about 12 % of their GDP till 2050. For comparison, countries which have already achieved a higher level of equality are expected to gain about 4 % in GDP growth (European Institute for Gender Equality, 2017, pp. 2–3) .

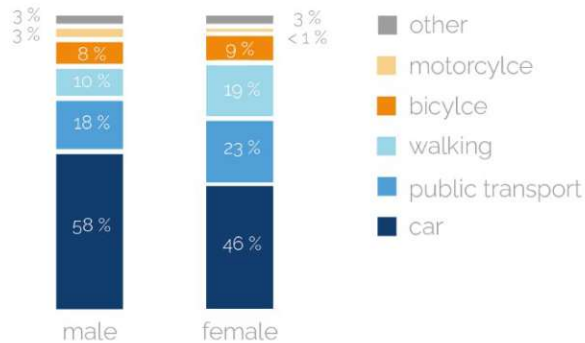


Figure 3 The following chart shows the differences in mode choices between genders in EU-27 in 2007<sup>2</sup>.

**Key findings:** Women, care responsibilities and therefore, job opportunities at the labor market, economic activities and commuting seems like a closed loop, which is slowly breaking up. There are a lot of studies which outline the importance of women participating fully on the labor market as well as building up facilities for child-care etc. Moreover, leading economic and welfare countries such as Sweden show, how to close the gender inequality gap successfully.

## Urbanization

As written before there will be an additional two billion people on the planet in the next 30 years, which leads to the question where these people will live. Having a look at where people live at present, it is not surprising that the future takes place in cities or metropolitan areas. The European Commission estimates that about 85 % of the population already live in urban areas today, but having a look on the definition of urban areas and their density which in this case means more than 5.000 inhabitants and more than 300 people per square kilometer is controversial if European definitions of urban and rural areas are comparable to others in the world (Pesaresi et al., 2016, p. 23). For example, in Japan cities are defined by having more than 50,000 inhabitants (Ritchie and Roser, 2018).

Nevertheless, the most common number that can be found about the level of urbanization today is 55 %. This number is estimated to rise up to around 68 % in 2050 or roughly two thirds of the world population. This urbanization process is expected to be highly concentrated in China, India and Nigeria (United Nations, Department of Economic and Social Affairs, Population Division, 2019c, p. XIX).

## Megacities

Therefore, the number of megacities will increase. According to the *UN* there are currently 33 megacities worldwide. For definition, cities with more than 10 million inhabitants are called “megacities”. Worldwide, the number of megacities is projected to rise from 33 in 2018 to 43 in 2030 (United Nations, Department of Economic and Social Affairs, Population Division, 2018, p. 4), though, this number is disputed because there is no official data on how many people live in those cities and where the borders of the metropolitan areas are. The number varies between the different sources.

<sup>2</sup> Maffii et al. (2020, p. 15).

Also the projections are fuzzy: In 2030 about 43 megacities are projected, for 2050 experts from the University Ontario forecast about 50 megacities around the world (Hoornweg and Pope, 2014, pp. 9–11).

For some of those cities the danger of growing “too fast” occurs, which means that they are not able to provide enough infrastructure for the fast moving-in-process, which leads to the rise of substandard areas or even slums. Focusing on the *OECD* countries, there are currently seven megacities with more than 10 million inhabitants (Hoornweg and Pope, 2014, pp. 9–11). Despite the growth of megacities, especially in Europe and North America smaller cities with less than 1 million inhabitants will increase, followed by cities between 1 and 5 million residents. These cities currently grow twice as fast as megacities and will be centers for economic activities, recipients of migration movements, innovations and political issues (Gaub, 2019, p. 12).

*Key findings:* Urbanization will take place in cities of every size, mainly in smaller cities with up to 5 million residents. Nevertheless the challenges which all of them are facing are providing fast and well planned infrastructure like water, energy, (public) transportation etc. as well as mixed land uses and affordable housing to ensure livable neighborhoods and therefore prevent crime, segregation and other social problems.

#### Trending suburbs

Recent trends, Covid-19 brought up that for people who have a high income, the chance for working remotely buying single-family-houses and moving in suburbs of their metropolitan area or back in their hometowns which are often in rural areas will remain (Kramer et al., 2020, pp. 9–11). When taking a global look on this phenomenon, this is just a small percentage of people especially young families in Europe, Northern America or Australia.

Jerusalem Demsas, a reporter about housing and infrastructure, writes at *Vox online*, that homeownership is becoming an increasingly exclusive club: housing in the United States. is getting more expensive, there are only a few properties on the market, the prices will increase even more and therefore, only a small amount of people can afford buying a home (Demsas, 2021). People who are moving to suburban areas are mostly graduates who are looking for more space e.g. for home office and an own garden. Other reasons to move to suburbs or smaller towns are better education for kids, affordable housing, safety and quality of life. Therefore, they are taking longer commuting into account.

*Key findings:* Single family house owners in suburbs are only a small part of certain socioeconomic groups, with the increase of working remotely, more people are looking for such properties and prices are still increasing; therefore, experts do not see a big growth in the next few years. For public transport this phenomena can have two major characteristics: On the one hand more remote workers in the suburbs can relieve networks whereas on the other hand public transit networks in suburbia are often relatively underdeveloped and less riders would even downgrade it.

#### 15-minute-city

The 15-minute-city means that everything from living, working, health care, shopping, education, culture and sports can be found within a 15 minute walk or ride with the bike or public transport from home. Anne Hidalgo, mayor of Paris, brought back the concept to the masses, as she announced in 2020 that Paris will be an overall 15-minute-city. Originally though, the concept is quite old: almost

every city was a 15-minute-city in the 19<sup>th</sup> century until the first cars appeared. In the 1960s Jane Jacobs brought this idea back with walkable and socially mixed neighborhoods (Jacobs, 1961).

Some cities have similar concepts such as Singapore, where the goal is to implement *20-minutes towns* until 2040 (Hanyan, 2021). Melbourne, Portland and Scotland want to establish *20-minute-neighborhoods* and Shanghai goes even further in bringing their *15-minute community life circle* into the suburbs (Yiying, 2021). Another similar concept are the superblocks in Barcelona or *Barrios Vitales* in Bogotá. This walking-cycling-neighborhood-phenomena can be observed worldwide.

The concept of a 15-minute-city poses a big challenge, especially for cities which have functional separations between classical residential districts and central business districts, to bring mixed-uses to business districts: because there are almost no buildings for housing and high rents, it is more difficult for smaller companies or recreational facilities to access those areas (Erdly and Song, 2020). This does not mean that there are no big company locations anymore, but in certain jobs people will use the co-working space in the local neighborhood and travel e.g. once every week to the headquarters on the other end of the city. This will lead to free capacities in public transport which e.g. can be used by commuters who currently commute from the outside in the city with their private vehicle.

There are also some negative aspects and criticism about the 15-minute-concept, which is not as inclusive as it seems. In the first place wealthier well established inner city areas will turn into 15-minute-neighborhoods which already have experienced gentrification. The socio-economic group, who can afford to live there, often consists of conscious people who are caring for environmental issues, see the health aspects of active mobility and further even have the chance to work from home or in co-working spaces. In those areas it is easier to establish the concept, whereas in socially disadvantaged areas in the outskirts of cities it can be more difficult to introduce the concept, because e.g. there is no mixed-land-use but rather residential areas only and people are commuting to other parts of the town or/and have jobs which cannot be done from home. Therefore, cities will face a big challenge to mix their neighborhoods in order to prevent segregation. However, this is a unique opportunity to upgrade certain neighborhoods (O'Sullivan, 2021).

One can note that this concept would relieve inner-city lines from congestion e.g. people who are now using the tram for a 30 minute ride to the next area to visit a certain location. In a 15-minute-town people can reach their desired destination by foot or bike. These free capacities in public transport could be used by commuters who are coming from outside the town.

**Key findings:** The idea of the 15-minute-city has great potential to strengthen neighborhoods, tackle pollution and public health issues. For public transport it can bring a decrease in ridership in inner cities in the first place, but over the long ride it will settle down and capacities can be used in other areas of the town.

### Shopping streets

Beside whole cities which are growing and housing issues, another aspect will transform cities of today: Due to the rise of online shopping, stationery retail will disappear or more positively, will develop further in the future and change city centers of today, which means getting away from land allocations of shops and turn into places for social interaction and entertainment e.g. indoor rock climbing or video game centers. First class shopping streets are estimated to stay relatively the same because big brands will present their best products in big showrooms, customers can visit them, have a look, feel the product and get an experience in order to go home without buying the product on the spot and order

it online afterwards. *Secondary* locations of local importance will either show up with vacant stores or turn into *living streets* with a lot of restaurants, co-working spaces and cafes with high quality such as pop-up stores and be a place of interaction for the local community (Frei and Jack, 2021).

Keeping those streets alive is therefore a challenge for governments and landlords, as adapting to new needs and re-thinking high streets is difficult. Moreover, it affects public transport as e.g. on Saturdays less people go into the city center for Christmas shopping and rather stay in their neighborhood to meet up with friends, because presents get delivered anyways.

*Key findings:* The challenge for reinventing shopping streets and keeping them attractive and alive is in the first place a task for city councils and real estate owners and not an issue which transport operators can handle. They can offer their service, adapt to the new structure and roll it out.

## Climate change

Climate change is probably the biggest challenge society is currently facing. There are different scenarios and forecasts, but it is certain that global warming will rise and natural disasters such as heat and extreme weather conditions will accumulate and it is about time to prevent further catastrophes.

In order to reach international agreements like the *Paris Agreement* (keep global warming below 2°C) and as a result the different governmental goals of being CO<sub>2</sub>-neutral till 2030/2040/2050 or whatever each nation has set for themselves, there will be policies to accomplish these goals. As the transport sector is responsible for about 25 % of all energy related greenhouse gas emissions, strict and impactful measures are needed to reduce those emissions (UN Environment Programme).

Given the fact, that most of fossil fuels in transport are burnt for road, rail, air and marine transportation, the share for emissions burnt in urban public transit is relatively low, whereas the rapidly growing freight transport is primarily responsible for greenhouse gases (Wang and Ge, 2019). Nevertheless, there is a potential to optimize electrified railways and trams in e.g. making it possible for them to operate with stored electricity and reducing requirements for constant grid connection (Rode et al., 2015, p. 9).

Further, private vehicles and individual transport are causing emissions and especially cities setting measurements to reduce individual motorized transport to reduce emission and improve air quality as well to enhance neighborhoods and make them livable. To achieve this step modal share goals have been set in order to shift those individuals to public transit, shared modes or active mobility. To meet the 1,5 °C target the modal share of public transit and active modes needs to be between 40 % and 80 % whereas most cities current share is between roughly 30 % and 60 % (Khan and Baswedan, 2021, p. 3). Combining this transition and the ongoing urbanization forces public transport operations and city council to take action. According to *C40*, a network of mayors of nearly 100 world-wide leading cities, public transport must double by 2030 in order to meet the 1,5 °C target (C40 Cities).

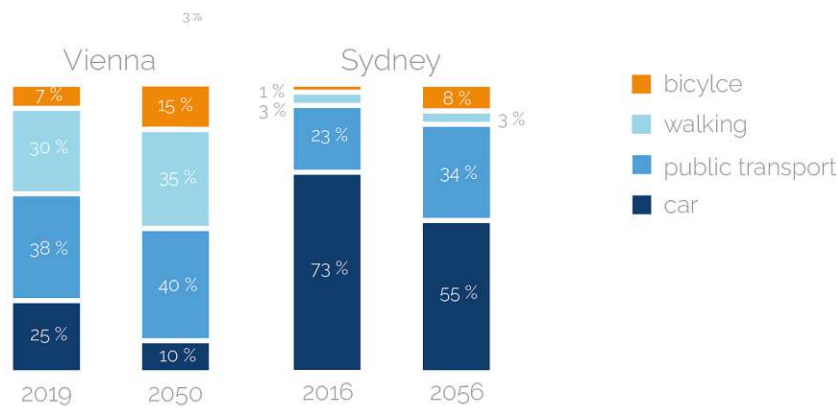


Figure 4 The following figure shows the current state of two different cities, as well as their modal share goals for the future (it should be noted that survey methods can vary between countries). On the left side, the goals for Vienna in 2019<sup>3</sup> and 2050<sup>4</sup> are shown. On the right side, the numbers for Sydney<sup>5</sup> in 2016 and the desired numbers for 2056 are demonstrated.

### Decarbonization

In urban public transport, where trams, metros and trains are already electrified, the main task will be phasing out fossil fuels from buses. Electrification and hydrogen-power are the current solutions to tackle CO<sub>2</sub>-emissions, although it needs to be distinguished how electricity or hydrogen is being produced otherwise, those sources have impacts in generate high levels of CO<sub>2</sub>. As technology develops and vehicles improve alternative fuels will be more common in a couple of years. Operators have already rolled out testing electric buses and hydrogen-power and some like *Transport for London* or *Transports Metropolitans de Barcelona* have already started replacing their fleet with emission free vehicles (Lertxundi, 2021).

Another part of public transport which will be affected are taxis. With the implementation of policies like low emission zones and access restrictions in inner cities, companies have already started to adapt their fleets and sooner or later these vehicles will be replaced by autonomous ones which run without fossil fuels and (due to algorithms) fully utilized and therefore, more efficient.

As written in the introduction of this chapter it is not (only) about a transition to more sustainable fuels which will be regulated by the development of technology and financial incentives, it is even more about a shift in riders and drivers behaviors.

In urban areas, restrictions like low emissions zones, increasing prices for parking in public spaces etc. will appear and infrastructure will privilege public transport as well as (re)building infrastructure for secure cycling and walking. Apart from these technical and physical aspects, there are also shifts in behavior needed: Especially the true (external) costs for car owners are often unknown and further, drivers often get tax benefits. Therefore a lot of awareness needs to be raised – on a political and economic level as well as in society.

**Key findings:** The final decision in planning transport infrastructure and in climate issues will be made by politicians. In order to reach climate goals they have to push public transport and active mobility forward and make it attractive and moreover, approve projects from public transport operators and

<sup>3</sup> Wiener Linien (2020).

<sup>4</sup> Veigl et al. (2019, p. 32).

<sup>5</sup> Asongroup (2020, p. 404).

fund them to ensure enough capacities. As planning and legal procedures to build e.g. a metro line often takes several years, decisions should be made sooner than later.

## Work 2050

Since jobs determine daily life, it is necessary to look at different trends in work life and give a brief overview of possible developments and their impacts on commuting. Even though less than 20 % of peoples trips are commuting trips (Tippett, 2015) - average commuting trips are longer in time and distance than most of the other trips people do - those commuting trips are accountable for peak loads of traffic in the morning/midday/evening and a homogenization would relief networks (Department for Transport, 2011, pp. 1–3). Besides commuting, trips for education, shopping, business etc. are responsible for those peaks and moreover, those events are all linked to each other and the organization of work plays a key role in this chain.

Moreover, the rising digitalization and automation as well as the adoption to climate change require shifts in professions and at the labor market. According to the *U.S. Bureau of Labor Statistics* there will be 11.9 million new jobs created in the United States until 2030. The fastest growth rate hold jobs in the renewable energy sector as well as in health care. Further, a lot of new jobs will be created in the computer and mathematical group (Ross, 2021). The greatest loss is expected in jobs in office jobs and administrative support as well as in production of goods and sales jobs due to automation, Ross writes. Dr Carl Frey and Dr Michael Osborne from Oxford University predict a loss from about 40 % of all jobs on account of automation – which means robots and algorithms will overtake highly specific tasks. The most important skill for humans in their future working life will be staying highly adaptable and continually updating their skills with the latest technological trends. Further, creativity and other qualities of good leadership will be crucial for workers, as those cannot be covered by automation (Seager, 2016).

Another aspect which determines future mobility is how many hours an average person will spend at work (currently the average lays at about 8 hours/day) and if working hours drop down, will this increase leisure trips? There are some pilot projects running, in which people decrease their working hours to around 4 to 6 hours/day. Most of the studies only looked at productivity at work and there are no findings on how this will affect travel patterns (Kelly, 2021).

## Working from home

The winners of working remotely are most likely high-income-men in highly profitable companies. For example software engineers in their 30s or 40s who work for big tech companies in the city center and can now work from their house in the suburbs (Thompson, 2021). The *U.S. National Bureau of Economic Research* published a paper where they found out that 37 % of jobs can be done completely from home although the variance between industries is high. Further, these are highly paid jobs which presume higher education (Dingel and Neiman, 2020, p. 2). The gap ranges from about 10 % of people who can work from home without a high school degree to around 50 % of graduated people who can work from home (Maas, 2021).

The Covid-19-pandemic has shown that key workers in care e.g. of lower-income-groups had to go to work and their mobility was roughly the same as in pre-pandemic times, staying at home is (was) not possible in several fields. Further those who stayed at home from this group were the first ones who were forced to come back to regular work patterns after losing the restrictions and no adjustments to working hours or home office like in other divisions have been made (Santana Junior et al., 2020, pp. 9–10). Typical industries for jobs which cannot be done from home are: accommodation and food

services, retail, agriculture, construction, transportation and warehousing, manufacturing, health care and social assistance (Dingel and Neiman, 2020, p. 8).

One of the most popular reasons why people prefer working from home is to save commuting time and avoid stressful situations in their car or when taking public transport. Other reasons are better focus and an increase in work-life balance. On the downside of working from home is the lack of social contact as well a decrease in team work and knowledge spillovers. Several surveys have shown, that most people can imagine some kind of hybrid work model, where they spend between 2-4 days per week - when people are fully employed - at home and the rest of the week in office for social interactions with coworkers etc. (Holzwarth, 2021).

Even if it is not clear yet how many jobs will be done from home by 2050 or how many people in different industries have the opportunity, clearly mass transit will be affected, because daily commuters with weekly, monthly or even annual passes are a big source of income until now.

*Key findings:* Working from home will not be possible for everyone, but offices are trying to implement a hybrid working model where their employees spend between 60-80 % of the time at home. Therefore, public transport operators need to come up with flexible ticket options and ideas for steady utilization.

### Remote work

Between July and September 2021 long-term-stays (28 days and more) were *AirBnB's* fastest growing sector and they are currently rolling out internet-speed tests for hosts in order to enhance remote working even more (Tobin, 2021). Since not a lot of people can afford such long vacations this fact shows that working remote and leisure are going together and people are moving away from office centered lifestyles. Therefore, the question rises who those people are working remotely in *AirBnB's*. In fact this is a really small number of people, so called digital nomads, often associated with a laptop on the other side of the world on a white beach. Digital nomads mostly spend a certain amount of time (months, years) of working and living away from home and are representing a small group of people with high freedom (financially, nationality, skills, familywise etc.) (Lufkin, 2021).

Further, Adam Ozimek, a labor economist asserts in an interview that we are currently in the early stages of remote working and firms will experience a lot more spillovers in the future. There will be changes in the labor market and moreover, the success of cities and places will be less dependent on the strengths of the local labor market (Frick, 2021).

This phenomenon will rise in the next couple of years, a smaller group of society will be digital nomads, but it will definitely be more common and firms will know how to deal with it. Most people will enjoy the benefits of working remote from home because of the flexibility they get through it, they can focus and choose on which work they want to do actually – impartial from their place of residence - and it is less about the travel aspect (Liu, 2021).

*Key findings:* Remote working will eventually decrease commuting in urban areas because a lot of people will work remotely in a company somewhere else then their residence and stay at home or use a shared office in their neighborhood in walking or cycling distance. Remote travelers can be neglected.

### Gig economy

*Gig economy* or *platform economy* describes working project based or concluding given tasks, this can be anything from driving a taxi, editing documents or performing art. There are three components in



the gig economy: First there are consumers or businesses with an order, gig workers who execute this specific task for them and companies who bring those two together which mostly run over digital platforms. Companies like *Uber* or *Fiverr* are just examples for the link between consumers and gig workers and therefore get revenue. The gigs are mostly short term, project based and/or on a freelance basis (N26 GmbH, 2021).

According to the *European Commission* there are around 28 million Europeans currently working in the platform economy and this number is expected to increase to about 43 million by 2025. Within only four years from 2016-2020 revenues from the platform economy expanded from around € 3 billion up to € 14 billion (European Commission, 2021a). A survey of the market analytics company *Gallup* has shown, that in 2017 in the United States around 36 % of all workers have already been involved at some point in gig economy (Gallup, 2018, p. 6). Nonetheless, the data situation on this topic is poor, governments have no idea how many people are actually involved in the gig economy. Only the platforms themselves have numbers, but they do not know if people are working for several platforms, however.

Obviously there are some benefits for gig workers. The main reasons are freedom, flexibility and (extra or essential) money. People can work whenever they want and how much they like. Other positive aspects are the low entry requirements, the chance for better work-life-balance, putting up a personalized working schedule or having gig-jobs as a side hustle. On the negative side, there is exploitation of the gig-workers with often cunning contracts, uncertainty over the order situation, responsibility on paying taxes etc. by yourself, in addition to a lack of insurance, pension savings and sick leave as well as holiday.

After advantages and disadvantages there needs to be differentiated between jobs with low entry requirements like delivering goods and those gigs which demand specific knowledge in the field e.g. coding. With the increase of digitalization, more opportunities for gig workers of the skill-based field will rise even more as the biggest growth is expected in the creative, tech and knowledge-intensive industries.

As the circumstances are precarious e.g. there are no minimum wages, people are organizing themselves to some kind of labor unions together and fight for better conditions. Also, governments have acknowledged that gig workers are not a marginal group anymore and lots of employees are affected by those low standards (Rankin, 2021). The transport sector, not only public transit also delivery services etc., is affected through ride-hailing services. Those ride-hailing platforms work through scale and efficient artificial intelligence programs and have already a certain coverage because of convenience for users. The question remains, whether those rides substitute or complete mass transit in e.g. areas with low density and higher on-demand needs or in order to save trips with private vehicles (Singapore-MIT Alliance for Research and Technology, 2021).

*Key findings:* A lot of knowledge intensive gig work will be done from home in the future, which decreases mobility. On the other hand, people who are dependent on doing more than one side job, which cannot be done from home, will maybe even travel more than before. Looking at the transit services gig economy offers there is a chance to support public transport in areas with a lean network, if the practical implantation is user friendly.

## Distribution of wealth and income

As prosperity is still growing worldwide, there are shifts in income (earnings from employment) and wealth (personal assets like properties, businesses, stock-market portfolios etc.) expected. Especially in Asia the middle class increases and therefore, consumption and travels of the people there are expanding. A growth from around 17 % from 2 billion in 2020 to 3.5 billion people in 2030 is expected there, whereas middle classes in America and Europe are stagnating or even shrinking (Buchholz, 2020). One point to consider is, if with the increasing middle classes in other parts of the world has impacts on the planets condition in terms of pollution and resources.

To understand this development of wages a short historical explanation is needed: Before the 1970s wages and benefits for middle class workers grew equally with labor productivity, since then it is relatively stagnant (Peter G. Peterson Foundation, 2019). Reasons for that cut were the declining manufacturing and production work due to automation as well as international trade which shifted production to low-wage countries. Moreover, in the 1980s, many jobs have been replaced by office computing and the rising productivity there. Those mentioned jobs were all done without academic degree. This means that in the past, people with basically the same education, performed better jobs than today. So former middle-skilled jobs turned into low-wage-occupations (Autor, 2019). Another reason for the rising inequality since the 1980s are political decisions (e.g. Reagan-Thatcher revolution) regarding deregulation and liberalization programs which took away public welfare (Chancel et al., 2021, p. 11).

In 2021 the top 10 % of people regarding income share about 52 % of the global income, the middle 40 % owns about 39,5 % of the total income and the lowest group, which are around 50 % of people worldwide, earn around 8,5 % of the total income (Chancel et al., 2021, p. 10).

Incomes of households and individuals are influenced by various factors like total employment, taxes, wages by industry or population and age, therefore the topic is complex and prognoses are rather difficult. Some influencing variables have already been discussed in earlier chapters, e.g. shift in industries and the rising of health care and social assistance as well as expanding of the working age (Ambrogi, 2020, p. 2). For different socio-economic groups, the composition of household incomes varies. Lower-income household budget consists of around 70 % wages and the other 30 % are from public assistance like social programs (Ambrogi, 2020, p. 4). Therefore, inequality is lower in rich countries.

Another issue which arises with distribution of income is gender inequality: The share of women's total income was around 30 % in 1990 and only increased around 5 % till 2020 (Chancel et al., 2021, p. 16). According to the *World Economic Forum* it will take another 136 years till the global gender pay gap is closing and the share of women and men is 50:50 (Armstrong, 2021). A report from the *Office for National Statistics UK* shows that the ethnicity pay gap is even larger with large differences regarding the countries of origin (Evans, 2020).

Examples for actions to reduce inequality in distribution of wealth and income are rising taxes for high-income people, increasing minimum wages, governments providing equal opportunities in health and education for everyone, end residential segregation etc. Another idea to reduce gaps in inequality is the implementation of unconditional basic income, which creates dispute between experts. Different countries tested for such systems for specific groups, but still no country has implemented it for all citizens. Leading experts in technology like Elon Musk or Mark Zuckerberg expect some sort of

universal basic income in the future, on the one hand due to automation and on the other hand as a result of rethinking social contracts of society (Clifford, 2019).

*Key findings:* As occupations have changed through technology, requirements of workers changed and therefore their income. It is very likely that these patterns are ongoing through further transitions in technology. That is why governments need to provide infrastructure for housing, education, health etc. to reduce the widening gap and to ensure more equal opportunities for everyone. Also, good service of affordable public transportation can counteract this phenomena.

## Mobility

Future mobility will be about connecting infrastructure and vehicles through technology. Achieving this better relationship allows optimal usage of the current network and leads to frictionless mobility between the different modes of transport. For implementing frictionless mobility and offering mobility on demand a few requirements like a cloud-based open system with real-time data needs to be implemented (Roat, 2019).

Further, there will be changes around individual modes of transport towards shared mobility. At the moment, cars are parked 95 % of the time (Ratti et al., 2018) and parking spots cover over 5 % of all urban land in the United States (Overstreet, 2022). Through shared mobility and later on automated vehicles there are unique opportunities to change cities: because of the reduction of the amount of cars and the increase of utilization of cars which are driving around, less space is needed. With this, mobility is evolving slightly away from private ownership to sharing concepts, no matter if it are private cars, scooters or bikes, because people are not using their vehicles on a daily basis rather occasional and due to that, they do not have to deal with insurance, repairing, parking etc.

### Mobility as a Service

The term *Mobility as a Service* (MaaS) gained a lot of attention in 2014 when Sampo Hietanen and Sonja Heikkila together with the *Finnish Ministry for Transport* introduced this concept for multimodal travelling (Smith, G., 2020). For the implementation five levels were introduced. From level zero, where single, separate services are used to multimodal travel planner with price information up to level four where society goals are integrated (van Audenhove et al., 2021).

In the end, passengers can use a single account for everything, to get information and plan journeys, book tickets and pay for them or reserve a seat. The main idea is to provide easy access for all modes of public and private transport (bike, scooter, public transport, taxi, ride-hailing, car-sharing, etc.). Moreover, users can choose cost, time and convenience when they plan their journey and the goal is to get people away from private (car-)ownership and to give them the freedom to choose their mode of ride depending on the individual situation e.g. cycling to work in the morning to wake up, taking public transport after work to get to the store afterwards because it started to rain, in order to rent some extra chairs for the dinner party on Saturday and taking a rental car to bring them home.

A lot of implementation projects are going on right now on a private as well as on a governmental level, yet there are some barriers. Currently apps and services appear and disappear on a daily basis. In some cities like Helsinki MaaS is known under the name *whim* where already around 70.000 users are registered, but the big breakthrough, the ultimate product/solution is still missing (Hartikainen et al., 2019, p. 10).

In fact, there is much going on in this field and a lot of money is spent on studies which provide promising numbers for the upcoming years. Latest studies estimate a rapid growth within the next few

years and include big players e.g. *Uber* and *Daimler* like the forecast published by *Technavio* in March 2021. They expect MaaS to grow £ 235.00 bn between 2021-2025 (Technavio, 2021). Another study from *Emergen Research* estimates a revenue of about \$ 523.61 bn for 2027 (Emergen Research, 2020).

On the regulation and framework side also a lot of significant progress happens (e.g. the *European Union* published a report: MaaS – A digital roadmap for public authorities) although with another speed and with a different budget. In order to strengthen public transport, public authorities need to push this topic forward or inverse operators have to push the authorities to set an inclusive, competitive framework, otherwise private stakeholders with e.g. cars and scooters overtake public transit in cost, time and convenience. If those private stakeholders are interested in including operators in their service, operators should have a fundamental basis for negotiation. Especially, when autonomous vehicles are ready to operate fully they will be a competitor for public transport (Crozet and Coldefy, 2021).

*Key findings:* As almost every day new MaaS providers and applications are popping up, the competition is ongoing. At some point one service will break through or one provider with a lot of money will determine the race either worldwide or in specific areas. For transport operators this breakthrough will start a new era, because then a big group of users will be convinced by the service and the possibility of accessing mobility easily and MaaS is not going to be a niche anymore.

### Micro-mobility

One big part of MaaS and its concept is to get from door to door. With the help of micro-mobility the first-mile/last-mile from the station to the final destination should be easy to conquer. The definitions for micro-mobility vary a little bit. What it is clear, is that micro-mobility is not suitable for sidewalks where people are walking (except really slow ones e.g. for personal assistance) nor on streets where vehicles drive, which ends up with bicycle lanes. Other criteria can be speed maximum, human-powered or support with electricity, docked or dock-less, which mostly means (shared) e-scooters, bikes and pedelecs (Zarif et al., 2019).

An open issue is the regulation of the public space, currently dock-less e-scooters are parked on sidewalks, bike lanes and in many other places where they are not supposed to be. Cities are forced to develop ideas (together with operators) to solve this problem. The municipality of Copenhagen e.g. has banned e-scooters in the whole city in 2020 and allowed them again in October 2021 with strict rules and high fees on parking violations (Iotkovska, 2021).

*Key findings:* The importance of micro-mobility for making future cities CO<sub>2</sub>-neutral and shifting current car-trips to public transport in combination with such a first/last-mile solution is high, although what it will look like and the regulations are still a bit fuzzy.

### Connected and autonomous vehicles

Autonomous driving, or in a more technical term connected and automated vehicles (CAVs), is one of the most intensely discussed topics in car industry and a game changer in many ways: It will lower emissions, vehicles will drive more energy efficient, traffic flow and safety will increase and ownership patterns will change. Moreover, CAVs can go around 24/7 (except charging times) which leads to full utilization and huge spaces from stationary traffic can be transformed in to public space (Mitteregger et al., 2021, p. 29).

There are six levels of automation from level 0 (no driving automation) to level 5 (driving fully automated). Until level 2 drivers are completely in control of the vehicle and get assistance e.g. line

centering, which is already possible today. From level 3 on, vehicles can steer themselves under certain conditions. With reaching level 5 the vehicle is able to go fully on its own in every surrounding. (SAE International, 2021) Several studies expect a growth of individual mobility with increasing levels of automation, because new user groups of people which are not able to drive themselves are reached (Mitteregger et al., 2021, p. 206).

Currently, CAVs are in the early stage of development and testing procedures are in progress. A big range of experts from different disciplines beginning from sociologists to hackers are included in those development processes, as there are still a lot of open issues e.g. ethical questions in case of emergency and the decision over life and death and complex environments. Some separated test-sides with robo-taxis e.g. in New York or in China will have CAVs within the next couple of years, but a full roll-out, where one can sit their kid in a self-driving vehicle, which will bring it to school, is not expected before the 2030s. Moreover, CAVs will still be expensive at this point, Necmiye Ozay, an associate professor of electrical and computer engineering at the University of Michigan says (Cusack, 2021).

As a preparation cities will need to adapt in order infrastructure and communication between different vehicles (CAVs and buses, light rails, metro etc.) operates smoothly and moreover, CAVs are still individual means of transport and will not be the ultimate solution to get traffic flowing and need more space than other modes of transport and therefore, are not capable for mass transit. Light rails and metros will still transport most people between the main points of infrastructure and connect facilities: infrastructure, educational, lifestyle or culture e.g. between the city center and university campus (Powell, 2021). Moreover, short distances should be covered by active modes of mobility and in order to manage the transformation of the transportation system a well-thought-through political framework builds the base for bringing CAVs in cities (Mitteregger et al., 2021, p. 22).

*Key findings:* If implementation of CAVs in urban areas is fully completed and they are used for on-demand-rides, special needs etc. it is a big chance to offer added value to an inclusive mobility system, if not, problems like traffic congestions will stay the same.

### Super commuting

Definitions for the term super commuting vary. The one of the *U.S. Census Bureau* defines the term via time: extreme commuting (travelling 90+ minutes to work), long-distance commuting (travelling 50+ miles to work) and mega commuting (travelling 90+ minutes and 50+ miles to work) (Rapino and Fields, 2013, p. 1). Notwithstanding, there needs to be distinguished between daily and weekly or even monthly commuters.

A study about long distance commuting in Australia shows, that people are not only commuting from rural areas or suburbs into major cities, but also from one metropolitan area to another by taking the plane or high speed trains. This specific socioeconomic group of people has high skills with mostly an academic degree and is highly geographically mobile (Silva et al., 2011, p. 16). Example for this specific group would be delegated persons of the *European Union* who travel between their home country and Brussels. On the other hand, there are people with no/lower skills who cannot decide if they would like to commute or not. One reason for super commuters are housing prices in metropolitan areas such as New York or Los Angeles, where people of lower income spend hours on the bus because they simply cannot afford housing there. In these expensive areas, the number of extreme commuters is constantly rising. Mostly people even live within 30 miles of their job, but public transport services are deficient (Kolomatsky, 2021). Another reason are certain professions like construction and mining

workers, social assistance and care or tourism where people are needed for a specific time at a particular place.

Since working from home for a couple of days per week and working almost fully remotely are getting more common, more people are taking super commuting into consideration in order to improve life quality and afford housing. Moreover, better trains with stable Wi-Fi-connection allows people to work while commuting, whereby the legal framework is not yet clear everywhere.

*Key findings:* Impacts on mass transit in urban areas through super commuters of high income groups are relatively low, whereas extreme commuters of lower income groups who spend more than 90 minutes per direction to work on public transport can eventually rise because of growing metropolitan areas and increasing housing prices, which forces people to work and live in different parts of a city.

### (Unpredictable) events

Something which cannot be considered as a megatrend, nevertheless is also defined as a life changing happening – worldwide or for a certain amount of people – are unpredictable events. Terror attacks, wars, pandemics, blackouts etc. are events which are often considered as *unpredictable* are in most cases quite predictable albeit in different ways. That is why futurology is about *wild cards* which have a low probability of occurrence but are likely to have a high influence on everyday life (e.g. pandemic or discovery of a new source of energy). There are six parameters which have to occur, that certain events are so called wild cards: it has to be a particular event (occurs once), not reversible, with a high impact on society, low probability (within the next 50 years – which is a common time frame in future foresights), imaginable (even if it is not predictable) and they can be positive or negative (Fergnani, 2021).

Immediately after the event people tend to change their behaviors because of external circumstances and a different psychological safety perception e.g. after 9/11 a lot of people thought taking the plane would be risky and took the car instead. This shift from air to the road caused a lot more accidents and deaths on the road than the actual attack. Something similar with a positive effect happened in London 2005 after terror attacks in the metro more people switched to cycling and the share on cyclist increased (Litman, 2020, p. 7). Still long term observations on commuting from *Georgia Tech* show, that crisis like earthquakes or 9/11 have short term effects on commuting choices, but after some time, everything went back to the original behaviors (Badger, 2021).

Events which are more likely and imaginable to happen in the future are black outs and cyber-attacks, either worldwide or in particular cities or regions. Recently, *MTA* in New York City or *Nottingham City Transport* were victims of cyber-attacks. Smaller attacks happen nearly on a daily basis. Therefore, operators are faced with setting precautionary measures on their IT-systems because someday an attack will happen. The big questions are when, where and who will be affected by it. One reason as to why transportation companies are so interesting is customer data beginning from payment information to route choice (Fosu, 2021).

*Key findings:* *Unpredictable predictable* events can hit transportation in many different ways and, there is no ultimate solution for protection. What transport operators can do is setting up resilient IT-systems, secure safety measures against terror attacks, brace for black outs and quick reaction in case of emergency.

## Conclusio Megatrends

To sum it up, megatrends which are already happening on a global scale can be distinguished in two main categories: On the one hand, there are some slower, steadier megatrends like demographic change and urbanization which influence the transport sector over a long timescale. These transformations are rather foreseeable. On the other hand, there are megatrends which are more dynamic and can change the world as it is known within a few months or even days completely. For example, climate change with its extreme weather events or new technologies which are developing faster than ever can change work life radically and therefore, can affect economic stability. It is more likely that disruptions occur in the second category. So the key challenge, especially for decision makers, is to build up resilient systems and constantly adapt to the challenges society faces.

Moreover, a lot of these megatrends overlap and occur differently depending on the city, culture and time. What is clear is, that through improved technologies people's daily lives changed over the past years and therefore, they started to organize their lives differently. Especially the connected world, where servers and clouds at the end of the world make it possible to start a business, which further leads to major changes in the way work environments are arranged, defines everyday life now.

For the transport sector this means, that people are either using different mobility services and/or ride less because of different offers like delivery services or working from home. Moreover, not only the amount of trips has changed, also the competition on the market heightened. New cloud-based technologies made it possible for services like ride-hailing, renting etc. to enter the market. Earlier, public transport did not have as many combatants. People now have the ability to choose between different offers every second. This freedom makes it possible to choose the best offer in every individual situation depending on price, CO<sub>2</sub>-emissions, time, space, comfort etc. Those dynamic market developments will lead to further changes in the mobility sector.

So nowadays there is a greater competition around customers in the transport sector than ever before. The slightly declining numbers of passengers in public transport shows that already and so action needs to be taken. Otherwise, these numbers are dropping further down. In order to fully participate in this competition, it is necessary to know why people prefer other options than public transportation. Talking about people, there is not such a thing as "the people". Passengers are a diverse group, where everyone has different needs and requirements. This various target groups must be taken into account. Some of those groups are already studied better than others, but as almost every person is a potential customer for public transport operators, there is a lot of potential to pick up new passengers.

## 2.2 Recent developments and ideas

Breaking these megatrends down on a more tangible level for transport, some operators, governments and financiers already know that changes need to be made in order to move on and make public transport more attractive for commuters. This chapter focuses on ideas which are currently in the pipeline or already being implemented. Further, there are some aspects which already exist in some countries or cities and have the potential to roll out. Some of them are smaller changes, some are more significant, but they are nevertheless making public transport experiences attractive, especially for new customers.

### Hygiene-standards

In pre-covid-times masks were already widespread in Asian countries like Taiwan or Japan, they have a long (cultural) tradition there. It is common to wear them in public transport or in public spaces to protect other people (e.g. when they have a cold and they do not want to infect other passengers) or to protect themselves from air pollution (Jennings, 2020).

Another aspect for increased hygiene is reducing the number of surfaces which riders must touch in order to use public transport, whether during the payment process, checking in at fareboxes, elevators or doors which automatically open. There are various systems like touchless push buttons or ultraviolet light to disinfect surfaces (often used at airports and hospitals) which kills bacteria and viruses. Moreover, air ventilation systems in vehicles are improving constantly with air cleaning and filtering systems, air condition and temperature control systems.

### Real-time data

As static time schedules are getting outdated, people are using their smartphone to keep updated regarding the latest travel information and adjusting their trips. Especially when travelling, multi-modal, real-time data to rely on is a key aspect for riders and operators.

In urban areas, especially in inner cities, users expect high frequency, they do not even look at schedules, because the next train is arriving anyways within a few minutes. Whereas in smaller cities people are reliant on information with real-time data e.g. to know when the next bus arrives and if they need to hurry up, otherwise they have to wait 20 minutes (Jaffe, 2018). It is even more important for operators to collect real-time data in order to get better in analyzing and prognosing future utilization by means of artificial intelligence for planning their services efficiently and providing enough capacities.

However, if people do not use public transport that often and want to avoid crowds and, moreover, have the ability to choose when they ride, using real-time data to see the degree of capacity utilization can be convenient. *Transport of London* has already implemented some kind of similar service in their travel app *TfL Go* where they show how busy London Underground stations are throughout the day (Intelligent Transport, 2021). For implementing future applications like [MaaS or autonomous driving](#), real-time data of public transportation will be a fundamental component (Stone, 2020).

### Flatten the curve

Currently, most people work in a typical nine to five job, which means they are leaving their homes in the morning (7 – 9 a.m.), commute to town and leave their offices either at lunch time or in the evening (4 - 7 p.m.), which leads to high amounts of traffic and congestions. The time frame varies from city to city. In some European countries where people work part time and school is also only half a day, there is often a third (weaker) rush hour around midday. Public transport and also motorway operators



dimension their infrastructure in relation to these maximum capacities, mostly paid by taxpayer's money. This high amount of traffic occurs about 4-6 hours a day, the rest of the day buses are empty and trains are not fully utilized. A lot of times these vehicles even stand around (Badger, 2021).

If the amount of people in traffic would spread over the whole day infrastructure would not need to be designed for the rush hours anymore. This means less vehicles and drivers are needed, which will further lead lower costs for everyone. Of course, there will always be peaks e.g. at the end of a big sport event like Super Bowl, when people are in the city and go back home at the same time (König Jerlmyr and Ratti, 2020).

Utilization on short trips in public transport in a city is a bit harder to plan as e.g. on long distance train journeys were people book their tickets in advance. Nevertheless, transport operators have data about expected utilization and should somehow communicate that in their fare rates and timetable information like *Google* is already doing it, with showing in *Google Maps* which lines currently have a high number of passengers from transit data they generated in the past (Nagarajan, 2020).

There are lots of ideas how to tackle peaks, several cities tried different methods such as dynamic pricing for public transport or incentives also in road traffic because lower amounts of traffic increase safety and improve life quality for citizens in the streets. With a more even distribution of passengers reliability rises, because points of conflicts get reduced (less crowded stations etc.) and a better service quality with fewer vehicles can be guaranteed.

### Mobility pricing

One idea of dynamic pricing is, that tickets during rush hour are more expensive than between 10 a.m. and 3 p.m., which can be an incentive for employees (e.g. one can attend an online meeting in the morning and go to the office at 11 a.m.). Therefore, the prices for owners of weekly/monthly passes get calculated automatically depending on the time frame they are using public transport. Especially for elderly people and tourists who can choose their time, this should be an incentive to avoid rush hour.

For example at the *LIRR* and *Metro-North* fares in New York City they are charging peak fares, which means that people pay an additional fee for riding between 6 – 10 a.m. and 4 - 8 p.m. (Metropolitan Transportation Authority, 2021). In the Australian state of Victoria travelling before 7:15 a.m. is free for people who own a public transport pass, this feature is called *early bird train travel* (Public Transport Victoria, 2021).

For equity reasons there must be a distinction between different socio-economic groups and occupations, people often cannot choose when they work, because there are e.g. shift workers in the warehouse or teachers. They need to take public transport during rush hour and it would be unfair if they had to pay the highest price. Therefore, some kind of discount which is based on professions or household income is necessary (König Jerlmyr and Ratti, 2020).

A Swiss study suggests solutions for “*peak spreading*” on different levels of responsibility (governmental authorities, public transport operators, companies etc.) like home office, online shopping, carpooling, spatial planning – mixed use, shifting school schedules, flexible opening hours for childcare facilities and shops, forecasts on utilized capacities of trains and busses, substitution to other means of transport like cycling or walking, tariff measures, congestions pricing etc. All those ideas have been measured on costs, effects and their potential for implementation (Gmünder et al., 2016, pp. 34–39).

Benefits of a more consistent distribution of riders over the day would bring better services off the peak times, wherefore especially people who rely on public transport would win (Badger, 2021). Further, people who avoid public transport now because of crowds may find it more comfortable if it is not that busy anymore.

### Smart ticketing

In order to make systems like dynamic pricing easy and convenient, smart ticketing with automatic pay off will help. E.g. the *Oyster card* in London already works with a “pay as you go” system: People check in and out at fareboxes, which means customers do not have to think about which ticket is the cheapest and fits their travels, the system chooses the cheapest option at the end of each journey. Meanwhile a lot of users have replaced their *Oyster card* by bank cards or by contactless paying with their smartphones. As this is (at the moment) not possible for everyone, the typical *Oyster card* will stay in order to tackle the widening gap of digital poverty and inequalities (Low, 2021).

A similar ticketing-as-a-service system which works app-based and contactless is *Fairtiq*, where customers check in and out on their smartphone and the system recognizes the chosen route, transfer points and calculates the cheapest price at the end of the day. *Fairtiq* is currently rolled out in Switzerland and some areas in Austria and Germany. In the future an automatic check out will be possible (Manniello, 2021).

As existing cities grow together, city borders will disappear and agglomerations are getting bigger and customers who travel from e.g. their suburb into the city center are not interested in which company operates which trains and where zones end, they want to rely on the fastest connection and a fair price which will be calculated at the end of the day/month/year. Therefore, those systems mentioned need to function frictionless. Stefan Carsten, mobility expert, outlines that these technologies like smart ticketing should already be the norm in order to make public transport attractive for the future (*Städte für Menschen*, 2021, 22:40–23:22).

### Safe and inclusive

When talking about making public transport more attractive, certain groups (women, people with reduced mobility, elderly people, ethnic minorities, BIPOC, LGBTQI people etc.) need to be included. Those people currently avoid mass transit for specific reasons and often get upstaged in the planning and design process because of a lack of participation and/or missing awareness from providers (Bettati et al., 2022, p. 2).

The particular groups are typically not using public transit because they feel not comfortable or even in danger. This has several reasons such as violence, harassment, lack of navigation and infrastructure like elevators or personal assistance, not enough space etc. Especially at off-peak hours respectively nighttime, people feel unsafe or simply cannot get the assistance they would need to e.g. enter a train. Carriages with security service or at least with tools which allow customers to stay in contact with members of staff would help people to feel safer (Bettati et al., 2022, p. 4).

Another reason for not taking urban mass transit is a lack of space for wheelchairs and baby carriages or, moreover, gaps and stairs which cannot be passed. Further, injured people or persons with luggage are affected by those deficient infrastructures. According to the *UNFPA* worldwide, over 46 % of the people 60+ are disabled in some way, so there is an urgent need to make public transport more inclusive (Guzmán et al., 2012, p. 61).

Aside this visible physical disabilities there are non-visible or hidden disabilities which are influencing everyday life of people such as autism, autoimmune diseases, mental health conditions, diabetes, cancer etc. Family resources survey 2018/19 from the United Kingdom shows that around 21 % of the citizens have an impairment (Department for Work and Pensions, 2020, p. 7).

The design of vehicles and also stations should fulfill those people's needs, so everybody can participate in public transport. Especially the technical part can be solved relatively easily, when stations get adapted or vehicles get replaced.

### 3. Methods

After looking at developments in megatrends and their current status, a closer look in how individual mobility needs of passengers are influenced by those changes was taken. The described megatrends have all different kinds of impacts on mobility. In order to find out, which factors are driving future developments, a distinction between factors which are the same across all scenarios and those, which have individual effects on the different scenarios, has been made. The first factors, which are the same in every scenario, can be classified as quite secure. They occur anyway without special events like the demographic change and its aging society. The second ones, also called key factors, can develop, depending on the scenario, in different directions and further, can be influenced by various stakeholder e.g. the vehicle designers or operators (Gausemeier et al., 1995, p. 217). To give an example: Mobility as a Service, in one scenario it could be the case, that everyone is using this service, whereas in another scenario, there is no MaaS existing anymore, because a new product replaced it. So the future of those key factors is rather uncertain, which makes them so important in scenario planning.

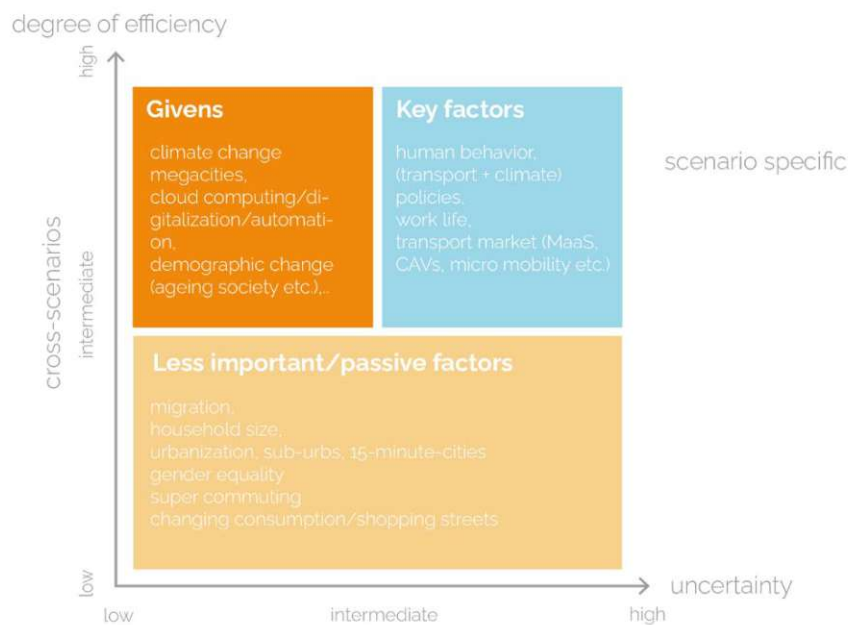


Figure 5 This diagram pictures the classification of the key factors, which are defined with a high impact and a high uncertainty. (own diagram)

A first approach, to identify those key factors was, asking students from the master’s program spatial planning at Technical University Vienna, who attend the specialization lecture *Mobilität und Mobilitätsmanagement* (280.899) about their expertise and assessments regarding the importance of the factors. On a scale from one (low influence) to five (high influence) the students rated their assumptions and had the chance to point out missing key factors and issues. The results can be found in the appendix.

The second approach to find those key factors, was analyzing and/or conducting qualitative interviews with experts in the field of public transport and railway as well as from other sciences. The main task was to find key drivers for the future of the public transport industry. To find out what people from their field of expertise think is majorly important for the further development. The sources for the interviews vary, most of them have been conducted by *C Space*, a customer agency, on behalf of

Siemens Mobility. They have an expertise in the field of market research and work in communication and consulting. Another source is a recently held webinar from *RAIL magazine* on 31.03.2022 about Reimagining & Rebooting our Passenger Railway: The Passenger Experience.

The outcomes of the students discussion as well as those from conversations are the final key factors, which were taken for the scenario building in a later step. Some factors from the chapter of megatrends have been combined or extended by thematic related topics, which were not addressed in depth or not addressed at all, but the students and/or experts missed them.

Each one of the four key factors has been described more in detail and supplemented, with different characteristics of the factor, further research in literature and aspects from different perspectives and interviews (Gausemeier et al., 1995, p. 228). Based on that potential paths of development, where opportunities and threats have been displayed and a morphological analysis after Fritz Zwicky have been conducted (Schawel and Billing, 2011, pp. 132–133). This morphological analysis pictures a multidimensional matrix, sums up the main outcomes and the different forms of the features and shows how different possible characteristics affect the development of the key factor. For example taking the key factor (Public) Transport Market (Supply Side): In the morphological analysis of this chapter, one main point are CAVs, which can develop in several directions, either the technology stays the same as today (level 2 or 3) or level 4 or level 5 will occur or they even disappear completely. In the morphological box this procedure needs to be done for about 5-10 features (Ritchey, 2002 (revised 2013), p. 3).

Afterwards for each key factor two or three possible projections were developed out of those features from the morphological analysis. The idea was to develop the directions of those projections as consistent within the projection, but also as different as possible between the three paths (Gausemeier et al., 1995, pp. 240–241).

## Methodological Sequence

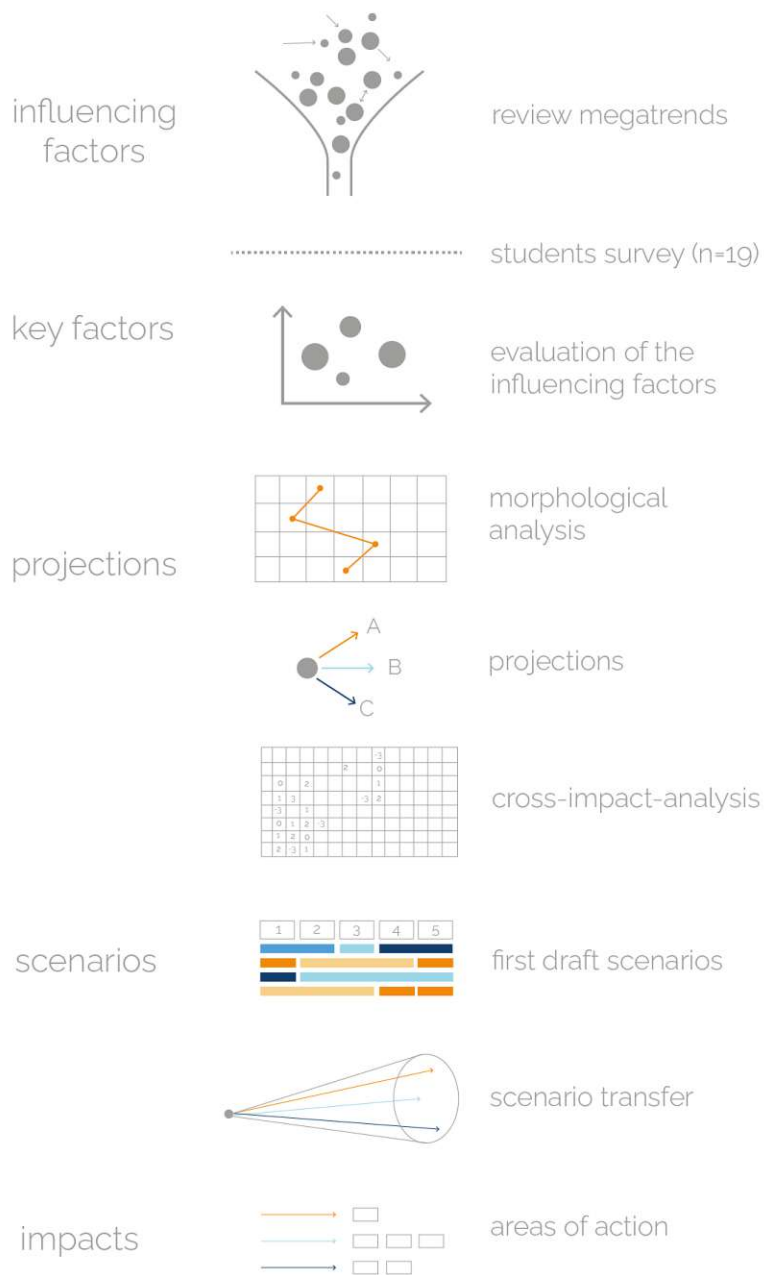


Figure 6 Methodological sequence (own diagram)

### 3.1 Key factors

As already described in the introduction of the methods, one approach to select key factors or respectively to reduce key factors was to use students (n=19) to discuss the megatrends and state missing issues. The result of ranking the megatrends on a scale from 1 (low influence) to 5 (high influence) were summed up and the average was calculated. Megacities and the 15-minute city had the highest average of 4.7 followed by Mobility as a Service and automation with 4.4. Decarbonation 4.3 was on the fifth place, just before connected and autonomous vehicles, suburbanization and digitalization with an average ranking of 4.2.

Factors were seldomly rated to have low or zero influence, which shows once more how connected developments in working, commuting, technology and society are. Nevertheless, the area with the lowest ratings was demographics: migration, household size and gender equality were rated below 2.8, only the ageing society was assessed a little higher with 3.4. Out of this, it can be concluded, that this factor can be considered as given and is the same across all the different scenarios.

Terms which have been mentioned as missing can be clustered in areas like the attitudes of individuals (openness to technological ideas, behavior), globalization, blackout, affordability of public transport, democratic development, the political sphere and regulation level was one of the most mentioned areas (international and national politics/political treaties e.g. silk road China), besides the influence of companies (power dynamics, politics automobile industries, lobbying and its regulation) and drive technologies (power dynamics, potential of e-fuels). Another topic which came up was climate change regarding the environment in the city (e.g. heat), public transport as cool places, safety, pushing forward cycling as well as the higher costs for car users (parking, driving, congestion fees, car free cities etc.).

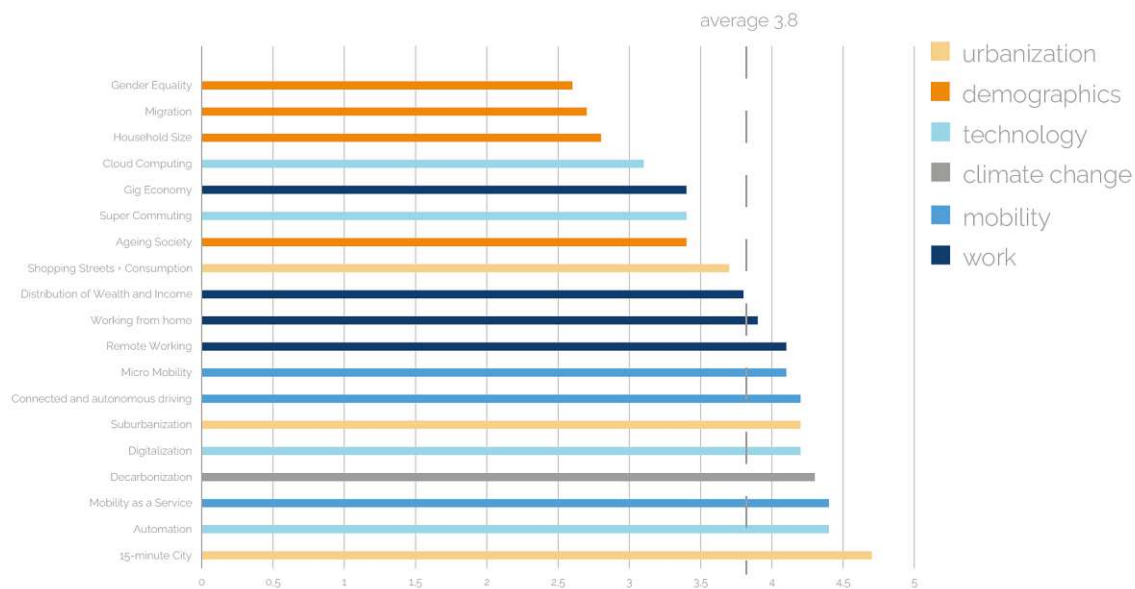


Figure 7 This ranking shows the rating of the students. The colors of the bars should help to understand, which megatrends have higher impacts on travel patterns in the future, according to them.

Some of the open issues have already been discussed in the thesis like the risk of a blackout or affordability, but due to limited time in the little workshop I did not introduce those to the students. Therefore, only new aspects were researched more in detail in the further process.

After trying to minimize the number of megatrends to the most influencing factors, I recognized, that some of them are too narrow and therefore, not suitable for the ongoing process. A slightly broader perspective is necessary for describing the possible directions of development and modeling the scenarios. Therefore, the most influential factors – regarding the ranking - have been put together in thematic groups or clusters as key factors.

These results should be regarded with caution, because the students are only in the beginning of their career as urban/transport planners and might have a different perspective than professionals.



## Key factor 1: human aspect (demand side)

Under the buzzword “the human aspect” different views of people and about people were summed up. On one side, there is the attitude of people towards all the different types of mobility, their narratives, their travel patterns as well as their needs and requirements on public transport or respectively to all modes of transport. On the other side, the perspective of operators, politicians, the industry and how they see humans or more specific passengers and work with them has been taken into account.

### Affinity towards mobility

In the following subchapter the attitudes of individuals, but also of specific groups, towards different modes of transport and services have been considered. Different personas, which are built on household incomes, social norms and narratives, age etc., have diverse opinions on public transport and further, new forms of mobility. With the help of studies, which have analyzed those target groups in detail and built up personas profiles, complex behaviors and shifts in mobility can be better understood.

### Target groups

What distinguishes passengers from usual customer target groups in marketing and strategies is, that unlike for the most e.g. products, target groups are limited to certain socio-economic or age groups. In the public transport sector the goal is to make it possible for everyone to use it, regardless of income, physical or cognitive disabilities or age group, because everyone has needs to fulfill like accessing health care, education, shopping or culture (Lang, 2022).

Given this wide range of people and needs, it is extremely complex to offer public transportation services which suits everyone. On one hand, it is necessary to plan for the bottom of the pyramid, transit consultant, Jarrett Walker, states. Particularly, this means taking a look of the less wealthy which cannot make pluralistic decisions. Those people e.g. rely on punctuality of public transit because they live in a more objective time with time scarcity (Walker, 2021).

On the other hand, there is the quote from Enrique Peñalosa, the former mayor of Bogotá, “An advanced city is not where the poor use cars, but rather one where even the rich use public transport”, which emphasis that there is ridership potential in every group (Peñalosa, 2013, 0:50-0:58). No matter how people are grouped in the research, planning and design process, the goal should be, that people should be proud to use public transportation, and it should be self-understood to travel with public transport, where no cycling and walking is possible and consider all other modes second. However, the main focus should be on creating an equal transport opportunities for everyone and therefore, it is necessary to plan for the weakest first.

It takes sensitivity to know who the passengers are. There are several studies and researches of personas in public transport, which are exploring those individual needs in detail. As this topic is quite large, for the following thesis a delamination has been taken, which Elisabeth Oberzaucher, a biologist with a focus on the evolution of humans and behavioral science, has brought up in the interview. She says, that it is not really necessary to look at what distinguishes people, but rather at what all people have in common, because a) long term basic needs like comfort do not change – they are deeply grounded in humans evolution biology and b) it is difficult to separate people into different personas and groups, because in every hour of the day other people use public transport and have other requirements. Moreover, vehicle in metro and railway are typically used 40 years more and therefore, it is not wise, to invest in short term trends (Oberzaucher, 2022).

Long term people's basic needs for comfort do not change, they have developed over thousands of years and it is enough (first this state needs to be reached) to focus on people's overall needs first. This also means investing in barrier free inclusive design, from which everyone can benefit, as physical conditions can change overnight.

It can make sense to distinguish in different target groups and their preferences, when gaining new customers and picking people up at their status quo – but this topic is more relevant for marketing experts e.g. to get people's attention and know their preferences. Moreover, people are more easily changing their travel behavior, when they are in a life-changing situation, where new habits are built like after graduation, when moving houses or when starting a family.

A study which examined this topic of mobility attitude groups in order to identify the group's specific needs, constrains and travel preferences has been conducted by the London School of Economics and the Innovation Centre for Mobility and Societal Change Berlin. Travelers were distinguished in six different groups: Traditional car-oriented (driving is highly rated, medium – high age, higher income, lives in the outskirts, not amenable for new offers like apps, electric cars etc.), pragmatic transit skeptics (high age, lower incomes, does not like technology, uses either public transport or own car, main aspect is convenience), green travel oriented (prefers sustainable modes, low car ownership rate, medium to higher age, low income, located more centrally in the city, responsive to social norms), pragmatic transit-oriented (rates public transport high, medium age, low car use, less affinity towards technology), technology focused individualists (loves to be autonomy, enjoy route driving, cycling and using the latest technology, younger, high income, not responsive to social norms, higher car ownership rate) and innovative access-oriented (well aware of transport alternatives, uses digital technology, younger, high incomes, low car ownership rate, strong amenable to new travel modes and services) (Rode et al., 2015, pp. 3–4).

### *Peoples values*

Understanding people's values, social norms and their affinity towards sharing economy, privacy, ownership, technology, individual modes, climate change and environmental awareness etc. can help to get to know future riders better and to create an offer that suits customers wishes. E.g. it can help to understand the willingness to use combined offers like a smart card for public transport and sharing offers.

### *Affinity towards sharing*

Under a Horizon 2020 project of the European Union a comparison of different studies about people's affinity to participate in the sharing economy was conducted. The outcomes of the studies indicated similar motives to participate: One was money; either people participate to generate income or save costs through sharing. The second motive is more social driven and about community, bonding and participation, whereas normative motives were about altruism, sustainability and environment. Of course these classifications vary and some are more in detail and divide in intrinsic and extrinsic motives and it has to be said, that in this case different kind of sharing (goods- and service sharing) for several fields (mobility, food, accommodation) were considered (Andreotti et al., 2017, pp. 13–14).

One of the main findings is, that the affinity and (non-)participation is different among sociodemographic groups. There is a kind of *participation divide* and sharing has more offers for wealthier, educated citizens than for lower income groups who would benefit more (Andreotti et al., 2017, pp. 30–31).

### *Privacy*

When talking about people's privacy in public transport, one main idea is, how humans want to share their spaces in a bus or if they prefer taking their own car or how the surrounding area should look like e.g. seat design. The other idea, which is already important, but which will be focused on more with IoT will be data privacy. The first question which arises here is, whether privacy will be a more valuable good than ever before or whether it will be self-evident to share all aspects of life (health, income, consumer behavior, travel routes etc.) with the world. The second one is, whether individuals are even in the position to make decisions about their data and what happens to it or not. This choice and the required actions is in the power of policy makers, who are responsible for the necessary legislation. For simplicity reasons the topic is ranked in low priority – misuse of power (from companies, governments etc.), transparency, high priority – self-control from people's perspective.

### *Summary*

To sum it up, there is no such thing as an end stage in transport for humans. Needs of society and culture and requirements are constantly changing and the planning and design process is always adaptable. Therefore, it is necessary to constantly observe the taken measures and monitoring needs to be done: What works well? What can be seen as lesson learned? How can xy be done better?

It is important to shape an environment where people feel like they can use their time wisely and feel comfortable, especially when public transport is a choice - they can choose if they want to work from home or in the office or use other modes – everything has to be done, to make the public transport system as attractive as possible. To sum it up, people's affinity towards different aspects can go in contrasting directions. Sometimes it is intrinsic and goes along with deeply rooted values, whereas other human aspects are just reactions from what is happening around them – either positive or negative.

Morphological box: Human aspect (demand side)

feature	forms				
values and attitudes	hold on		wind of change		
ownership/possession	important		post material		
resources (money, time)	lots of money & little time	lots of time & lots of money	little money & lots of time	little time & little money	
affinity towards technology and digitalization	low		medium	high	
peoples attitude towards public transport	open minded, curious for innovations; access-oriented	anxious regarding public health; transit skeptics	technology focused individualists	convenience and pragmatic transit oriented	environmental awareness - green travel oriented
affinity towards climate crisis & consciousness	low	medium	high – urgency	high - voluntary	
affinity towards individual modes	importance of freedom and choice		less important		
personal privacy	transparency	low priority – misuse of power		highest priority – self-control	
affinity towards sharing (shared mobility)	instrumental motives (monetary, convenience etc.)	socio-hedonic motives (community, fun etc.)	normative motives (altruism, sustainability etc.)		
world view	egocentric		solidary		

Projections: Human aspect (demand side)

	Projections		
	A1	A2	A3
title	Open and aware	Anxious - privacy	Per duty
short description	People are aware of the environmental necessity of switching to less polluting modes and are open to new technologies and innovations. They try out new modes, new vehicles, new services etc., which smoothens operations	People prefer individual modes like the car or bike and try to avoid public transport because of health issues and the face-to-face interaction with other social groups They are not open to technological innovations.	There are simple no other options than using public transport because of the true costs of cars and the political forces. Due to rising economic inequality and the dramatic consequences of the climate crisis, there is a high urgency to act. This leads to a strong increase in the usage of public transport.
People's mindset	curious and open minded customers	anxious customers regarding public health	customers have to switch per duty, they not really want to
strategy of operators	operators try out new modes, different services	operators are not fulfilling the rising hygienic requirements of customers	operators try to use all capacities they have to keep the overloaded service running
resources	customers have time and money	customers have money	customers are short on resources
travel behavior	decisions are made individual depending on the context of the situation	people having their habit and do not want to adapt to new structures	resistance against public transport in the beginning, after some time it is normal
digital services	high importance – to check the best option for each context (price, availability etc.)	are not that necessary, because people rely on their individual vehicle and digital services are only used to avoid crowds	are highly important to steer people and give them the opportunity to find the best connection

## Key factor 2: work life (demand side)

The following chapter of future work life has been already explained extensively in the section of megatrends. Therefore, going further into detail is not really necessary. Nevertheless, a few open issues around physical spaces, commuting and working hours were left, and have been elaborated.

The main development will be a shift of tasks from the “analog world” in the digital sphere, simple tasks which are currently done by humans can be overtaken by computers and will be automatized. Moreover, through the connected world, it will not be necessary to go everywhere in person e.g. a construction site visit can be done from one person who records everything there and the other engineers can experience the situation on site via VR-glasses. Further, lots of jobs will be gone completely, and new ones will be established.

### Physical spaces

Expect some places like hospitals, institutions, construction sites etc. where people have to be physically present at a certain level, working environments will transform somehow. In the description of megatrends, concepts like co-working spaces, working from home and similar ideas were already explained briefly. If offices still exist in 2050 as they are known today, their main purpose will be to function as a central space for social interaction and activities without allocated desks and rooms. In a more regressive future people use offices the same way as now. This can be related to trust issues that employers have in relation to their employees or because people have a lack of infrastructure at home (no separate room, no desk because of housing prices or similar) and in their surrounding neighborhood. On the contrary, no offices will exist anymore in physical space, but only in virtual spaces.

Moreover, in a more connected world physical tasks can be automated and controlled from other places and therefore, depending on the field of work, it might even not be necessary to commute, because people can send out orders to robots and control things from home or the company and so fewer people have to commute.

### Working hours

Between the 1880s and 1940 the length of work days decreased. From 10 hours/6 days per week, to 8 hours/6 days per week till 8 hours/5 days a week, in the last 60 years there was no further decline, but regulations for holidays, sick leave etc. were introduced (Costa, 2000, p. 158). Nonetheless, technology has improved labor rapidly and machines made (work) life easier over the past decades, so the question when the next decline in working hours will occur can only be a matter of time.

Several studies and projects have already proven that working over six hours does not lead to more productivity and a better output, this phenomena is described as Parkinson’s-law, which means the more time people have for certain tasks, the more time they need, because they do not work efficiently (Glaveski, 2018). Beside employees satisfaction and health rises with declining working hours (Lufkin and Mudditt, 2021).

On the contrary, it is also possible that humans have to work more in the future, especially in western societies, where the [population is aging](#) so fast. Those countries depend on migration and workers from abroad. If this integration and transformation are not succeeding the work needs to be done by those few(er) people who are able to work. As written in the [chapter megatrends](#), a lot of technicians are needed for installing renewable energy or taking of health care jobs etc. Another reasons as to why

people have to work more in the future is, that the costs for living keep on rising and especially lower incoming groups need to work even more in order to afford their daily living.

The great resignation, which is currently ongoing, shows already that people are willing to accept rising cost of living and stagnating salaries. They are not willing to work in underpaid jobs, which they do not like, without any flexible working models and without employment benefits, anymore. If governmental institutions and politicians are not reacting on those current happenings, it can be expected, that dissatisfaction rises.

### Commuting

Depending on the development of working hours, the question of how often and how far people are [commuting](#) arises. There are several ideas how lives will be organized, and it strongly depends on the field of work and age groups. To give an example, commuting will probably stay the same for parents which bring their kids to school (regarding the further developments in the education sector, but as social interactions are highly important for kids, it is likely that kids will get dropped off for certain hours at a physical place). So parents have to make their trip together with their children per bike, public transport etc. or an autonomous vehicle picks up the kids in the morning. Another possibility would be, that parents walk their kids to school and then go back home and work from there, but nevertheless, the education system (at least for children) will not be as flexible as other branches, so there will still be a certain timeframe, where those activities will take place.

Another determining factor on commuting will be housing prices and how they develop. If the affordability decreases further and renting prices stay quite high in the city and people have no extra space for working from home, they either prefer offices or therefore, they move further away, where housing is cheaper and turn into (super) commuters. So there might be a higher tendency for super commuting as in the past, either within a city (longer than xx minutes) or from outside.

Another solution for commuting, which often rises up with [breaking the rush hour](#), are highly flexible work models, where people can go to work whenever they want and therefore avoid traffic peaks. In certain jobs it is already possible to work highly flexible, whenever and wherever people want, they get their tasks per organization tools and work free, if some problems occur they solve it via written communication or similar. They either will work from home or an office, but a lot of jobs are bound to a certain production process or other stakeholders, so core working hours are with real-time (online or physical) interaction are necessary. Even if working more flexible than that or even completely flexible would be possible, the questions rises, if people would accept the offer or would use the possibility (except from working a few hours in the morning, taking time off when there is nice weather outside or working when the kids are in bed etc.), because there is still a natural circadian rhythm along which most of the humans function quite well.

### Summary

To come to a conclusion about this key factor, it can be said that how many hours people work and how they commute depends a lot on how costs of living and the social system with its financial compensations develop. Learning from history, the trends lead to less heavy labor, but how the surrounding environment will look like is something which needs to be figured out and is a field which employers and behavioral scientists are experimenting a lot. Again, the human aspect, which matters in the transport industry, is also important and needs to be even more explored in the world of work, because people spend many more hours there.

Morphological box: Work life (demand side)

feature	forms				
legal form & salary	precarious gig economy	full-time & part-time employment		well established gig economy	unconditional basic income
physical spaces	home	remote	co-working spaces	mixed forms	offices/factories etc.
work culture	skeptical regarding new forms of employment (trust issues etc.)		acceptance of new forms of work		highly welcoming new forms of flexible work
commuting	5 days/week	3-4 days/week	less than 2 days/week	physical meetings 1x/month	no more commutes needed
regulation of working hours	low		medium		high
level of employment	employment increases	declines slightly		stays the same	strong decline
independence of employers about new forms of work	free in their decisions			tight – no legal freedom	
digitalization in society	highly digitalized (e-government)		somewhere in between		no digital offers
working hours	40h+/week	around 30h/week	around 20h/week	less than 10h	
level of automation	low		medium		high



Projections: Work life (demand side)

	Projections	
	B1	B2
title	Free and flexibility	More and heavier
short description	A high level of digitalization makes it possible to work flexible. A high level of automation is responsible for the diminishing of numerous jobs, but also creates new ones in the knowledge industry (people can basically decide if/how much they want to work or respectively need).	Technology develops further, but with a slow pace and salaries as well as education do not adapt to the market. As a consequence, a digital divide occurs and people have to do several jobs to earn a living. Trust issues and a lack of internet infrastructure make it difficult to work flexible.
state of the art: technology	high level of digitalization and automation in all fields of life	increase in automation of manufacturing processes etc., but there is no overall digital society
forms of employment	short contracts, on demand, fair payments, project based, basic income gives people security	either permanent contracts or gigs with exploiting working conditions
distribution of income and wealth	through different and flexible job opportunities the inequality gap gets smaller	income gap, digital divide, in general inequality increases
commuting patterns	People still commute, but less, and it is hard to predict, because they know it only a few days in advance. Additionally, leisure trips occur more often, because people have more spare time.	Besides the e.g. office jobs where people commute today a few days per week, additional jobs occur (some of them require commuting, others are online). Commuting gets tighter and more stressful.

### Key factor 3: (public) transport market

The second key factor “(public) Transport market” was already described in detail with all the different levels of implementation under *mobility* in the chapter megatrends. Therefore, in the following section, the focus was laid on the competition between different modes and operators and the consequences and opportunities for public transport to figure out possible directions of developments.

#### Competition and pricing

[MaaS](#) could probably be declared as successful, if level four is reached, and it is possible to choose the mode of transportation regarding an individual situation and the service/technology behind MaaS “distributes” passengers quite steadily between different routes and modes.

One of the main competitors for public transport currently are and will be cars. Hence, the driving technology changes with ongoing electrification, automation and connectivity, but cars will always be individual modes of transport with a much higher land use than public transport or bicycles. In 2050 the chance that CAVs reach the final stage of autonomy level 5 is quite high, but it is rather expected that vehicles will go around in suburban areas which are already car-friendly, because it is easier to implement services here, than in inner city areas where a lot of people are walking and where the build structures are not car friendly at all e.g. Rome or Amsterdam. This would be the future to strive for, so [CAVs](#) are taking over the outskirts of cities or suburban areas in order to relieve buses or offer a service, where none is currently offered, because a bus would be too expensive and an autonomous vehicle can go around and pick up people on demand. Another question which arises here is, whether CAVs are in private ownership or completely shared.

Due to the fact, that developing new technologies and new vehicles like air taxis, which often can be seen in futuristic scenarios and movies, is a slow process, it is rather uncertain, that there are going to be completely new competitors on the market. The development of the electric car shows that these processes to make a product ready for the market and affordable for the broad population take several decades (Kuchta, 2022).

Another direction of development are rather low prices and people who are currently use public transport most of the time and occasionally treat themselves with an *Uber* would switch to CAVs more often because it is more convenient. As it is rather difficult to make suggestion as to where to set the prices for using the CAVs, because the question about when and how they fully operate is too uncertain. An article from the *City Observatory* from 2016 has summed up price estimations from several consulting firms, players of the automotive industry as well as from universities. The outcome and suggestions lie between 43 cents (KPMG) and \$ 1.00 per mile (Ford). Moreover, the Rocky Mountain Institute expects a steady decline (Cortright, 2017). Though, these number are already a couple of years old and its results strongly depends on the market developments.

Speaking of pricing, pricing policies for public transport are a topic which underlies more general discussion, which can be found in the chapter of (Transport) Policy. Micro-mobility offers have a high potential for the first- and last-mile solution. Possible to create more traffic in inner cities on short distances, but can be neglected on the scale of the public transport network, because scooters and similar features are no competition on longer distances.

#### Operators and management - frictionless travelling

The question of who owns MaaS/mobility platform(s) and therefore manages transport, was already discussed in the chapter of megatrends. Still, this is an open issue, which is a lot about passengers data,

steering and decisions. Just to give an example, if big tech enterprises like Google or Amazon would be the provider of the (one or maybe a handful leading) MaaS platforms, they would have certain power, especially on pricing and over public transport providers. Another option would be a public-private-partnership between governments and tech companies, either nationally or transnationally. That means that the public sector uses either resources or expertise of the private sector to implement public infrastructure, and risks and responsibilities are shared (The World Bank Group, 2022).

For offering a MaaS-platform certain companies like ride-hailing companies *Uber* and *Bolt* or e-scooter providers like *Lime* or *Bird* have a huge advantage over public transport operators because companies are already collecting data over years, which makes it easier to provide the service. For example, they have collected data about payment, travel speed, route choice, frequency till price decisions and driving behavior of their users. With this collected data they try to understand how humans work, infrastructure requirements and how to react on it in order to create future offers (Little, 2021).

This technical edge can hardly be caught up by public transport providers or governments. So the future of frictionless travelling lies presumably in the hands of tech companies if political stakeholders do not take initiative soon. Nevertheless, transport operators have a lot of data, but they need to start using it, bring it to a certain standard and see the added value they can get with connecting their own data and use it for optimization of their processes (Monshaw, 2021). Moreover, operators have to start sharing their data with other public transport operators across service areas and there has to be a common understanding, that operators need to work together, not against each other, to make travelling for passengers frictionless. Otherwise, they are losing their voice against the tech companies.

Another possible future might be, that MaaS is thought further and some kind of combination with delivering goods can occur or public transport operators offer other services as well. Although this is not part of the thesis, it should be a suggestion to think about the public transport topic more broadly and bring up alternative business areas to operators.

### Operators view on people

#### *Customer experience*

The first main outcome of the different interviews is, that there is already an ongoing shift on how passengers are seen in the planning and operating processes, which will become even more important in the future. The key is to understand passengers better in what their needs are today and what might be their needs tomorrow, Aaron Barrett, Lead Research Analyst from *Rail Safety and Standards Board (RSSB)*, which is based in London, points out. Especially, after coming out of a pandemic, passengers expectations have changed and will change further on. Therefore, it is important to understand this change, reflect on it and to be able to deliver a good customer experience. People do not tolerate crowded commuting trains anymore. For operators and planners it is necessary to truly understand that, because that might be the difference between why people choose to go to the office one day a week or three days a week and in there lies a big revenue opportunity (RAIL magazine, 2022, 23:05-24:20).

For the purpose of understanding the passengers experience in public transport, especially on trains/trams/metros and to respond to the passengers requirements, a look at the field of marketing, where brands and companies are spending an enormous amount of resources in researching customers' needs, has been taken. *Gartner's Glossary* defines *customer experience (CX)* as the following: " the customer's perceptions and related feelings caused by the one-off and cumulative effect of interactions with a supplier's employees, systems, channels or products" (Gartner Glossary).

This contains collecting a lot of data, doing customer surveys and also trying to understand human behaviors in terms of psychology, emotions and on a subconscious level as well as defining personas, social listening and customer segmentation (Pemberton, 2018).

Often there is a misunderstanding because customer service and customer experience are used as the same term. Customer service is only a part of customer experience and describes interactions between the company and the customers, in this case operators and passengers. This can be face-to-face interactions in a station or on a train, chatbots, websites, the service hotline etc. (Xu, 2022). Although, customer service is only a small part of CX, it is really crucial as people tend to remember only peak moments and it is not predictable which memories stay in one's head. For example the train service runs perfectly all time and then a customer has a certain request and the member of staff are very friendly and helpful, the person will think about a positive experience, but of course this can happen the other way around as well: Trains run punctual all the time and someone has a problem and no one from the operator side is there to help, or it is hard to reach someone at the call center, the customer will be angry and complains about an overall bad service (Solomon, 2018).

Besides CX, which is, as mentioned not (yet) a common understanding in public transport, there is also the term *passenger experience (PX)*, which is mainly used in aviation and describes every interaction between the customer and the airline. In earlier days it was defined by physical actions starting from the check-in, whereas nowadays, it starts with the first online interactions and the airline's digital presence (Glenn, 2016). So, the question is what can public transport learn from PX and CX or how can public transport implement CX to increase the positive experience and how to transform successfully.

First, a main aspect of the topic of how passengers are seen is that they are recognized as load, goods or self-loading freight which gets on at one station and steps off at another (Dyson and Sutherland, 2021, p. 4). Jacqueline Starr, CEO of the *Railway Delivery Group*, prefers the word customer rather than passenger, because she does not believe that the industry recognizes people as customers, although there is a big (cultural) difference between treating someone like a passenger or a customer (RAIL magazine, 2022, 28:17-29:15).

Coming from the term of self-loading freight and putting as many people as possible on the train, the general understanding often is, that people want to get to their destination as fast as possible. On a rational scale this would be the most efficient, and it is a main reason for choosing a certain mode of transport, but again, the experience people have on their journey is more important, as Wi-Fi-data from TfL shows. Around 40 % of the trips made between the stations Kings Cross and Waterloo are not made with the two fastest lines, but rather on individual preferences and (subjective) perception like utilization, sense of time, design of transfer points etc. (Transport for London, 2017, p. 14).

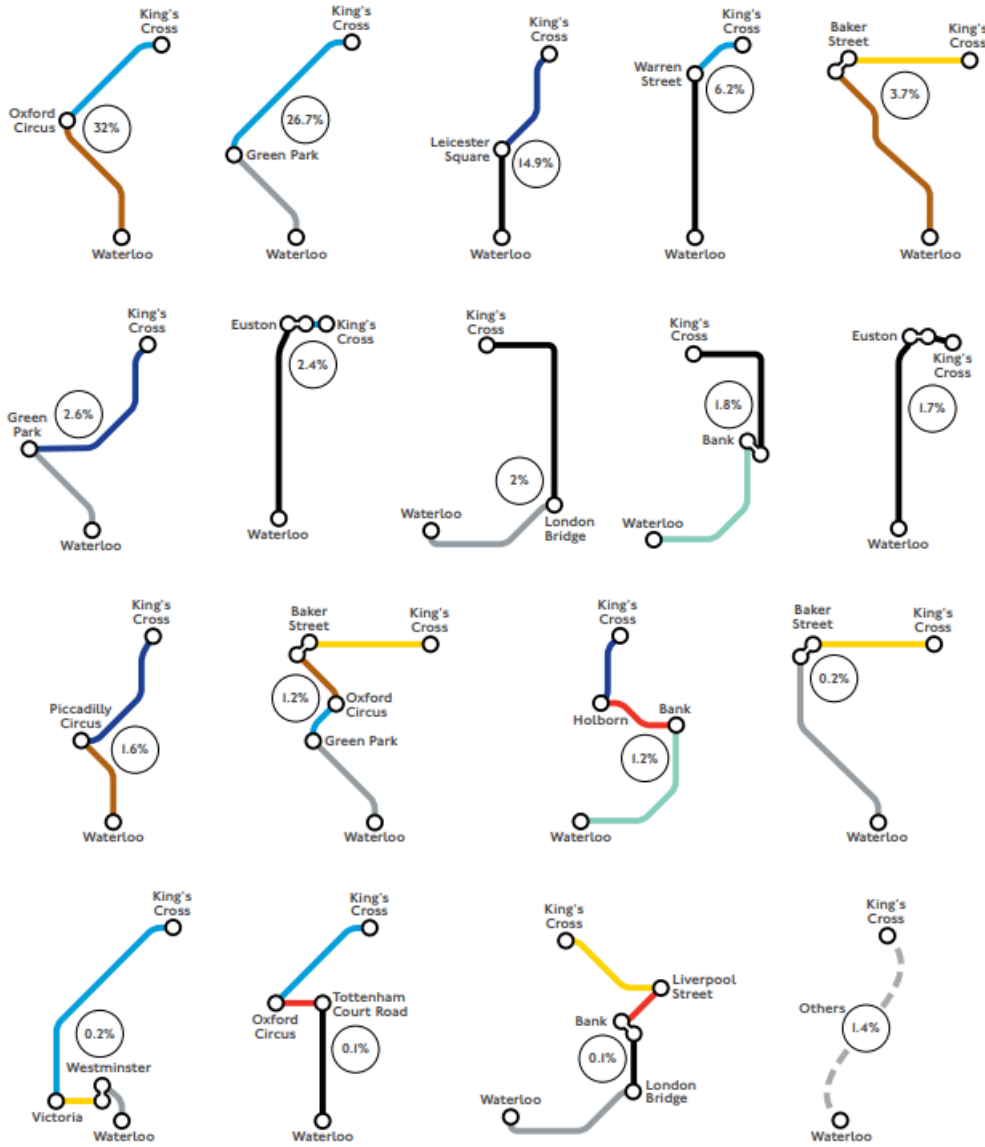


Figure 8 This figure from TfL shows passengers route choices between King's Cross St. Pancras and Waterloo. Over 40 percent of them did not choose the two fastest routes.<sup>6</sup>

A more sensitive wording could put the human scale with all the needs of individuals in front, so passengers are not seen as self-evident. It is important to offer the passenger a service like serving a guest in a restaurant or asking a customer in a shop if help is needed, because otherwise, with increasing possibilities of different services in mobility people choose not only the most convenient service, but also those where they feel most welcome, understood and well treated.

Another point is, people often treat themselves with taking an *Uber* for special occasions like going to a wedding, a job interview or back home from somewhere after a long day. Pete Dyson, Behavioral Scientist at *Department for Transport* in the United Kingdom and author of *Transport for Humans*, gave this example to state out the gap between private and public transport, because what does it tell about the quality of a service like public transport, when people take an *Uber* instead of other options (Dyson, 2021).

<sup>6</sup> Transport for London (2017, p. 41).

To sum it up, CX in public transport describes all the positive and negative emotions people have when taking a train or actually before, when they choose their mode of transport, think about traveling with public transport and plan a journey. So the challenge is to get the overall human-centered business culture within the industry on a certain level of quality across the different actors and operators in order for people to be able to rely on services and frictionless travelling and have positive perception of public transport.

If the industry knows how their customers are currently feeling, action can be taken to shift in the right direction and work towards fulfilling customer's needs. After having good experiences with public transport, the positive perception of people rises and satisfied customers are the best *brand* ambassadors. As a result, satisfied customers help to gain new customers, because they want to share their positive experience with friends, who may try to take the train afterwards as well (Solomon, 2018). This increases not only the brand's value, but also saves costs for e.g. marketing and in customer service through reduced complaints (Xu, 2022).

### *Local aspect*

Each city or metropolitan area has its own characteristics and is shaped by the people who live there, the geographical and historical context, the labor market and its dominating companies or sectors etc. This individual cultural context should be considered in every planning and designing process, within the realm of possibility, to make smaller adaptations to the carriages or stations. For example people, who live in the alps bring their skiing equipment with them on public transport whereas in another city this extra luggage can be the bike or a surfboard. The variety is endless and the main point here is, to go into detail as much as necessary, but as little as possible.

An important point which Keith Williams (Williams Rail Review of the British railway) states in the *Passenger Experience webinar* is, that although, individual requirements should be considered, it would not make sense to configurate every aircraft/vehicle differently. This would be a suboptimal solution for the customer/passenger because they never know what they are going to get when they travel. In the airline industry, this standardization was quite successful, because people experience more or less the same no matter where they travel (RAIL magazine, 2022, 35:52-36:50).

### *Summary*

To conclude the chapter on the public transport market it can be said, as already stated in the chapter of [megatrends](#), that the future of MaaS is highly dependent of who owns and operates such an integrated mobility service. The importance of one single service for public transport is high, as planning, booking and combining it with other modes will get more convenient. Moreover, customers' treatment and price policies will play an important role.

Morphological box: Transport market

feature	forms			
MaaS	failed	current status continues	partly operating	fully operating
MaaS offers	private controlled offers		public offers	mixed public-private-partnership
competitors	active modes/micro-mobility		individual modes /CAVs (low prices)	flight taxis, Hyperloops
CAVs – level of operation	level 3 (current one)		level 4	level 5
CAVs – form of organization	shared		private	
integration of shared mobility	weak		strong	
management - legislation	laws/policies	industry	controlled by AI	individual
importance of customer service	low: extreme savings		medium: increase staff	highest priority: technology and humans
rush hour	decreases/diminishes almost completely	stays the same	flattens to a level, which is economic and utilization wise bearable	increases
operation data policy	private		public-private-partnership	open source

Projections: Transport market

	Projections		
	C1	C2	C3
title	No need to change	Next level mobility	Frictionless mobility
short description	The transport market stays more or less the same and developments are slow: CAVs have no breakthrough, electric and hybrid cars are on the road; active modes increase slightly and public transport stays the same (no prioritization).	Overrun and reinvention of the transport market: CAVs, Hyperloops and flight taxis are the new modes. Public transport as known as today plays a subordinated role and active modes are just for leisure activities.	More interaction and redistribution between the existing modes with space for innovations: Public transport for main routes, short trips are made by active modes and micro-mobility. CAVs support public transport in suburban areas.
status of MaaS	level 2 or 3	there is no MaaS anymore	level 4
management and operating of MaaS	Public transport operators and cities have their own MaaS service	tech companies (oligopoly)	Public-Private-Partnership e.g. EU works with tech companies on a level – they provide the service together.
shared mobility	People are skeptical regarding sharing – no matter if goods- or a service-sharing, they prefer their own vehicle.	Ownership is not existing anymore and sharing is a question of affordability. If passengers pay more, they get a vehicle for themselves.	People rarely own vehicles, the urban transport system is build up on sharing models, which are affordable and inclusive.
utilization	As there is no a big change in behaviors, utilization in rush hours stays the same, which leads to a higher demand on vehicles	Through the high level of technology and therefore the elimination of commutes, utilization is almost the same across the day	Operators manage to spread passengers across the different lines around the day and create a balance in the network. Therefore, fewer busses and metros are needed, which leads to a reduction of costs.
how passengers get treated	Passengers get similarly treated as today, there is no specific focus on customer satisfaction.	Chatbots and robots work in customer service and requests get answered immediately.	Through savings, because of driverless tubes and co, staff can help passengers at stations etc.



## Key factor 4: (transport) policy

A topic, which was mentioned only marginally, but has a major effect on future developments are political and institutional regulations and frameworks in different cities and countries regarding transport but also climate change. The students from the workshop emphasized the importance of this regulation issue as well. Further, the chapter [megatrends](#) the climate topic, which has a major role in regulations, was already mentioned briefly, but only in the relation to the [decarbonization of public transportation](#) and less about the effects on people's daily life.

In governmental climate strategies, public transport operators need to be involved somehow, otherwise meeting the CO<sub>2</sub>-targets will probably not be possible. On the one hand this brings a lot of pressure to operators, but on the other hand enables a lot of possibilities for testing and implementing new measures and further, will bring financial support from public authorities to strengthen public transportation if the authorities want to tackle the emission-problem.

### Climate change

Taking a look at different climate scenarios, on how the world could look like in 2050 and how daily lives are affected by it, might be rather uncomfortable, because a lot of events like rising temperatures and sea levels, distribution of vectors of diseases, sinking air and water quality or natural hazards are not stoppable anymore. There are a lot of scenarios of how daily life in urban areas might look like. For example, people need to wear air-filtration masks, or it is getting impossible to cycle because average outside temperatures in summer are 40 degrees Celsius and more. As a consequence, health issues like cardiovascular problems occur.

To give an example of how the temperature will change, a few cities with their average temperatures today and the prognoses for 2050 are shown below. It is important to note, that these assumptions are occurring in the best case scenario, which means meeting the Paris goals and global warming stays around 2 degrees Celsius. Researchers from ETH Zürich conducted a study to visualize, which cities climate conditions would be similar in 2050. For example, London would face similar weather conditions as Barcelona has today (Bastin et al., 2019, p. 1).



Figure 9 This map illustrates what the temperatures in different cities across Europe will look like in 2050 when meeting the goals of the Paris Agreement. For example, in London temperatures will most likely be as they are currently in Barcelona.<sup>7</sup>

<sup>7</sup> Bastin et al. (2019, database).

For public transport this means, that all vehicles and stations need to have air filtration and air condition as a minimum standard in order to keep traveling bearable for people, but the primary responsibility for an overall strategy lies with policy makers.

### *National Strategies for transport and climate*

National transport/climate strategies are often covering all modes of transport and are more specific for freight transport, which is obvious, as there is more reduction potential in emissions. Thus, it is hard to find strategies or targets which should be achieved in urban public transport on a national level, the measurement and therefore, responsibility here lies with each city. Additionally, climate strategies are different around the globe, depending on the form of government. As this thesis puts a focus on western and wealthier countries, where private vehicles are quite common, one main focus to reduce transport related emissions in urban areas, is to reduce the car usage (or at least the emissions) and try to make other modes of transport more attractive. Some countries already set themselves individual goals and bring up different solutions like Norway, which promotes clean energy and electric cars, whereas Luxembourg implemented free public transportation for environmental reasons, to promote the shift from a private car to public transport, but also for social equality reasons etc. (Figg, 2021).

Solutions mostly compromise from a mix of several measures like incentives (pull-factors), rising awareness, restrictions (push-factors) as well as new and more efficient technologies. There is no single truth, each solution has positive and negative aspects, and every country has its own potential in certain areas. Taking the example from Norway, where they obtain almost 98 % of their energy from renewable sources, which is currently impossible for most of the countries (Ministry of Petroleum and Energy, 2016).

Looking at some examples for strategies in transport, there is the 2021 infrastructure plan of president Biden, which is, as the name says, for infrastructure investments, mostly for replacing old infrastructure like rail, roads and vehicles and less for sustainable improvement of transport offers and meeting customers demand (Berrebi, 2021). Long missed opportunities in land-use planning and planning car-centric or car-friendly cities makes it heavier, than for example in Europe to reduce urban transport related emissions. Taking for example Chicago, where around 77 % of trips are made by car (Deloitte MCS Limited, 2017, p. 1). The United States are planning to have a net-zero mobility sector by 2050, no clear strategies have been found other than switching from driving technologies from fossil fuels to electric energy and investing more in rapid buses, which will presumably not be enough to tackle climate issues.

In Europe, one of the most significant measures for the transformation of the transport sector will be the emission pricing of the European Commission, from which public transport is excluded, but due to the fact, that other modes will be more expensive as long as they are using fossil fuels, member states with a higher usage of public transport will be less affected. Although the question arises how long this emission pricing effect will last, because as soon as cars will drive with alternative fuels the CO<sub>2</sub>-pricing is not relevant anymore (Schroten et al., 2022, p. 37).

Another strategy of the European Union on a metropolitan level is the *The New EU Urban Mobility Framework*, which provides guidelines and targets for cutting 90 % of the greenhouse gas emissions until 2050. Through project based funding, providing tools for measurement and strategy mapping, research and development etc. (European Commission, 2021b).

Australia published a development strategy for the next 15 years and beyond in 2019, where they obtained data about access and quality of public transportation. This document is more of a guideline for future investments, but is rather vague on public transport strategies for the future similar to the American one (Infrastructure Australia, 2019).

Looking at all those (trans)national strategies or guidelines, which resulted from international climate agreements, there are hardly any consequences for penalties for not meeting the agreements for governments, despite the worsening condition of the planet. Though, this can change rapidly within the next few years, as deadlines like the year 2030 are getting closer and radical change is needed.

### *Cities strategies*

One trend, which was already discussed in the chapter megatrends and ranked with a very high influence from the students on future mobility patterns, was the [15-minute city](#). This concept seems cheap and effective, as building cycle lanes and reorganizing traffic is comparable to e.g. implementing a new metro line and is also part of the *New Urban Mobility Plan* in Europe. Therefore, shifting towards active modes for short distances will be a measure, which can be implemented in a rather short time frame. Car-centric street design gives a lot of space for redesigning streets for cycling lanes and prioritizing buses. Together with other regulations like congestion fees, additional money can be earned and redirected to public transport providers like the congestion charge in London, where all the earnings from the daily charge of £ 15, which vehicles need to pay in order to enter the city center receives *Tfl* (Transport for London).

Looking at measurements cities are taking right now or strive for, to fight against urban heat islands and relieve their streets from traffic and reaching their goal of becoming carbon-neutral, they need to ensure, that their ambitious plans (goals are mostly set by themselves) get implemented. E.g. the goal of the city of Vienna is to have a modal share in car traffic from about 20 % till 2025. Currently (August 2022), this number is about 26 % and it will be hard to reach the goal, which the city set itself (Hönigsberger, 2022). This shows again, that it requires a lot of work not to end in empty promises. The long lead times often get underestimated, first on a political level, afterwards in the planning procedure and then sometimes even in the construction phase, with rising construction costs etc.

Despite all those challenges, cities across the globe are willing to change and started to take action. For example, there is the initiative *C40 Cities*, where around 100 world-leading cities work together to reduce climate impacts (C40 Cities).

One aspect which is noticeable throughout all concepts and strategies on national levels as well as on city-level is, that transport is hardly thought together as one big project, rather every mode has its own department, with its own strategy. It is mostly separated in road traffic, freight, maritime, aviation, public transport and active modes – which makes it harder to establish a system which allows frictionless travelling.

### *Pricing and transport market*

Different models of pricing, smart ticketing, including lower income groups and make it socially fair as well the latest developments were already discussed in the [introduction](#): average households have a relatively high budget for mobility, so there is no fundamental necessity to make public transport free of cost.

Maybe, pay-as-you-go-solutions, where passengers pay for each ride they take, experiences a comeback when people work from home more on a regular basis. With [digital accounting, which automatically calculates the cheapest price](#), it will be convenient to use.

Another possible option is, that typical season tickets (monthly or annual) or flat-rate-tickets stay the same and people buy their public transport pass for the area in which they are commuting. There are some newer, successful examples for such tickets which a valuable across the country for all different providers like the € 9-ticket in Germany, which is valid over the summer 2022, for the whole public transport network (without high speed trains). The price is, as the name says, € 9/month (DB Vertrieb GmbH, 2022) or the Austrian Klimaticket, with which it is possible to use all kinds of public transportation for € 1.095 for one year (One Mobility Ticketing GmbH, 2022, 2022).

Perhaps there a some other subscription options in the future e.g. for € 20 a month people have 5 public transport rides and can take a shared bike 10 times and with higher basic fee people can use public transport all the time and have some bike and scooter rides included.

Other options are completely free public transportation, regardless from it pros and cons, as well as a completely free market approach, which would be regulated after demand and offers, which could lead to increased fares, which is questionable because of the compatibility with the basic principle of a public service.

### Transport laws

Currently, operators underline strict obligations on how to operate and get people from A to B. This feature which brings a lot of positive aspects like guarantees for passengers with it, but has also some negative aspects, which makes it hard to run operations economically. To give an example: operators have to fulfill contracts e.g. drive an almost empty tram or bus around at 11 p.m. because it is set in the schedule, whereas it might be cheaper to use ride-sharing or similar offers to bring the customers, who need this service, to their desired destination.

Those contracts (e.g. in Austria or Germany) are set over certain periods, which can be 10+ years, which is a long time in a fast-moving society. Looking back 10 years from now smartphones just at the beginning of their development, whereas today they are not only a big part of people's daily life, but also part of the transport system and how people book and plan their trips. These concessions limit the entrepreneurial scope of operators a lot (Polst et al., 2022, pp. 17–18). Though, it is a long process to reform those tender procedures as they sometimes underlay not only national laws, but also transnational laws, like in the European Union, where it is about issues like competition regulations etc. (Polst et al., 2022, p. 48).

These conditions all have their justification, but for a more flexible transport system, which should be economically more rentable and have fewer expenses on services which are not used that much, a loosening of regulations would be helpful.

On-demand-stations/or virtual stations at off-peak-hours or in suburban areas and ride-sharing or ride-hailing are just two examples to make public transport more adaptable. To mention one advantage of flexible stations, especially in off-peak-times e.g. between 10 p.m. and 6 a.m., is increased safety for women and minor groups, as an example from Madrid's interurban bus lines show (Modijefsky, 2020). Moreover, flexible stops would be an improvement, at all day times, for people with disabilities, who are not able to walk to the station.

Offering on-demand right-sharing in off-peak-hours as it is for example done in Florida with a program called “late shift”, where transit authorities cooperate with *Uber* to provide shift workers with low-income a service, also underlies criticism, because beneficiaries are private providers, which are subsidized by transport authorities.

Nevertheless, in order to implement more flexible offers not only a change in federal laws is necessary, it is also mandatory to have a well-functioning digital system, which matches needs and services.

### Summary

To summarize this political issue of pricing and regulations it can be said, that actions needs to be taken fast, when net-zero-targets should be met till 2050. The potential for cities to redesign their cities with fewer cars and a strong focus on public transport and active modes is high, and digital solutions can help to act fast. Ideal would be a combination of strict regulations for emissions and congestions, as well as the financial support and a clear commitment of politicians towards public transportation.

### Morphological box: Transport policy

feature	forms			
interaction market & politics	strong politics -weak industry	uncontrolled	balanced	strong industry – weak politics
political system	liberal	authoritarian	social	conservative
fares	flat-rate (different packages)		pay-as-you-go	free public transport
political goals	free market economy	sustainability	social inclusion	growth stability and wealth
development of climate change	technology inventions stops global warming	below 2 °C	between 3-5 degrees	extreme + 5 degrees
ranking of importance of public transport from policymakers	high	low	intermediate	
steering	push	push and pull		pull
interests of innovation (governments)	Innovative & open, active actions		wait and see, defensive	
promotion of modes	active	balanced	shared mobility	public transport individual transport
cities regulations	pro individual motorized modes		tight regulations for parking, congestions etc.	
rush hour - framework	flexibilization in all areas of life (work, education, leisure etc.)	flexibilization is only possible partly		stays the same

## Projections: Transport policy

	Projections		
	D1	D2	D3
title	Moving forward	Market decisions	Standing still
short description	Through strict policies and following the latest technological developments it succeeds to slow down climate change and meet the goals of the Paris climate agreement and developments are towards an equal transport network.	Regulations and politics are out fashioned and get over rolled by technology firms, which overtake the market with their solutions. They react much faster than politicians.	Outdated politics (ignoring climate science and digital developments) lead the world, which leads to dissatisfaction in the population and disturbances can occur.
political goals	sustainability	economic growth	preserve values
transport politics	Renewal transport policies – leave a margin possibility for operators and create balance between economical aspects and serving obligations.	Liberal market with a permanent improve of the economic-wise most profitable services, public transport gets a complete new meaning. Politics follow the industry.	fixed pricing with season tickets; maintaining of the existing network; tendency higher investments in motorized individual modes
substitution of transport and infrastructure	prioritization of funding for active modes and public transport (Extension public transport network, bike + pedestrian network as well as digital infrastructure (broad brand expansion))	For less lucrative routes in the network public funding is needed, otherwise there would not be a service offered.	Infrastructure funding stays the same as now with a lot of money going in the automotive industry. Due to that, the transport industry has no possibility to change.
pricing	Variable prices (depending on rush hour, income, time of booking etc.); incentives for mode switch	prices are created through demand and supply	fixed prices, the true costs of the different modes are not known
climate	livable cities	cool cities because of technological innovations	extreme weather conditions
flexibility	all areas of life removed from fixed hours to flextime	The high technological world makes it possible to be flexible all the time, e.g. university lectures can be done at night, because learn-bots answer questions	Contracts and legal framework for beginning and end times are getting more flexible, but with a slower pace and low acceptance.

## 3.2 Scenarios

In order to create the different scenarios the projections from the key factors, a Cross-Impact-Matrix has been conducted. Therefore, the open source tool Scenario Wizard has been used, to identify, which projections could go along with each other in the different scenarios. In the Cross-Impact-Matrix, the question “How much does a change in the first variable (row) affect the second variable (column)?” is the starting position for the rating process. The scale for the assessing ranges from -3 to 3, therefore the interaction between the projections can have seven types. The scale is inspired by (Sardesai et al., 2021, p. 49) and (Breu et al., 2021, pp. 186–187):

- +3: characterizes a strong positive influence
- +2: describes a moderate positive influence
- +1: defines factors which are slightly supporting each other
- 0: means a neutral position without any positive or negative impact, and one factor does not affect the other
- -1: describes a low inhibiting influence
- -2: describes a moderate inhabiting influence
- -3: describes a strong inhabiting influence

The argumentation for the assessment can be found in the appendix. To give an example: How does the increasing flexibility in work life affect the affinity of curious people, who are open for innovations regarding the usage of public transport? After weighing up the findings from analyzing the megatrends and the key factors, the answer, is a strong supporting influence (+3). A more flexible work life would force people to start to organize their life’s differently because of new routines and therefore get curious to test out new services etc. and further, a more flexibility work life has the chance to create more innovations in the field of transport and mobility.

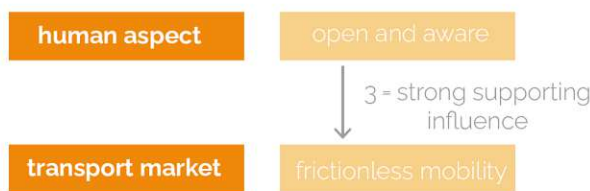


Figure 10 shows the assessment of different projections (own diagram)

In order to figure out the scenarios, the sum for each projection over rows and columns has been calculated. Factors with higher numbers are important for scenarios, which will define future travel patterns the most. It needs to be distinguished between active and passive sums. The first one describes, how strong the impact of a factor on all other factors is, whereas the second one is all about, how strong the factor is impacted by all the others (Gausemeier et al., 1998, p. 119).



## Cross-Impact-Matrix

	A1	A2	A3	B1	B2	C1	C2	C3	D1	D2	D3
<b>A Human Aspect:</b>											
A1 Open and aware				3	-3	-1	3	3	3	3	-2
A2 Anxious - privacy				1	-1	1	-1	1	1	-1	2
A3 Per duty				0	2	-3	2	2	3	1	-3
<b>B Work life:</b>											
B1 Free and flexible				3	1	2			-1	2	3
B2 More and heavier				-3	-1	2			-2	3	1
<b>C Transport Market:</b>											
C1 No need to change				-2	3	-3	-1	-2			
C2 Next level mobility				3	2	0	3	2			
C3 Frictionless mobility				2	1	3	3	3			
<b>D (Transport) Policy:</b>											
D1 Moving forward				3	2	3	3	1	-2	2	3
D2 Market decision				3	-1	-3	2	2	-3	3	1
D3 Standing still				-2	2	-3	-3	2	3	-1	-2

Figure 11 The Cross-Impact-Matrix shows the influence of the projections on each other. (own diagram)

According to the weighting, the program automatically combines possible scenarios. The literature suggest coming up with between two and four final scenarios, whereby it does not make sense to define the concrete number of scenarios in the beginning. It rather depends on how different the scenarios are and how plausible they are (Gausemeier et al., 1995, p. 273). The first result after the rating with ScenarioWizard brought up five possible scenarios. The goal for the distinction between the scenarios is, that they are as homogeneous and coherent within the scenario, but as different as possible to all the other scenarios (Gausemeier et al., 1995, p. 280).

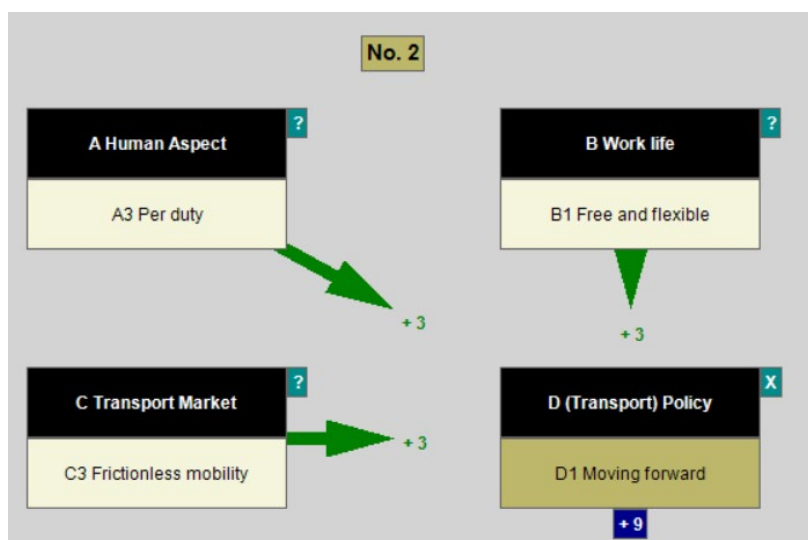


Figure 12 This output of the software ScenarioWizard shows how the scenarios are calculated.

Szenario Nr. 1	Szenario Nr. 2	Szenario Nr. 3	Szenario Nr. 4	Szenario Nr. 5
A Human Aspect: A1 Open and aware	A Human Aspect: A3 Per duty		A Human Aspect: A1 Open and aware	A Human Aspect: A2 Anxious - privacy
B Work life: B1 Free and flexible		B Work life: B2 More and heavier	B Work life: B1 Free and flexible	B Work life: B2 More and heavier
C Transport Market: C3 Frictionless mobility			C Transport Market: C2 Next level mobility	C Transport Market: C1 No need to change
D (Transport) Policy: D1 Moving forward			D (Transport) Policy: D2 Market decision	D (Transport) Policy: D3 Standing still

Figure 13 This output presents the differences between the five scenarios with the highest scores.

Taking the total impact of each scenario, scenario number 1 is the most consistent one, followed by number 4. In order to make the future scenarios as different as possible, for further processing, the following three scenarios have been chosen: Scenario 1, Scenario 3 and Scenario 5. The final step in creating the scenarios was to write and create a story around them.

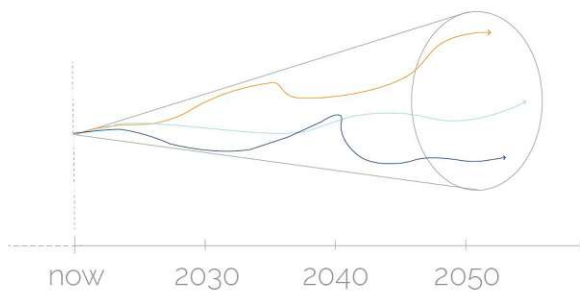


Figure 14 The scenario tunnel shows the same starting point – which is now – and the different paths, which can occur. (own diagram)

The idea of scenarios is to give an overview in what possible can or will happen in the future. Presumably, not one specific scenario will occur, rather a mix of all of them will be observable. The following three scenarios should also show, how different impacts of the megatrends can occur. There are different kinds of scenarios: On the one hand there are trend scenarios, which describe an ongoing, probabilistic development of the current situation and the other hand there are extreme scenarios, which describe more unlikely and extreme developments on purpose (Gausemeier et al., 1995, pp. 224–225). For better imagination, hard facts are packed in a narrative story, which describe, how (public) transport will look like in 2050 and how people use it in their daily life. Moreover, for each scenario a connection to the *IMaG:NE* study, which describes innovative measures for decreasing peak demands in traffic as well as for the efficient utilization of transport capacity across the day, has been established. The study was conducted by researchers of the Technical Universities of Vienna and Graz as well as from a traffic engineering company on behalf of *BMK* and published in 2022. Due to the necessity of thinking those complex topics of transport and societies day-to-day-life together, the study completes the scenarios partly. Although the focus of the study is Austria, the problems occurs similar across the world and different measures in organizational procedures and time processes interact on different levels (Sodl-Niederecker et al., 2022, pp. 6–9).

Moreover, in every scenario the temporal and spatial distribution as well as the transport policy gets explained more in detail. For example, the sketches for spatial distribution should picture how different land-use policies can look like e.g. mixed-structures, separation of functions or spatial development along axes. As a consequence, the (public) transport system develops according to this land-use-patterns or the other way around, settlement develops along the routes. The thicker dark blue lines show suburban railways and metros and the thinner lines describe light rails - on a conceptual level. The bigger the circles are, the higher is the function and size of the city. This should not be a detailed analysis of land-uses or of proper theories of spatial or regional developments.

#### Scenarios – overall situation

	Acting retrogressive	Somewhere in between	Towards a prospering future
	5 - negative scenario	3 - trend-scenario	1 - positive scenario
attitude	trust issues	private possession are slightly declining	sharing
owner/operator	public	public-private-partnership	mainly private
employment situation	bad wages and long working hours	people work longer (age wise), but less hours, still fixed contracts	less hours, gig-economy (good conditions)
commuting/ number of work trips	high	medium	low
modes	preferred individual modes	sustainable modes, individual modes are slightly declining	switch between shared modes
pricing	per trip/fixed prices	flat-rate	pay-as-you-go
transport policy	political failure	slow environmental policies	spirit of innovation

## Acting retrogressively (negative scenario)

When Pete enters the train station in the agglomeration area around Madrid he passes the memorial of the [cyber-attack](#) 7 years ago, which caused several accidents on rail and led to a blackout. Not only was his brother a victim, over 160 people were killed that day. Ever since then, everyone who does not need to take the metro or the suburban railway travels per car or bike. But Pete has no financial resources to buy a car and he needs the time on the metro to work on his second job, in order to have enough money to pay the rent – as housing prices keep on rising and wages are stagnating. All of that happened because politicians were too cowardly to face urgent topics of society and ignored the ageing population and transforming the labor market, investing in digital infrastructure and education as well as acting on global warming. Through this ongoing political failure, people are scared, have no high trust in technology and innovations. As a consequence, political upheavals occur.

Despite all these negative memories and anger, which come up during the [90 minute train](#) ride, he enjoys sitting in his silent seat capsule and having the privacy to work – this upgrade is worth every cent. Particularly so, because he can take off his masks. Moreover, through sitting in his capsule, Pete has not to [worry about viruses or similar](#), because of the physical barrier between him and the other passengers. Although these capsules are over ten years old now, they are perfect. It is possible to regulate temperature and air circulation, they are noise-cancelling and it is possible to charge devices and to have calls, which the other passengers cannot hear. Currently, this is only possible on overground trains, because the wireless connection under the surface would be too weak for a teleconference. At the time when these new trains with capsules got installed, most people did not understand, why operators did that, but now they are more than happy to have this private safe space. The idea behind these capsules was to give passengers the individual space and the same space, which they would have in their own car in order to make [public transport more competitive](#).

Luckily, it is October and the measured air values are ok and he does not need to wear his air-filter-mask, when he steps out the station in central Madrid, but in summer when wildfires arise around the city, air quality deteriorates rapidly and outdoors, people always wear these masks in order to prevent respiratory illnesses.

If his train arrives punctual, one of his colleagues, who owns an old car, picks him up at the station for the 10 minutes ride to the office, but this happens quite rarely, as trains are late most of the time. If the train is late, he has to walk or take a bike or a scooter for his last mile, which again costs extra money. This is quite annoying, because before the attack politicians and operators were on a good path and offered integrated mobility packages, which made it possible to use the scooter ten days per month, if you own a season ticket, but then the infrastructure was destroyed through the cyber-attack and there is no money to reinstall those services. So, now he buys a monthly ticket for the train, because it would be too expensive to cover the price for an annual ticket in advance.

This scenario goes along with scenario C *old paths* of the *IMaG:NE* study, because similarities like a failing MaaS service occur. This is caused by a lack of investment in building digital infrastructure. On it, inflexible working hours with outdated and analog organization structures lead also to setbacks in education and childcare policies. Besides that, people prefer having their own vehicles and try to avoid public transport (Sodl-Niederecker et al., 2022, pp. 78–82).

## Temporal distribution

Rush hour is heavier than it is nowadays, because no big investments for capacity and network extension have been made and people have no alternatives on the main routes, either they have car

congestions or full trains, where they stand a lot. Still, through the attempt to make public transport attractive and competitive and offering silent boxes etc., the trains have a high quality and last for ages. So the demand for suburban trains and metro is high and they are fully engaged around the day.

As metro and suburban lines are all led on separated tracks, so theoretical it would be possible to reach the technical potential and perform a high frequency with minimum distance between the vehicles and reliable schedule. Due to the cyberattack operational disturbances occur almost on a daily basis and this leads to delays (Anderhub et al., 2008, pp. 8–9).

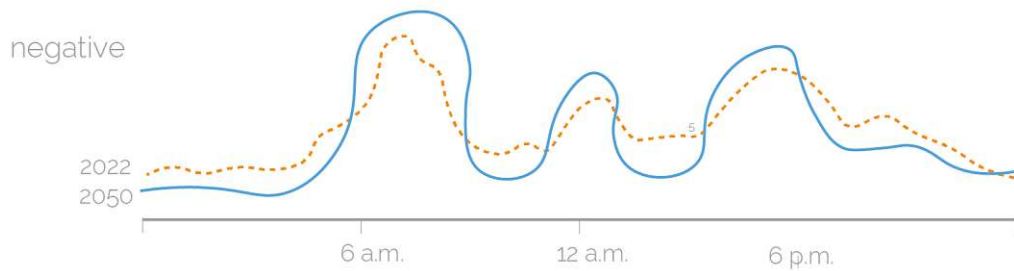


Figure 15 This diagram shows the distribution of passengers across the day, which occurs in this scenario, with higher peaks during rush hours.

### Spatial distribution

Spatial development is characterized through a strong segregation of functions with typical housing areas, business districts, shopping malls and industrial areas. This leads to a higher volume of traffic as people commute longer because they live further away from the cities or respectively from the places of everyday necessity. Some typical commuting distances can almost be considered as super-commuter routes, as average commuting times are much long than nowadays. Across main routes there is a relatively strong network (car, rail), but aside it is not easy to reach and access settlements etc.

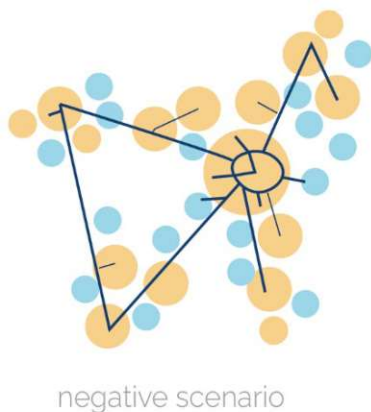


Figure 16 The main public transport routes are well-developed, there areas in between bigger settlements have poor access.

### Transport policy

Politicians missed out several topics and basically stopped investing in network extensions, the goal was to maintain the existing one. Over time, with overall rising costs, investments in infrastructure – not only public transport – were decreasing. Missed opportunities lead to recurrent malfunctions. Moreover, as money is tight, fares for transport are not sufficiently funded. Politicians in 2050 are

trying to improve the system and get out of this emergency state again after the cyberattack which destroyed a lot and set everything back for a couple of years.

## Somewhere in between (trend-scenario)

71-year-old Ann leaves the house and takes the foldable bike to the closest station, in order to take the regional tram to Utrecht, where she currently works in an elementary school as self-learn-supporter for kids. Because of the [ageing society](#) in the western world she is still working, her pension would be too little to cover the basic costs of living and moreover, not all vacancies would be staffed, since migration politics did not work out (low birth rate, hard immigration policy). So she works quite flexibly about 20h/week since she is 60 years old, but she loves it to be surrounded by kids and help them to study and pass on her knowledge from her former career as an ai-expert.

When she enters the tram, which takes her from Amersfoort to Utrecht in 20 minutes and stops in every settlement, she opens up her laptop and starts checking how the kids did their online assessment and indulges in reminiscences, where she had to fight with her employee to use the commuting time for work. With the first pandemic, which started in 2020, she moved with her little baby to the smaller town of Amersfoort in the Randstad metropolitan area to live in a calmer and greener neighborhood and started to take longer commutes of about an hour in the morning and one in the evening twice a week and spend the other days working from home. It was hard to convince her boss for paying her working during the train ride, but with the [second pandemic in 2026](#) the national work law got adapted and moreover, employees which travel with sustainable modes are allowed to count this time on public transport as working time in order to set incentives to tackle congestion and pollution issues.

When she moved out of Amsterdam and started commuting, she first regretted her decision, to move in the south and not to the seaside, but as the sea level started rising over the last couple of years, she is happier than ever before, because some of their friends had to leave the houses near the beach, because living there would be too dangerous.

When she was younger she took the car (which would not be affordable anymore as parking costs and purchasing prices skyrocketed) or had a 25-minute bike ride to the next train station, but over the last years the investment in sustainable transport, especially light rail, was huge. In 2035, they build a new tram, now she takes this one and does not need a car anymore, occasionally she takes one of the [shared CAVs](#). This is cheap and convenient.

During working in the tram, she looks around and thinks about how much has changed in the interior of the tram since she was a kid. She sees fast-chargers for electronic devices, [real-time-based travel](#) information in overhead boards for the upcoming planned and possible stops as well as the tram “driver”, who does not need to be in the front all the time anymore, only in more complex traffic situations and otherwise assists people who need extra help or is just here for chatting with the passengers. Trains, metros and even trams offer now spaces for bikes, at least one carriage, with lockers for longer rides, where she puts in her foldable bike and which can be opened and closed easily with the chip in her watch, which brings more relaxation to ride, because it is not necessary to keep an eye on personal belongings. Moreover, it is possible to deliver things in those lockers e.g. she checks in parcel and gives the approval in her app, that the post office can open the box, when the tram is in the service center, which is also a logistic hub nowadays. Reversely, the logistic hub can place parcels for her in a tram, if she gives due notice, which trams she takes the next morning. This saves delivery costs and extra trips. But she has to admit, that this service is not that well-functioning as of now: last time the logistic hub lost her grocery delivery for a couple of days and it smelled disgustingly.

Pricing of today’s transport is simple, the flat-rate she pays monthly is [adjusted with her age, income](#), route length, mode choice (modes with fewer emissions are cheaper) and the ability of how flexibly

she can choose the travel time e.g. as self-learn-supporter she has to be in school at certain times and cannot choose when she wants to go, therefore she has no rush-hour-extra-fees to pay, which occur, when people e.g. use the train during the rush hour to get to their sports class.

This scenario can be connected to *Field of action 3: Strengthen sustainable transportation* of the *IMaG:NE* study, where measure like huge investments in bicycle infrastructure and public transport infrastructure but also increasing of frequency, transport policies to make car-usage more unattractive, time-bound ticket pricing and more offers like CAVs etc. to the “traditional” public transport range are suggested.

### Temporal distribution

Through attractive offers, utilization on weekdays is almost the same across the day as people schedule their tasks according to transport prices. This leads to a steady utilization across the day in shorter vehicles, which have fewer seats and therefore, still a lot of space for people. The demand for transport is still high, as people travel up to an old age and have more leisure trips. This scenario is stronger networked-oriented as the transfer between the different lines and modes at central point’s needs to be coordinated in order to have a well-functioning transport system.

In the newer areas between the bigger cities trams are going mostly on separated tracks and it is possible that more lines share the tracks as the frequency for this fine distribution is not too high e.g. trams go every 10 minutes. In inner cities metro and trams systems often get to limit, as they share tracks and stations and the frequency is high, but as the rail systems are on the latest technical standard there is currently no room for improvement. (Anderhub et al., 2008, pp. 64–65) Moreover, in some city centers trams still share their tracks with other individual vehicles like CAVs, but disruptions are close to zero as CAVs are sub orientated to public transport. In areas where it would not be economic to run trams, on-demand carpooling is used to collect people.

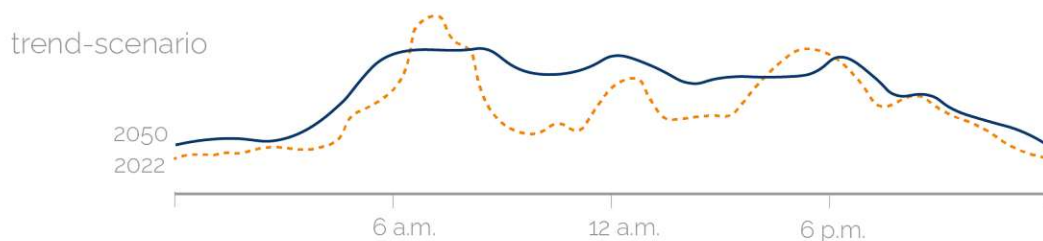
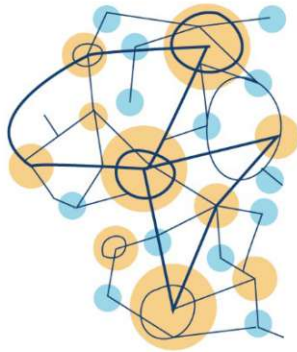


Figure 17 The temporal distribution across 24 hours is in this scenario slightly lower during the rush hours in the morning and in the evening, although the overall utilization is higher across the day.

### Spatial distribution

In this scenario boundaries between cities and suburb diminish more and more. Free land gets filled up with smaller towns or almost urban settlements and cities grow together. In those newer smaller structures with lots of terraced houses, a mix of local, regional and central businesses can be found. For shorter distances, those new settlements provide infrastructure for active modes, but people have to do slightly more trips as before and distances did not get shorter, through these developments active modes got less and public transit extend in the form of trams, busses and shared vehicles.





trend-scenario

*Figure 18* Densification in settlement structure lead also to more finely woven public transport network.

### Transport policy

The political pressure is high, because of a rising scarcity of resources and global warming have caused dramatic events in 2020s. From this point on, investments in sustainable transport have the highest priority, which means building infrastructure for public transport, cyclists and pedestrians. Stronger restrictions (parking prices, taxes, etc.) for car drivers show the truth cost of individual modes. In order to fasten the transition to sustainable modes incentives for sustainable modes, (reduce in working hours, benefits etc.) are set up. In the beginning things often did not work out that well and vehicles were crowded, but after some time a well-functioning transport system was established.

## Together towards a prospering future (positive scenario)

It is a sunny Monday in March, when Zulu takes the scooter in front of the apartment building in Sydney, where she is living in, to overcome the 900 meters to the metro station. Initially, she wanted to take the bike from the mobility hub, which every bigger building offers, but then the app send her a notification, that bikes are currently popular and therefore, more pricey. If she takes a [e-scooter](#) or a skateboard, she will get a discount for her next ride. Another option would have been to sign on the tram, which should be passing by within the next 10 minutes, for a virtual-stop on her smart gadget, but she loves to spend time outdoors and wants to be at the station sooner.

On her short ride to the closest metro station she enjoys the fresh air and the pleasant temperature of 28 degrees, and she thinks about the stories her mother always tells her, about how bad the climate situation was, when she was younger. Droughts, water and electricity shortages, wildfires etc. were daily business, but then the emission-cutting-machine was invented and stopped the suffering. Hope came up and it was imaginable to have kids again, because of the prospering future. Zulu is not able to imagine this situation, as she never knew another life.

Currently, the 17-year-old commutes to a lot of different places, as her school career is coming to an end (where she can decide on her own which classes to take and which she attends online and which at school), she wants to find out which company to work for suits her the best. Depending on the location she takes either the metro, a minibus, a bike or a scooter - with her [pay-as-you-go-ticket](#) she is flexible in every situation and gets suggested the route with the lowest congestion and cheapest price in the end.

As soon as she finds the best company(s), she will work from her local [coworking space](#) on trust-based working hours on the different projects and is [not really reliant on public transport](#), except she is going to social gatherings in her company or joins volunteering activities in other parts of town. This is quite common as the number of people working fewer hours and solidarity within the society has increased. Due to the high level of digitalization and automation, people mostly work in knowledge based jobs and enjoy doing handcraft or drawing or spending time in the nature and in interaction with others even more. When she wants to spend a night out, she has a [safe and secure connection](#) home all the time, either by the metro, which runs 24/7 or via ride-sharing organized by the operator.

As [everything is sharing based](#), there are no private bikes or cars anymore, because that would take up too much space in the city for parking, which can so be used to play or to do sports, and moreover, would reduce people's flexibility. There are various offers and people move away from personal belongings and enjoy using apps and technology for sharing goods, in order to move around more efficiently– they have a high trust in apps and services which show you the best current route option.

Another benefit of the not-owning-structures and the full coverage of bike-sharing-systems, is that it helps to keep vehicles empty from bikes and metros and the vehicles can switch their interior (lock tip-up seats, switch between vertical and horizontal seats etc.) theoretical every time they reach the final station. Thanks to an almost steady utilization between 6 a.m. and 22 p.m. this is hardly necessary. During the nighttime shorter vehicles go around. A simple mechanism for the separation of the carriage makes this possible. Moreover, the flexible interior allows operators to customize vehicles for events, e.g. at the stadium. However, these are concerns of operators, which people like Zulu do not really recognize, because the transition between the changes work out so smooth, that customers never have any limitations.

This scenario can be linked to scenario A *everything different* of the *IMaG:NE* study (Sodl-Niederecker et al., 2022, pp. 68–72). Moreover, it goes along with *Field of action 2: Making everyday life more flexible*, which is all about, as the name already says, breaking up fixed timetables and decreasing rush hour and strive for a more steady utilization across the day. This field of action describes smart working contracts, decentralized co-working spaces, flextime and hybrid teaching in schools (especially for older students), 24/7 childcare facilities, utilization based offers for leisure and tourism, a broader thinking of stationary retail and e-government, as possible solutions (Sodl-Niederecker et al., 2022, pp. 174–195).

### Temporal distribution

As nearly everything happens locally, no long commutes at typical rush hour times occur. Through the [lower utilization across the day](#), there is more space for comfortable seats. Which can be modified and then there is more space for people standing e.g. for events. As utilization is rather low, it stays roughly the same across the day. On weekends, which do not differs so much from weekdays as they do now, the demand is slightly higher, but again, flexible interior helps here. Automatization in operating processes helps to deliver a service which is on time and use energy efficient. Disruptions hardly occur.

Besides operational criteria and rush-hour utilization, comfort-orientated performance can be taken into account. This means that in off-peak hours everybody has the possibility to seat and in peak times – which are not comparable with today's, passengers stand, but have enough space e.g. to turn around with a backpack (Anderhub et al., 2008, pp. 62–63). As people spend more time in suburban trains than in metros, suburban trains already have a higher number of seats and are comfort-oriented, metros will develop in the same way, but slightly more progressively. In this scenario comfort is the main criteria when creating from the operators perspective.

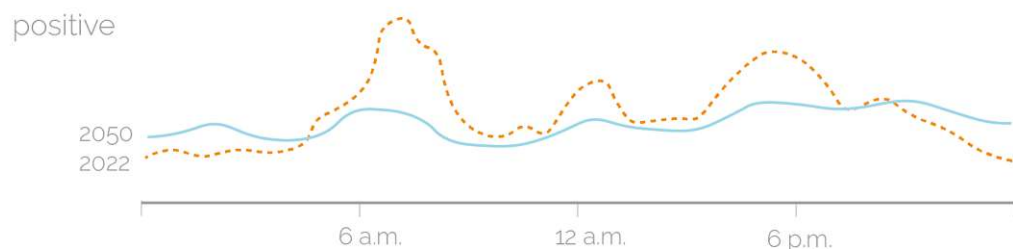
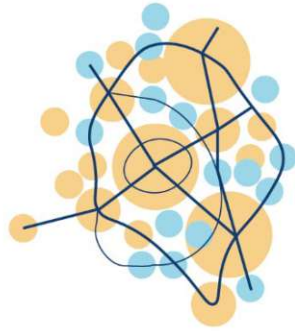


Figure 19 In this scenario, overall utilization is lower and steady across the day.

### Spatial distribution

In this scenario people find everything they need in their neighborhoods and hardly need to leave their area, expect they want to do so for pleasure, seeing friends and family or for highly specialized errands. Co-working spaces, which are allocated across the city almost in every apartment building and hardly big companies and headquarters in combination with a world, where a lot happens in the virtual space, makes this possible. Further, a mixed-land-use supports small distances and active and micro-mobility. Nevertheless, a solid rail network connects the different sub centers.



positive scenario

*Figure 20 Strong main routes which are easy to access build the backbone for a well-functioning city.*

### Transport policy

Opening up the transport market for public private partnership has brought huge impacts in design and frequency of the line – of course only for the more frequent ones. This liberalization changes the public transport sector completely. Despite the strong main routes in the metro system, politicians managed to not completely lose the supply guarantee. Policymakers decided to put the focus on sharing systems for bikes and co and managed to have full coverage across the city, which is much more important as people hardly leave the area. Moreover, they provide the multi-mobility-platform, over which all trips are made and earn their money with it.

### 3.3 Comparison

#### What does this mean for transport?

The following chart should give an overview about the overall transport situation in the three different scenarios. The modal split categories for the scenarios have been slightly adopted, because with new forms of mobility and new services, the current ones are not ideal to describe future possibilities. Therefore, a clustering has been taken. Cycling and walking as known today can be found in the category "active modes". "Micro-mobility" describes all forms of smaller vehicles like scooters and whatever developments occur. "Public transport" is kind of the same, but with a stronger focus on on-demand-features and "individual modes" cover CAVs as well as normal cars (shared or private).

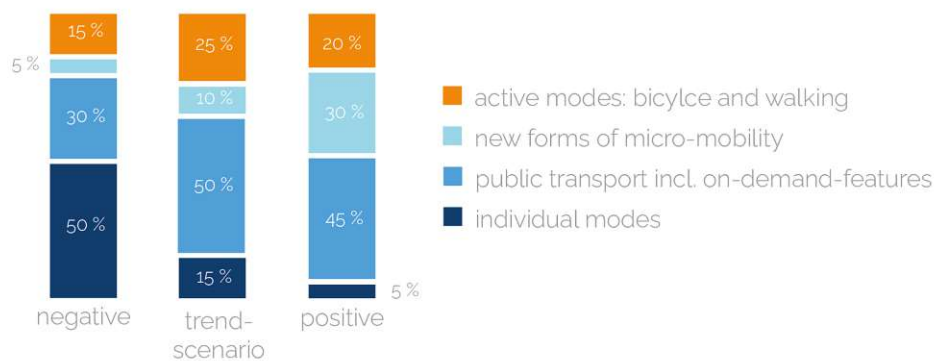


Figure 21 Modal share for the scenarios. (own diagram)

The table on the following page compares the different approaches of policymakers regarding transport and how these relate to the utilization of vehicles. Every decision for investing in certain infrastructure or adapting a law has long-term effects. For example, in the negative scenario savings in public transport and investing in other infrastructure such as highways are responsible for a high utilization in trains (because of the low capacities) and unreliability. If the overall demand stays the same as in the negative scenario, this decline in passengers lead to an increase in other modes. In this case, the share of motorized individual transport grows. That phenomena appears also within the public transport sector, e.g. changes in the time schedules of trains can lead to changes in travel behavior and vice versa. There is always a balance at some point.

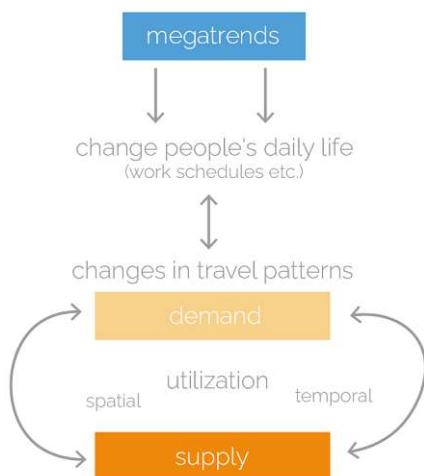


Figure 22 This figure shows how demand and supply interlock and changes in component can affect the whole system.

Transport demand

+ increase    - decline    O stays the same    colored fields are preferred modes

scenario	overall demand	metro	tram	bus	suburban railway	active modes/micro-mob	other (taxi, on demand)	motorized	Utilization of vehicles	Action politics / operators
negative	O	+	O	O	+	O	-	++	Very high	Overall demand stays the same, but with <b>extreme savings</b> . The system is not functioning and vehicle use is not optimized, some existing modes are getting more crowded and some work better than others e.g. rail-bound. That is also why individual modes are rising. Active modes do not rise that much because of air quality, temperature etc.
trend-scenario	++	+	++	O	+	+	++	-	Constantly relatively high, weaker peaks	The overall demand rises because of huge investments public transport is getting really attractive, on-demand services replace bus fleets and motorized individuals decline because of the costs. Improvements in rail, especially light-rail, smoothens operations. <b>Increasing use, but also increase in frequency and number of vehicles.</b>
positive	-	O	O	-	O	++	+	-	Moderate across the day	Overall mobility declines because of mixed land-use, flexible working etc. Most trips are done in neighborhoods, so active modes and micro-mobility increase. All the other modes stay kind of the same, <b>existing capacities are used more efficient</b> , and riders spread quite the same across the day.

## 3.4 People's needs

One aspect which all of these scenarios share are the people who use public transport. To get back to [Elisabeth Oberzaucher's statement](#), where she said, that the point of view should always lay on what people have in common instead of focusing on what distinguishes humans and what are their individual needs (Oberzaucher, 2022). The following basics should give an answer for long-term measures.

When responding to people's needs, it is crucial to have a certain hierarchy of implementing measures. For example, it is pointless to invest amounts of money into new interior and better designs for e.g. seats, if trains are continuing to run always late or getting cancelled and people cannot rely on the service. So a step-by-step plan and implementation is necessary for operators. They have to prioritize their actions regarding implementation time, economic costs and added value, but smaller details like choosing a more pleasant color of brackets for people's perception can make a huge difference and does not cost any more extra money (Tyler, 2021).

Regarding the point of reliability, which is again not as important for metros, as they have a high frequency, but rather for buses or suburban railways which run e.g. every 15 minutes, is reliability or as Pete Dyson prefers to say: dependability. He compares a service which runs 99 % of the time punctual, but where a 100 trains a week get cancelled, with one, which runs quite well 90 % of the time and trains are a few minutes late here and then, but they never got cancelled. Further, he empathizes what it is worth to people to have a service that is so punctual, but with a high chance of disruption or cancellation, so it is better to have a service where people can depend on. This might be the reason why people rather take a train to a job interview than a bus, because they cannot depend on it that much (Dyson, 2021).

### Zoning

Rest is a major advantage of public transport and one of the main reasons – and further, a selling point - why people choose public transport, whether people sleep or read a book. Therefore, commuter trains like suburban railways should definitely have a “quiet zone”. For example when there is a hospital like the *Charité* in Berlin with over 17.600 employees and people from all over the city are commuting to the different locations, which often takes them one hour and more, because jobs are so specific and working from home is not possible or people have to commute there, because there are lots of low-skilled jobs like cleaning available and affordable housing is in different parts of the city. (Charité – Universitätsmedizin Berlin, 2022) People choose public transport because of long shifts, often more than 24 hours, and need to rest on the way to the hospital or when they get home. They have the possibility to use their transition time for sleeping or dozing, or at least do not have to focus on driving a car in busy traffic. The time between home and work or place A and B is also called liminal space, which describes the time between two places. The concept of liminality is, that people value some aspects of their journey time, not just the economic value it brings to their life, but the way it sometimes enables other elements of their life, the ability to switch off, to consume news, listen to entertainment, talk to someone etc., explains Pete Dyson (Dyson, 2021).

A study during Covid-19 has shown, that around 32 % of the people in Sydney (Aoustin and Levinson, 2021, pp. 4–5) missed their (daily) commute (depending on their mode of transport: cyclists and walkers missed their commute the most followed by public transport user, car drivers missed their trips hardly), not because of crowded trains and being stuck in congestion, but rather because of the structure these trips bring to their day through habits they performed before, environmental triggers

like the physical distinction of the office and their private apartment and further, the blurring lines between business and private life which occur while working from home (Kaysen, 2020).

These outcomes underline the importance of taking those needs serious and thinking about proper zoning. For trams and buses the implementation of quiet zones, to make this transition time between to places better, might not be as easy as on long distance trains with less passenger exchange, but for suburban railways and metros, which have e.g. eight carriages and depending on the length of the line and the districts and neighborhoods they connect such quiet zone could add value for the passengers. Aspects like the design of the platforms and stations with entrances and exits affect those arrangements and functionality of keeping the noise level in those specific carriages lower.

An element, which would mark those quiet zones, which is already common in long-distance trains in Switzerland and Austria, are displays and information boards on the platform, which show the position of individual carriages. According to that, people know where to board the train with a wheelchair, baby carriage or a bicycle, or at least in which area they can expect to find a specific carriage with extra space. This lowers stress, when people are boarding the train, and leads to a smoother passenger exchange. In the ideal case, there is extra space at every entrance for people who need it.

If this communication on the platform or app etc. does not work well and passengers do not know where to find the specific carriage, they are looking for on the first hand and eventually not behave exactly how it is required in the zone e.g. whispering in the quiet zone, dissatisfaction at other passenger rises, because their expectations are not fulfilled. So, operators have to know quite exactly how many passengers are in this specific target group in order to design for them and if they are not capable to realize their promises, it is maybe better to not have zones at all (Oberzaucher, 2022).

### *Orientation*

Navigation basically describes getting from one place to another, without any disruptions. It is one of the key elements when designing vehicles or stations and explains e.g. why crowds are “flowing” when entering a train or get stuck in bottlenecks at certain exits at a station. The goal should be to create more seamless and intuitive transitions that make a frictionless travel experience possible and avoids crowds formation. This can be achieved through typical supporting elements either visual (signs, maps, lights etc.) or acoustic. So, the design of stations and platforms is substantially responsible for the even distribution of people to all carriages. This specific subject would require its own separate work.

Further, people should always know while commuting, where they currently are and what the next stop will be. It should always be possible for passengers to see and hear information, about which station is next and which possible connections there are. Further, it helps people to read the name of stations (where they currently are stopping at) by looking outside the window of the vehicle or stations have different designs e.g. colors to recognize them. These points are especially important for passengers to reduce anxiety, because people are often anxious about where they are and what is happening. For example, if someone is reading a book, the person needs to rely on visual cues as to where they are at the moment. When the person is constantly anxious about missing the stop, it is not possible to use this time, which is one of the big selling points of public transport (Walker, 2021).

So, Jarret Walker points out the fact, that anxiety can be directly transformed in travel time and quieter and cleaner carriages make people feel more comfortable which leads to the perception that travel times are shorter. This is because peoples’ sense of time is based on how much they are able to disconnect from the outside world and can focus on other tasks (Dyson, 2021).



## Interior

When talking about improving the riding experience in public transport, interior design is a key point, which influences people's comfort, but also perception. In recent years the paradigm changed slightly from getting as many seats and people into a vehicle and technical engineering in every step to a more human centered design, but this development is just in the beginning.

One point which might not be a topic in urban transit is luggage, because usually commuters do not take suitcases or similar with them, but rather a scooter or a foldable bike for their last mile. However, tourists and travelers should not be left behind, when they bring the suitcase with them on the subway when going to the airport. As long as trains are not too crowded and nobody gets disturbed by those extra pieces, there are not too many points of conflict, but especially for people who need extra space e.g. with wheelchairs those objects can be obstacles, no matter if they are in the entrance area or in the walkway between the seats, and they cannot pass.

Another aspects that Helen Dolphins, expert for accessibility at Network rail, points out are different kind of seat design, some people just want to lean, others need armrest or handrails to push themselves up to stand up again or other need more space between the seats to even have the possibility to sit down. Moreover, she mentions that is often impossible for wheelchair users to travel together, because there is just one wheelchair space per carriage (Dolphin, Eglinton, 2021).

Another issue is the availability of priority seats, there is a certain inhibition threshold with priority seats, Caroline Eglinton (Access & Inclusion Manager at Network Rail) explains, because people with hidden or invisible disabilities, which are the majority of all concerned persons, do not want to be in the spotlight and ask if they could sit down, since it is unknown how other people react, so they rather stick to standing multiple stations (Dolphin, Eglinton, 2021).

Therefore, offering a variety of seats is crucial e.g. give passengers something to lean on, offer more mounted folded seats which can provide extra space for wheelchairs, luggage, foldable bikes etc. There are a lot of design ideas on how to offer a more flexible interior for different kinds of utilization.

People naturally prefer a protected back, where they have a good overview of the room, when they stay somewhere. It does not matter if this is a public square, a train station, a seat in metro or they are standing in the tram (Oberzaucher, 2017, p. 53). For shorter rides, people accept "losses" in this situation as well as with smaller individual distance they have with stranger, because they are aware of this situation (Oberzaucher, 2022). When people are taking longer rides, for example on commuter trains or suburban trains, this situation changes, and they have additional requirements like offering a toilet or electricity and fold-down tables for work. Generally, more privacy is required and already getting implemented, which means e.g. higher backrest with a protected head space. If this privacy issues will be thought broader and people's desire for privacy rises, privacy areas like silent cabins or similar can be implemented in order that passengers can spend their commuting time more usefully.

## Thermal comfort

The term *thermal comfort* describes "when a person experiences the air temperature, the air humidity, the air movement and the thermal radiation of the environment as optimal and desires neither warmer nor colder, neither drier nor more humid room air" and is mainly influenced by personal factors (level of activity, clothing, duration of stay), spatial factors (radiation temperature) and air ventilation related factors (air temperature, air velocity, humidity). Other factors, which influence comfort as well, are lightning, coloring, noise, smells, dust (Haller, 2006, p. 1).

Elisabeth Oberzaucher writes in her book *homo urbanus* of the stress leaving effect of plants and natural landscapes which affect people's well-being positively – an idea which came up then was to cover walls and fronts in vehicles with wallpapers of plants or landscape and she agreed, that this could help to feel more comfortable while taking the metro. Moreover, she explained, that this might help to reduce vandalism, as walls without color or with the wrong color are inviting for scribbling and graffities (Oberzaucher, 2022).

To answer the question of what is the right color, other questions like how people should feel when they see the color of the seat, wall etc. and how these different colors interact with each other must be answered. Therefore, the color theory can be taken into account, which determines, what effects the different colors have on people and how they influence people's behavior, mood and emotions etc. (Fanguy, 2020) In addition to the color question, the question about unobtrusive patterns and the right material arises. For example, the fabric of a seat cover in metro needs to consist from long-lasting textures, that are comfortable and easy to maintain/clean and hygienic and which are graffiti and fire-resistant (Brown, 2019).

Lightning has similar affects like choosing the right color, e.g. pink or red tend to diffuse the sense that is warm and comfortable. Basically, there are two different sorts of light, which can be seen by the human eye and are therefore relevant for the ongoing work: shortwave or blue light and longwave or red light. The first one, the blue one, occurs in the morning and is slightly more intensive as the second one, which naturally occurs in the afternoon, is more red. The answer to the question which one to take, depends on goal should be achieved: In the morning it could be a good idea, to "wake" people up with blue light and in the evening are more red light could help to calm people down, Nick Tyler (UCL Centre for Transport Studies) explains. Taking the example of a metro line, which goes to the airport, it can make sense to only use blue light, to keep people awake that they catch their flight (Tyler, 2021). Elisabeth Oberzaucher on the other hand tends towards are more long-waved light, because people are while using public transport in a situation of higher excitation and a more calming light could help to reduce stress (Oberzaucher, 2022).

Besides the effects of the degree activity, Nick Tyler mentions that the color of light can influence the temperature up to 2 - 3 degrees e.g. taking warmer light instead of cooler, white light which makes it then chillier. Still, the effect of this measure is not a hundred percent known yet, but it has the chance to save operators a lot of money, because heating/cooling is extra money to spend, whereas lights are needed anyway (Tyler, 2021).

To go on with temperature, Nick Tyler further recommends thinking rather about comfort than temperature like warm and cold, because comfort relates to how safe people feel, how they behave, how they feel/interact with other people (Tyler, 2021). Elisabeth Oberzaucher suggest the selection of the vehicle temperature should be made in relative context to the outside temperature, instead of having extremely cooled down carriages in summer and people get almost a small "shock" when they enter/leaver a vehicle. The same applies for cold outside temperatures in winter, when people wear warm jackets and coats and they enter a fully heated vehicle. Avoiding this extreme temperature jumps would protect the body from physiological effort (Oberzaucher, 2022).

The argument, which both experts underlined, is that evolution of homo sapiens is very, very slow and the design of the environment (light, acoustics, temperature etc.) should meet the basic needs of humans, so that they feel comfortable.

## Disability and accessibility

In the introduction, the issue of safe and inclusive transport was already briefly mentioned. Due to the high importance, because of the growing group of concerned persons, it will be elaborated here. Some features like same-level-access between vehicles and platforms, guiding systems for blind people, elevators and escalators are commonly known as standard facilities for accessibility, but it is about a lot more components to offer an inclusive service.

In terms of passenger experience, pre-travel means being anticipated in taking the train instead of the car, looking forward to a relaxed ride and not having anxiety issues because of a crowded train and being nervous about catching a train or even having the chance to get a place to sit -this is even more important for people with an impairment (Dolphin, Eglington, 2021). Further, in terms of pre-travel-experience (not part of this thesis), it is important to make the information and planning process of the trip and the ticket buying process barrier free as well as designing stations adequate on the requirements of passengers (navigation, offer people something like shops, warm waiting areas etc.). Moreover, giving the passengers the help they need and assist them at the station (helping to enter the vehicle, give information etc.) completes offering a good service. For example, nowadays people in a wheelchair have to book the service to help them to enter the vehicle 24 hours in advance in the United Kingdom, which makes it impossible to travel spontaneously (Smith, R., 2020).

An aspect that comes along with accessibility is language. Plain language often gets forgotten, but certain target groups need clear language with simple words, short sentences, active voice etc. Announcements in stations, signs, apps always need to be designed for the weakest of society, no matter if they have a low reading literacy or speak a foreign language. Especially, at particular events like cancellations, constructions works, redirections often get communicated in a very complicated manner. In particular when there are bigger events planned like rebuilding a station, extra staff, whose only purpose is the explanation of the situation, can help to improve the experience people have (Pulrang, 2020).

People who suffer from mental health issues can be easily overstrained and stressed through ads, announcements, lights, noises etc. Therefore, unnecessary external stimulants like avoiding to use displays in a vehicle which show operational information for promotional purpose should be reduced (Walker, 2021).

## Conclusio people's needs

The following table shows how the different needs and requirements of passengers look in the different scenarios. The first columns show how important the explained criteria are. Afterwards, there is one column with the affinity of operators/manufactures and one, which shows how passengers feel about the situation.

People's needs in the different scenarios

+ increase    - decline    O stays the same    colored fields are preferred modes

scenario	zoning	orientation	interior	thermal comfort	disability and accessibility	priorities of manufacturers / operators	passengers perspective
negative	O	O	+	-	+	It was tried to fulfil the basic standards for accessibility and buy new interior to <b>update old vehicles visually</b> and <b>safe investment costs</b> e.g. for new air-ventilation-systems.	Passengers travel mostly with headphones, as the noise level of the old trains is high. Further, the temperature regulation does not work, either it is too hot or too cold. Accessibility works only at certain stations, where the intervention started, before the money run out.
trend-scenario	O	++	-	+	++	<b>Cost-benefit-relations</b> and making it easy to use public transport have the highest priority. This means accessibility and orientation. Other aspects are only considered if there is financial scope.	Passengers accept the fact, that some shorter tram lines have cheaper interior with less comfortable seats than longer suburban railways. For that, they have well-functioning Wi-Fi and comfortable temperatures in vehicles.
positive	+	O	++	++	+	A lot of resources were put into behavioral sciences, medicine etc. to <b>understanding how humans work</b> and design vehicles according to their needs.	Passengers are feeling safe and comfortable on public transport.

## 4. Conclusio

The scenarios resulting from social developments are rather overstated in order to get an idea in which directions societies needs and mobility patterns can develop. The following chapter sums up the substantial customer demands and how the different stakeholders in public transport such as operators and manufacturers can act or react.

Before listing up the requirements which every stakeholder has, it should be noted, that one of the main outcomes of this thesis is, that changes in this fast moving world happen faster than ever before and therefore, a high level of adaptability is needed. This means trying to be always up-to-date, keep track of technological developments and have courage to take action and deal with high uncertainty. Despite that, there are these long-term developments like the ageing society and urbanization, which are quite foreseeable and where the public transport sector (operators + manufacturers + policymakers) can prepare for.

### Research question and hypothesis

To answer the research question on what are future demands on public transport according to passengers travel patterns, the scenarios show that developments can occur in various directions and focusing straight on one path would not be the solution. One issues, which is the same for every possible scenario and should have the highest priority when developing new vehicles, planning new stations and implanting new services is a barrier free transport system, which allows everybody to participate. Further, investing in interior according to basic human needs like comfort makes taking public transport more pleasant. Another point, which relates more to the different scenarios, is to establish a transport system, which is dynamic and has the possible to “breath” and adopt to different situations.

The [hypothesis](#), that it will not be possible to measure future success of transport operators on the number of passengers, since people's individual mobility needs are changing due to social developments and therefore new indicators and parameters should be used, can be confirmed. This is mainly due to the flexibilization across all sectors in life and breaking up current work patterns, where people do not commute to their workplace five days a week anymore. This might not mean necessary less trips, but rather a shift from typical commuter trips to leisure trips. Additionally a more resource efficient acting will be necessary in the future e.g. economic wise, energy wise or personnel availability and new competing offers will stir up the transportation market – so a change or an evolution of the public transport sector is essential.

### What are the individual mobility needs of passengers and what are the resulting customer demands on public transport?

**Dependability** - Customers want to rely on public transport at all day- and nighttime's, which means offering a high frequency of services that people do not need to check schedules with flexible fares (affordable, easy to book etc.) and integrated services which allow frictionless travelling. This does not necessary mean, that a tram needs to show up at 11 p.m. it can rather be a pooled car which brings the passenger to their destination. It means that services satisfy the current demand of the customer in every situation.

**Feeling welcome** – This means barrier free design and inclusion on all levels starting with purchasing a ticket, to navigate through a station, to access a vehicle etc. This should not only be considered for people with disabilities, this makes it easier for everyone to participate, especially for new and

occasional customers. Moreover, increasing passengers experience by having a comparable feeling (design, cleanness, customer experience etc.) when taking public transport as it would be when individual transport. Of course, it is not possible to compare those different means exactly but making public transport trips more pleasant, to something people enjoy or at least do not avoid and it is self-evident.

### How can vehicle manufacturers respond?

Know the passengers and be flexible - Work with the local circumstances (if it is in an economic framework e.g. if a whole metro line is (re)build a detailed research of personas can be helpful, for a few buses this will probably not be profitable) and more important try to understand human behaviors e.g. where to they enter the train and implement guidance systems to lead passengers to less crowded carriages or create an interior, which is versatile for respectively higher demands, for events, for bicycles on the weekends or even just for bad weather. Design vehicles which can adopt within short times, e.g. overnight. For example, design modular interior for vehicles, where seats are not attached to the floor anymore, instead they are hooked up on the sides with profiles and can be changed. E.g. there can be one seat or a double seat or the seats can be vertical as well or they disappear completely and people can only stand, which means more passengers fit in the vehicle. Therefore, often a shorter train would be enough to move all the people, with the economic benefit that the train only needs half of the energy to move.

Timeless design with focus on humans - Create an environment where people feel comfortable all the time, take basic human needs: light, comfort, temperature, noise, navigation, access etc. Because other trends come and go and there is a need to adapt to them fast e.g. wireless connection or pandemic health issues – but these requests have a much shorter time frame. In case of a health issue like Covid-19, this means a few days whereas it takes several years to upgrade a wireless connection, whereas the lifespan of urban rolling stock is 40+ years. Above all that, barrier free design never gets out of fashion and means more than planning one wheelchair spot at one entrance. Especially with the ageing society, the percentage of people with impairments will rise - not only physical but also mental.

### How can operators respond?

Know your customers through data - observe route choices, trips purposes, transitions to other means, utilization, travel time, but also ask customers, what are they missing, what are existing barriers etc. With this collected data, future offers can be created on customers' demands. If this collected data is used intelligent, real-time-data can help to steer passenger flows, direct people to less frequent routes, create price incentives for passengers who use less frequent routes, show utilization of carriages and much more. With digitalization those operational processes can be optimized. Therefore, huge investments in digital infrastructure as well as in human resources will be necessary.

Put the customer in front – hire people or shift staff from fields which will be automated in the future e.g. driverless tubes, to other places, where they can help passengers to buy their ticket at the machine, even when there will be no more tickets machine in the near future, place staff, which shows passengers how to use the ticket apps, where to navigate etc. and simple be visible. This means be present with staff especially at nighttime to make stations less frightening. Despite the physical appearance also the online presentation matters, where people often have their first interaction with the company, when they research ticket prices etc.

**Prioritize investments** - Design matters, but if vehicles are late, or dirty, customers will not care about how comfortable the seats are, and they are rather disgusted or angry about the service. That is why a prioritization of investments is needed. Operators should have as an idea on their values and make a step-by-step list, how to achieve these goals in logical order. This applies also for tomorrow's network: Strengthen and ensure main routes and neglect weaker routes, this does not mean not to offer a service there anymore, this means to go away from the idea to send a bus everywhere or the around the whole day - there are other cheaper options e.g. serve more on demand in areas with low density, change buses size and use CAVs. Try to focus on those unbeatable routes and think public transport on those "weaker" routes different.

## 5. Discussion

Through the broad look on developments in society across different sectors, this work scratches on the surface of different issues. This brings limitation when talking about interaction between the megatrends and how strong they appear in different countries and cities.

The complexity lays in knowing the interactions between the megatrends, because one trend can never be considered on its own: For example, changes in work life lead to new travel patterns, but this changes depend on the first hand on technological innovations followed by political regulations like work laws. At the same time the education sector changes, because employees have a new time schedule and so the schedule of their kids get reinvented as well which sets up the foundation, if people commute and how often they commute.

The results indicate that it is actually quite hard to plan and predict how transport and vehicles will look like in 2050 in this fast changing world. The complex interaction between the evolving megatrends and the high influence of [politicians regarding transport laws and regulations](#), but also other areas like [climate change](#) and [digitalization](#), make prognoses hard.

Nevertheless, the results are an important foundation for future investments as they emphasize the necessity for the long-term investments on the [accessibility](#) of public transport. Moreover, investing in [basics](#), which are a benefit for everybody should be considered in designing future vehicles. However, there is rather little research on this topic until now, because it was not a priority in the past for vehicles manufactures. Therefore, there are lots of research opportunities.

### Planning considerations on the scenarios

The environment in which the people live in the three scenarios (without the transport topic) distinguishes a lot. Responsible therefore are, like in transport, political decisions e.g. on urban and spatial development, housing politics and economic decisions. These different surroundings play an important role on people's travel decisions and habits. As in the megatrend chapters [mobility](#) and [urbanization](#) mentioned, human-centered neighborhoods lead to an increase in active mobility, whereas on the other hand car-friendly areas force people to a certain lifestyle. That is why urban planning and zoning are amongst the most important fundaments for transport.

### Methodological reflection

The results are not able to tell anything on how to organize future transport system. Many aspects, which are relevant for future offers have been mentioned in this thesis, but no specific approaches have been explored. The three scenarios are only able to show in which directions (out of endless options) the current system can possible develop.

The [scenario technique](#) is a good methodical tool to demonstrate different futures. Though the expense for one single-person would have been beyond the scope of a master thesis, because numerous experts need to be involved to get different opinions and rank the trends. That is why a simplified approach has been used. The [scores of the cross-impact-matrix](#) for scenarios are all given by myself. To justify the results for a decision in planning or similar, it would have been necessary to involve a variety of stakeholders (behavioral scientists, experts in economics, climate change, work, digitalization, politics, basically every field, which was mentioned in the megatrend section) in the rating process to create legacy.



## Outlook

A next step to implement these scenarios into real actions would be the connection with travel demand models in order to see, how eligible existing transport networks are and what needs to be adjusted. A research project *NAIXTransit* from the University of Aachen used this approach to cover a similar topic: the researchers created scenarios on how autonomous public transport could look like in the future with a transport simulation software and applied the different scenarios on the city of Aachen (Louen et al., 2022). A dissertation, which deals with a similar topic and could be an inspiration for a possible next step to continue this work, addresses impact assessment of traffic planning, which is relevant for using scenarios in real life. With the help of a transport model, estimations on how the [temporal and spatial distribution](#) look in detail in different scenarios has been taken (Klönne, 2008, pp. 160–161).

As mentioned in the chapter megatrends, [connected and autonomous driving](#) will lead to changes in the mobility sector, which will also affect public transport. Pooling offers and virtual stops like in the scenario [prospering future](#) will reshape the industry (Bruns et al., 2018, p. 3). The design of such offers for public transport is in the beginning of the development and there is still research required in order to create a frictionless transport system. A further topic which addresses frictionless travelling in general, is the complementation of the different means of transport and thinking the different modes together and combining their advantages for making travelling easier. For example, if there are good bike sharing offers, railway operators have fewer customers who take their bike with them on the train and therefore, fewer points of conflict occur. Mobility hubs, [Mobility as a Service](#) applications and closer cooperation between operators can be possible solutions, which are already (partly) implemented, but often fail. Here further research can be taken to understand better, why [customers using these services](#) and why not etc.

Further, future work should deepen on breaking this long-term perspective and ideas down to short-term actions for the near future on specific use cases like a city or a country in order to make it more specific and think about implementation measures to tackle those challenges. Another possibility for ongoing work on this subject of future travel patterns and therefore, future offers, can be, to take a closer look on the political and regulation level. This can be either on national or on transnational level e.g. European Union in order to put pressure on decision makers. These regulations build the legal foundation for a strong public transport system and are a big opportunity for operators in an ongoing competition.

# Table of Figures

Figure 1 This diagram should illustrate how the extensive topic of megatrends will be brought step by step to the level of individuals. .... 2

Figure 2 Distribution of age groups in 2020 and 2050 worldwide. The steps are in 5-year-age-groups (y-axis) and the numbers on x-axis are in thousands. It can be seen clearly, that the amount of elderly increases a lot..... 11

Figure 3 The following chart shows the differences in mode choices between genders in EU-27 in 2007. .... 14

Figure 4 The following figure shows the current state of two different cities, as well as their modal share goals for the future (it should be noted that survey methods can vary between countries). On the left side, the goals for Vienna in 2019 and 2050 are shown. On the right side, the numbers for Sydney in 2016 and the desired numbers for 2056 are demonstrated. .... 18

Figure 5 This diagram pictures the classification of the key factors, which are defined with a high impact and a high uncertainty. (own diagram) ..... 32

Figure 6 Methodological sequence (own diagram)..... 34

Figure 7 This ranking shows the rating of the students. The colors of the bars should help to understand, which megatrends have higher impacts on travel patterns in the future, according to them..... 35

Figure 8 This figure from TfL shows passengers routes choices between King’s Cross St. Pancras and Waterloo. Over 40 percent of them did not choose the two fastest routes. .... 49

Figure 9 This map illustrates what the temperatures in different cities across Europe will look like in 2050 when meeting the goals of the Paris Agreement. For example, in London temperatures will most likely be as they are currently in Barcelona. .... 53

Figure 10 shows the assessment of different projections (own diagram) ..... 60

Figure 11 The Cross-Impact-Matrix shows the influence of the projections on each other. (own diagram) ..... 61

Figure 12 This output of the software ScenarioWizard shows how the scenarios are calculated. .... 61

Figure 13 This output presents the differences between the five scenarios with the highest scores. 62

Figure 14 The scenario tunnel shows the same starting point – which is now – and the different paths, which can occur. (own diagram) ..... 62

Figure 15 This diagram shows the distribution of passengers across the day, which occurs in this scenario, with higher peaks during rush hours. .... 65

Figure 16 The main public transport routes are well-developed, there areas in between bigger settlements have poor access. .... 65

Figure 17 The temporal distribution across 24 hours is in this scenario slightly lower during the rush hours in the morning and in the evening, although the overall utilization is higher across the day.... 68

Figure 18 Densification in settlement structure lead also to more finely woven public transport network. .... 69

Figure 19 In this scenario, overall utilization is lower and steady across the day. .... 71

Figure 20 Strong main routes which are easy to acces build the backbone for a well-functioning city. .... 72

Figure 21 Modal share for the scenarios. (own diagram) ..... 73

Figure 22 This figure shows how demand and supply interlock and changes in component can affect the whole system. .... 73

## References

- Ahmed, M., Srivastava, N., Tipnis, G. and Matsumura, S. (2020) 'A study of Mumbai and Hyderabad's intermodal transportation hubs and their potential in the future railway-led urban development in India', *Transportation Research Procedia*, vol. 48, pp. 1968–1986 [Online]. DOI: 10.1016/j.trpro.2020.08.008 (Accessed 18 September 2022).
- Albalade, D. and Bel, G. (2009) *Tourism and urban public transport: Holding demand pressure under supply constraints*, Universitat de Barcelona [Online]. Available at <http://www.ub.edu/gim/wp-content/uploads/2013/10/Tourism-and-urban-public-transport.pdf> (Accessed 7 January 2022).
- Ambrogi, M. (2020) *Household Income Forecast* [Online]. Available at <https://trpc.org/DocumentCenter/View/8007/2020-08-12-DRAFT-Income-Forecast?bidId=> (Accessed 7 January 2022).
- Anderhub, G., Dorbritz, R. and Weidmann, U. (2008) *Leistungsfähigkeitsbestimmung öffentlicher Verkehrssysteme*, Institut für Verkehrsplanung und Transportsysteme [Online]. Available at <https://www.research-collection.ethz.ch/handle/20.500.11850/28520>.
- Andreotti, A., Anselmi, G., Eichhorn, T., Hoffmann, C. P. and Micheli, M. (2017) *Participation in the Sharing Economy: Report from the EU H2020 Research Project Ps2Share: Participation, Privacy, and Power in the Sharing Economy* [Online] (Accessed 1 August 2022).
- Aoustin, L. and Levinson, D. M. (2021) *Longing to Travel: Commute Appreciation during COVID-19* [Online]. Available at <https://findingspress.org/article/18523-longing-to-travel-commute-appreciation-during-covid-19> (Accessed 18 May 2022).
- Armstrong, M. (2021) *It will take another 136 years to close the global gender gap* [Online]. Available at <https://www.weforum.org/agenda/2021/04/136-years-is-the-estimated-journey-time-to-gender-equality/#:~:text=COVID%2D19%20has%20set%20back%20progress%20for%20women's%20rights.&text=The%20global%20gender%20gap%20is,Forum's%20Global%20Gender%20Gap%20report.> (Accessed 16 February 2022).
- Artuso, F. and Guijt, I. (2020) *Global Megatrends: Mapping the forces that affect us all*, Oxfam GB [Online]. Available at <https://oxfamilibrary.openrepository.com/bitstream/handle/10546/620942/dp-global-megatrends-mapping-forces-affect-us-all-310120-en.pdf;jsessionid=B85DFCA019D2E09129FFA7ED318DF4B5?sequence=1> (Accessed 6 January 2022).
- Asongroup (ed) (2020) *Preliminary Travel Plan - Attachment C8* [Online]. Available at <https://meetings.cityofsydney.nsw.gov.au/documents/s43546/Attachment%20C8%20%20Proponent%20Preliminary%20Travel%20Plan.pdf> (Accessed 15 June 2022).
- Autor, D. (2019) *Work of the past, work of the future*, Centre for Economic Policy Research [Online]. Available at <https://voxeu.org/article/work-past-work-future> (Accessed 16 February 2022).
- Autor, D., Mindell, D. A. and Reynolds, E. B. (2022) *Why 'the future of AI is the future of work'*, MIT Sloan School of Management [Online]. Available at <https://mitsloan.mit.edu/ideas-made-to-matter/why-future-ai-future-work> (Accessed 9 February 2022).
- Badger, E. (2021) *A Little More Remote Work Could Change Rush Hour a Lot*, The New York Times [Online]. Available at <https://www.nytimes.com/2021/06/11/upshot/rush-hour-remote-work.html>.
- Bassetti, F. (2019) *Environmental Migrants: Up to 1 Billion by 2050*, Foresight the CMCC observatory on climate policies and futures powered by CMCC Foundation [Online]. Available at <https://www.climateforesight.eu/migrations-inequalities/environmental-migrants-up-to-1-billion-by-2050/> (Accessed 18 September 2022).

Bastin, J.-F., Clark, E., Elliott, T., Hart, S., van den Hoogen, J., Hordijk, I., Ma, H., Majumder, S., Manoli, G., Maschler, J., Mo, L., Routh, D., Yu, K., Zohner, C. M. and Crowther, T. W. (2019) 'Correction: Understanding climate change from a global analysis of city analogues', *PLoS one*, vol. 14, no. 10, e0224120.

Berrebi, S. (2021) *The Case For a Transit-First Infrastructure Plan* [Online]. Available at <https://www.bloomberg.com/news/articles/2021-04-13/biden-s-infrastructure-plan-must-put-transit-first> (Accessed 29 July 2022).

Bettati, A., Milani, L., Pozzato, F. and Sandri, N. (2022) *Fostering an inclusive urban-transit system: How can we make traveling in cities safer and more comfortable for members of at-risk groups?* [Online]. Available at [https://www.mckinsey.com/~media/mckinsey/industries/travel%20logistics%20and%20infrastructure/our%20insights/fostering%20an%20inclusive%20urban%20transit%20system/fostering-an-inclusive-urban-transit-system\\_vf.pdf?shouldIndex=false](https://www.mckinsey.com/~media/mckinsey/industries/travel%20logistics%20and%20infrastructure/our%20insights/fostering%20an%20inclusive%20urban%20transit%20system/fostering-an-inclusive-urban-transit-system_vf.pdf?shouldIndex=false) (Accessed 18 February 2022).

Bloomberg, J. (2018) *Digitization, Digitalization, And Digital Transformation: Confuse Them At Your Peril* [Online]. Available at <https://www.forbes.com/sites/jasonbloomberg/2018/04/29/digitization-digitalization-and-digital-transformation-confuse-them-at-your-peril/?sh=81ea9ca2f2c7> (Accessed 18 September 2022).

Breu, T., Bergöö, M., Ebnetter, L., Pham-Truffert, M., Bieri, S., Messerli, P., Ott, C. and Bader, C. (2021) 'Where to begin? Defining national strategies for implementing the 2030 Agenda: the case of Switzerland', *Sustainability Science*, vol. 16, no. 1, pp. 183–201.

Brown, J. (2019) *Why public transport has such brightly-coloured seats*, Domain Group [Online]. Available at <https://www.commercialrealestate.com.au/news/why-public-transport-has-such-brightly-coloured-seats-30068/> (Accessed 7 August 2022).

Bruns, F., Rothenfluh, M., Neuenschwander, M., Sutter, M., Belart, B. and Egger, M. (2018) *Einsatz automatisierter Fahrzeuge im Alltag – Denkbare Anwendungen und Effekte in der Schweiz* [Online]. Available at [https://www.ebp.ch/sites/default/files/project/uploads/2018-04-19%20aFn\\_3c%20M%C3%B6gliche%20Angebotsformen%20im%20kollektiven%20Verkehr\\_Schlussbericht\\_0.pdf](https://www.ebp.ch/sites/default/files/project/uploads/2018-04-19%20aFn_3c%20M%C3%B6gliche%20Angebotsformen%20im%20kollektiven%20Verkehr_Schlussbericht_0.pdf) (Accessed 6 October 2022).

Buchholz, K. (2020) *This chart shows the rise of the Asian Middle Class* [Online]. Available at <https://www.weforum.org/agenda/2020/07/the-rise-of-the-asian-middle-class#:~:text=In%202020%2C%20an%20estimated%202, and%20689%20million%20in%202030.> (Accessed 11 February 2022).

Bulman, M. (2018) *Netflix, Deliveroo and terrorism blamed for huge dip in Tube passenger numbers* [Online]. Available at <https://www.independent.co.uk/news/uk/home-news/netflix-deliveroo-london-tube-underground-numbers-terrorism-blamed-drop-a8140456.html> (Accessed 18 September 2022).

C40 Cities *About C40* [Online]. Available at <https://www.c40.org/about-c40/> (Accessed 2 August 2022).

Chakravorti, B. (2021) *How to Close the Digital Divide in the U.S.*, Harvard Business Review [Online]. Available at <https://hbr.org/2021/07/how-to-close-the-digital-divide-in-the-u-s> (Accessed 18 September 2022).

Chancel, L., Piketty, T., Saez, E. and Zucman, G. (2021) *World Inequality Report 2022* [Online]. Available at [https://wir2022.wid.world/www-site/uploads/2022/01/Summary\\_WorldInequalityReport2022\\_English.pdf](https://wir2022.wid.world/www-site/uploads/2022/01/Summary_WorldInequalityReport2022_English.pdf) (Accessed 16 February 2022).

Charité – Universitätsmedizin Berlin (2022) *Charité – Universitätsmedizin Berlin* [Online], Berlin, Germany. Available at <https://www.charite.de/#:~:text=Mit%20mehr%20als%2017.600%20Mitarbeiterinnen,hat%20die%20Charit%C3%A9%202020.900%20Besch%C3%A4ftigte>. (Accessed 18 May 2022).

Clifford, C. (2019) *Why everyone is talking about free cash handouts—an explainer on universal basic income* [Online]. Available at <https://www.cnn.com/2019/06/27/free-cash-handouts-what-is-universal-basic-income-or-ubi.html> (Accessed 22 February 2022).

Cortright, J. (2017) *What price for autonomous vehicles?*, City Observatory [Online]. Available at [https://cityobservatory.org/what-price\\_autonomous\\_vehicles/](https://cityobservatory.org/what-price_autonomous_vehicles/) (Accessed 14 June 2022).

Costa, D. L. (2000) 'The Wage and the Length of the Work Day: From the 1890s to 1991', *Journal of Labor Economics*, vol. 18, no. 1, pp. 156–181.

Crozet, Y. and Coldefy, J. (2021) *Mobility as a Service (MaaS): A digital roadmap for public transport authorities*, Centre on Regulation in Europe [Online]. Available at <https://euagenda.eu/publications/mobility-as-a-service-maas-a-digital-roadmap-for-organisational-authorities>.

Cusack, J. (2021) *Self-driving vehicles are steadily becoming a reality despite the many hurdles still to be overcome – and they could change our world in some unexpected ways*. [Online]. Available at <https://www.bbc.com/future/article/20211126-how-driverless-cars-will-change-our-world> (Accessed 21 February 2022).

Dabla-Norris, E. and Kochhar, K. (2019) *Closing the Gender Gap: The economic benefits of bringing more women into the labor force are greater than previously thought* [Online]. Available at <https://www.imf.org/external/pubs/ft/fandd/2019/03/pdf/closing-the-gender-gap-dabla.pdf> (Accessed 22 February 2022).

DB Vertrieb GmbH (ed) (2022) *9-Euro-Ticket* [Online]. Available at <https://www.bahn.de/angebot/regio/9-euro-ticket> (Accessed 27 July 2022).

Deloitte (ed) (2015) *Single-person households: Another look at the changing American family: Behind the Numbers* [Online]. Available at <https://www2.deloitte.com/us/en/insights/economy/behind-the-numbers/single-person-households-and-changing-american-family.html> (Accessed 18 September 2022).

Deloitte MCS Limited (ed) (2017) *Deloitte City Mobility Index: Chicago* [Online] (Accessed 26 June 2022).

Demsas, J. (2021) *Covid-19 caused a recession. So why did the housing market boom?*, Vox Media [Online]. Available at <https://www.vox.com/22264268/covid-19-housing-insecurity-housing-prices-mortgage-rates-pandemic-zoning-supply-demand> (Accessed 18 September 2022).

Department for Transport (ed) (2011) *Commuting and business travel factsheet – April 2011: Trends in commuting and business trips*, Government Digital Service [Online]. Available at [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/230553/Commuting\\_and\\_business\\_travel\\_factsheet\\_\\_\\_April\\_2011.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/230553/Commuting_and_business_travel_factsheet___April_2011.pdf) (Accessed 31 December 2021).

Department for Work and Pensions (ed) (2020) *Family Resources Survey 2018/19*, Government Digital Service [Online]. Available at <https://assets.publishing.service.gov.uk/government/uploads/>



- Evans, T. (2020) *Ethnicity pay gaps: 2019*, UK Statistics Authority [Online]. Available at <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/articles/ethnicitypaygapsingreatbritain/2019> (Accessed 16 February 2022).
- EYQ (ed) (2020) *Are you reframing your future or is the future reframing you?: Megatrends 2020 and beyond, 3rd edition*, EYGM Limited [Online]. Available at [https://assets.ey.com/content/dam/ey-sites/ey-com/en\\_gl/topics/megatrends/ey-megatrends-2020-report.pdf](https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/megatrends/ey-megatrends-2020-report.pdf) (Accessed 6 January 2022).
- Fanguy, W. (2020) *What Is Color Theory? Meaning & Fundamentals* [Online]. Available at <https://xd.adobe.com/ideas/process/ui-design/what-is-color-theory/> (Accessed 7 August 2022).
- Fernani, A. (2021) *Wild Cards: What They Are and How to Use Them in Futures & Foresight* [Online]. Available at <https://medium.com/predict/wild-cards-what-they-are-and-how-to-use-them-in-futures-foresight-64d4755cd35b>.
- Figg, H. (2021) *Free passenger transport - exploring the benefits and disadvantages*, European Commission [Online]. Available at <https://www.eltis.org/resources/case-studies/free-passenger-transport-exploring-benefits-and-disadvantages> (Accessed 26 June 2022).
- Fosu, A. (2021) *Sector Focus: Public Transport* [Online]. Available at <https://www.lexology.com/library/detail.aspx?g=c9505b24-b006-4673-8852-8e11605ff230>.
- Foutty, J. and Bawa, R. (2018) *The Societal Impact of Cloud* [Online]. Available at <https://deloitte.wsj.com/articles/the-societal-impact-of-cloud-1542247330#:~:text=Not%20only%20does%20the%20cloud,they%20are%20invented%20and%20matured.> (Accessed 13 April 2021).
- Francis, T. (2021) *The next big cloud competition is the race to zero emissions* [Online]. Available at <https://www.weforum.org/agenda/2021/09/the-next-big-cloud-competition-is-the-race-to-zero-emissions/> #:~:text=Cloud%20computing%20and%20data%20centres%20have%20become%20core%20global%20infrastructure,emissions%20for%20many%20tech%20companies. (Accessed 13 April 2022).
- Frei, R. and Jack, L. (2021) *Future of high streets: how to prevent our city centres from turning into ghost towns* [Online]. Available at <https://theconversation.com/future-of-high-streets-how-to-prevent-our-city-centres-from-turning-into-ghost-towns-154108>.
- Frick, W. (2021) *The next phase of remote work will be even more disruptive* [Online]. Available at <https://www.weforum.org/agenda/2021/11/remote-work-employment-employers-covid-pandemic/>.
- G20 Employment Working Group (ed) (2017) *Future of Work and Skills*, Organisation for Economic Co-operation and Development [Online]. Available at [https://www.oecd.org/els/emp/wcms\\_556984.pdf](https://www.oecd.org/els/emp/wcms_556984.pdf) (Accessed 22 February 2022).
- (2018) *Gallup's Perspective on The Gig Economy and Alternative Work Arrangements*.
- Gartner Glossary *Cloud Computing* [Online]. Available at <https://www.gartner.com/en/information-technology/glossary/cloud-computing>.
- Gartner Glossary *Customer Experience* [Online]. Available at [gartner.com/en/information-technology/glossary/customer-experience](https://www.gartner.com/en/information-technology/glossary/customer-experience) (Accessed 13 April 2022).
- Gartner Glossary *Information Technology Glossary: Digitalization* [Online]. Available at <https://www.gartner.com/en/information-technology/glossary/digitalization>.

- Gaub, F. (2019) *Challenges and Choices for Europe: Global Trends to 2030*, European Strategy and Policy Analysis System [Online]. Available at [https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/ESPAS\\_Report2019\\_V14.pdf](https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/ESPAS_Report2019_V14.pdf).
- Gausemeier, J., Fink, A. and Schlake, O. (1995) *Szenario-Management: Planen und Führen mit Szenarien*, Carl Hanser Verlag München Wien.
- Gausemeier, J., Fink, A. and Schlake, O. (1998) 'Scenario Management: An Approach to Develop Future Potentials', *Technological Forecasting and Social Change*, vol. 59, no. 2, pp. 111–130 [Online]. DOI: 10.1016/S0040-1625(97)00166-2 (Accessed 9 May 2022).
- Glaveski, S. (2018) *The Case for the 6-Hour Workday* [Online]. Available at <https://hbr.org/2018/12/the-case-for-the-6-hour-workday> (Accessed 8 June 2022).
- Glenn, J. (2016) *Redefining Passenger Experience for Airlines* [Online]. Available at <https://www.everymundo.com/redefining-passenger-experience-airlines/#:~:text=Traditionally%2C%20the%20%E2%80%9Cpassenger%20experience%E2%80%9D,check%2Din%20through%20baggage%20claim.> (Accessed 26 July 2022).
- Gmünder, M., Koch, P., Chlond, B., Minster, C., Vortisch, P., Dasen, S. and Maierl, A. (2016) *Zeitliche Homogenisierung der Verkehrsbelastung – Brechen von Spitzen*, Bundesamt für Strassen.
- Gutman, A. and Drexler, M. (2015) *The Aging Game: Perils and Promises of a Graying Society*, Harvard University [Online]. Available at <https://cdn1.sph.harvard.edu/wp-content/uploads/sites/21/2015/09/HPHFALL15.pdf> (Accessed 18 September 2022).
- Guzmán, J. M., Pawliczko, A., Beales, S. and Voelcker, I. (2012) *Ageing in the Twenty-First Century: A Celebration and A Challenge* ISBN 978-0-89714-981-5.
- Haider, M. (2016) *Is The Gig Economy Hurting Public Transit?* [Online]. Available at [https://www.huffpost.com/archive/ca/entry/gig-economy-public-transit\\_b\\_10222036](https://www.huffpost.com/archive/ca/entry/gig-economy-public-transit_b_10222036) (Accessed 16 February 2022).
- Haller, G. (2006) *Thermische Behaglichkeit in Schienenfahrzeugen* [Online]. Available at [http://www.rta.eu/images/stories/pdf/Fachartikel/Thermische-Behaglichkeit\\_de.pdf](http://www.rta.eu/images/stories/pdf/Fachartikel/Thermische-Behaglichkeit_de.pdf) (Accessed 28 July 2022).
- Hanyan, S. (2021) *20-minute Towns*, Urban Land Institute [Online]. Available at <https://singapore.uli.org/20-minute-towns/> (Accessed 18 September 2022).
- Hartikainen, A., Pitkänen, J.-P., Riihelä, A., Räsänen, J., Sacs, I., Sirkiä, A. and Uteng, A. (2019) *Whimpack: Insights from the world's first Mobility-as-a-Service (MaaS) system*.
- Holzwarth, A. (2021) *Remote Work Is (Mostly) Here To Stay* [Online]. Available at <https://www.forbes.com/sites/alineholzwarth/2021/02/16/remote-work-is-mostly-here-to-stay/?sh=3945f3064b5c>.
- Hönigsberger, G. (2022) '30 Prozent der Autos müssten weg', *Wiener Zeitung GmbH*, 30 July [Online]. Available at <https://www.wienerzeitung.at/nachrichten/chronik/wien-chronik/2156484-30-Prozent-der-Autos-muessten-weg.html> (Accessed 2 August 2022).
- Hoornweg, D. and Pope, K. (2014) *Socioeconomic Pathways and Regional Distribution of the World's 101 Largest Cities*, University of Toronto, Global Cities Institute Working Paper 04 [Online]. Available at [https://shared.uoit.ca/shared/faculty-sites/sustainability-today/publications/largest\\_cities.pdf](https://shared.uoit.ca/shared/faculty-sites/sustainability-today/publications/largest_cities.pdf) (Accessed 18 September 2022).
- Horx, T. *Get started - Keynote* [Online], Rottweil, Deutschland. Available at <https://www.tristan-horx.com/videos/>.



Hutt, R. (2019) *How the gender commuting gap could be harming women's careers* [Online]. Available at <https://www.weforum.org/agenda/2019/01/how-the-gender-commuting-gap-could-harm-womens-careers/> (Accessed 22 February 2022).

Infrastructure Australia (ed) (2019) *An Assessment of Australia's Future Infrastructure Needs - Executive Summary*, Australian Government [Online]. Available at [https://www.infrastructureaustralia.gov.au/sites/default/files/2020-09/audit\\_passenger.pdf](https://www.infrastructureaustralia.gov.au/sites/default/files/2020-09/audit_passenger.pdf) (Accessed 26 June 2022).

Intelligent Transport (ed) (2021) *TfL providing real-time crowdedness information through app update* [Online], Kent, United Kingdom, Russell Publishing Ltd. (Accessed 4 January 2022).

Iotkovska, S. (2021) *E-scooters return to Copenhagen but with significant restrictions* [Online]. Available at <https://www.themayor.eu/en/a/view/e-scooters-return-to-copenhagen-but-with-significant-restrictions-9134>.

ITF (2021) *ITF Transport Outlook 2021: 3. Urban passenger transport: Cities can make mobility sustainable, equitable and resilient* 9789282114087 [Online]. Available at <https://www.oecd-ilibrary.org/sites/316ba973-en/index.html?itemId=/content/component/316ba973-en#section-d1e12394> (Accessed 31 December 2021).

Jacobs, J. (1961) *The Death and Life of Great American Cities*, New York, Random House.

Jaffe, E. (2015) *How Much Money U.S. Transit Systems Lose Per Trip, in 1 Chart*, Bloomberg Media Group [Online]. Available at <https://www.bloomberg.com/news/articles/2015-06-08/one-chart-showing-how-much-money-major-u-s-public-transportation-systems-lose-per-trip> (Accessed 6 January 2022).

Jaffe, E. (2018) *The real benefits of real-time transit data* [Online] (Accessed 4 January 2022).

Jennings, R. (2020) *Not Just Coronavirus: Asians Have Worn Face Masks for Decades* [Online]. Available at [https://www.voanews.com/a/science-health\\_coronavirus-outbreak\\_not-just-coronavirus-asians-have-worn-face-masks-decades/6185597.html](https://www.voanews.com/a/science-health_coronavirus-outbreak_not-just-coronavirus-asians-have-worn-face-masks-decades/6185597.html) (Accessed 2 January 2022).

Kaysen, R. (2020) *Can I Actually Be Missing the Commute?* [Online]. Available at <https://www.nytimes.com/2020/10/23/realestate/can-i-actually-be-missing-the-commute.html> (Accessed 18 May 2022).

Keegan, M. (2019) *How public transport actually turns a profit in Hong Kong* [Online]. Available at <https://www.theguardian.com/cities/2019/mar/19/how-public-transport-actually-turns-a-profit-in-hong-kong> (Accessed 6 November 2022).

Kelly, J. (2021) *The Future Of Work Will Be Five-Hour Days, A Four-Day Workweek And Flexible Staggered Schedules* [Online]. Available at <https://www.forbes.com/sites/jackkelly/2021/05/28/the-future-of-work-will-be-----five-hour-days-a-four-day-workweek-and-flexible-staggered-schedules/?sh=70d79bbd16f1>.

Kenny, C. and Yang, G. (2021) *Can Africa Help Europe Avoid Its Looming Aging Crisis?*, Center for Global Development 202.416.4000 [Online]. Available at <https://www.cgdev.org/sites/default/files/can-africa-help-europe-avoid-looming-aging-crisis.pdf> (Accessed 31 December 2021).

Khan, S. and Baswedan, A. (2021) *Public transport global coalition statement* [Online]. Available at <https://www.c40.org/wp-content/uploads/2021/11/Global-coalition-statement-ENG.pdf> (Accessed 31 December 2021).

Klönne, M. (2008) *Methodik und Prozessgestaltung strategischer kommunaler Verkehrsplanungen: Anwendungsmöglichkeiten von systemdynamischen Modellen zur Bewertung kommunaler*

*Verkehrsstrategien in der Planungspraxis*, Dissertation, Aachen, RWTH Aachen [Online]. Available at <https://d-nb.info/989087026/34> (Accessed 6 October 2022).

Kolomatsky, M. (2021) *Where Are Workers Making the Longest Commutes?* [Online]. Available at <https://www.nytimes.com/2021/08/26/realestate/supercommuter-longest-commutes.html#:~:text=Surprisingly%2C%20distance%20from%20work%20was,30%20miles%20of%20the%20job.> (Accessed 11 February 2022).

König Jerlmyr, A. and Ratti, C. (2020) *'Flatten the curve' of traffic to make cities liveable* [Online]. Available at <https://www.ft.com/content/6bec3f77-bc43-4ca9-8d80-b11bac764402>.

Kramer, A., Warren, A., Maher, W., McLaughlin, M., Nelson, A., Payne, O. and Tsang, E. (2020) *Emerging Trends in Real Estate 2021: United States | Canada* [Online]. Available at <https://www.pwc.com/us/en/asset-management/real-estate/assets/pwc-emerging-trends-in-real-estate-2021.pdf> (Accessed 18 September 2022).

Kuchta, D. M. (2022) *The History of the Electric Car: A Timeline*, Dotdash Meredith [Online]. Available at <https://www.treehugger.com/history-of-the-electric-car-trials-and-triumphs-5193009> (Accessed 9 June 2022).

Lang, N. (2022) *Why mobility matters when it comes to social inclusion* [Online]. Available at <https://www.weforum.org/agenda/2022/05/when-it-comes-to-social-inclusion-mobility-matters/> (Accessed 6 June 2022).

Lertxundi, G. (2021) *TMB tackling decarbonisation in Barcelona's public transport* [Online], Kent, United Kingdom, Russell Publishing Ltd. Available at <https://www.intelligenttransport.com/transport-articles/126471/decarbonisation-barcelona-public-transport/> (Accessed 5 January 2022).

Litman, T. (2020) *Terrorism, Transit and Public Safety: Evaluating the Risks* [Online]. Available at <https://www.vtpi.org/transitrisk.pdf>.

Little, S. (2021) *Using data to improve the e-scooter experience for everyone* [Online]. Available at <https://www.intelligenttransport.com/transport-articles/129012/data-improve-e-scooter-experience/> (Accessed 9 June 2022).

Liu, W. (2021) *Remote Workers Are Not All Digital Nomads* [Online]. Available at <https://www.forbes.com/sites/theyec/2020/01/29/remote-workers-are-not-all-digital-nomads/?sh=73149d637d83>.

Louen, C., Burla, P., Höing, N. and Böhnen, C. (2022) *Entwicklung und Wirkungsanalyse von ÖPNV-Netzkonfigurationen mit autonomen Shuttles am Beispiel der Stadt Aachen* [Online], RWTH Aachen (Accessed 6 October 2022).

Low, H. (2021) *London's Oyster card: Are its days numbered?* [Online]. Available at <https://www.bbc.com/news/uk-england-london-58197631> (Accessed 2 February 2022).

Lufkin, B. (2021) *Is the great digital-nomad workforce actually coming?* [Online]. Available at <https://www.bbc.com/worklife/article/20210615-is-the-great-digital-nomad-workforce-actually-coming>.

Lufkin, B. and Mudditt, J. (2021) *The case for a shorter workweek* [Online]. Available at <https://www.bbc.com/worklife/article/20210819-the-case-for-a-shorter-workweek#:~:text=The%20productivity%20boost%20derived%20from,%2C%20healthier%2C%20more%20engaged%20workforces.> (Accessed 8 June 2022).

Maas, S. (2021) *New study shows how much more productive a hybrid workforce can be* [Online]. Available at <https://www.weforum.org/agenda/2021/07/work-form-home-hybrid-working-covid-pandemic-us-office>.

Maffii, S., Malgieri, P. and Di Bartolo, C. (2020) *Smart choices for cities - Gender equality and mobility: mind the gap!* [Online]. Available at [https://civitas.eu/sites/default/files/civ\\_pol-an2\\_m\\_web.pdf](https://civitas.eu/sites/default/files/civ_pol-an2_m_web.pdf) (Accessed 10 August 2022).

Manniello, L. (2021) *Die technologische Entwicklung der FAIRTIQ-App* [Online], Bern, Switzerland. Available at <https://fairtiq.com/de-at/blog/die-technologische-entwicklung-der-fairtiq-app> (Accessed 2 January 2022).

Markets and Markets (ed) (2021) *Cloud Computing Market by Service Model (Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS)), Deployment Model (Public and Private), Organization Size, Vertical, and Region - Global Forecast to 2026* [Online]. Available at <https://www.marketsandmarkets.com/Market-Reports/cloud-computing-market-234.html#:~:text=cloud%20computing%20market%3F-The%20global%20cloud%20computing%20market%20size%20is%20expected%20to%20grow,16.3%25%20during%20the%20forecast%20period.> (Accessed 13 April 2022).

Marr, B. (2022) *The 5 Technologies That Will Change The Future Of The Human Race* [Online]. Available at <https://www.forbes.com/sites/bernardmarr/2022/02/07/the-5-technologies-that-will-change-the-future-of-the-human-race/?sh=29d519888f1c> (Accessed 10 February 2022).

Metropolitan Transportation Authority (ed) (2021) *LIRR and Metro-North fares* [Online]. Available at <https://new.mta.info/fares/lirr-metro-north> (Accessed 22 October 2021).

Ministry of Petroleum and Energy (ed) (2016) *Renewable energy production in Norway* [Online]. Available at <https://www.regjeringen.no/en/topics/energy/renewable-energy/renewable-energy-production-in-norway/id2343462/> (Accessed 26 June 2022).

Miskolczi, M., Földes, D., Munkácsy, A. and Jászberényi, M. (2021) 'Urban mobility scenarios until the 2030s', *Sustainable Cities and Society*, vol. 72.

Mitteregger, M., Bruck, E. M., Soteropoulos, A., Stickler, A., Berger, M., Dangschat, J. S., Scheuven, R. and Banerjee, I. (eds) (2021) *AVENUE21. Politische und planerische Aspekte der automatisierten Mobilität: Automatisiertes und vernetztes Fahren im Kontext einer nachhaltigen Verkehrs- und Mobilitätswende* [Online], Berlin, Germany, Springer Vieweg. Available at <https://link.springer.com/book/10.1007/978-3-662-63354-0> (Accessed 21 February 2022).

Modijefsky, M. (2020) *Stops on demand for women and minors in all night interurban bus lines Madrid* [Online]. Available at <https://www.eltis.org/in-brief/news/stops-demand-women-and-minors-all-night-interurban-bus-lines-madrid> (Accessed 25 July 2022).

Monshaw, A. (2021) *Public transport data and the next steps for better operations* [Online]. Available at <https://www.intelligenttransport.com/transport-articles/126662/public-transport-data-and-the-next-steps-for-better-operations/> (Accessed 9 June 2022).

Moovit App Global Ltd. (ed) *Commute time by public transit* [Online]. Available at [https://moovitapp.com/insights/en/Moovit\\_Insights\\_Public\\_Transit\\_Index-commute-time](https://moovitapp.com/insights/en/Moovit_Insights_Public_Transit_Index-commute-time) (Accessed 2 October 2022).

Muro, M., Liu, S., Whiton, J. and Kulkarni, S. (2017) *Digitalization and the American Workforce*, Brookings [Online]. Available at [https://www.brookings.edu/wp-content/uploads/2017/11/mpp\\_2017nov15\\_digitalization\\_full\\_report.pdf](https://www.brookings.edu/wp-content/uploads/2017/11/mpp_2017nov15_digitalization_full_report.pdf) (Accessed 18 September 2022).

N26 GmbH (ed) (2021) *The rise of the gig economy has changed the way we work forever* [Online]. Available at <https://n26.com/en-eu/blog/gig-economy.>

Nagarajan, R. (2020) *Get around safely with these new Google Maps features* [Online]. Available at <https://www.blog.google/products/maps/get-around-safely-these-new-google-maps-features/> (Accessed 13 June 2022).

Naisbitt, J. (1982) *Megatrends - 10 Perspektiven, die unser Leben verändern werden*, 2nd edn, Beyreuth, Germany, Hestia Verlag GmbH.

Namung, M. and Akar, G. (2014) 'Role of Gender and Attitudes on Public Transportation Use', *Transportation Research Record*, vol. 2415, no. 1, pp. 136–144 [Online]. DOI: 10.3141/2415-15 (Accessed 22 February 2022).

O'Toole, R. (2018) *Charting Public Transit's Decline*, CATO Institute [Online]. Available at <https://www.cato.org/policy-analysis/charting-public-transits-decline#> (Accessed 18 September 2022).

Oberzaucher, E. (2017) *Homo urbanus: Ein evolutionsbiologischer Blick in die Zukunft der Städte*, Berlin, Germany, Springer-Verlag GmbH.

Oberzaucher, Elisabeth (2022) Unpublished interview conducted by Sophie Hofbauer, 7 July.

OECD (ed) (2019) *The Future of Work OECD Employment Outlook 2019: Highlights* [Online]. Available at <https://www.oecd.org/employment/Employment-Outlook-2019-Highlight-EN.pdf> (Accessed 31 December 2021).

Omankwu, O., Ezeme, C. and Ugwa, C. (2016) *Impacts of Cloud Computing in the Society* [Online]. Available at <https://www.theijes.com/papers/v5-i6/version-2/O050602086097.pdf> (Accessed 13 April 2022).

One Mobility Ticketing GmbH (ed) (2022) *Wie viel kostet das KlimaTicket Ö?* [Online]. Available at <https://www.klimaticket.at/de/#wieviel-kostet-das-klimaticket>.

O'Sullivan, F. (2021) *Where the '15-Minute City' Falls Short*, Bloomberg Media Group [Online]. Available at <https://www.bloomberg.com/news/articles/2021-03-02/the-downsides-of-a-15-minute-city> (Accessed 18 September 2022).

Overstreet, K. (2022) *When 5% of the United States is Covered By Parking Lots, How Do We Redesign our Cities?* [Online]. Available at <https://www.archdaily.com/976069/when-5-percent-of-the-united-states-is-covered-by-parking-lots-how-do-we-redesign-our-cities> (Accessed 23 February 2022).

Pemberton, C. (2018) *Key Findings From the Gartner Customer Experience Survey* [Online]. Available at <https://www.gartner.com/en/marketing/insights/articles/key-findings-from-the-gartner-customer-experience-survey> (Accessed 5 May 2022).

Peñalosa, E. (2013) *Why buses represent democracy in action* [Online] (Accessed 6 June 2022).

Pesaresi, M., Melchiorri, M., Siragusa, A. and Kemper, T. (2016) *Atlas of the Human Planet 2016: Mapping Human Presence on Earth with the Global Human Settlement Layer*, European Commission.

Peter G. Peterson Foundation (ed) (2019) *What are the trends slowing wage growth and fuelling income inequality?* [Online]. Available at <https://www.pgpf.org/blog/2019/07/what-are-the-trends-slowing-wage-growth-and-fueling-income-inequality> (Accessed 15 February 2022).

Pfeifer, S. (2022) *'Factory of the future' offers new blueprint for manufacturers* [Online]. Available at <https://www.ft.com/content/36737e33-f58d-4728-9e15-f9da5fac9d78?desktop=true&segmentId=0e5502c2-a654-17b7-29eb-3bb1c22ff1ba#myft:notification:daily-empty-email:content>.

Polst, S., Menning, P., Schmitt, A. and Scholz, K. (2022) *»Mobilitätswende 2030« Vom Linienbus zur öffentlichen Mobilität der Zukunft* [Online]. Available at <https://www.iese.fraunhofer.de/content/>

dam/iese/dokumente/media/studien/mobilitaetswende\_2030-dt-fraunhofer\_iese.pdf (Accessed 25 July 2022).

Powell, A. (2021) *Light Rail: The future of smarter transport infrastructure* [Online]. Available at <https://infrastructuremagazine.com.au/2021/09/16/light-rail-the-future-of-smarter-transport-infrastructure/>.

Public Transport Victoria (2021) *Travel benefits: Early Bird train travel* [Online]. Available at <https://www.ptv.vic.gov.au/tickets/myki/travel-with-myki/travel-benefits/> (Accessed 22 October 2021).

Pulrang, A. (2020): *Use plain language* [Online]. Available at <https://www.forbes.com/sites/andrewpulrang/2020/10/22/plain-language-writing---an-essential-part-of-accessibility/?sh=53b4d2ef7935> (Accessed 6 June 2022).

Racca, D. P. and Ratledge, E. (2003) *Factors That Affect and/or Can Alter Mode Choice*, University of Delaware [Online]. Available at <https://cpb-us-w2.wpmucdn.com/sites.udel.edu/dist/1/1139/files/2013/10/Rpt.-159-Factors-that-Affect-and-or-Can-Alter-Mode-Choice-yzxqre.pdf> (Accessed 21 February 2022).

RAIL magazine (2022) *Reimagining & Rebooting our passenger railway: the passenger experience* [Online], Peterborough, United Kingdom, Bauer Consumer Media Ltd. Available at [https://www.bigmarker.com/bauer-media/Reimagining-Rebooting-our-passenger-railway-The-Passenger-Experience--A-RAIL-webinar?bmid=74b3d6ed968f&source\\_from=invitation](https://www.bigmarker.com/bauer-media/Reimagining-Rebooting-our-passenger-railway-The-Passenger-Experience--A-RAIL-webinar?bmid=74b3d6ed968f&source_from=invitation) (Accessed 13 April 2022).

Rankin, J. (2021) *Gig economy workers to get employee rights under EU proposals* [Online]. Available at <https://www.theguardian.com/business/2021/dec/09/gig-economy-workers-to-get-employee-rights-under-eu-proposals>.

Rapino, M. A. and Fields, A. K. (2013) *Mega Commuting in the U.S.: Time and Distance in Defining Long Commutes using the 2006-2010 American Community Survey*, United States Census Bureau 301.763.5877 [Online]. Available at <https://www.census.gov/content/dam/Census/library/working-papers/2013/demo/SEHSD-WP2013-03.pdf> (Accessed 11 February 2022).

Ratti, C., Kondor, D., Santi, P., Duarte, F., So, W. and Du, G. (2018) *How many parking spots will be needed with Autonomous Vehicles? New research by Senseable City Lab at MIT and Allianz quantifies potential for unprecedented reduction* [Online]. Available at <https://senseable.mit.edu/unparking/> (Accessed 23 February 2022).

Richter, F. (2022) *Amazon Leads \$180-Billion Cloud Market*, Statista [Online]. Available at <https://www.statista.com/chart/18819/worldwide-market-share-of-leading-cloud-infrastructure-service-providers/> (Accessed 13 April 2022).

Ritchey, T. (2002 (revised 2013)) *General Morphological Analysis\* - A general method for non-quantified modelling* [Online]. Available at <https://www.swemorph.com/pdf/gma.pdf> (Accessed 17 June 2022).

Ritchie, H. and Roser, M. (2018) *Urbanization* [Online]. Available at <https://ourworldindata.org/urbanization>.

Roat, D. (2019) *Frictionless travel: benefitting the user, the operator and society*, Russell Publishing Ltd. [Online]. Available at <https://www.intelligenttransport.com/transport-articles/74487/frictionless-travel-user-operator-society/>.

Rode, P., Hoffmann, C., Kandt, J., Smith, D. and Graff, A. (2015) *Towards New Urban Mobility: The case of London and Berlin* [Online]. Available at <https://www.lse.ac.uk/cities/Assets/Documents/Research-Reports/Towards-New-Urban-Mobility-London-and-Berlin.pdf> (Accessed 6 June 2022).

Ross, J. (2021) *These are the fastest growing jobs in the United States*, World Economic Forum [Online]. Available at [https://www.weforum.org/agenda/2021/09/fastest-growing-jobs-employment-skills/?utm\\_source=sfmc&utm\\_medium=email&utm\\_campaign=2755935\\_Agenda\\_weekly-24September2021&utm\\_term=&emailType=Agenda%20Weekly](https://www.weforum.org/agenda/2021/09/fastest-growing-jobs-employment-skills/?utm_source=sfmc&utm_medium=email&utm_campaign=2755935_Agenda_weekly-24September2021&utm_term=&emailType=Agenda%20Weekly).

Ruiz, N., Noe-Bustamante, L. and Saber, N. (2020) *Coming of Age* [Online], Washington DC (Finance & Development Volume 57). Available at <https://www.imf.org/external/pubs/ft/fandd/2020/03/pdf/fd0320.pdf>.

SAE International (ed) (2021) *SAE J3016 levels of driving automation* [Online]. Available at [https://www.sae.org/binaries/content/assets/cm/content/blog/sae-j3016-visual-chart\\_5.3.21.pdf](https://www.sae.org/binaries/content/assets/cm/content/blog/sae-j3016-visual-chart_5.3.21.pdf) (Accessed 20 February 2022).

Santana Junior, C., Botta, F., Barbosa, H., Privitera, F., Menezes, R. and Di Clemente, R. (2020) *Analysis of socioeconomic aspects related to mobility patterns in the UK during the COVID-19 pandemic* [Online]. Available at [https://www.researchgate.net/publication/342068773\\_Analysis\\_of\\_socioeconomic\\_aspects\\_related\\_to\\_mobility\\_patterns\\_in\\_the\\_UK\\_during\\_the\\_COVID-19\\_pandemic](https://www.researchgate.net/publication/342068773_Analysis_of_socioeconomic_aspects_related_to_mobility_patterns_in_the_UK_during_the_COVID-19_pandemic) (Accessed 18 September 2022).

Sardesai, S., Stute, M. and Kamphues, J. (2021) 'A Methodology for Future Scenario Planning', in Fornasiero, R., Sardesai, S., Barros, A. C. and Matopoulos, A. (eds) *Next Generation Supply Chains: A Roadmap for Research and Innovation*, Cham, Springer International Publishing, pp. 35–59.

Schawel, C. and Billing, F. (2011) 'Morphologischer Kasten', in *Top 100 Management Tools: Das wichtigste Buch eines Managers*, Wiesbaden, Gabler, pp. 132–133.

Scheer, J., Wolf, I. and Middendorf, S. (2020) *Modal-Split-Untersuchung 2019*, Landkreis Augsburg [Online]. Available at [https://www.landkreis-augsburg.de/fileadmin/user\\_upload/Klimaschutz/Mobilitaet\\_Radverkehr/Langfassung\\_der\\_Mobilitaetsuntersuchung\\_2019.pdf](https://www.landkreis-augsburg.de/fileadmin/user_upload/Klimaschutz/Mobilitaet_Radverkehr/Langfassung_der_Mobilitaetsuntersuchung_2019.pdf) (Accessed 18 September 2022).

Schroten, A., Kiraly, J. and Scholten, P. (2022) *Research for TRAN Committee – Pricing instruments on transport emissions*, European Parliament [Online]. Available at [https://www.europarl.europa.eu/RegData/etudes/STUD/2022/699641/IPOL\\_STU\(2022\)699641\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2022/699641/IPOL_STU(2022)699641_EN.pdf) (Accessed 26 June 2022).

Seager, C. (2016) *Will jobs exist in 2050?* [Online].

Silva, H. de, Johnson, L. and Wade, K. (2011) *Long distance commuters in Australia: A socio-economic and demographic profile* [Online]. Available at [https://www.bitre.gov.au/sites/default/files/sp\\_005\\_DeSilva\\_Johnson\\_Wade.pdf](https://www.bitre.gov.au/sites/default/files/sp_005_DeSilva_Johnson_Wade.pdf) (Accessed 10 October 2021).

Singapore-MIT Alliance for Research and Technology (2021) *Does ride-sharing substitute for or complement public transit?*, Massachusetts Institute of Technology [Online]. Available at <https://news.mit.edu/2020/how-does-ridesourcing-substitute-public-transit-network-0727> (Accessed 30 December 2021).

Smith, G. (2020) *Making Mobility-as-a-Service: Towards Governance Principles and Pathways*, Gothenburg, Sweden, Chalmers University of Technology [Online]. Available at [https://research.chalmers.se/publication/516812/file/516812\\_Fulltext.pdf](https://research.chalmers.se/publication/516812/file/516812_Fulltext.pdf).

Smith, R. (2020) *How can the transport sector incorporate more inclusive design?* [Online]. Available at <https://www.linkedin.com/pulse/how-can-transport-sector-incorporate-more-inclusive-design-smith/> (Accessed 7 August 2022).

Sodl-Niederecker, V., Soteropoulos, A., Kammerhofer, A., Berger, M., Herbst, L., Fellendorf, M., Selz, E. and Platzer, M. (2022) *IMaG:NE - Innovative Maßnahmen zur Glättung von Nachfragespitzen und*

*Effizienten Kapazitätsnutzung* [Online]. Available at [https://projekte.ffg.at/anhang/62a9d1f3e7bf4\\_IMAGINE\\_Ergebnisbericht\\_final.pdf](https://projekte.ffg.at/anhang/62a9d1f3e7bf4_IMAGINE_Ergebnisbericht_final.pdf) (Accessed 13 August 2022).

Solomon, M. (2018) *The Scientific Way To Design A Customer Experience For Maximum Retention (And Results)* [Online]. Available at <https://www.forbes.com/sites/micahsolomon/2018/02/28/what-science-tells-us-about-customer-experience-and-memory-and-how-this-can-help-your-bottom-line/?sh=417ada862a88> (Accessed 19 April 2022).

*Städte für Menschen* (2021) *Hypermotion - Future Mobility & Logistics*, 6 August.

Statista Research Department (2022) *Number of social network users worldwide from 2017 to 2025* [Online]. Available at <https://www.statista.com/statistics/278414/number-of-worldwide-social-network-users/> (Accessed 13 April 2022).

Statistisches Bundesamt (2021) *Mobility costs: households spend an average 233 euros per month on cars, 33 euros on bus, railway etc.* [Online], Wiesbaden. Available at [https://www.destatis.de/EN/Press/2021/07/PE21\\_N045\\_639.html](https://www.destatis.de/EN/Press/2021/07/PE21_N045_639.html) (Accessed 6 January 2022).

Stone, T. (2020) *Why public transport must now enable real-time data sharing* [Online], Kent, United Kingdom, Mark Allen Group Limited (Accessed 4 January 2022).

Subramanian, A. (2019) *How Uber & Airbnb made billions through cloud computing.* [Online]. Available at [https://medium.com/@webmaster\\_86047/how-uber-airbnb-made-billions-through-cloud-computing-b98ba108a7fc](https://medium.com/@webmaster_86047/how-uber-airbnb-made-billions-through-cloud-computing-b98ba108a7fc) (Accessed 13 April 2022).

Technavio (ed) (2021) *Mobility-as-a-Service Market by Service and Geography - Forecast and Analysis: 2021-2025*, Infiniti Research Limited [Online]. Available at <https://www.prnewswire.com/news-releases/mobility-as-a-service-market-size-to-grow-by-usd-235-bn--increase-in-the-use-of-smart-connected-devices-to-boost-market-growth--17-000-technavio-research-reports-301407703.html>.

The World Bank Group (ed) (2022) *About Public-Private Partnerships* [Online]. Available at <https://ppp.worldbank.org/public-private-partnership/about-public-private-partnerships> (Accessed 1 August 2022).

Thompson, D. (2021) *Winners and Losers of the Work-From-Home Revolution* [Online]. Available at <https://www.theatlantic.com/ideas/archive/2021/06/winners-losers-work-home-remote/619181/> (Accessed 18 September 2022).

Tippett, R. (2015) *What commuting statistics can't tell us about transportation use: Fewer than 1 in 5 trips are for commuting*, University of North Carolina [Online]. Available at <https://www.ncdemography.org/2015/09/14/what-commuting-statistics-cant-tell-us-about-transportation-use/> (Accessed 31 December 2021).

Tobin, M. (2021) *Airbnb Adds New Tools in Bet Remote Work Is Here to Stay.*

Transport for London (ed) *Congestion Charge* [Online]. Available at <https://tfl.gov.uk/modes/driving/congestion-charge> (Accessed 29 July 2022).

Transport for London (2017) *Review of the TfL WiFi pilot* [Online]. Available at <https://content.tfl.gov.uk/review-tfl-wifi-pilot.pdf> (Accessed 7 May 2022).

Transport for London (2021) *Keeping London moving safely: Annual Report and Statement of Accounts 2020/21* [Online]. Available at <https://content.tfl.gov.uk/tfl-annual-report-9-august-2021-acc.pdf> (Accessed 6 January 2022).

Tyler, Nick (2021) Unpublished interview conducted by Nick Coates, 5 November.

UN Environment Programme (ed) *Transport: Promoting sustainable low emissions transport*, UN Environment Programme [Online]. Available at <https://www.unep.org/explore-topics/energy/what-we-do/transport> (Accessed 31 December 2021).

UNFPA and HelpAge International (2012) *Ageing in the Twenty-First Century: A Celebration and A Challenge* [Online], New York, and HelpAge International, London. Available at <https://www.unfpa.org/sites/default/files/pub-pdf/Ageing%20report.pdf> (Accessed 18 September 2022).

Union Internationale des Transports Publics (ed) (2020) *Flattening Peak Travel Time: Measures to better distribute travel demand* [Online]. Available at [https://cms.uitp.org/wp/wp-content/uploads/2021/01/Knowledge-Brief-Flattening-the-Peak\\_DEC2020.pdf](https://cms.uitp.org/wp/wp-content/uploads/2021/01/Knowledge-Brief-Flattening-the-Peak_DEC2020.pdf).

United Nations, Department of Economic and Social Affairs (ed) (2019) *World Population Prospects 2019: Highlights* [Online], New York, United Nations. Available at [https://population.un.org/wpp/Publications/Files/WPP2019\\_Highlights.pdf](https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf).

United Nations, Department of Economic and Social Affairs, Population Division (2018) *World Urbanization Prospects: The 2018 Revision* [Online]. Available at [https://www.un.org/en/events/citiesday/assets/pdf/the\\_worlds\\_cities\\_in\\_2018\\_data\\_booklet.pdf](https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf).

United Nations, Department of Economic and Social Affairs, Population Division (ed) (2019a) *Patterns and trends in household size and composition: Evidence from a United Nations dataset* [Online]. Available at [https://www.un.org/en/development/desa/population/publications/pdf/ageing/household\\_size\\_and\\_composition\\_technical\\_report.pdf](https://www.un.org/en/development/desa/population/publications/pdf/ageing/household_size_and_composition_technical_report.pdf).

United Nations, Department of Economic and Social Affairs, Population Division (ed) (2019b) *World Population Prospects 2019: Population by Age Groups 2019 - Total population by age* [Online]. Available at <https://population.un.org/wpp/Download/Probabilistic/Population/> (Accessed 3 May 2022).

United Nations, Department of Economic and Social Affairs, Population Division (2019c) *World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420)* [Online]. Available at <https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf> (Accessed 18 September 2022).

van Audenhove, F.-J., Arby, H., Rominger, G. and Tauvel, M. (2021) *How to realize the promise of Mobility-as-a-Service* [Online]. Available at <https://www.adlittle.com/en/insights/report/how-realize-promise-mobility-service>.

Veigl, A., Watzak-Helmer, M. and Cervený, M. (2019) *Wiens Klima- & Energieziele für 2030 & 2050: Dokumentation von Berechnungen im Rahmen der Aktualisierung der Smart City Wien Rahmenstrategie 2018/2019* [Online]. Available at <https://smartcity.wien.gv.at/wp-content/uploads/sites/3/2019/06/Dokumentation-der-Berechnungen-zur-Aktualisierung-der-Smart-City-Wien-Rahmenstrategie.pdf> (Accessed 10 August 2022).

Walker, Jarret (2021) Unpublished interview conducted by Nick Coates, 2 November.

Wang, S. and Ge, M. (2019) *Everything You Need to Know About the Fastest-Growing Source of Global Emissions: Transport* [Online]. Available at <https://www.wri.org/insights/everything-you-need-know-about-fastest-growing-source-global-emissions-transport> (Accessed 31 December 2021).

Wiener Linien (ed) (2020) *Sima/Steinbauer: Neuer Rekord – 852.000 JahreskartenbesitzerInnen nutzen umweltfreundliche Öffis* [Online]. Available at [https://www.wien.gv.at/presse/bilder/2020/02/12/modal-split-2019\\_wiener-linien-png](https://www.wien.gv.at/presse/bilder/2020/02/12/modal-split-2019_wiener-linien-png) (Accessed 10 August 2022).

Xu, A. (2022) *What Is Customer Experience? Definition, Examples, & Tools* [Online]. Available at <https://amplitude.com/blog/customer-experience-definition> (Accessed 14 April 2022).



Yeung, W.-J. J. and Cheung, A. K.-L. (2015) *Living alone: One-person households in Asia*, Demographic Research 32 [Online]. Available at <https://www.demographic-research.org/volumes/vol32/40/32-40.pdf> (Accessed 18 September 2022).

Yiying, F. (2021) *Shanghai Expands `15-Minute Community` to the Suburbs*, Shanghai United Media Group [Online]. Available at <https://www.sixthtone.com/news/1008493/shanghai-expands-15-minute-community-to-the-suburbs-> (Accessed 18 September 2022).

Zarif, R., Kelman, B. and Pankratz, D. (2019) *Small is beautiful: Making micromobility work for citizens, cities, and service providers*.

Zhen, S. (2021) *Rethinking public transportation for women's safety and security* [Online]. Available at <https://sustainablemobility.iclei.org/rethinking-public-transportation-for-womens-safety-and-security/> (Accessed 23 February 2022).

Zukunftsinstitut GmbH (ed) *Verschiedene Trends und Trendkategorien: Definition und Dauer verschiedener Trends* [Online], Frankfurt am Main. Available at <https://www.zukunftsinstitut.de/artikel/trends-grundlagenwissen/> (Accessed 18 September 2022).

# Appendix

## Appendix 01: Students Survey

Appendix 01: Students Survey 2022/05/17 Technical University Vienna, Mobilität und Mobilitätsmanagement (280.899)

Zeitstempel OZ 2022/05/17	Digitalization	Cloud Computing	Automation	Ageing Society	Household Size	Migration	Gender Equality	Megacities	Suburbanization	15-minute City	Shopping Streets + Consumption	Decarbonization	Connected and autonomous driving	Mobility as a Service	Micro Mobility	Super Commuting	Remote Working	Working from home	Distribution of Wealth and Income	Gig Economy	Which key factors/topics do you think are missing?
2:24:24 PM	3	2	3	5	4	2	2	5	5	5	5	5	3	3	4	4	4	5	5		
2:24:46 PM																					The political sphere: democratic development, influence of companies, power dynamics
2:24:51 PM	5	3	5	4	3	4	2	5	5	5	4	3	5	4	4	3	3	3	2	3	
2:24:54 PM	5	3	4	1	1	2	4	5	5	5	4	5	4	4	5	3	5	5	5	3	VI noch Leistbarkeit der Angebote
2:24:59 PM	4	5	3	3	4	2	5	3	5	5	4	4	4	4	4	4	4	4	4	4	
2:25:06 PM	4	1	4	3	1	1	4	5	3	4	5	5	2	4	2	3	5	5	3	3	
2:25:25 PM	5	5	5	4	4	3	2	4	3	4	2	3	5	5	4	4	4	4	4	3	Behaviour,
2:25:38 PM	4	2	4	3	3	2	3	5	5	5	3	3	4	5	4	3	4	4	4	4	Blackout
2:25:42 PM	3	4	5	3	2	2	1	5	5	5	3	5	5	4	4	4	3	3	2	3	
2:26:46 PM	3	4	4	4	4	4	3	5	5	5	3	3	5	5	5	3	4	5	4	3	
2:26:54 PM	5	5	5	2	3	2	2	5	4	5	3	4	5	4	5	4	5	3	2		Technologieoffenheit, Potential von E-Fuels
2:27:06 PM	4	3	4	2	3	2	3	5	5	5	4	5	4	4	5	3	4	4	5	3	
2:27:14 PM	4	3	5	3	5	5	4	5	4	4	4	4	5	3	5	4	5	3	3	5	4 Politics
2:27:29 PM	5	3	5	4	3	4	2	3	4	3	4	3	5	5	4	3	4	3	2	3	
2:28:08 PM	5	4	5	3	2	2	2	5	5	5	5	5	5	5	4	4	4	4	5	3	Regarding climate change: environment in the city (eg. heat), public transport as cool places
2:28:47 PM	3	2	4	4	2	1	3	4	3	5	2	5	3	5	4	2	4	2	2		
2:28:48 PM	5	5	5	4	4	3	3	4	5	5	5	5	5	5	5	5	5	5	5	5	Power dynamics, automobile industries, lobbying and its regulation
2:29:24 PM	3	1	5	4	1	1	2	4	4	5	2	5	5	5	2	2	4	4	4	5	Safety, Push for Bike city, higher costs for car user (parking, driving, city-maut, car free cities, etc.)
2:30:53 PM	5	4	3	5	3	4	3	5	3	5	3	5	3	4	4	3	4	5	5	3	international and national politics / political treaties (e.g. silk road china), globalisation
Average	4,2	3,1	4,4	3,4	2,8	2,7	2,6	4,7	4,2	4,7	3,7	4,3	4,2	4,4	4,1	3,4	4,1	3,9	3,8	3,4	

## Appendix 02: Cross-Impact-Matrix arguments

### A Human Aspect -> B Work life:

-----  
A1-B1: open people welcome innovation  
A1-B2: more and heavier work goes not along with the values of open minded progressive people who look to a better future  
A2-B1: anxious people who value privacy would be interested in a slightly more flexible work model, to avoid crowds etc. but too much change would be too much  
A2-B2: those people like the schedules and value their time, more and heavier work would inhibit those values  
A3-B1: doing things per duty, because government requires it, is neutral  
A3-B2: if people have no other choice to survive they would follow more work

### A Human Aspect -> C Transport Market:

-----  
A1-C1: open minded people will influence the no need to change market by being stubborn and demanding  
A1-C2: open minded innovative people are curious on new developments  
A1-C3: open minded innovative people are curious on new developments and try out stuff  
A2-C1: people who value things as they are, see no necessity for change  
A2-C2: anxious people are scared from too much fast changing innovations and therefore slightly inhibit them  
A2-C3: if frictionless mobility will be implemented step by step, people are ok with it  
A3-C1: people who change their behaviour out of urgency, are not ok with a not changing market  
A3-C2: people welcome new forms of mobility if they help to tackle the problem  
A3-C3: people welcome a better working mobility system

### A Human Aspect -> D (Transport) Policy:

-----  
A1-D1: open minded people strongly support moving forward policies  
A1-D2: innovative people welcome new ideas  
A1-D3: innovative people are not satisfied with standing still policies  
A2-D1: people who look for security, are open for innovation, but rather in a slow tempo  
A2-D2: new innovations are rather scary for people who are looking for stability and slow processes  
A2-D3: people who don't see reasons to change are strongly support standing still policies  
A3-D1: people who change their behaviours out of a society crisis welcoming a new forward movement  
A3-D2: people who are changing for external reasons (climate, social equality labor conditions etc.) are not in favor with market driven decisions  
A3-D3: if there is a crisis, people are getting mad with standing still policies and will do everything to avoid such a politics

### B Work life -> A Human Aspect:

-----  
B1-A1: flexible work supports the values of open and aware people  
B1-A2: as anxious people value their privacy, more flexible work could help to create the ideal surrounding, but the environment should not change too much  
B1-A3: flexible work can make the mandatory switch easier  
B2-A1: more and heavier work disagrees with the concept of open and aware people who want progression  
B2-A2: more and heavier work inhibits the life of anxious people, as

they follow their values  
B2-A3: heavier work is not really welcome, but people follow the rules  
and if it necessary and they have no other option, they follow the  
instructions

B Work life -> C Transport Market:  
-----

B1-C1: flexible work requires flexible transport and therefore inhibits  
the no need to change projection  
B1-C2: next level mobility is affected by a more flexible structures  
B1-C3: flexible work supports frictionless mobility strongly, as it  
helps to spread passengers across time and modes  
B2-C1: more and heavier work would lead - with people doing several jobs  
- to more traffic. therefore the current system would need to adopt  
B2-C2: next level mobility builds up on a high technology level, more  
and heavier work disagrees with that concept  
B2-C3: more and heavier work would require a more frictionless transport  
system, to make travelling more efficient

B Work life -> D (Transport) Policy:  
-----

B1-D1: innovative world of work and forward-looking traffic policy  
strongly support each other  
B1-D2: free and flexible work would support the market driven idea  
B1-D3: free and flexible work do not accompany with a standing still  
policy and would inhibit it  
B2-D1: more and heavier work is quite neutral on moving forward  
policies, as adoptions to the new requirements of workers need to be  
made  
B2-D2: the market would react on the new working requirements and would  
adopt  
B2-D3: more work and standing still have the same background idea and  
would support each other

C Transport Market -> A Human Aspect:  
-----

C1-A1: not changing politics have no influence on open aware people,  
expect disappointment of missing chances to make the transport system  
better  
C1-A2: no need to change supports people who are looking for consistency  
C1-A3: no need to change on the market will have a negative impact on  
people if they switch per duty to pt and it is overloaded  
C2-A1: new forms of mobility will support ideas of open minded people  
C2-A2: next level mobility can create a private safe space for anxious  
people  
C2-A3: next level mobility might influence people who see it as their  
duty to switch behaviours either positive or negative  
C3-A1: frictionless and better mobility options will be welcomed by  
curious people  
C3-A2: frictionless mobility can make travelling easier for anxious  
people because of seeing the utilization and cost  
C3-A3: a more efficient transport system helps people to fulfill their  
necessities

C Transport Market -> B Work life:  
-----

C1-B1: a not adopting transport system make a flexible working life more  
difficult  
C1-B2: a transport system, which is not changing, will struggle even  
more with more people  
C2-B1: new forms of mobility support a new ways of work

C2-B2: new forms of mobility support can make working more, more efficient  
C3-B1: frictionless mob would support flexible working hours and organizations  
C3-B2: frictionless mob would make it easier to travel around, when people are short on time

C Transport Market -> D (Transport) Policy:  
-----

C1-D1: a transport market which dont want to change is inhibitating a moving forward policy  
C1-D2: a transport market which is not willing to change, supports a more market driven approach slightly  
C1-D3: if the market isnt changing, it supports standing still policicies a lot  
C2-D1: if the transport market is radically changing, progressive policy gets supported a lot  
C2-D2: innovations and big tech is strongly supporting a market driven policy  
C2-D3: if mob is changing rapidly, standing still policys will not work over long time  
C3-D1: frictionless mob supports progressiv policy a lot  
C3-D2: frictionless mob is a also a strong driver of market based decisions  
C3-D3: frictionless mob has slight impact on a not changig politics

D (Transport) Policy -> A Human Aspect:  
-----

D1-A1: Moving forward encourages open minded people to be part of this development  
D1-A2: moving forward leading helps insecure and on the first look skeptical people to step out of their comfort zone  
D1-A3: moving forward, with more on-time-policy helps to face immedeate challenges and supports people and their actions  
D2-A1: a market driven industry supports open and innovative minds  
D2-A2: a fast changing industry, can seem scary to people, who a looking for stability and security in their lifes  
D2-A3: market based decision making will not bring people to act on duty  
D3-A1: standing still makes curious people who strive for innovation angry and disappointed  
D3-A2: standing still and privacy go along quite well, beacuse of the same valeus  
D3-A3: standing still is strongly inhibitating a society which reacts immedeatly and per duty, beacuse there are no other options

D (Transport) Policy -> B Work life:  
-----

D1-B1: moving forward transport policys are the foundation for a more flexible transport system  
D1-B2: moving forward in trasnport policy can make it easier to arrange more work better, unlikely that politcans go two such contrary paths  
D2-B1: if it possible to oraganize labor more free and flexible to strengthen the economy, it supports this work model  
D2-B2: if it is necessary for economic growth to work harder, the market supports working more and heavier  
D3-B1: standing still will inhibit free and flexible work models  
D3-B2: standing still and not reacting to current problems leads to more and heavier work

D (Transport) Policy -> C Transport Market:  
-----

D1-C1: moving forward in transport policy, but not implement it, those not go along  
D1-C2: a moving forward policy supports next level mobility strong  
D1-C3: moving forward with transport policy is the foundation for frictionless mobility  
D2-C1: if the market set the tone for the transport industry, it will definitely change  
D2-C2: market based policy will support the interests of tech companies a lot  
D2-C3: market will help frictionless mobility to grow, but it might be not as social inclusive  
D3-C1: standing still because of not seeing reasons to change strongly supports each other  
D3-C2: standing still will slow down developments and innovations on the market  
D3-C3: standing still will even more slow down developments and innovations in which politics should be involved

## Appendix 03: Consistency

Konsistente Szenarien der CI-Matrix versuch02.scw:  
Starke Konsistenz

```
=====
Szenario Nr. 1
Konsistenzwert: 0
Wirkungstotale: 35
```

```
-----
A Human Aspect      : A1 Open and aware
B Work life         : B1 Free and flexible
C Transport Market  : C3 Frictionless mobility
D (Transport) Policy: D1 Moving forward
=====
```

```
=====
Szenario Nr. 2
Konsistenzwert: 0
Wirkungstotale: 31
```

```
-----
A Human Aspect      : A3 Per duty
B Work life         : B1 Free and flexible
C Transport Market  : C3 Frictionless mobility
D (Transport) Policy: D1 Moving forward
=====
```

```
=====
Szenario Nr. 3
Konsistenzwert: 0
Wirkungstotale: 24
```

```
-----
A Human Aspect      : A3 Per duty
B Work life         : B2 More and heavier
C Transport Market  : C3 Frictionless mobility
D (Transport) Policy: D1 Moving forward
=====
```

```
=====
Szenario Nr. 4
Konsistenzwert: 0
Wirkungstotale: 33
```

```
-----
A Human Aspect      : A1 Open and aware
B Work life         : B1 Free and flexible
C Transport Market  : C2 Next level mobility
D (Transport) Policy: D2 Market decision
=====
```

```
=====
Szenario Nr. 5
Konsistenzwert: 2
Wirkungstotale: 12
```

```
-----
A Human Aspect      : A2 Anxious - privacy
B Work life         : B2 More and heavier
C Transport Market  : C1 No need to change
D (Transport) Policy: D3 Standing still
=====
```