Urban Mobility Concepts

Trend Report 2011

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Julian Sußmann · Benedikt Römer (Editors)

Urban Mobility Concepts

Trend Report 2011

Urban Mobility Concepts. Trend Report 2011

Edited by: Julian Sußmann, Benedikt Römer

The Center for Digital Technology and Management (CDTM) is a joint institution of the Technische Universität München (TUM) and the Ludwig-Maximilians-Universität München (LMU). This report was created by CDTM students and is one element of a comprehensive research project. The CDTM is part of the Elitenetzwerk Bayern.

Preface

Four mega trends are shaping the world today: demographic change, climate change, globalization and urbanization. Consequences of these megatrends can most clearly be seen in cities: a steadily growing demand for energy, rising water consumption and a need for high-quality and affordable healthcare are just some of the challenges that authorities in cities all over the world face today and will have to face even more in the future.

Urbanization is a growing phenomenon and, in 2009, for the first time more people lived in cities than in the countryside. Over the next 20 years, the percentage of the world's population that lives in cities will rise from 50% to 60%, meaning that about 1.4 billion more people will be living in cities. The economic growth of cities is expected to reach 4.4% by 2025, higher than overall global economic growth and the rate of growth outside of cities. Already today, about half of the global economic growth is generated in the world's 600 biggest cities. Cities are responsible for 75% of the world's energy use and produce more than 80% of all greenhouse gas emissions. With most of the cities growing at staggering rates, there is increasing pressure to somehow manage often chaotic urban areas. Facing the diverse challenges, majors and officials have to keep two things in mind: To keep their city a place worth living for their current inhabitants and at the same time succeed in a more and more international competition for economical growth and labor force. Many municipalities have set themselves rigorous targets to reduce the carbon footprint of the entire city. With CO_2 emission not just being a measure for environmental-friendly development, these targets will also guide the way to a sustainable urban development. There is a huge number of levers to be shifted, e.g. efficient and effective mobility, sustainable, decentralized energy supply, efficient water supply and waste management When asked, city administrators overwhelmingly cite transport as the most urgent infrastructure investment to enhance their city's sustainability. This is for two reasons: Cities cannot function without a fast, efficient and affordable system of mass transit and logistics.Also, the use of private vehicles is one of the main contributors to CO_2 emissions, which cities are eager to curb. With an efficient, environmental-friendly and intermodally connected transport system, cities contribute on a local, national and international scale. Sustainable logistics in megacities will support local and national economical growth. Finally, local reduction of emission and pollution (fine dust, noise) as well as less demand of infrastructure and space will set the path towards a city worth living in. All these challenges will not be solved by independently investing in the different modes of transport and logistics but require a holistic approach for mobility solutions in urban areas. The megatrends form the core of Siemens' strategic orientation. The goal: provide answers to the world's most pressing questions. And Siemens addresses one the biggest questions of

modern day society: how to assure affordable and reliable mobility for people and goods? To be more precise: how does the future of individual transport look like? How will future transport build up on existing urban infrastructure? What role will electromobility play? What role will central management systems play that gather and smartly connect transport, traffic and personal information thus revolutionizing the way we travel? The Siemens unit "Innovative Mobility Solutions" (IMS) is the entrepreneurial implementation of Siemens strategic vision aiming at identifying technological trends and turning them into real life business solutions. Finding new ideas is just one stepping stone. Analyzing and testing them for "future readiness" is another. And here Siemens and CDTM found each other in a perfect match. Within this trend seminar student teams analyzed new trends in the topic "urban mobility concepts" with Siemens as their industrial partner and sponsor. The first part of this report consists of a basic analysis of trends regarding technology, market, society and customer needs, the political and legal framework as well as emerging business models. The second part of the report provides an outlook on the future and analyzes the identified drivers for future developments. As a result, possible business solutions in various future scenarios are deduced and analyzed for business feasibility.

Throughout the process the student groups were guided and coached by the CDTM program coordinators Julian Sußmann and Benedikt Römer. On Siemens side the project was coordinated by Martin Birkner and Dr. Martin Prescher (both from Siemens Innovative Mobility Solutions). We, on behalf of Siemens Innovative Mobility Solution, want to thank the students for their tremendous work throughout the program and ultimately resulting in this trend report. We have been deeply impressed by the creativity, professionalism and determination of each student group. The results clearly have the potential to serve as a basis for real life applications in the field of urban mobility. Of course we also want to thank Julian Sußmann and Benedikt Römer for a perfect and very enjoyable collaboration that needs to be repeated.

Munich, Spring 2011

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The entire report was written by CDTM students under the close guidance of research assistants in 2011. The papers compiled here do not claim to be scientifically accurate in every case; they are rather meant to give a structured and broad overview of trends relevant in the urban mobility context.

Contents

List of Figures

List of Tables

Part I

Trends

1

Technology Trends

David Heiny, Beatrice Lamche, Nora Liesenfeld, Martin Rassl, Bekir Topaloglu

Urbanization has become a phenomenon. More than half of the world's population now lives in urban areas. The larger and the more crowded cities become, the more complex technologies are required, in order to maintain a desirable level of mobility. In this paper, a three-level analysis on status quo and trend technologies which facilitate urban mobility is deployed.

Today's rapidly growing and converging technological environment provides a wide range portfolio consisting of comprehensive solutions from different fields. First of all, developments in material science and engineering technology like smart materials or innovations in the electrical powertrain bring new solutions to today's crucial challenges for urban mobility systems. Secondly, new approaches in energy generation, distribution and storage such as decentralized electricity and hydrogen supply provoke new capabilities for mobility. Finally, information and communication technologies such as augmented reality or vehicle-to-vehicle communication provide smart systems for managing and optimizing mobility infrastructure within a metropolitan area.

Although urbanization has already caused huge problems in particular cities, its impact on urban mobility will definitely grow in huge amounts while affecting more and more cities every year. Fortunately, if expected technological developments can be realized in the short run, it will be possible to facilitate mobility in urban areas.

1.1 Introduction

Starting with the first suburban train built in 1863, which was powered by a steam engine, London has been constantly changing its face and currently has the world's largest suburban train system with an overall length of 415 km.

All over the world the suburban train systems show how the development of cities was accompanied by huge developments in technologies concerning urban mobility. To go a step further - especially when it comes to urban mobility - the way our cities work nowadays is enabled by modern technologies. Due to the challenges that the upcoming global urbanization will provide, new technologies will play a crucial role in the mobility of tomorrow. In the following, the status quo and the trends of technology concerning urban mobility will be discussed.

1.2 Status Quo

To get an idea what technology trends will come up within the next years, it is important to have an understanding of the already existing technology that is commonly used in urban mobility. As a wide range of technologies emerges when it comes to urban mobility only a general overview of technologies, which play crucial roles in "Mechanics and Eletronics", "Energy" and "Information and Communication Technology", will be presented.

1.2.1 Material Science and Engineering

The main role of mechanical and electronical technologies in urban mobility consists of the transportation of humans and goods either into the city or in between locations within the city. The process of transportation is mainly done by vehicles which include mechatronical systems that handle the weight in a stable and intelligent way. The following section will explain today's common solutions.

1.2.1.1 Engine Technologies

The internal combustion engine (ICE) is the main engine technology for moving vehicles. Reasons are durability, costs, power density and ease of control. In the last few years, extensive development work improved efficiency and reduced exhaust emissions. At the moment, in modern ICE vehicles about 40% of the fuel combustion energy is completely wasted. Another 35% are lost due to coolant and friction, whereas only about 25% are utilized for vehicle operations (see figure 1.1) [80, p. 1119].

Although the efficiency of ICE has already improved within the last years, the individual technologies remain a field of broad research (compare section 1.3.1.4).
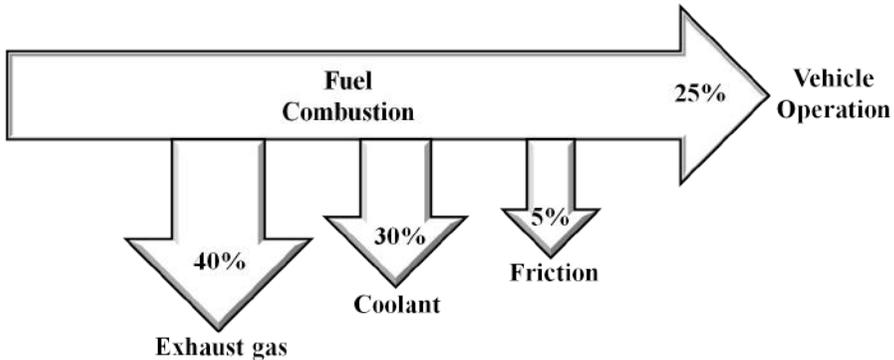
Figure 1.1: Consumption of fuel combustion
Source: adapted from Zhang [80, p. 1119]

Moreover, there is a worldwide growing need to find solutions to recover the waste energy of exhaust gas. Until today vehicles driven by electric motors are mainly means of public transport and only few privately used road vehicles: whereas electric motor produce higher energy economy, the energy storage remains a key point for a successful market establishment of private vehicles (compare section 1.3.1.4).

One approach to combine the already realizable advantages of both the combustion engine and the electric motor propulsion system is the hybrid electric vehicle (HEV). The big advantage of these HEVs is the high fuel economy, which can be increased up to 20% by storing the recovered energy in the battery which then can run the additional electric motor. [80, p. 1119]

1.2.1.2 Road and Railbound Technologies

Aside from the street, bridge and tunnel design which consider characteristics like environment, feasibility and functionality for road vehicles, road construction is also a matter of materials: above the apparent rock layers there is a transitional layer composed of multiplex soils and artificial rocks like ash, slag or colliery wastes. These complex mixtures have to pass density und durability processes in order to resist loading, wearing and weathering. [51, p. 92, 105-106, 114, 135-139]

When it comes to rail bound technologies, the wheel/rail-system is the most common for public transits: trams or metros are conducted on vignol or grooved rails by steel wheels with wheel flanges [70, p. 8-9]. It could be replaced by non-contact electromagnetic fields as it can be seen in the still rare but technological established magnetic levitation train, a fast, low-noise, low-wear and driverless alternative to the wheel/rail-system which also is able to surmount inclines [70,

p. 33-34, 84-85].

1.2.1.3 Vehicle Construction and Design

Naturally, every engine needs a chassis in order to move humans or goods from one point to another in a secure and comfortable way. Mass-reduction, which goes along with energy savings and consequently costs and CO_2 emission reducing, and maintaining safety and comfort standards at the same time shaped this field of technology the most in recent years. [21, p. 30, 38]

The so-called lightweight construction has been possible because material composition shifted to new materials which weren't usable before, due to manufacturing or cost problems. Nowadays, many vehicle body components consist partly of high strength steel alloys. Furthermore, even lighter aluminum alloys and also magnesium components, with the lowest dense of all possible materials at present, supplant the heavy lower carbon steel and push the option to create bodies-in-white with lower weight. [56, p. 6-8]

Considering the fact that the possible fuel saving through lightweight construction for cars can amount to 0.1 - 0.5 l/100km at a reduction of the vehicle weight of 100 kg depending on the vehicle size and driving cycle, or even more for trucks, metros or trains, one can see that this will be a huge research area reducing energy waste in the future (compare section 1.3.1.3)[21, p. 29][49].

Lightweight construction does not only contribute to energy saving by material substitution but also by shaping the vehicle body or decreasing the amount of components. Although the speed and the front surface are the most relevant characteristics, air resistance can be reduced by lightweight design surface improvements or facings [39, p. 67].

1.2.2 Energy

Energy in form of fuel or electricity is needed to run not only vehicles, but also to operate all other useful supporting products and infrastructure for urban mobility. Facing the megatrend urbanization and thus the need for more and more energy in cities, a general view of the existing technologies is given hereafter.

1.2.2.1 Generation Technologies

While oil and gas production by drilling will remain centralized because they are tied to the resource location, the generation of electricity can be done by both centralized and decentralized facilities. Although centralized facilities like nuclear or fossil fuel plants are still responsible for over 80% in global electricity generation today, distributed generation, especially the increasing amount of emission-free renewables, is a future key factor for enhanced mobility. [43, p. 9]

Renewables can be generated locally in many ways with solar and wind power as two high-potential technologies. Solar power is mainly utilized in the form of photovoltaic or solar collectors. In the first case, current is generated by absorbed photons enabling electrons in a semiconductor to flow, whereas solar collectors use solar radiation to heat a liquid which is then used for heating or powering a generator. Today's efficiency rate of commercially produced solar cells amount to 5-18% depending on the silicium quality. [31, p. 77, 132]

Wind turbine technology uses rotor blades to transfer rotation motion via a shaft to a generator transforming it into electricity. Technical improvements have made it possible to increase the maximum capacity to 6MW and the average capacity from 50kW to nearly 2MW within the last 20 years. [31, p. 64-65] Further options are hydropower, geothermal power and biomass power whereby the potential energy of dammed water, the terrestrial heat respectively and the combustion and anaerobic digestion of bio mass is used to gain electricity via specific turbines and generators [31, p. 72, 96, 113].

1.2.2.2 Distribution and Storage Technologies

Oil and gas, which are distributed via pipeline systems and trucks to be stored at gas stations, reveal the dependency on the supply chain. Far more technology is behind the electricity grid: a transmission network with extra-high voltage grids, which usually consist of alternating current (AC) overhead power lines that are more and more being replaced by the more efficient high-voltage direct current (HVDC) power transmission systems[1], routes the electricity to distribution substations [71]. Via transformers, which reduce the voltage levels and change it to AC drive if necessary, as well as medium and low voltage power lines it is then possible to drive electrical public transits, to operate traffic systems or to light roads. [79, p. 7-9]

By transforming electricity to chemical energy, accumulators provide a smart solution for the problem that electricity cannot easily be stored. The following types of batteries are used for propulsion of electric vehicles [29]:

- Lead-acid batteries can be discharged up to 90% and have an energy density of 30-40 Wh/kg.

- Nickel metal hydride batteries are frequently used for HEVs. Although the discharge rate is lower (80%), they provide the advantage of an energy density, 30-80 Wh/kg, and a long life [61, p. 10, 12].

- Beside these mature technologies, lithium polymer batteries which are already used for consumer electronics are the foundation for further traction battery developments [61, p. 10].

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[1]HVDC power transmission systems can reduce transmission losses to 3% for every 1000 kilometres which is 30-40% less than with AC [71].

1.2.3 Information and Communication Technology

Modern information and communication technologies which have shaped our world considerably in the past already allow the realization of the following concepts which help to increase urban mobility.

1.2.3.1 Positioning Technologies

Positioning technologies are highly valuable for both moving faster from one place to another in traffic situations and for the management of traffic systems.

Global Positioning System (GPS) is the most widely spread technology on the globe that is premised on satellites radiating coded radio signals. GPS devices can then calculate their position and speed from signal propagation delay. Thus, horizontal accuracy of 7.8m can be ensured with the existing and on-going improved technology, whereas this can be enhanced further by satellite-based augmentation systems or differential GPS to an accuracy of 0.5 - 5m for moving vehicles. [18, p. 40][69, p. 5]

For shorter scopes also Radio Frequency Identification (RFID) technology, where radio waves are used to exchange data between a reading device and an electronic tag, provides an option to monitor objects. An advantage which nowadays is especially used in traffic of goods as tracking is also possible in case of unfavorable object positions or dirt contrary to optical reading systems like barcodes or data matrices. [34, p. 11-12, 18]

1.2.3.2 Traffic Management Systems

Aside from the use of traffic lights and signs, intelligent transport systems (ITS) enhance the traffic management and consequently urban mobility as well as road safety and the reduction of CO_2 emissions.

In addition to positioning technologies (compare section 1.2.3.1) today's ITS also make use of loop detection. Passing through the loop's magnetic field, vehicles can be detected, thus the number of vehicles but also the length, weight and speed of vehicles can be calculated [57, p. 1]. Video vehicle detection consists of video cameras feeding processors which then analyze the video camera's changing features if a vehicle passes, therewith compute vehicle speeds and determines as well the occupancy rate for each lane [10, p. 1-2].

The stated technologies enable many applications with the following already commonly used:

- dynamic traffic light sequence [9]

- variable traffic signs and speed limits [36, p. 4-5]

- speed control and red light cameras [68, p. 30]

1.2.3.3 Access Technologies and Devices for Mobile Internet

Mobile Internet enables access to internet or internet-connected applications from a mobile device by the means of different wireless access technologies. The higher the data rate and broader the bandwidth range, the more sophisticated applications can be offered as data processing is enhanced. Thus, wireless access technologies replace each other over time providing even higher data rates, but maintaining a shared medium as bandwidths are constraint due to sharing of transmitting capacity.

- GSM[2], the first and most widespread standard for digital signal transmission facilitating circuit-switched and packet-switched data transmission, and its add-ons GPRS[3] and E-GPRS provide a data rate up to 236 kbit/s.

- Mainly because of a new radio access technology, wideband CDMA[4], new mobile communication standards like UMTS[5] have risen which can transmit and receive data simultaneously. The add-ons of UMTS, HSDPA and HSUPA[6], reach data rates up to 7,2 Mbit/s for downloading and 1,45 Mbit/s for uploading. [41, p. 15-16]

- Due to multiple access technologies like OFDM[7] and multiantenna schemes such as MIMO[8], LTE[9] can offer data rates of 50Mbit/s uplink and 100 Mbit/s downlink as well as a wider bandwidth range from 1,25 to 20 MHz supporting users with different capabilities.

- Another way to realize mobile internet is WLAN[10], a local radio network to exchange coded data in specific frequencies with a net data rate maximum of 22Mbit/s in practice, whereby the scope can reach a maximum of 50 meters but is often limited because of barriers such as walls which make it suitable only for small hot spot locations [24, p. 4, 8]. [78]

End user devices for mobile internet are mobile phones, smartphones as well as note- and netbooks.

1.3 Trends

In the following sections the major technology trends that shape urban mobility are outlined. As in the status quo, here the technologies are structured in "Mate-

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[2]Global System for Mobile Communications
[3]General Packet Radio Service
[4]Code Division Multiple Access
[5]Universal Mobile Telecommunications System
[6]High Speed Downlink Packet Access and High Speed Uplink Packet Access
[7]Orthogonal Frequency-Division Multiplexing
[8]Multiple Input and Multiple Output
[9]Long Term Evolution
[10]Wireless Local Area Network

rial Science and Engineering", "Energy" and "Information and Communication Technology".

1.3.1 Material Science and Engineering

The expression "Engineers make our world move" shows the broad awareness for the meaning of engineering achievements regarding urban mobility. In the following some of the big upcoming technologies, that could have an impact on the picture of urban mobility, will be described. Due to the fact that countless technologies are used in nearly every stage of the value chain in nowadays engineering products, only the most important of them will be presented. First three promising material trends, namely "Smart Materials", "Multi Functional Materials" and "Carbon Materials" are viewed. Afterwards, the development of the core technologies of the ICE based and the electric propulsion based powertrain of urban vehicles as one of the major technological aspects of urban mobility will be discussed.

1.3.1.1 Increasing Use of Smart Materials

The development of material science has lead to materials that are able to interact with their environment - the so called smart materials. Not only do these materials have the traditional material functions, but they also have functions such as actuation, sensibility and microprocessing capabilities - they change their characteristics as a response to environment stimuli like heat, electricity or magneticism [40].

Smart materials are divided into the following categories:

- Piezoelectric Materials (Transformation: electricity - mechanical energy)

- Shape Memory Alloys (former shape adoption due to heat)

- Electro-Active Conductive Polymers (electrical induced polymer movement)

- Biomaterials (large range of materials that could be used medically)

- Electro-Rheological Fluids (fluid changes structure due to magneto-electric stimuli)

Due to the shortness of this article only one of them will be explained in more detail: The Piezoelectric materials have the ability to convert electricity to movement and vice versa. This effect results from the materials inner structure: There are two different crystalline configurations in the material that switch between each other when a voltage is present. Voltage is generated if the structure is deformed because of force effect. This effect is called electrostriction [40].

Impact on Urban Mobility

There are countless possible applications for smart materials not only because of the huge variety of existing effects. The previously mentioned piezoelectric effect, for example, is used by the Fraunhofer Institut that invented new adaptive systems for vehicles that will integrate the shock-absorbing functionality into wheel suspension [1] which could improve vehicle layout but also other engineering applications. Another application is the use of a magneto-rhological fluid that contains small magnetic particles which form rows if magnetic stimuli is there - the fluid solidifies. This fluid is meant to be used among other applications in future gear boxes - not only in cars, but all other vehicles and machinery [2].

1.3.1.2 New Applications possible due to Multi Functional Materials

Nowadays different requirement aspects lead engineers to design their products - from classical automotive to civil engineering applications - cheaper, lighter and smaller. Besides some other functions integration is one of the most promising strategies to attack future product requirements [73]. This strategy is applied on many layers but during the last years the integration of function into materials has increased constantly and researchers mostly in industry companies [72] are developing Multi Functional Materials (MFMs) in order to reach higher efficiency, smaller proportions and less weight of their products. In contrast to the smart materials, the functionality of the MFMs is based on an intelligent material combination and not because of the materials' characteristics itself.

There are several examples and prototypes of successful function integration in materials: A German car manufacturer in cooperation with a German chemical company have developed a solar-vehicle-rooftop called "Space-Up Blue" that integrates solar modules into a polymer layer. Other material developments provide lighting directly in one of its layers [72]. Furthermore, other basic functionalities like conductance or special stress resistance can be integrated into structural material so that designing will follow other paths [42].

Impact on Urban Mobility

Many of these previous mentioned developments take place in the automotive industry with a direct impact on future urban vehicles where MFMs will enable lighter and smarter constructions, but there are many more application fields in urban mobility where function integration will be very valuable like innovative facade materials [50].

1.3.1.3 Increasing Use of Carbon Materials

Carbon materials - due to their special combination of characteristics like good electrical and thermal conductivity, heat and corrosion resistance, low friction and reduced weight while maintaining high strength at the same time - are

in the focus of industry and research. This, as well as the fact that carbon materials could have an impact on urban mobility, are both proven by the development that several car manufacturers are highly interested in buying shares of carbon material suppliers[3].

A possible proof for that and also for the fact that carbon materials could have an impact on urban mobility is that the several car manufacturers are highly interested in buying shares of carbon material suppliers [3].

There is a wide range of materials that use the unique properties of carbon structures, but one of the most promising is carbon fiber reinforced plastics (CFRP). CFRP is a composite material or fiber-reinforced polymer that has been known for several years especially in the aerospace industry. Due to the growing need for lightweight structures with high stability at the same time as well as the enhanced knowhow in manufacturing processes of CFRP, the application fields for this material are increasing. Due to the limited space, several combinations and other carbon materials are not mentioned here.

Impact on Urban mobility

The increasing use of carbon materials and especially CFRP could influence the picture of urban mobility, not only in vehicle design, but also in civil engineering projects like bridge construction or in the casing of mobile devices. With its unique combination of characteristics and the growing knowledge of handling these materials during the manufacturing process, carbon materials are well suited for facing the requirements of future engineering in urban mobility.

1.3.1.4 Further Optimization of the Powertrain Engineering in Urban Vehicles

Growing environmental issues and restrictive government regulations force engineers to improve the fuel efficiency of urban vehicles. Besides the aerodynamic of a vehicle and its weight, the powertrain provides an enourmos potential to reduce fuel consumption. As the ICE will stay the basic propulsion technology during the next five years, the further development and optimization of the traditional ICE-based powertrain will be important for reaching the environmental goals. Aside from this development, the electric propulsion based powertrains will become more widespread in urban vehicles in the future. Therefore a short overview over the potential of both systems is given hereafter.

Optimization of the ICE-based powertrain   The levers of enhancing fuel efficiency in nowadays ICE-based powertrains can be structured into three types: thermodynamic improvements, reduction of mechanical friction and the optimization of the entire powertrain. These technologies will not have a huge impact on the CO_2 emission of ICE-based powertrains each for itself, but in total they can reduce emission significantly up to 40% - depending if they are

applied in a diesel or a gasoline engine. Besides the traditional engineering disciplines of thermodynamical and mechanical optimization, different types of hybridization of ICEs have come up during the last years and promise further developments all over the the segments from Micro-hybrid to Full hybrid [15, p. 21].

Impact on Urban Mobility

The ICE-based powertrain may not be able to reach all of the restrictive environmental goals many administrations have set. However, as e-mobility technology will need time to spread and struggles with capacity problems which prevent going long distances, the previous mentioned improvements of the ICE-based powertrain will probably be implemented faster in many of the upcoming urban vehicles.
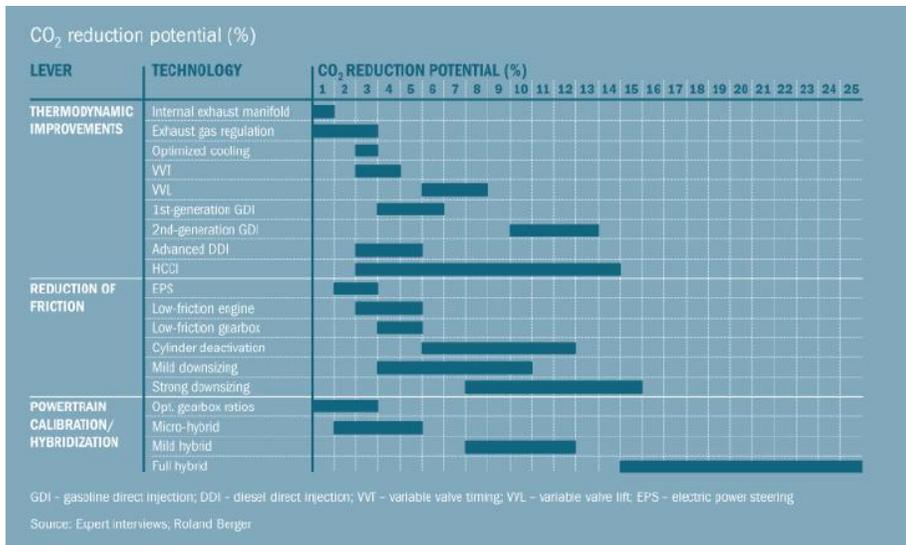
Figure 1.2: Key ICE optimization technologies and their CO2 reduction potential
Source: Roland Berger [15, p.22]

Upcoming technologies regarding the electric propulsion based powertrain
Although there are many different concepts of e-vehicles, one can divide mainly between two promising types during the next years: The electric vehicle (EV) that runs only with an electric engine and the plug-in hybrid electric vehicle (PHEV) which shares the characteristic of both the aforesaid conventional hybrid vehicle and an all-electric vehicle which can be connected to the electricity grid.

The energy storage system as a core technology for e-mobility will be discussed later (compare section 1.3.2.2) [15, p. 33]. One of the other core technologies is the electric motor: Although electric motors are already a mass market, the requirements for motors that are built for vehicles are often much higher than for other application. Besides the two well known motors, the induction motor and the permanent magnet synchronous motor (PMSM), engineers are currently investigating several other motor technologies. Two promising examples are the switched reluctance motors (SRMs) and the transverse flux motors (TFMs). As the electric motor design for vehicle application is a young discipline and suppliers and manufacturers are at the beginning of their investment, more and more technologies will come up within the next years [15, p. 36-40]. The second core technology field of e-vehicles are power electronics. They consist of four main components: traction inverter, battery charger, DC/DC converter and in case of a range extender a generator inverter. All of them are current fields of research that may lead to vehicle-specific power electronics components in the near future [15, p. 40-43].
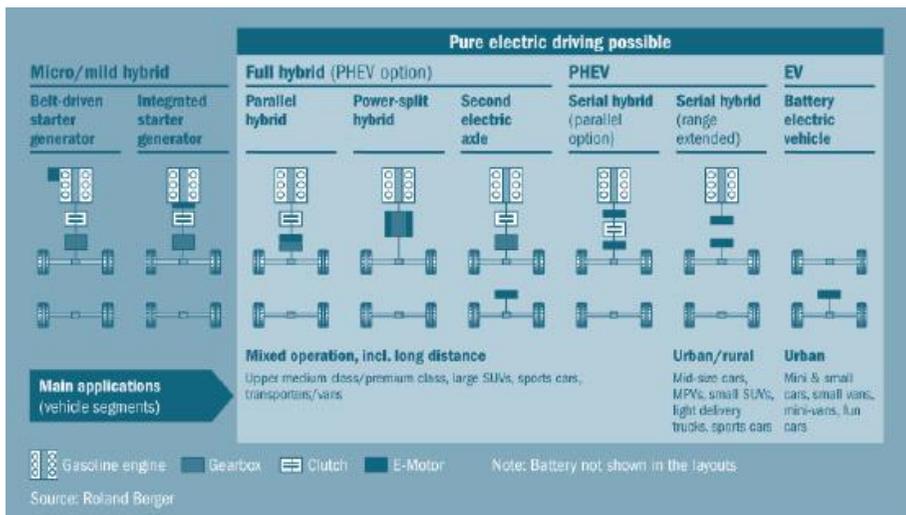
Figure 1.3: Different options for electrifying power trains
Source: Roland Berger [15, p. 35]

Impact on Urban mobility

An extension of e-vehicles will only be possible with technologies that are highly cost-efficient, sustainable and as comfortable as ICE based vehicles. Therefore further research as well as optimization of technologies that are applied in e-vehicles is crucial for their success. Due to the fact that the whole

infrastructure for e-mobility has to be built, it will have an enormous impact on urban mobility.

1.3.2 Energy

Traffic Infra Tech, a journal focusing on urban mobility, states that energy consumption by urban transport already represents 20 to 50 percent of urban energy balance. Furthermore, the trends forecast that this consumption will experience the highest growth among all other shares in urban energy balance in near future. [67]

Therefore, in order to guarantee the urban mobility expansion, there is a strong need for secure and efficient energy resources and increased availability by innovative generation, storage and distribution technologies. The developments in these areas are going to shape the understanding of urban mobility in communities.

1.3.2.1 Growth of Decentralized Electricity Generation

Today's centralized power generation systems are known to be very inefficient. Greenpeace states that 67% of primary energy input is wasted in the current global centralised model of power generation [38, pp. 10, 24]. In addition, due to the limited sources and environmental effects, they are not sustainable. However, due to rapidly increasing needs for energy supply, such inefficient and unsustainable processes are no longer affordable.

Instead of dealing with the drawbacks of centralized generation systems, generation systems are now aimed to be decentralized. Basically, the location of decentralized generation is defined as the installation and operation of electric power generation units connected directly to the distribution network or connected to the network on the customer side of the grid [4].

Boston Consulting Group states that, with the help of increased efficiency, feasibility and customer interactivity, decentralized generation will account for 40 percent of installed base in EU-27 states by 2020 [48, p. 3].

The technological trends which lead to decentralization can be investigated in 2 major fields such as increasing use of renewable resources and increasing number of combined heat and power (CHP) plants:

Renewable Resources   With the help of technological developments and increasing public awareness, the share of renewable resources in electricity generation is expected to hit 33% by 2015 [76]. Due to their limited capacities per unit, renewable generation technologies are more likely to be expanded by individual applications on houses or buildings, rather than enourmous centralized plants. Therefore, emerging renewable energy generation techniques eventually result in decentralization of energy generation.

Combined Heat and Power Plants Inspite of being a mature technology, combined heat and power (CHP) has become more attractive than ever, thanks to its ability to cut costs, energy losses, and greenhouse gas emissions [44, p. 22]. CHP plants basically produce distributable heat in addition to power as a result of the general condensation process for power generation. Therefore, unlikely to conventional plants, the utilization rate reaches over 90%.
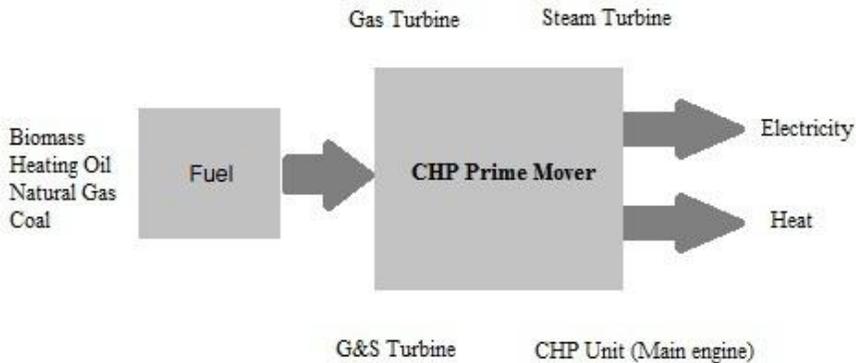
Figure 1.4: The flow diagram of a Combined Heat and Power Plant
Source: adapted from Auer [12, p. 1]

Due to their high efficiency, CHPs are getting huge attention in the public. To use fuels more efficiently in the future, the share of CHP-based power production is to be raised from around 12% in overall electricity generation in Germany at present to about 25% by 2020 [12].

In order to deliver heat provided by CHP to the end customers without a remarkable loss, CHP must be placed in urban areas. Therefore, the increasing use of combined heat and power plants leads to the decentralization of energy generation.

Impact on Urban Mobility

As Greenpeace states, a decentralised energy system would equip buildings with devices such as solar panels, small wind turbines and combined heat and power boilers. The electricity created would be used directly by the house or workplace and by the emerging smart grid technologies, the surplus would be fed into a local network [37]. Therefore, end users will be able to actively take part in electricity generation and consumption with less financial or environmental concerns. This will increase the attractiveness of different means of transportation powered by electricity. As a summary, growth of decentralized electricity generation forces all urban mobility solutions to converge to the electricity driven technologies.

1.3.2.2 Increasing Use of Storage Solutions with High Capacity and Efficiency

In order to provide long operation durations for mobility services, the capacities of storage solutions are crucial. Additionally, while concerning the performance, cost and safety of the storage solutions are extremely important.

There are currently two major forms of energy that are expected to feed mobility services in the near future: electricity and hydrogen driven fuel cells. Globally, a lot of efforts have been devoted to implement storage solutions with higher capacity and efficiency for these energy sources.

Electricity Storage The most promising technology for storing electricity in near future is based mainly on lithium polymer chemistries. As it is stated in Boston Consulting Group(BCG)'s trend report, called "Batteries for Electric Cars", the emerging electricity storage applications are moslty based on lithium-nickel-cobalt-aluminum (NCA), lithium-nickel-manganese-cobalt (NMC), lithium-manganese-spinel (LMO), lithium-titanate (LTO), lithium-iron-phosphate (LFP) chemistries. [26, p. 1]. The comparison of the performance of these applications are shown in the following figure:
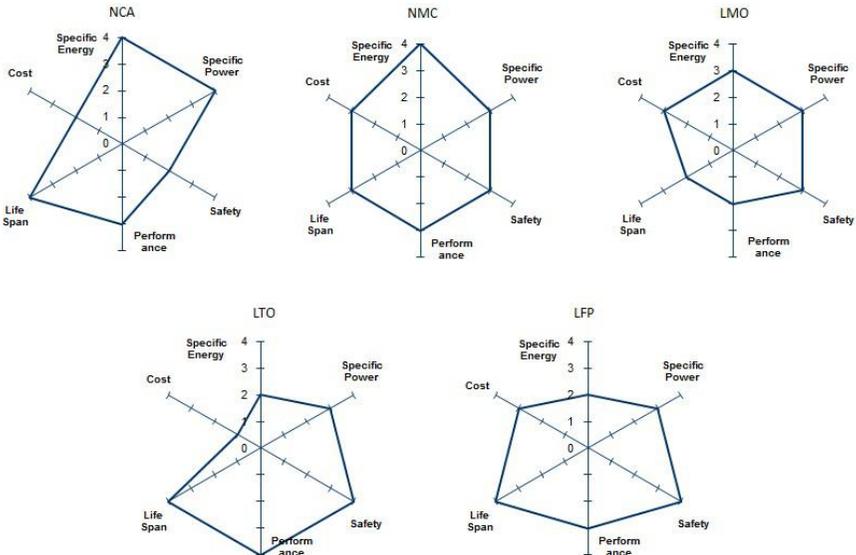
Figure 1.5: The performance comparison of different battery technologies
Source: Adapted from BCG Research [26, p. 3]

As a result of the developments in these technologies, the expected drive

range allowed by batteries is going to reach a level between 250-300 kilometers. Additionally, the specific energy, i.e their capacity for storing energy per kilogram of weight, is expected to double and hit 200 Wh/kg in by 2020, compared with 1300 Wh/kg for gasoline today. On the other hand, the price of a battery unit is expected to decrease to roughly US$400 per kWh in 2020, from its current value of US$1000 per kWh. In order to push the price decrease, the vehicle manufacturers tend to install smaller batteries with shorter lifespan and ask end users to replace their batteries in 5-7 years. [26, p. 4]

Hydrogen Storage   As a result of the new fuel cell technologies driven by hydrogen such as proton exchange membran cells and high temperature cells like solid oxide fuel cell (SOFC) and molten carbonate fuel cells (MCFC), hydrogen stands for a promising energy source for vehicles. However, due to its characteristics, it is really hard to store hydrogen in any vehicle. It has to be kept in very heavy and secure tanks, which is not a feasible solution for mobility.

Thanks to the technological improvements in hydrogen storage systems which mainly exploit using metal hydrides, chemical hydrogen storage and adsorbents, the performance specifications in figure 1.6 are expected in the near future.

Storage Parameter	Units	2010	2015
System Gravimetric Capacity			
Usable, specific-energy from H_2	kWh / kg	1,5	1,8
Net useful energy / max system mass	kg H2 / kg system	0,045	0,055
System Volumetric Capacity			
Usable energy density from H_2	kWh / L	0,9	1,3
Net useful energy / max system volume	kg H2 / L system	0,028	0,040
Storage System Cost	$ / kWh	4	2
	$ / kg H2	133	67

Figure 1.6: The expected storage capacities for hydrogen in near future
Source: Adapted from [75, p. 3.3-9]

Impact On Urban Mobility

With the help of high performance electric batteries and hydrogen tanks, the personal and public transportation vehicles can travel for longer distances with desirable speeds at a reasonable cost without harming the environment. Therefore, gasoline driven vehicles are going to be replaced by electricity and hydrogen driven vehicles for feeding mobility services.

1.3.2.3 Increasing Availability of Distribution Channels

In near future, with the help of developing technologies, electricity charging stations and hydrogen filling stations are going to be major forms of energy distribution which feeds urban mobility.

Electricity Charging Stations: While the capacities of the storage systems increase rapidly, being able to charge these within reasonable timeframes for different purposes becomes a challenge.

In order to deal with power-current tradeoffs, emerging charging systems are considered in 3 levels. Level 1 and level 2 AC charging solutions aim at charging a general type of car battery in 8 to 12 hours, while level 3 DC charging techniques can perform the same task in 15 to 20 minutes [5]. Regarding the timings, level 1 and 2 solutions are meant to be used in the home systems, while level 3 solutions perfectly fit the public charging needs. With the help of charging equipments at each level, charging the electric vehicles either during a long stay at home and a moderate stay in a parking lot or during a very short break at a charging station are technically possible now. The prototypes are ready to be commercialized in the market in the very short run.

Furthermore, there are some technical efforts to add storing capability to current charging devices. This capability will enable storing energy during off-peak times by exploting lower energy rates, and using it to charge electric vehicles even at peak hours with a lower cumulative cost [6].

Hydrogen Filling Stations: As U.S. Department of Energy states, the delivery costs of hydrogen associated with compression, storage, and dispensing at the refueling station or stationary power site are significant and need to be minimized. Furthermore, as U.S Department of Energy suggests, there are three possible techniques to reduce hydrogen distribution cost that consist of gaseous delivery, liquified transportation and transportation in form of higher energy density carriers. With all these efforts, by 2015, it is expected to reduce the cost of compression, storage, and dispensing at refueling stations and stationary power facilities to $< \$0.40/\text{gge}$ of hydrogen (independent of transport) [75, p. 3.2.1-3][11]

On the other hand, as a result of a cooperative project of the companies OMV, Linde, and Daimler AG, Linde, as the world's largest manufacturer of hydrogen facilities, has developed prototypes that uses ion-compression techniques so that cars and buses powered by hydrogen driven fuel cells can be refueled within a matter of minutes [23]. There are already a few examples of such hydrogen filling stations in Germany. Furthermore, it is reported that in Germany, where there is a huge attention on hydrogen fuel cells, leading energy companies

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[11]gge: Gasoline gallon equivalent, the amount of alternative fuel it takes to equal the energy content of one liquid gallon of gasoline

have announced a collaboration on the establishment of up to 1,000 hydrogen refuelling stations by 2017 [25].

Impact on Urban Mobility

Thanks to the improvements in distribution technologies for electricity and hydrogen, the availability of the distribution channels is increasing. This tendency enables constructing higher number of charging stations with better efficiency and reasonable costs. Therefore, the urban mobility services which use electricity or hydrogen as the main energy form are getting much attraction in the public and they become easily reachable. As a result, increasing use of highly available distribution systems will force gas stations to be replaced by hydrogen and electricity charging stations for enhanced mobility services.

1.3.3 Information and Communication Technology

The following section provides an insight into selected technological trends concerning information and communication technologies (ICT). In order to cover the most important technologies, the focus will lie on "Growing Use of Car2Car Communication", "Advanced Mobile Payment Systems", "Increasing Abilities of Traffic Management Systems" and "Growing use of Augmented Reality".

1.3.3.1 Growing Use of Car2Car Communication

The technology vehicle-to-vehicle communication (V2VC), has gained increasing attention. V2VC can be implemented in two different ways. It can be distinguished between V2VC applications based on inter-vehicle communication and infrastructure-based services.

Regarding inter-vehicle communication, several technologies exist that can be used for V2VC. [28, p. 1] The IEEE 802.11 wireless LAN (WLAN) technology is expected to prevail as the future communication standard for inter-vehicle communication [32, p. 22]. This technology can be used for exchanging messages between vehicles in an vehicular ad hoc network (VANET), however, it lacks the capability for very large networks [28, p. 2]. VANETs enable nodes, in this case moving cars or road-side infrastructure, to communicate with each other in a mobile network over single or multiple hops. Every participating car acts as end points, as well as routers. Vehicles in this mobile network can broadcast messages to each other via vehicular networking protocols. The distance range is up to 300m. [27, p. 179]

Infrastructure-based services are also based on an ad hoc network. This network is composed of road side units (RSU), stationary units along the road, and on-board units (OBUs) inside the vehicles. Within this network, RSUs and OBUs can communicate to each other by using the same kind of routing
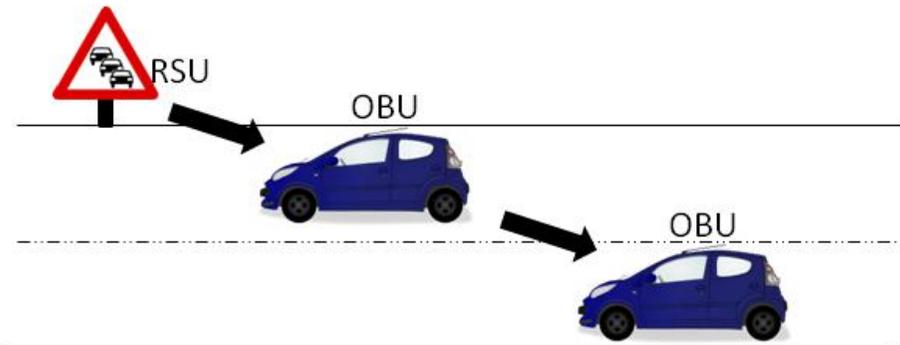
Figure 1.7: A RSU acts as information source
Source: Adapted from Baldessari et al. [14, p. 32]

protocols either directly (if wireless connectivity exists among the nodes) or via multi-hop communications, that can be realized via dedicated routing protocols (see figure 1.7). . In this case, the data is forwarded between different OBUs, until it reaches the arrival point. [14, p. 25]

In order to be able to make use of V2VC in future urban mobility, a number of technical challenges have to be overcome: The deployment of scalable protocols, in order for the number of users and the traffic volume to be easily increased, the integration of security mechanisms as well as data privacy, enabling high-speed real-time communication and the simulation of vehicular ad hoc networks, an essential method to evaluate new approaches. [28, p. 3-4] Furthermore, it is important, that vehicles of various makes will be able to communicate with each other, independently of the current place and country. Therefore, standards for all components of cooperative systems have to be created centrally. [65, p. 60]

The greatest challenge is probably the guarantee of security and data privacy. First of all, there are unknown partners in the ad hoc network, but nevertheless, messages have to be verified quickly. Furthermore, the wireless technology is based on a standard for office and home use, so, it has to be protected against hacker attacks. [55, p. 3] Lastly, concerning privacy issues, in view of the fact that within V2VC, personal data is created, stored and exchanged over wireless communication links and a huge amount of location data is generated [65, p. 59].

Impact on Urban Mobility

The implementation of V2VC aims at improving vehicular traffic safety and traffic efficiently. The real impact on urban mobility of V2VC is still quite hard

to estimate. To enable an impact assessment of such applications, simulation tools have to be developed to allow performance studies by simulation means. Furthermore, the two evaluation goals, improving vehicular traffic safety and traffic efficiency, need different modeling views, so that two different simulation models will have to be developed. [47, p. 129-134]

Another problem, that has to be resolved in the near future, is that these new communication systems are subject to emitting and absorbing electromagnetic radiation. Therefore, the radio system performance can be reduced and inadvertent electromagnetic disturbances can be caused. [19, p. 1]

The specific services and applications enabled through V2VC will be presented in the business trends section (compare section 1.3.2) of urban mobility.

1.3.3.2 Advanced Mobile Payment Systems

Mobile payment is an alternative to the traditional payment system, such as paying with credit card, cash or cheque. The idea is to allow users to pay with their mobile phones.

The over 30 different mobile payment solutions identified by the Electronic Payment Systems Observatory (ePSO) can be clustered by several distinctive features, the payment settlement being the most significant. Those are prepaid (using smart cards or digital wallet), instant paid (direct debiting or offline payment) or post paid (credit card or telephone bill). The requirements, payment processes and used technologies for each type vary. [59, p. 197]

There are two classification features, either *effected type of payment* or *provided IT landscape*, that can be used to give an overview about existing forms. One can differentiate between the following billing solutions [20]:

- Bank account based

- Credit card based

- Telecommunication company billing based

Although technology is continuously improving, it is important to note that, among other things, security plays a crucial role in mobile commerce [74, p. 7]. Security attacks and vulnerabilities that affect mobile payment include repudiation, impersonation and unauthorized access (see figure 1.8) [7, p. 147]. Depending on the application area and already *provided IT landscape* there are different technologies that can be implemented as we can see in the following paragraphs. These currently coexist, and will continue to do so until one or more mobile payment solutions prevail [46, p. 242]. At the moment this is unpredictable.
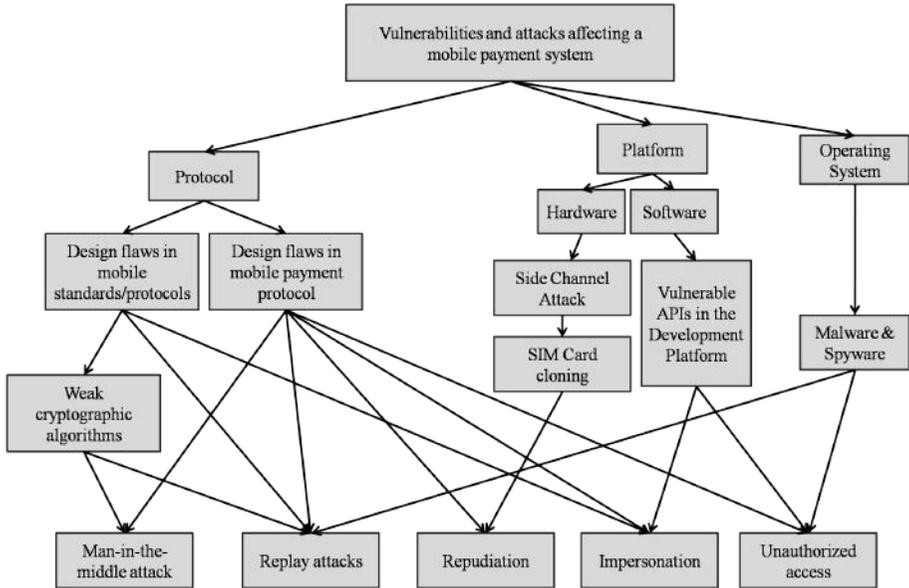
Figure 1.8: Taxonomy of vulnerabilities affecting an m-payment system
Source: Adapted from Agarwal, Khapra, Menezes and Uchat [7, p. 147]

Short Message Service SMS serves as a channel to either access one's bank account information status (informational) or to transmit payment instructions from the phone (transactional). [77]

Unstructured Supplementary Service Data USSD is similar to GSM and supports the transmitting of information over the signaling channels of the GSM network. It is a session-based communication type (compared to the SMS store and forward technology). [20]

General Packet Radio Service technology GPRS provides packet-switched data for GSM networks and enables services such as WAP access as well as email and WWW access in mobile phones for internet communication. [20]

J2ME/BREW Developed in Java for GSM phones or binary runtime environment for wireless (BREW) for code division multiple access (CDMA) phones. [20]

Subscriber Identity Module A SIM is a small chip to store and process information, protected by cryptographic algorithms and keys, which makes the

use of SIM more secure compared to phone based applications. It is used in GSM mobile phones. [20]

Near Field Communication   NFC combines a contactless smartcard (RFID compare section 1.2.3.1) with a mobile phone card to use it as a contactless card which enables new opportunities for innovative applications. [20]

Dual chip   Several mobile phones provide two slots for mini chips, one for the SIM card and one for a payment chip card. The mobile payment method however usually needs a customized application in the SIM card. Also if there is only one card, an agreement with the telecommunication operator is necessary. The dual chip allows full control over the chip and therefore is preferred. [46][20]

2D Barcode   A 2D Barcode is encrypted data in form of a 2D Barcode which can be decoded with the smartphone. Two types exist, Stacked 2D Barcodes and Matrix 2D Barcodes. [35]

Impact on Urban Mobility

In the area Asia/Pacific area, varying solutions of mobile payment are already in play with varying degrees of success [22]. Mobile payment simplifies the mechatronical billing system that has been around for decades, making it redundant because of the replacement of its main functions. By allowing payment transactions to become so easy, other systems are affected, such as city tolling in which mobile payment solutions provide the opportunity to allow traffic to flow, rather than stagnate at the tolling booths, so that the driver can pay without stopping.

1.3.3.3 Increasing Abilities of Traffic Management Systems

With the increase in urbanization, the number of vehicles in cities is growing rapidly. This places a greater demand on the development of efficient traffic management systems. [8, p. 1]

The increasing emergence and installation of sensor technologies, such as GPS sensors, aims to collect several types of data on the state of the transport system [16, p. 1]. The method "Telegeoinformatics" combines and processes this GPS data with geographic information system (GIS) data, using wireless communication [62, p. 251]. The location of a mobile resource is determined through GPS receivers in combination with a mobile telecommunication technology, such as UMTS or GSM [53, p. 4241]. This location data will then be imported to a geographic information system, and there, combined with other data [45, p. 5-6].
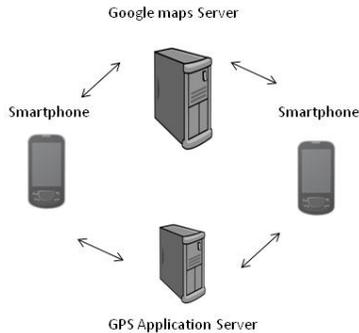
Figure 1.9: Architecture of the mobile device based real-time tracking system
Source: Adapted from Lee et al. [52, p. 179]

With the increasing number of smartphones, providing a GPS receiver, Wireless LAN (WLAN) as well as a mobile telecommunication technology, such as UMTS or GSM, the current location of the user can be determined quickly and accurately. Therefore, location based services, connecting geographic location with user requests, can be realized. Furthermore, the system has to be connected to a central database. [66, p. 55-56] The received longitude and latitude data can be transfered to the GPS application server via the Transmission Control Protocol and the Internet Protocol (TCP/IP) (see figure 1.9) [52, p. 179].

Cloud computing is an appropriate service to support efficient traffic management systems. This technology allows computer application developers to use services within a cloud, which is available through a network, without detailed knowledge of the inner workings. [11, p. 1]

To be able to make use of traffic management systems in future urban mobility, a number of technical challenges have to be overcome. First of all, future developments of traffic management systems have to fulfill the following criteria: Confidentiality, integrity, availability of information, data origin authentication, non-repudiation of messages, non-duplication of information as well as preserve the anonymity of the user's real-life identity. [66, p. 59] Furthermore, the value of traffic management systems mostly depends on the distribution and number of devices mounted with a GPS receiver [63].

Impact on Urban Mobility

By means of GPS, high quality traffic data for real time traffic monitoring and management can be provided [16, p. 1]. A large number of vehicles sending real-time GPS data for the city allows the processing of real-time data, so that a picture of the traffic conditions in time and space can be created [16, p. 4]. The method "Telegeoinformatics" supports real-time routing. This approach

is also used in the newest navigation system for android users, developed by Google, but is currently only available in few countries. [64]

Location based services may also help avoiding traffic. These traffic services can be utilized by any ordinary person who solely needs to own a WLAN-enabled GPS device, that is also compatible with mobile telecommunications technologies (e.g. UMTS or GSM), such as a modern smartphone. [66, p. 55-56]

Agent-based traffic management systems face the challenge to cope with the large amounts of computing resources and storage. With the support of cloud computing technologies, traffic strategy agents and mass transport data can be used effectively. [54, p. 73] Distributed resources will be used by the cloud to support the running and storage of agents and their performances efficiently. This approach is particularly suitable for the implementation of modern urban transportation systems. [54, p. 78]

The services and applications enabled through traffic management systems will be presented in the business trends section (compare section 1.3.2) of urban mobility.

1.3.3.4 Growing Use of Augmented Reality

Over the past years there have been many developments in the area of augmented reality (AR). Compared to virtual reality (VR) where the environment is entirely virtual (see figure 1.10), AR enriches the real world by adding virtual objects to an environment, running interactively, in real time, registering real and virtual objects with each other and applies to the user's senses. [13]
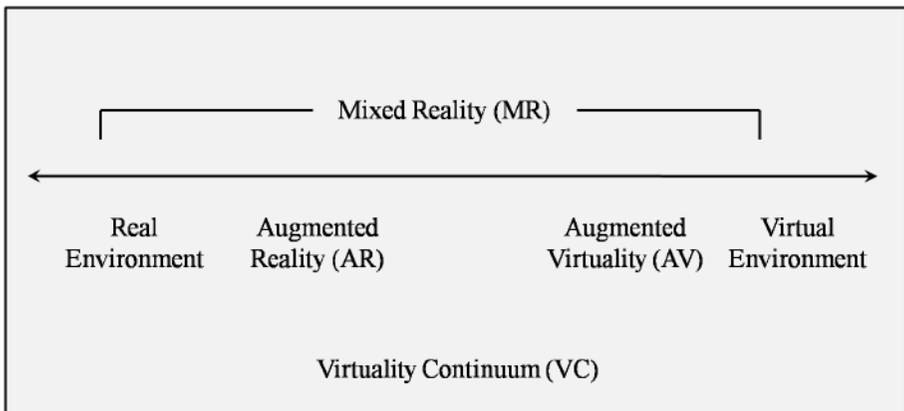
Figure 1.10: Simplified representation of a "virtuality continuum"
Source: Adapted from Milgram and Kishino [58, p. 3]

In order to make AR possible the base of the infrastructure consists of displays,

tracking and sensing as well as rendering (see figure 1.11). [30] In the following only displays and tracking will be explained in more detail.

User
Application

Interaction Devices and Techniques	Presentation	Authoring
Tracking and Registration	Display Technology	Rendering
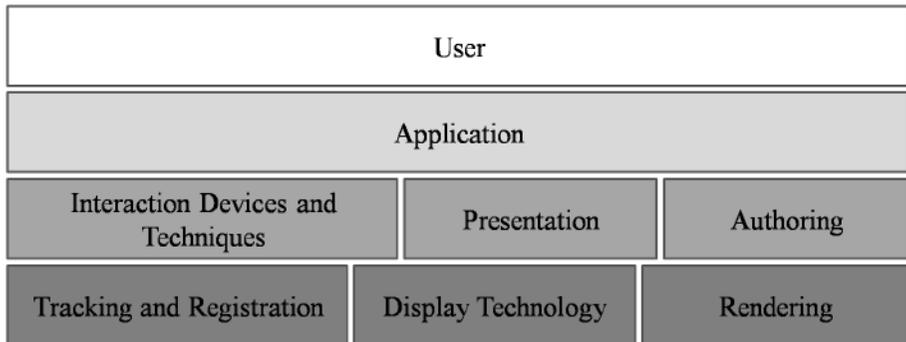
Figure 1.11: Building blocks for augmented reality
Source: Adapted from Bimber and Raskar [17, p. 6]

Displays   In case of displays there are many different technologies that can be classified as head-worn displays (HWD), handheld displays, or projection displays. A head-worn display is a device the user mounts to his head, which displays images infront of his eyes. There are two forms, either optical see-through or video see-through, which compared to the former uses video images as the background from video cameras mounted on the head-worn display. The optical see-through display is transparent. [13, p. 35]

Handheld displays are flat-panel liquid crystal displays (LCD). The enhancements are video see-through-based and provided through a video camera that is attached. The device shows the real object with an AR overlay serving as a window or magnifying glass. [13, p. 35]

Projection displays can either be realized with or without the need for headworn projectors. The virtual objects are projected directly onto the physical surface and objects that are to be enriched. [13, p. 35]

Tracking and Sensing   Tracking can be divided into outside-in tracking and inside-out tracking. Tracking and sensing involves trackers that track emitters. Outside-in tracking describes a system where sensors are fixed within the environment and track moving objects with attached emitters whereas inside-out describes a system the trackers and emitters switch positions. Here the emitters are fixed within the environment and the sensor is attached to the moving object. The sensors calculate their position in relation to the fixed emitters. [17, p. 4]

Impact on Urban Mobility

Although AR still faces challenges, such as the maturity of the technology In the near future the way people perceive their environment will change significantly. Not only does AR offer new possibilities in the way people do business, making more interactiv and physical conference calls possible but it also changes the way people travel, e.g. through the enrichment of navigational systems and a more interactiv exchange of information. Enriching navigational systems with AR will optimize traffic, by e.g. helping the driver avoid traffic, and finding his way easier around a new environment [60]. The greater physicality and interactivity that AR allows also has influence on e.g workshops, collaborative or maintenance tasks, allowing an expert in a remote location to guide and assist a user, or allowing remote users to interact collaboratively with the same CAD model [33, p. 118]. This in turn decreases the need to travel.

1.4 Conclusion

The examples of promising trends in urban mobility technologies in the last chapters showed that developments in nearly every technical discipline can have an impact on how the future of mobility will look like. Therefore it is hardly possible to predict which technological trends will be the most important ones. Even though three major trends can be identified how urban mobility technologies will evolve: First, technologies will become more intelligent. Smart materials and augmented reality are only examples of upcoming more intelligent solutions in urban mobility. Second they will become more and more interconnected: vehicle-to-vehicle communication will provide new possibilities to exchange information and also other technologies will improve the interconnection of our cities. Lastly the technologies of tomorrow will become more sustainable: Caring for our environment will force every sector of urban mobility to become more sustainable - this will also be enabled by sustainable technologies.

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2

Market Trends

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The increasing extent of the urban mobility market determines numerous companies from different industry sectors to search for entry or growth opportunities. Over the course of the next years, the market will experience structural changes in each of its key sectors, all linked by the unanimous tendency to improve the current status quo. The urban mobility market of tomorrow is characterized by increasing possibilities of public-private collaborations and cross-domain strategic partnerships, omnipresent influence of information technology, the orientation of the automotive industry towards electric vehicles, all developing within a supportive legal framework. The goal of each of the players involved is to base its economic growth on adding value to a certain step in the mobility value chain, such as in the energy, information and communication technologies (ICT) or traffic routes sectors, or bring disruptive technologies closer to mass-market adoption through cost reduction and subsidies, like in the automotive industry. Transportation services will experience a gain in efficiency and a reduction of costs thanks to the leverage of technical solutions and new conditions that foster market competition.

2.1 Introduction

Mobility is a very important part of urban life and implies a widely spread market which involves several industry sectors. Urban sprawl leads to longer inner-city distances, and the resulting demand for fast and comfortable transport solutions drives technological development constantly forward. Simultaneously, the urban mobility market extends and changes structure continuously. Incorporating more and more entities, it has become more complex over the years and will continue to do so. Additionally, the changes of legal frameworks and social needs influence the market structure, as well as vice versa. Especially higher demands in terms of environmental consciousness and individualization lead to new markets, players and changing power relations.

Understanding the inner workings, reasons and directions of development and changes in the mobility market is essential for recognizing business opportunities. Also, a comprehensive image of the market can only be achieved by taking into account the perspectives of each participating players. In order to do so, the market has to be divided in submarkets and even a level further to reduce its complexity and enable a proper analysis.

In the first part of this chapter the status quo of the single market segments and their players, as well as their relation to each other are examined. All considered segments are also expected to undergo transformations of their markets in the near future. These trends are discussed in the second part of the chapter and, to sum up, a conclusion is drawn in the end.

2.2 Status Quo

The status quo of urban mobility related markets and market players worldwide is discussed in the following. As there are reams of influencing and participating parties around urban mobility this status quo can hardly cover all of them and concentrates on the most important ones.

2.2.1 Market Segments and their Players

Urban mobility forms a complex and widely spread network of participating markets wich can be devided in five main segemnts (see figure 2.1).
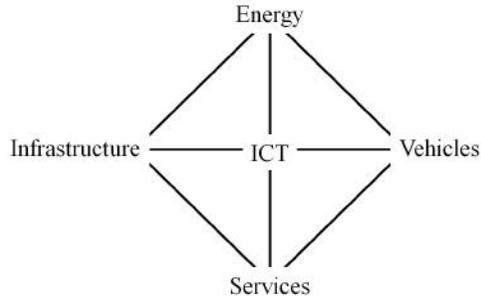
Figure 2.1: Market segments of urban mobility
Source: Own illustration

The infrastructure of urban mobility consists of traffic infrastructure such as streets, tunnels or railways, traffic management systems e.g. signs, lights, tolling and parking solutions. Vehicles are either produced for mass transport, as in the case of metros, light railway vehicles (LRVs), busses, for individual transport - cars, bicycles or for freight transport e.g. trucks. Vehicles need energy to run and this also influences the infrastructure, as gas stations are needed. Supply of services arises around urban mobility. Some are mainly for transportation of people e.g. public transport, taxis, car rental services and some just for freight transport as logistic services. The information and communication technologies (ICT) industry has become increasingly important by being involved in developing more intelligent traffic management systems, vehicles and services. In the following sections the most important markets and market players are discussed (but this report does not claim to completeness due to the complexity of the topic).

2.2.1.1 Mobility Infrastructure Market

The concept of mobility infrastructure encompasses different market segments. Market players of the traffic infrastructure segment e.g. railway constructors have very good prospects especially in the developing countries of Asia due to the rapidly expanding infrastructure [113]. For the same reasons a high competition exists in the market of urban road infrastructure [95]. North America also invests heavily in the construction of new urban road and rail transportation systems in order to improve and extend the current infrastructure [82, p. 2][120, p. 4]. The extent of the investment has determined several key European companies to tap into this market by acquiring US companies [120, pp. 6-9], thus positioning themselves for future growth through public-private partnerships.

Traffic management systems as well as parking solutions and fuel distribution infrastructure are also part of the urban mobility infrastructure. Their mar-

kets are discussed in section 2.2.1.2, ICT Markets and section 2.2.1.3, Energy Market.

2.2.1.2 ICT Market

In the ICT field, the market is characterized by a low level of fragmentation, consisting of several companies that regularly compete for implementing innovative technological solutions worldwide. The market is divided between companies which have the necessary financial strength to develop, test and deploy city-wide systems, that necessitate high hardware and software costs, as well as a logistic effort. In several cities in Europe, an extensive and highly customizable software suite for better management of fixed-route transportation services has been installed [160], along with advanced, contactless ticketing system using NFC technology [161, pp. 2-5].

The large extent of public transportation also gives ICT companies opportunities to launch programs [109, pp. 1-2] for consulting and implementing traffic analysis systems globally. More and more companies are leveraging data and location analysis in order to help cities have a more fluid and rapid public transport [122, pp. 1-2]. To also improve traffic management, Traffic Management Systems (TMCs) have been installed in European cities [146, pp. 6-20][152], along with signaling control systems which have been tested in the US [162, pp. 11-15].

In parking management, the market is highly competitive. Few big companies have systems deployed worldwide e.g at shopping centers and airports [145, pp. 3-7]. There are also small software firms that have just local or regional scope and offer less advanced features in their products.

2.2.1.3 Energy Market

Fuel based on crude oil and electricity are the nowadays most important energy sources for urban mobility. Pricing of fuel is influenced by the price of crude oil sold on a global basis and the fuel tax in the respective country. Therefore prices differ greatly between North America and Europe, but within a country the companies can hardly compete through pricing. [159, p. 63] In addition, oil extraction is very expensive and needs international agreements. These aspects lead to a low fragmented market which is dominated by a small number of global players. Most of the distribution infrastructure is also provided by these oil companies. [159, p. 68].

In contrast, the production of electrical energy is performed worldwide by a high number of mostly smaller regional players. They include state-owned companies like in France and China but also independent players in the United States and Germany. The distribution rests with a high number of regional grid operators. A lot of them are state-owned or function as subsidiaries of leading utilities. [159, p. 63] Directives of the European Union demanded the

unbundling of the value chain in its member states until 2007. Therefore the generation, the running of the transmission grid and the supply of electricity have been separated (see figure 2.2). The goal was to advoid possible cross-subsidization, to improve competition and the complete opening of the European energy market. [98, p. 2]

Value chain steps			
Provision Generation Whole sale	Transfer	Distribution	Sale
Provision Whole sale	Grid		Sales market
Competition	Monopoly		Competition
Markets			

Figure 2.2: Value chain steps and markets
Source: Forensika study [98, p. 3]

Around nine hundred smaller local and regional suppliers exist in Germany. Despite this high number of players, the concentration of the German energy market clearly increased due to horizontal integration (see figure 2.3). Another fact which underlines the dominance of these four leading players is their production capacity which has risen from around 42% in 2000 to around 61% in 2004 of the overall produced electricity in Germany. [98, p. 3] Like fuel prices, electricity prices also differ worldwide from region to region. This is caused by taxes as well as price differentiation because of the source of electricity e.g. nuclear, wind. [159, p. 63]
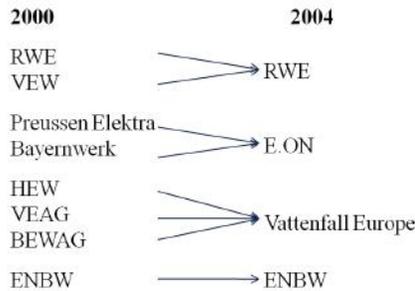
Figure 2.3: Increasing concentration of the German electricity market
Source: Forensika study [98, p. 3]

To satisfy the need for more environment-friendly motor fuels, hydrogen, fuel extracted from oil plants, fuel mixtures with bio-ethanol and bio-gases have been introduced but have not gained sufficient traction yet [86]. Therefore, these smaller markets are not considered in this status quo.

2.2.1.4 Vehicle Industry Market

In general, the market for mass transportation vehicles is rather consolidated (see figure 2.4). A good example is the German market for metros which is almost equally divided between three private companies. Each of these suppliers serves the German cities on their own without competition. [140, pp. 12-13] This restriction in competition is due to the saturated markets of developed countries which have become mainly replacement markets. In contrast to that the competition in developing countries is thriving because many cities do not have an efficient mass transit system yet. [142, pp. 43, 75, 95, 105] Thus the Asian market for metro vehicles is more fragmented and dominated by five big companies. Two Chinese companies even cover the whole extent of the Chinese market and also expand to other countries having the competitive advantage of low pricing. [142, pp. 78-79] The same two companies also dominate the light railway vehicle (LRV) market in Asia, totaling 67% market share (see figure 2.4). The lowest fragmentation shows South America's LRV market where only one company supplies all vehicles (see figure 2.4). [143, pp. 102, 120]
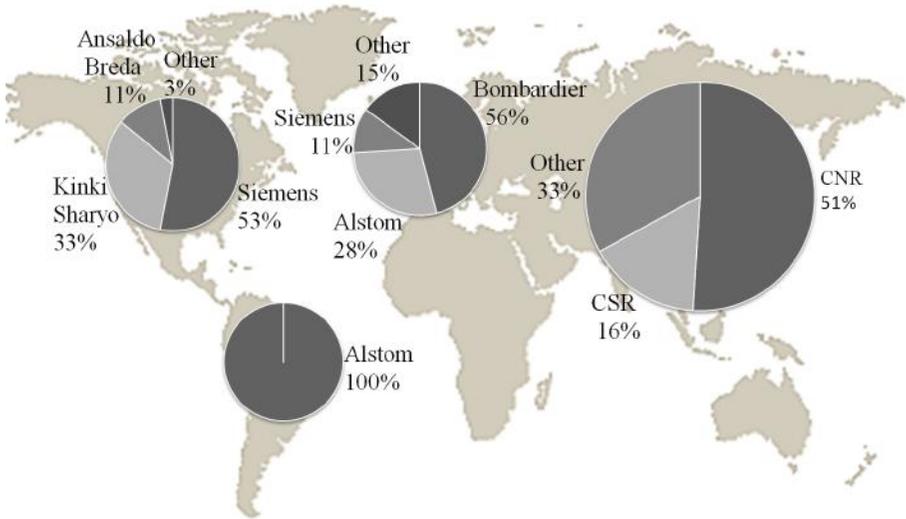
Figure 2.4: Market share of leading LRV suppliers in North America, South
America, Western Europe and Asia from 2005 until 2010
Source: Own illustration [143, pp. 48, 102, 113, 120]

The global bus market is consolidated with three manufacturers holding more
than 50% market share in 2009 [144, p. 11]. Due to a growing demand for
efficient and modern public transport systems, experienced the city bus segment
has especially an increase. [144, p. 3]

In contrast to the mass transportation market, the personal transportation
market is highly fragmented and the worldwide production of cars increases from
year to year (see figure 2.5). Next to the ten leading car manufacturers shown
in figure 2.5 around thirty more players compete in the international market.
The main consumption of cars took and still takes place in the developed and
wealthy countries. But due to their thorough motorization, a not growing
replacement market has developed. This leads to stagnation and even decrease
of car production numbers in the so far leading countries of America, Japan
and Germany (see figure 2.6) and to a high competition in their markets.
Meanwhile particularly emerging countries have a rapidly growing demand
of personal vehicles due to an exploding middle class (compare section **??**).
Therefore China finally became the world's largest car manfacturer in 2009 after
constantly increasing their production over the years (see figure 2.6). [136]
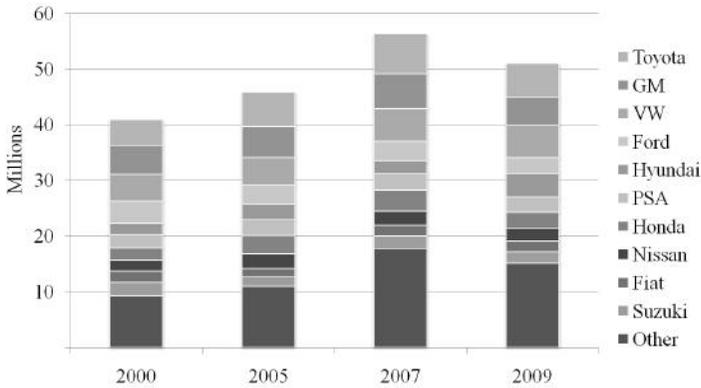
Figure 2.5: Car production numbers of leading automobile manufacturers
Source: Own illustration [127]
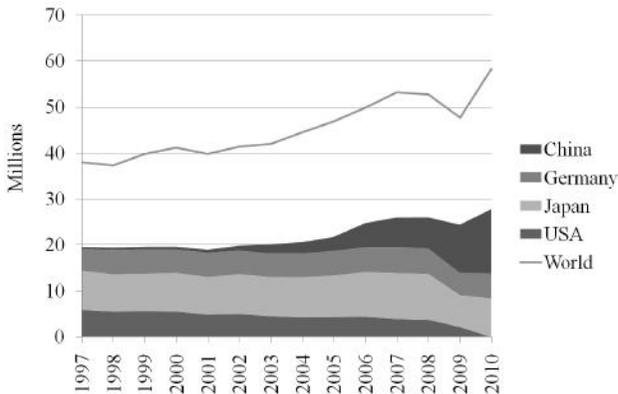
Figure 2.6: Cars production numbers by leading manufacturer countries
Source: Own illustration [127]

Due to the fact that every year twice as much bicycles are produced as cars, the market of not motorized personal vehicles is also worth mentioning. As in the car market, China is the leading producer and consumer worldwide. Although the motorization has contributed to a significant drop in the modal share of cycling in Asian cities, the bicycle is increasingly perceived as a sustainable mode of transportation in Western European countries. [135]

2.2.1.5 Transportation Service Market

Transportation services can be divided in people and freight transportation. Market segments like taxi, car rental and logistic services are present worldwide but because of their complexity will not be further detailed in the followig section. As the biggest transport service market, public transportation has the role of meeting public service demands and therefore a framework of law regulations. On the other hand, it struggles to compete with other urban mobility solutions on the economical market. Often public transport providers can not cover their operating costs which makes them dependend on subsidies. [110] For example, metro systems are expensive to build and therefore mainly run by municipal operators or big private companies with a license from the municipality. In contrast, a bus system does not need a special infrastructure [141, p. 154]. Still, urban bus service is usually provided by municipal operators but competition has proved valuable in other public service sectors like the energy market (compare section 2.2.1.3) and therefore the law regulations have been adjusted (compare section **??**). In this new framework several large private companies from UK and France operate now internationally by running lines of London's bus network, owning some small German bus companies and even provide whole bus systems in Scandinavian capitals. This shows that global players use new opportunities in markets where entering has been hard to realize so far due to law restrictions. [144, p. 7] Additionally, private medium-sized bus companies have the chance to close subcontracts with local transportation companies and directly access the market. Consequently, they face the danger not to fulfill the demands of the municipality because of insufficient capacity or financial resources. Although the market has opened up, the local authorities can ultimately decide if they want to organize a competition for services or just transfer them to an appropriate internal operator. [110]

Another threat for public transport services are alternative mobility solutions. Especially individual motorized vehicles gained a high usage rate in developed countries. They have a radical impact on public transport, like in the United States where only less than 2% of the transit is done via public services [137]. In contrast to that, the reliance on public transport tends to be higher in Europe and even more so in Asia [138]. Hong Kong has the highest rate of dependency worldwide with about 90% of the population [87].

2.2.2 Power Relations between Market Segments

The relations between the considered urban mobility markets differ. Some of them do not have a common focus, like the energy and the traffic route market while others strongly influence one another. Within the segments, the different regional markets grow together due to globalization, as seen in the automotive sector [159, p. 73].

This industry also faces some significant changes due to the current introduc-

tion of electric vehicles. On the one hand, traditional car manufacturers still have a strong market position by covering the need for comprehensive expertise, established brand names and strong customer relationships. On the other hand, they build up strategic joint ventures with battery suppliers and other original equipment manufacturers (OEMs) to remain competitive (see figure 2.7). [159, pp. 74-77]

Car manufacturer	Toyota	Nissan	Mitsubishi Motors	BYD	Daimler
Joint venture partner	Panasonic Japan	NEC Corporation Japan	GSYUASA Japan	BYD China	Evonik Industries Germany
Joint venture company	Primearth EV Energy 1996	Automotive Energy Supply Corporation (AESC) 2007	Lithium Energy Japan 2007	BYD produces its own batteries	Li-Tec Battery 2006
Car models	e.g. Toyota Prius, Lexus GS450h	Renault Megane, Subaru R1e	Mitsubishi i-MiEV	BYD F3DM	Daimler B-Class

Figure 2.7: Joint ventures of car manufacturers
Source: Own illustration [159, p. 75][129][124][116][117]

The new market situation leads to the fact that companies that are completely new to the business enter the market. Furthermore, companies that are already active in other parts of the value chain wish to expand and try to become OEMs. [159, p. 77] The business landscape also significantly changes as new players appeared along the value chain. There are battery suppliers, new OEMs and distributors. As seen in section 2.2.1 the ICT industry extends its influence over all market segments by adding value through more intelligent technical solutions. Given that electric vehicles need a charging infrastructure, market players of the electrical energy sector have the possibility to increase their impact. [159, p. 6] All in all, this forms a threat for the existing players.

2.3 Trends

In each market segment considered in the status quo section, trends for the near future can be identified. These are discussed in the following sections.

2.3.1 Mobility Infrastructure Market

Urban infrastructure in terms of routes like streets and tracks is a major backbone of every city and an essential driver for economic development. It is a vital market, given the urgent need of developing countries to build up and expand their infrastructure in order to support and foster their economic growth. But also for developed nations like the US it plays an important role, as they seek to modernize their infrastructure [99].

2.3.1.1 Increasing Public-Private Partnerships

In most countries, infrastructure is controlled by the state itself and in some countries like the US the access to the market for public "critical infrastructure" is even restricted for foreign investors [155]. Nevertheless a limited budget forces cities and regions to consider teaming up with private companies in order to sustain their competitiveness as a location [166].

Public-private partnerships (PPPs) are contractual agreements between the government and an investor from the private sector [155], which are considered very suitable for infrastructural project e.g building highways. The reason for that is that such undertakings involve a high investment for the construction and maintenance of routes, which might be hard to realize with the municipality's restricted budget [119, p. 3]. PPPs are particularly suited for infrastructure projects, giving the governmental side the opportunity to transfer risks [131] and costs [99] to a private company. The concept of these cooperations has already been used for a long time in countries like France and Spain, that have selected private companies to construct their highways [105, chapter 8] or in North America, where this trend already started in 1989 [123]. Nevertheless, both Europe and the US exhibit an increasing number of PPPs nowadays [119, p. 3], emphasizing this development as a future trend. The recognition of PPPs as a suitable manner of building future cities is also supported by the the World Economic Forum which launched the SlimCity initiative. This project supports public-private cooperations in order to build more sustainable cities [165].

Impact on Urban Mobility

The increase of PPPs as a manner of financing urban transportation infrastructure offers cities the possibility to realize more projects at lower costs and benefit from the companies' extensive experince. All these help rapidly and efficiently build and maintain the infrastructure needed for urban mobility in the near future.

2.3.1.2 Growing market for high-speed rail systems

Analyzing and comparing North America, Asia and Europe, the extent at which High-Speed Rail (HSR) networks are established varies widely among

continents and countries. While European countries like France and Germany already have an extensive high-speed railway network and several high-speed train operators like Thalys, Eurostar, ICE and TGV, in the United States these connections are rare, even though several plans have been examined. Thanks to those different stages of development, many countries, in particular in Asia, exhibit big potential for expansion. The global trend to build such networks is unequivocal, having in mind the vast amount of projects developed worldwide. High-speed railways like the connection between Rio de Janeiro and São Paulo or the $30bn project to interlink Beijing and Shanghai [133] are long-term investments for which companies from different countries are bidding. This means an enormous potential for manufacturers of various HSR components [139]. Countries worldwide recognize the crucial economic impact of these transportation systems and express their will to invest in this area of future infrastructure [139]. Therefore future investments in this market will be substantial, as European as well as Asian governments have announced to increase their roll out of high-speed rail (HSR) initiatives. [139] Furthermore the US administration decided on spending $8bn to lay the foundation for the High-Speed Intercity Passenger Rail Program, which had been put forward by the Obama administration [157]. Spain's commitment to spend $170bn and China investing $360bn to expand their networks [115] promote further evidence for this development.

Impact on Urban Mobility

As high-speed railway networks are built up and expanded worldwide, they provide a transport solution, which becomes increasingly competitive to other systems like road transport. As the system is a mean to connect different cities rather than supporting the traffic within the borders of one urban area, it reduces the pressure on routes for leaving and entering the city, like highways and airports. Hence it definitely has the potential to foster commuter and freight transport.

2.3.2 ICT Market

In the following section, general trends that are happening in the ICT industry will be described. As the ICT market is a very broad and diverse one, the analyzed trends are kept very general.

2.3.2.1 Growing Power of ICT Companies

One important trend that can be observed in the ICT market is that as it is embedded in an environment of rapidly growing markets for disruptive technologies, its power will rise. In general, spending will steadily grow throughout all ICT sectors at an average rate of 7.5% through 2015 with the service segment

having the highest growth rates [106]. This can be explained by global trends like cloud computing [101], of which the spendings will more than double till 2012 in the US [164, p. 15]. It is further backed by, for example the spread of mobile Internet and the popularity of mobile applications. It is predicted that by 2015 there will be a 90% global cellphone penetration [102]. Another forecast says that app downloads will increase from \$10bn in 2010 to \$25bn in 2011 which is partly due to the consumers whose spending share on ICT will increase from 28% to one third due to demand for mobile devices like smartphones and tablets [111]. Also investments in virtualization will continue [118]as buyers will be looking to minimize hardware purchase. Due to these developments and due to the increased demand for mobile voice and data services on both business and customer side, the telecommunication industry will increase their investments in expanding high speed broadband. This again will stimulate the whole ICT industry as for example an increasing amount of data being transmitted will also require more data security solutions [90] [164, p. 15]. Another indicator for the increasing power of the ICT companies is the share of venture capital investments into ICT. In the United States for example, 60% of Venture Capital is invested in ICT and clean technologies [126, p. 44] and in Germany around 40% are invested in ICT companies [103, p. 10]. This proves the growing importance and industry power of ICT companies. Governments will more and more depend on ICT in current core topics like energy and mobility, as well as will other markets like the health and the financial sector. These tendencies are further backed by the customers who increasingly want mobile access to the Internet, real time information, connected services, flexibility and independence (compare section 3).

Impact on Urban Mobility

Within the next five to ten years, the ICT industry will gain more and more power as it offers solutions for a big variety of growth markets centered around disruptive technologies. Therefore the ICT market is a driver for innovation. This in turn will also affect the rate of innovations being implemented in urban mobility.

2.3.2.2 Increasing Investments in Non-ICT Traditional Markets and Smart Solutions

The second trend that can be identified in the ICT market is the entrance of new or non-ICT-traditional markets and linked with this an increase in investments in smart solutions. "Smart solutions" seems to be the keyword of the ICT future. These solutions combine huge amounts of existing data with new or existing technologies in new ways, with an increasing number of connected parties and integrated intermodal settings. While network operators are still hesitating due to questions of refinancing, technology providers will actively continue investing

and developing in various areas like smart energy generation and distribution or intelligent traffic management solutions [107].

On the smart traffic solutions side, various market players will further invest in traffic telematics, gridlock management, green logistics, smart parking and solutions which provide communication services between vehicle and environment as well as virtualization software. ICT companies will also invest in systems for smart transportation pricing in order to manage transportation demand in urban areas [89]. The market size for congestion pricing solutions, as an example to show the market potential of smart traffic solutions, is projected to reach €2.05bn by 2015 [100] [108]. As ICT companies will also intensify their investments in e-mobility and e-cars, an example to mention here would be a global Internet company that recently developed a fully working, self-driving electronic car through which it could enter the transportation market [121].

On the smart energy solutions side, one will be able to observe that an increasing number of global electronics and software companies will developed smart grid solutions, as this development has already started [85][147]. This is a very promising market, as its projected market size will rise to €250bn by 2030 from €99bn today [107]. Another growth area of smart energy products is for example the market for enterprise software solutions for CO_2 emission reduction which is expected to grow by 600%. This means that ICT companies could play a leading role in the transition to an energy-efficient and low carbon economy [83]. Hardware vendors are more and more focusing on the energy efficiency of their equipment and turning it into a core business. Further fields of investments are long lasting batteries or for example the maintenance, development and production of applications for railway operators [163].

The reason why ICT companies will keep on entering these growth markets around e-mobility and e-energy is that they can easily offer solutions by leveraging existing core capabilities and technologies which have so far been underutilized in urban transportation and energy.

Impact on Urban Mobility

By entering the markets around e-energy and e-mobility, ICT companies might lead the way towards an infrastructure consisting of e-cars connected to smart grids and to a ubiquitous computing mobility infrastructure with vehicle to X communication. This will let consumers, vehicles, energy suppliers and other parties communicate in real time and thus result in an optimized traffic flow, less accidents, less energy consumption and a better traveling experience.

2.3.2.3 Increasing Cross-industry Convergence of ICT Players

Currently, many ICT companies are entering joint ventures. A significant increase in the number of vertical and horizontal partnerships between system integrators and local suppliers with the goal of a value chain extension, as well

as cost reduction, is predicted [149]. An example would be the partnerships between ICT suppliers and car manufacturers [81]. There is also a smart metering alliance of ICT companies in order to convince utilities to apply smart energy management [88]. A survey stated that „inter-industry partnerships are starting to emerge and thus leading the way to the development of commercially viable solutions for a low-carbon economy" [84]. Company borders will get more blurry and grow into an interlinked ecosystem of suppliers, producers and customers, as all the disruptive technologies will finally be integrated with one another. Restructuring makes it impossible to come up with an assumption as to who will be the industry leaders.

Impact on Urban Mobility

By joining forces, ICT companies might come up with more holistic solutions which are crucial to successfully tackling complex problems. Cross-industry collaborations will also enable an acceleration of the implementation speed of innovative urban mobility projects.

2.3.3 Energy Market

The following section covers some of the possible trends that may appear in the energy sector in conjuction with the new urban mobility paradigm.

2.3.3.1 Increasing Demand for Energy and Growing Ratio of Renewable Energies

During the next years the overall market trend will be an increase of global energy consumption by 1.4% annually [158]. Within the modal split of different energy resources, oil remains the most important [97, p. 2], even though the ratio of renewable resources within the energy mix increases [158][96, p. 27]. While the oil demand in OECD countries decreases, the world oil demand increases because emerging countries like China and India need to support their rapid economic growth [112, p. 2]. Non-OECD countries will further raise their consumption of energy even faster than OECD countries, expanding their leading position as consumer of energy [158].

In this development, national oil companies (NOC) gain more impact as private oil companies have access to only 7% of global oil and gas resources [104]. Furthermore these few countries are mainly within the Middle East [97, p. 3] and will further increase their output while the production from non-OPEC countries will start to decrease [112, p. 3]. Hence it follows that the Saudi-Arabian ratio of the global oil production increases and the purchase of oil becomes a political issue with certain risks threatening the security of energy supply. This also fosters new alliances in the market, bringing together international oil companies with national oil firms [93]. Therefore the call for

renewable energies covering a greater part of the overall energy demand will determine their further extension, even though at the same time governmental subventions are decreasing and privatization is used to diminish the public debt. As a result, renewable resources will count for more than 22% of total global electricity generation by 2015 [158].

Impact on urban Mobility

The described market developments will definitely push renewable energies as a resource for urban mobility and favor solutions based on these energies instead of oil. Nevertheless, it is also important to stress out the issue of how to store the produced energy and reach this change as fast as possible in order to avoid future dependencies.

2.3.3.2 Increasing Portfolio Expansion of Energy Suppliers

The investments of energy suppliers in smart energy distribution technologies will be ongoing. The global trend among the power generation and distribution players is an expansion of their core business activities towards building up a new revenue basis and entering new markets like the smart grid market [94]. Through this, a basis for efficient use of renewable energies will be created and thus a proportional enhancement of the market growth of renewable energies within the energy market. On the one hand this development offers major opportunities, as the global smart power management market has a growing financial potential [107]. On the other hand, it implies threats as energy suppliers leave their walled gardens and enter the increasingly competitive grid market which is accessed by other industries like ICT companies and established power-systems providers (compare section 2.3.2.2). As a consequence, it could be good to form vertical or horizontal strategic alliances to get the most out of market opportunities. [109]

Impact on Urban Mobility

With energy producers and distributors as one of the decisive forces when it comes the future development of urban mobility, their investments into smart grid technology, which foster efficient use of renewable energies, could be the beginning of a new infrastructure and thus be the basis to mass-market e-mobility.

2.3.4 Vehicle Industry Market

The following section describes some of the trends that will govern the vehicle market in the next 5 years and how the players in this area will try to overcome future challenges.

2.3.4.1 Increasing Investments in the EV Market

The next 5 years will represent a difficult period for the car manufacturers worldwide, partly because of the tendency of people to find alternative means of transportation and partly because they need to invest in sustainable development and fulfill the increasing popularity of electrical vehicles. In this respect, they have to continue the electrification of the powertrain, which also represents a high risk and a considerable investment [159, pp. 76-77][114, pp. 12-13]. In order to compete in both in emerging and well-established markets, several manufacturers have developed a clear future outline, among those being some well-established Japanese manufacturers that either focus on hybrid vehicles [156, p. 11] or complete electric ones [125, pp. 1-3].

The main focus of these manufacturers is the Asian market, because of the increased wealth and ecological orientation, but the market competition here will be fierce because local OEMs strive to close the gap to established players by taking advantage of lower labor costs, increased support from national authorities and availability of key components [159, p. 78].

Impact on Urban Mobility

Almost all well-established car manufacturers will try in the next years to slowly shift their product portfolio towards more eco-friendly vehicles. Naturally, this will offer the end user more advanced mobility solutions and sets the stage for a broad adoption of electric vehicles in the future.

2.3.4.2 New Cooperation Opportunities

One of the most pressing issues that vehicle manufacturers face today is the increasing cost of R&D activities. In order to reduce these expenses, and additionally share development risks, companies will increasingly look into the possibility of forming strategic alliances or joint ventures with other manufacturers. In a recent survey [114, p. 14] conducted among automotive industry executives, almost a third considered that alliances represent the best method to cut down costs in the future development. However, not surprisingly, the companies in the Asian region will also rely on loans, given that the governments strongly support an ecological strategy for local vehicle industry by generous stimulus packages [92, p. 2].

The strategic alliances of automakers will be made in two directions in order to ensure competitive advantage. Vertical partnerships [128, p. 4] with research institutions and OEM suppliers, e.g. [159, p. 75] will support co-development and an all-important know-how transfer. On the other hand, horizontal alliances with other manufacturers help reduce actual production costs by utilization of common solutions or entire platforms. Moreover, they will also facilitate the

transfer of important R&D and production know-how from one company to the other [134, pp. 1-3].

Impact on Urban Mobility

Cooperation opportunities will represent a valuable source for cost saving and therefore a way to make the EV, a center part of the future urban mobility, more accessible for the mass market.

2.3.4.3 Appearance of New Market Players

In the near future, the need for advanced technical solutions will determine the appearance of new competitors in the vehicle market and these will try to concentrate on the EV area, which traditional big players have only recently started to explore. Firstly, there are some companies that are already part of the current automotive value chain [130, pp. 2-7]and will try, with the help of sufficient financial resources and industry knowledge as well as a solid brand name, to challenge established OEMs in the EV sector [159, p. 78].

On the other hand, some totally new market players with very little experience in the vehicle manufacturing will appear [153]. These companies will build their strategy around the new auto industry paradigm that the powertrain and battery system, as opposed to the engine today, will be[154, pp. 1-5] the competitive advantage in the vehicles of the future.

Impact on Urban Mobility

It is expected that the automotive sector will see the appearance of new players, that will try to market their products as the promoters of the new energy-efficient urban mobility model.

2.3.5 Transportation Service Market

In the following section, some aspect regarding further evolution of the market for transportation services are being described.

2.3.5.1 Rising Competition for Transportation Service Providers

Local transportation service providers will face increasing competition by international companies entering the market. This is not only predicted for Germany [132, p. 1] but also for the United Kingdom, intensifying the rivalry within a mature market [148, p. 3]. In Europe, the tendency of national authorities to support deregulation of public transport services will lead to an open-access competition and consequently to lower costs for the end-user of the service. Given that the Asian market is a major focus area for each player in

the urban mobility value chain, it is expected that European transportation service providers will cross the continental border and compete in a truly global environment.

Impact on Urban Mobility

The described trend of increasing competition together with the trend of decreasing public funding forces public transport providers to concentrate on financial efficiency. This can have a negative effect on low frequented routes as operators might withdraw from those regions. Furthermore, passengers might have to contribute more to the financing of public transportation services, resulting in higher ticket prices. In general though, in the highly populated areas, the price of these services will decrease. [132, p. 2]

2.3.5.2 Increasing Dynamics in the Car Sharing Market

Car sharing fills the gap between individual transport and mass transport and as such, its market grows and increasingly influences the interfaces to them. For North America and Europe a continuous growth is expected for the next ten years, at a rate of 1000% and reaching about 10m car sharing memberships by 2016 [91]. Especially sectors like businesses and universities will experience an increase in car sharing [150, p. 1]. On the one hand, a growing car sharing market will represent competition for car rental companies, for example. One can therefore observe an increase of joint ventures between car rental and car sharing companies. On the other hand, an increasing amount of emerging car sharing companies also means more competition in the car sharing market itself, especially on a regional level. Therefore there will not only be more transnational cars sharing ventures like the various ones that have occurred just recently for example in the US and Canada or Germany and the Netherlands, but there will also be a broader choice for the customers and a more elaborate service offer. [150, p. 15] The mentioned trend particularly occurs in Germany and the United States.

Impact on Urban Mobility

With the car sharing market dynamically moving and gaining importance, three impacts on urban mobility can be deducted from that. It will mean less taxis and car rentals, as well as car sharing has the potential to reduce vehicle ownership and thereby will contribute to having more space and less cars in the city [151, p. 3]. In addition, the spreading of car sharing as a transportation service provides a basis for more EVs being used in cities, as car sharing implies a big fleet.

2.4 Conclusion

The future of urban mobility relies on the way in which different market players will find new and sustainable growth opportunitites, as well as ways to collaborate with each other. Also, the determination of local and national authorities in finding more efficient solutions for mobility and traffic management is essential. To realize this, they are increasingly opening up the market in order to allow more competition for sectors like traffic routes, vehicles or traffic management systems. In this respect, players engaged in key sectors of the urban mobility market see public-private partnerships as the most viable solution to implement wide-scale projects in almost any sector.

The market for ICT solutions has only begun to show its potential in improving many aspects in the urban mobility value chain. Besides increasing influence in the car manufacturing sector, companies dealing with technology discover new market opportunities in fields like traffic management or public transportation. It is almost a certainty that they will lead the way towards an interconnected and energy-efficient mobility landscape.

As a response to the surging research and development costs, companies in the vehicle manufacturing sector increasingly rely on strategic partnerships with other players involved in their industry value chain. This trend, combined with the appearance of new competitors and government subsidies, will lead to cheaper products for the end user and will drive mass-market adoption of energy-efficient vehicles. The growth of renewable energy production and distribution market will also be a contributing factor to this aspect.

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3

Chapter 3

Social Trends and Customer Needs

Michael Hörner, Daniel Seebauer, Christian Soyk and Jann Speyer

Social composition is and will be changing dramatically. Transformation of attitude and culture and their effect on urban mobility are explained in detail. Health consciousness regarding personal fitness and harmful air pollution will become more important. Higher environmental awareness as a social development will influence urban mobility. Increasing social cocooning and the spreading ability to work from home could relief urban transportation networks.

Customer segments in urban transportation will alter dramatically over the next years. An exploding middle class will increase the demand for comfort and individual mobility. Demographic change creates special needs in accessibility for elderly people.

City planners responsible for transportation will have to react to increasing urbanization. Strategies have to be developed to diminish effects of clustering and increasing land prices on urban mobility. Suburbanization decreases the efficiency of public transportation and therefore, solutions need to be found to alleviate this trend.

3.1 Introduction

"Transportation becomes an enabler where people want to go, moving the things they want, and defining how individuals choose to live with each other" [193, p. 285] - with this phrase Joseph Coughlin expresses the importance of mobility for society. In a city transportation is a major aspect for choosing where to live, where to take a job and how to take part in society. It defines to a great amount the quality of living, which becomes more and more the main competitive factor between cities. If a transportation system is erroneous, huge problems arise. The poor can not reach for jobs, as they have limited budgets for transportation or can not afford neighborhood housings. The elderly are excluded from society, as they are not able to stay mobile. Finally, a huge amount of time and money gets wasted and health is endangered, as massive traffic congestions bloc the city and pollute the air. Therefore, the base of a transportation system is the customer demand. Responding to this demand, transportation forms and changes as the composition and attitude of society forms and changes.

   The approach of this report defines a status quo where customer needs are identified and classified and where customer segments are distinguished from another. Afterwards, based on the findings of the status quo section, the trends concerning social developments are analyzed. These include drastic changes in attitude, customer segments and city planning. Developers, companies, politicians and city planners will have to react to that. Hence, in the trend section the most important developments that will show effect within the next five years and their impact on urban mobility will be pointed out.

3.2 Status Quo

Understanding the status quo of customer needs and segments is important to predict trends in urban mobility. Customers are the ones deciding which products they use. The first part of the status quo will only focus on customer needs. Subsequently, customers are divided into segments and addressed individually.

3.2.1 Customer Needs

Customer Needs are very important to be identified and classified as they are changing constantly. Based on research analysis, the classification of customer needs results in a pyramidal structure as seen in Figure 3.1. Inspired by Maslow's Hierarchy of Needs [217], the pyramid model shows most essential needs at the bottom which have to be fulfilled until less significant needs become important. Customer demands are different from one region to another. Through this hierarchy, also a regionally independent structure is created.

Figure 3.1: Hierarchical structure of customer needs in urban transportation
Source: Own illustration

Especially where there is more than one choice of transportation, travelers have to choose. Objective and subjective customer needs often vary [198, pp. 13-16]. They are not using an objective hierarchy as the one shown in Figure 3.1. Instead personal preferences and perceived needs impact the decision making. To have an applicable ranking, the pyramid focuses on the objective side.

3.2.1.1 Essential Needs

The level of essential customer needs within the urban travel sector is comparable to Maslow's level of physiological needs. It is most essential to arrive at the destination and that people are able to pay the price of transportation. Although the percentage of GDP spent on transportation in some parts of the world is decreasing [183], one may not forget that it is essential that transportation has to be affordable. For changing policies to increase access to mobility for the poor refer to chapter 4.3.1.3.

It is of crucial importance to arrive safely at the destination, which corresponds to Maslow's need of safety. In this article both physiological and safety needs are combined as they are essential for urban transport. Every type of transportation has a different degree of accidents and mortalities, the highest being road transport. It is estimated, that about 1.27 million people were killed in 2004[1] worldwide in just road crashes [219, p. 2] - tendency rising [220]. Road Safety increases in countries with higher income [219, p. 1]. Safety also refers to crime rates while travelling.

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[1] The most recent publically available data concerning this statistic was published in 2004. The WHO and other sources are still referring to this data today.

3.2.1.2 Important Needs

Maslow's level of safety needs contains health concerns [217]. This also refers to travelers. A recent study has shown that biking and walking commuters are generally healthier [201, p. 1]. However, moving around within a city either by foot, bike, or other means, can be hazardous to the person's health, if the air quality is poor, e.g. due to high amounts of Ozone close to the ground [196, p. 1085]. Other health hazards are unavailability of walking and biking paths, unprotected areas for bus and street-car boarding, or lacking maintenance of any pathways. Furthermore, the society in some parts of the world is becoming older [173, pp. 1-15] [193, pp. 301-310]. Elderly people have special transportation needs, e.g. wheelchair accessibility, elevators and escalators.

Other important needs for travelers are reliability, coverage, flexibility, and short travel time. These efficiency needs are significant because commuters have to be able to count on their preferred transportation. Customers want to be able to plan when they arrive. Therefore reliability is of great value to the customer. In addition, Murray states that coverage is critical for the acceptance of public transportation and thus can be stated as a general customer need [204, p. 187]. It is crucial to understand that service access includes both origin and destination based access, e.g. the closest bus stop to home or the nearest parking spot to work [204, p. 187]. For many customers it is important to be able to travel at any given time of the day, therefore transportation has to be flexible.[207, pp. 388-390]

In addition, the duration of travel plays a substantial role, especially in developed countries: Every minute a commuter is travelling, he is usually not working but instead spending money, for example on gas. Therefore the mobility customer prefers to keep this time short. Additionally, recent research has shown, that commuting time causes "systematically lower subjective well-being" [168, p. 363].

3.2.1.3 Comfort Needs

Comfort needs are not essential for transportation, but can be opportunities to convince travelers if there are several choices.

P. Newman and J. Kenworthy state that lack of cleanliness and degree of vandalism in public transport lower it's rate of acceptance [207, p. 128-237]. Thus customers will feel encouraged to use a certain type of transport, if the equipment is maintained and kept clean. The two authors state further, that "proper modal interchange points" and "direct-city connections" are vital for a transportation system [207, p. 128-237]. It is uncomfortable for customers to interchange often, even though it might be the quickest connection.

Information and orientation are also viable needs for the customer. Knowing the exact arrival time, how long a possible delay is and being able to evaluate eventual time-losses can be deciding arguments for the customer [207, p. 128-

237]. Orientation is important mainly for non-regular customers, such as visitors.

In several regions of the world, people become more environmental conscious which also reflects on the choice of travel medium [202, p. 844-848]. This trend will be described further in section 3.3.1.3. Being able to store goods can be a necessary add-on for customers. Having to hold one's luggage or goods during the whole time of travel is uncomfortable.

3.2.1.4 Luxury Needs

Luxury needs compose availability of entertainment, communication technologies, convenience in service, and prestige aspects. Especially the need for prestigious transportation can be compared to Maslow's need of self-esteem. Levels of prestige of different modes of travel are an important factor and "help define a person's identity" [200, p. 200]. The automobile industry in the developed world is a symbol of economic and technological progress [200, p. 209], which contributes further to the prestige of this type of transportation. Furthermore, transportation can be looked upon as a source of pleasure. Recreational aspects, and pride of ownership have considerable impact as well [200, p. 204].

Entertainment during transportation is a wide-ranging aspect. Car manufacturers integrate internet access and TV screens in their latest models. Several cities in Germany offer waiting travelers news and weather information on big screens. Some underground trains in Berlin and Hamburg carry TV screens, which present news and other information to the commuter. Large numbers of cell and smart phone users in developed countries create a demand for continuous access to a mobile network, also while commuting. In Singapore some railway stations exhibit artwork.

Convenient services refer to facile payment systems and intelligent tariff structures. An example for an advanced payment and tariff system is the Oyster card in London. Here the customer first has to store credit on his card. Payment proceeds when walking through a gate and the cheapest tariff is chosen automatically [194, p. 213].

3.2.2 Customer Segments

Despite sharing basic needs, a variety of customer segments with completely different demands and behavior towards mobility can be identified. Especially in large urban areas where a huge diversity of personalities, ways of life, wealth and culture coexists, transportation becomes a very complex task. In the following section the most important customer segments are described and distinguished from another.

3.2.2.1 Social Milieus after Income

The Poor   For the developing world the UN Report "Rethinking Poverty" defines US$1.25 per day as border to poverty. Despite a significant drop of those numbers from 1981 until 2005 still 25% of people in the developing world lived under this line. When focusing on China, this number dropped to 16% - in urban China there are only 1.7% below this income left [167, p. 25]. But measuring with norms of McKinsey [178, p. 62] still 77% of China's urban population is poor (income < US$3.000/year). In the developed world poverty normally is defined by relative poverty, i.e. income compared to the average income in the respective country [167, p. 37]. In Germany 11.4% of the population are counted as poor [211] and in the USA 13.4% [170, p. 358], whereas 15.4% in metropolitan areas compared to 10.4% of people in rural areas in the US live in poverty [170, p. 358]. Hence, these numbers show that an large part of the city population is living in poverty. Poorer households are less likely to afford an own car and thus are dependent on car pooling, public transit, walking or cycling [192, p. 363]. Especially a broader public transportation network in cities compared with non-urban areas is a major reason for the poor to move to the city [189, p. 1]. Given a good transportation system a better access to jobs and urban offers that rise quality of living is possible. Vice-versa, if a public transit system, like that in Los Angeles, lacks in efficiently connecting poor-living areas to areas where more and higher paid jobs are offered, people are less likely to get out of poverty [182, p. 11].

The Middle Class   The middle class can be seen as an engine for growth and demand [181, p. 7]. When regarding trends, the middle class is always among the most important driver groups as here the majority of people gather. There are various definitions for a middle class. In this section the term "middle class" is based on a matter of income. Goldman Sachs suggests a "world middle class" to have yearly incomes between $6,000 and $30,000 PPP (Purchasing Power Parity) [181, p. 7]. A higher income triggers off stronger needs for individualism, as basic needs are satisfied. This results amongst others in a stronger need for individual transport. One reason for that is that people move to more agreeable areas to live in (mostly suburbs) and therefore commuting longer distances [182, pp. 9, 10]. In the USA only 10% of all households are zero-vehicle households [192, p. 364]. This relates to the number of 451 passenger cars per 1000 people in the US. In the European Union (487 cars / 1000 people) this number is quite similiar, whereas in East Asia (58 cars / 1000 people) there are much less cars [171]. Figure 3.2 clarifies the connection between car-ownership and income world-wide.
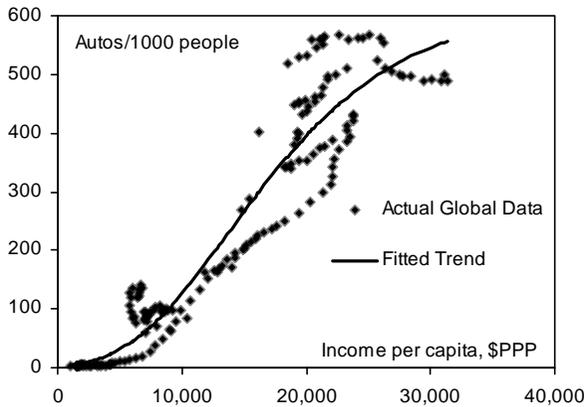
Figure 3.2: Car ownership patterns shift as income rise
Source: World Bank, GS Calculations [181, p. 17]

Especially in China over the last years a class formed, that lives exemplary principles of a individualistic consume culture [213, pp. 27, 28]. A new urban middle class rose over the last years due to economic growth and relative freedom of consume. This new middle class grew until 2005 to a size of over 20% of all urban households [178, p. 63]. This also explains the massive growth of sold cars in China over the last years. In contrast to that, the market for cars in developed countries is quite saturated as stated in ??. That means that people still buy cars, but only to substitute old ones - there has not been a remarkable decline in zero-vehicle households over the last years.

3.2.2.2 Social Milieus after Social Status and Basic Values

In the sections above only a very generic explanation for the needs towards individual or public transport could be given. When trying to explain different patterns and behaviors one needs to have a more differentiated view in social milieus.

Social Milieus can not only be characterized by income but also by basic values as "Tradition", "Modernization and individualization" or "Re-orientation" as mentioned in the Sinus Study [190].

Especially when it comes to the introduction of new technologies in a society, first-mover customers are needed that a) have the money to buy and b) bring the motivation to try out something new. The "Mover's and Shaker's", as stated in the Sinus Study, with their "hyper-individualistic" attitude and their "lookout for change" are exemplaric first-movers. 6% of the German population are assumed to be amongst this milieu[190].

But when introducing "green" technologies, such as electric cars, into the society additionally the "socio-ecological" milieu could play a major role. This milieu is characterized as "idealistic, discerning consumers with normative notions of the 'right' way to live: pronounced ecological and social conscience"[190].

In China it is a bit more difficult to differentiate, as the Chinese society has to obey an autocratic regime where not many different forms of individualistic attitude can prosper. But concerning money and consume, the Chinese nowadays are relatively free to develop individualism, as "83% believe that a modern person must be able to make money" [213, p. 29]. However, given the power of the autocratic regime and a still strong collectivistic culture in China, change can be planned and new technology can be implanted in society.

3.2.2.3 Demographics

Due to increasing wealth and healthcare over the last decades people in developed countries get older than former generations. Regarding data from the World Bank in tab. 3.1 in European countries the generation 65+ makes up 15-20% of the whole population. Due to immigration in the US this rate is a little lower, whereas emerging Asian countries nowadays still have 65+-rates that are typical for developing countries.

	Population 65+ [% of total]
World	7.5
East Asia	8.4
China	8.1
Hong Kong	12.8
United States	12.8
European Union	17.3
Germany	20.2

Table 3.1: World Bank data of population ages 65 and above
Source: World Bank [172]

Especially elderly people show specific mobility characteristics and have specific needs towards transportation (refer to 3.2.1.2). A major issue concerning mobility of elderly people is safety. Due to health conditions, people of older age face several risks in city traffic. Critical driving skills are needed for the interaction with other road users and maneuvers like yielding, turning, changing lanes and passing. According to Eby [177, p. 290] "Age-related declines in psychomotor, visual, and cognitive abilities can adversely affect many critical driving skills." Normally people then suddenly stop driving - that's when elderly stay at home or other ways of mobility become more important - walking,

cycling or public transportation [177, p. 295]. But as Rosenbloom [209, p. 338] figures, the 12% of whole US-population that are 65+ are involved in 20 % of all pedestrian fatalities.

3.3 Trends

In the following part, this report outlines the social trends in the urban mobility sector in the near future. Changes in attitude and culture, like the rising health or ecological awareness, will help to support clean transportation and will improve the urban quality of living (e.g. air quality). Furthermore over the next years customers for urban mobility services will change dramatically. Besides the demographic aging in the industrial nations, emerging countries will have to deal with an enormous growth of an upcoming middle class. Increasing diversity in customer needs (e.g. special requirements for families) will demand individual mobility solutions. And finally, to subdue the congestions in metropolises and to compete successfully for newcomers and immigrants, city planners are encouraged to develop new, sustainable and energy-efficient concepts for solving population density issues, traffic congestions and land shortage.

3.3.1 Attitude and Culture

All over the world cultures are changing due to various influencing factors like globalization, terrorism, pollution of the environment or aging of the population. All these global mega drivers affect the mobility habits of residents in urban areas. Beside the cultural aspects, the individual behaviors of citizen differ widely because of different personality and experiences [217].

3.3.1.1 Increase of Social Cocooning

Social cocooning describes the trend in which individuals draw back into their home and have less social contact with other people. The trend accrued primarily because of the rising availability of digital technologies at home. The wide spreading of the internet leads to increasing e-commerce in the B2C field [175, p. 18]. It also provides a new, comfortable media channel for all kinds of information (e.g. news and entertainment). The permanent availability of communication technologies makes interaction with other human beings easy and flexible without leaving the house [185, pp. 23-45]. Moreover in many fields of work the number of home workers is increasing. Companies introduce more flexibilize working conditions to help employees to improve their work-life-balance and treat the arising scarcity of specialist workers. [185, pp. 23-45]

Another important aspect for Social Cocooning is the fear of terrorism in the Western World [205, p. 99] and the global economic crisis [188, pp. 59-74].

Although these factors decline slowly the Boston Consulting Group states that the emotional impact will continue after 2010 [175, p. 18].

Impact on Urban Mobility

The general impact of social cocooning is the decline of the overall traffic volume. Since the terroristic attack of 9/11 a remarkable decline in transit habits was noticed [221, pp. 21-23]. A possible explanation for this fact could be the fear of public crowds and therefore the avoidance of mass-transportation due to security concerns. As commuters cannot change their employment or workplace overnight it is suggested that they tend to use cars more than public transportation [199, pp. 2-32]. But in the long run working from home also leads to fewer commuters [185, pp. 23-45] - especially for urban areas. Additionally people, who trend to stay more at home in their leisure time are less depended on public or private transport.

3.3.1.2 Rising Health Consciousness

Health consciousness is the awareness of people for their own health. To measure this trend Stephen Gould has developed the Health Consciousness Scale (HCS) [212, pp. 228-237]:

- Health Self-Consciousness: The ability to consciously observe one's own health.

- Health Self-Monitoring: The sensitivity for irregularities in personal health.

- Health Alertness: The wish and stimulus to react to a possible illness.

- Health Involvement: The personal involvement in a possible treatment when a disease occurs.

Health conscious people proactively decide and observe on the food they eat and the physical activity they undertake [203]. The trend arises because more precise results in the science of epidemiology are available. Health insurances, governments and institutions like the World Health Organization have a strong interest to inform people about disease concerns in order to achieve a healthier society. [218, p. 11]

Soaring increases in motorized road traffic over past decades pose a growing urban public health problem by pollution and unsafe streets. Urban transport patterns have been widely acknowledged as among the most important health determinants. By creating barriers to physical activities like walking and cycling, poorly planned urban transport 3.3.3 also encourages sedentary lifestyles, which is a risk factor for obesity. Transport-related noise is a factor in stress-related diseases. [218, p. 11]

Impact on Urban Mobility

At the moment residents of cities in developing countries are imperiled to high health risks. Mixing of pedestrian/cycle and road traffic, urban vehicle concentrations, polluting vehicles and poor infrastructure causes air pollution and traffic accidents. On the other hand active commuting is investigated as a good modality for maintaining or improving health. That is why the increasing number of health consciousness citizen urge for the expansion of bike paths and pedestrian ways. [191] [218, p. 11]

3.3.1.3 Higher Ecological Awareness

Recent years have shown an increasing public awareness for ecological problems in Germany. In 2008 it was the fourth most important concern for Germans, in 2010 the third [210, pp. 16-17]. As a result, companies and state officials will focus on more sustainable products and policies. This trend is recognizable in most western countries. The public in developing countries is also starting to become more environmentally aware [195, p. 4].

Through modern communication methods, pro-environmental organizations have the possibility to publish information widely and quickly. In 2007, Chinese environmentalists sent out one million text messages to residents and officials to protest against a new chemical plant in Xiamen City. As a result the government had to halt the plant construction [195, p.4]. Usage of these communication technologies increases world-wide. Therefore, the impact of environmentally active organizations could rise further. Government policies will also have an increasing effect on ecological awareness, as international guidelines will be stricter. For further details regarding policy issues refer to 4.3.4.

Education contributes to environmental open-mindedness of future generations. In Singapore, children learn about environmental issues and also how to bike safely in a city. Among other reasons, this leads to a higher biking acceptance within the city [206]. Ecologically friendly urban transportation is best accepted by young people. Therefore new business models such as car sharing might be accepted in the future [210, pp. 53-54].

84% of Germany's population think that car manufacturers have the second highest potential to influence environmental protection. The people's idea is that the introduction of new car technologies will help to decrease CO_2 emissions [210, pp. 21-22]. Therefore, comparably attractive products could be accepted easier. Further research should be conducted on how many people are willing to pay for environmentally friendly personal transportation.

Impact on urban mobility

The increasing public awareness for more sustainable transportation and higher acceptance of "green" technologies will introduce changes in companies and

public policy making. Governments and city planners will concede more bicycle paths and pedestrian ways. New sustainable technologies will be welcomed by the public if a comparable level of transportation for a reasonable price is offered. Eco-friendly propulsion systems (e.g. e-cars) might also benefit from subsidies.

3.3.2 Customer Segments

As described in section 3.2.2, identifying different customer segments is crucial to understand which needs towards mobility exist in an urban society. However, customer segments are not static. Economic growth, increased quality of living and better health care standards are amongst the most important factors that induce changes in society. In the following section the most drastic developments regarding customer segments and their effect on urban mobility will be analyzed.

3.3.2.1 Exploding Middle Class in Emerging Countries

The trend over the last years of a growing middle class in countries like China will continue. China's massive spending and efforts in education and economical development let the Chinese economy prosper. Hence, cities being centers of this rapid economic growth offer numerous opportunities and increasing income for people living there. Whereas today more than 20% of all urban households earn between US$3,000 - US$13,000 a year the rate will climb up over 70% in the coming 5 years [178, p. 62]. With US$13,000/year the possible life-style in Chinese cities is comparable to a US$40,000 household in the US [178, p. 63]. It is mainly a group of well educated people, such as doctors, teachers, engineers etc [213, p. 27], that increases in number and as mentioned in 3.2.2.1, they will mostly live in a individualistic consume culture. What especially is characteristic amongst this new rising middle class, is that the average income peaks in China now are between the ages 25-44 (compared to age 45-54 in the US) [178, p. 66].

This effect can not only be seen in China. India and Brazil are also moving in this direction followed by the N-11 (e.g. Egypt, Indonesia, Mexico and Vietnam). Figure 3.3 shows how the world incomes are supposed to shift towards a dominance of a middle income class in long terms.
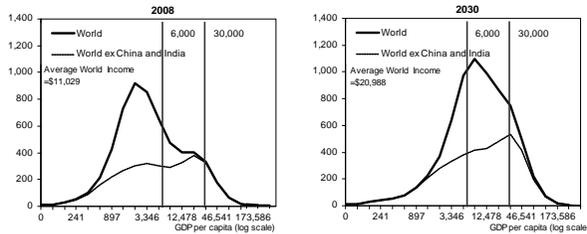
Figure 3.3: Global distribution of income
Source: Goldman Sachs [181, p. 11]

Impact on Urban Mobility

Chinese consumers will increase their spending on transportation and communications yearly by 9%. This will directly affect the individual mobility market, as people tend to buy cars when reaching an income level of about $9,000 PPP (Purchasing Power Parity) - for China that means an income of around US$3,000-US$4,000 [181, p. 6].

To deal with fast growing individual traffic and thus enormous congestion, governments and companies will have to develop alternatives and regulations - such as the extension of public transportation services as suggested in **??**. This alone will not stop the rapid "individualization" in urban traffic, so countries will also have to deal with problems like air pollution or energy consumption. As the highest incomes are received by a young and well educated generation that mostly trusts its government [213, pp. 29,30], there are not too many obstacles to introduce new technologies into the Chinese society.

Finally, road safety will be an much more important issue in emerging countries, as due to more traffic participants the accident numbers will increase.

3.3.2.2 Increasing Influence of Elderly People

"One baby boomer is turning 63 every 7 seconds" [193, p. 286] Joseph Coughlin states. The baby boomers form the largest generation in the US as nearly 80 million people were born between 1946 and 1964 [176, p. 301]. What applies for the US, applies for nearly every Western country. In the coming decades over 20% of the population will be 65+ years old [177, p. 289]. In Germany this mark has already been reached, in the US currently 12 percent are 65+ [173]. Not only are there numerous generations to come to that specific age, our life expectancy grows continuously due to better medical care and living standards. Thus, within the next five years we will experience an increase of elderly people living in our countries.

Even in South-East Asia, where the 65+-ratio is below 10% [173] a significant demographic change is to expect. As wealth and health increased a lot over the

last decades, the fertility rates went down and people live longer - and in the special case of China the one-child policy from 1978 will soon show additional effect [174, p. 147].

Despite the recent economic crisis, elderly people will hold more and more of the nations' wealth - most notably in the "gerontocratic" western countries where 40% of the disposable income is gained by the generation 50+ [176, p. 303].

It is quite clear that already within the next five years the elderly will play an increasing role concerning urban mobility. Especially the generations that are about to turn 65 and older have high expectations and hold specific needs towards mobility.

Here are people coming to an older age that are used to a better quality of life and a higher amount of mobility than those generations before - e.g. have more friends to visit, are used to more city offers like libraries and a huge variety of shops or expect themselves to continue with part time work (60% in the US) - therefore expect more from transportation [176, p. 307]. Additionally, many elderly live in suburban areas, which brings even more challenges to satisfy their needs for mobility [209, p. 339].

Impact on Urban Mobility

As mentioned above, safety is one of the major issues in transportation of the elderly. The quantitative effect is enormous, as nearly 100% of people in the US now turning 65 have a drivers license [209, p. 339]. Which will at first increase the number of potentially unsecure road participants.

Taking care of those essential security issues for elderly-mobility, governments and companies have to find solutions to those problems - e.g. through better vehicle design or specific supporting systems in vehicles like night vision enhancement or collision warning systems. Eby [177, p. 294] also demands changes in roadway design "such as protected left-turn signals and improved roadway channeling, stop signs, and signal timing" and roundabouts to improve the situation both for older drivers and pedestrians.

But in general, elderly people will need to make use of public transportation to stay mobile in the city. Regarding this especially, the following requirements towards public transportation are crucial:

- Accessability - How far do they have to walk? Are there elevators to the underground?

- Orientation and simplicity - Is the system understandable? Will there be electronic guide systems?

But with increasing importance, due to a huge wave of individualism over the last decades, a personalized form of public transportation will emerge [176, p.

307]. In whatever form this is realized, those points will be important:

- Coverage and automated vehicle location systems - Where is the next vehicle?

- Advanced traveler information systems [176, p. 307]

3.3.3 City Planning

City planning gets a more important role in modern society. Globalization, poverty, an exploding world population and increasing traffic represent challenging tasks to city planners. Modern city planning tries to consider and balance inefficiency that occurs through the impact of social trends on the city setup. The aim is to influence the developing structure of a city in order to maintain and form a sustainable metropolis in pattern of energy efficiency, environment, land use and transportation.

3.3.3.1 Urbanization

City life is becoming more and more attractive. Inhabitants of rural regions tend to have a lower average income and search for a higher income and a better life in the cities. This is also shown by the fact that there is a strong correlation between urbanization and income level of a country [179, pp. 32-37]. In 2003, 47% of the world's 6.3 billion inhabitants were living in urban areas. In more developed countries, even 75% of the population (1.2 billion) was residing in urban regions. It is the first time in history that more than 50% of the people worldwide are living in urban areas. Worldwide 3,486,326,000 people have been living in cities in 2010, that is 50.46% of the world population, in 2015 it will already be 3,824,073,000 [478, 479, 480]. Meanwhile Asia and especially China have a highly increasing urbanization, the city population in the United States is not that fast increasing and in Europe almost constant. For more detailed information also see tab. 3.2. In Germany, although the population is shrinking, within the next years city population will stay stable. Increasing urbanization generally leads to a higher population density in the cities, although increasing suburbanization counteracts this effect (compare 3.3.3.3).

	Urban Population 2010	Urban Population 2015	Urban Population 2010	Urban Population 2015	Annual Urban Growth Rate 2010-2015	Annual Urban Growth Rate 2015-2020
	[in 1000]	[in 1000]	[%]	[%]	[%]	[%]
World	3,486,326	3,824,073	50.46	52.37	1.85	1.76
China	635,839	713,091	46.96	51.08	2.29	1.97
Hong Kong	7,069	7,398	100	100	0.91	0.80
Singapore	4,837	5,059	100	100	0.90	0.63
Europe	533,295	543,276	72.78	74.02	0.37	0.34
Germany	60,598	60,696	73.85	74.62	0.03	0.04
France	53,398	56,159	85.25	87.89	1.01	0.74
UK	49,295	51,103	79.64	80.44	0.72	0.73
USA	261,375	277,973	82.29	83.64	1.23	1.10

Table 3.2: Overview of urban population
Source: [478, 479, 480]

At the top of this development are the so called megacities. These are cities with a population higher than 10 Million. The number of these is going to rise from five in 1975 to approximately 26 in 2015. 22 megacities will be in developing countries. Another development are so called mega-urban regions, which are huge agglomerations of merging, even faster growing, small and medium sized cities.[180, pp. 1-5][184, pp. 1-5]

Impact on Urban Mobility

In growing cities more transportation with larger scales in terms of frequency and capacity will be needed. Most megacities already have huge traffic problems. Also the increasing density is leading to space problems. The use of expensive land has to be reduced to a minimum. "Research carried out in the Paris region showed that the private car, which accounts for 33% of total trips, consumes 94% of road space/hour, while the bus, with 19% of total trips consumes only 2.3%. In other words, a bus in movement consumes 24 times less space per passenger than a single car" [208, p. 5]. As a result a trend towards growing public mass transportation and smaller private vehicles occurs. Another way to deal with traffic congestions would be to shift traffic underground or in further distant future to the air. Politics also approach traffic problems from a different angle by trying to decrease the need for transportation through modern town planning [208, pp. 3-12].

"Cities concentrate investment and employment opportunities, promoting

economic growth and increasing productivity. They provide higher-income jobs, as well as greater access to goods, services and facilities" [184, pp. 1-5]. Particular megacities have high concentration of industrial production. For those reasons logistics and large-scale transportation of goods within a city will also become an important part in the future of city planning and transportation provision. [187]

3.3.3.2 Geographical Clustering in Cities

Especially industrial countries tend to develop a high residential specialization within cities. This leads to a segregation of work and living space, business and industrial areas. But areas are not only separated by matters of usage. Differences in costs of living form districts that are segregated by its class of population. [208, p. 199-203]

Impact on Urban Mobility

Clustering leads among other reasons to high distances between work and living areas that have to be bridged by very individual transportation. This dispersion of destinations can hardly be "adequately served by the public transportation infrastructure [208, pp. 210, 213]." On the contrary it drives the necessity of a technology that can provide access to the increasingly dispersed and specialized urban areas, as for example a private owned vehicle does. In the future flexibility of transportation becomes highly important. The growing usage of private vehicles puts a strong pressure on the capacities of transportation infrastructures and leads to congestions. Politics and city planners try to take countermeasures against this inefficient development in prescribing mixed district usage. The aim is to come back to a compact city with its traditional diversity. [208, pp. 1-2, 11-14]

3.3.3.3 Suburbanization

In industrialized countries, high rents and land prices, declining quality of living due to traffic congestion, degradation of public places and pollution in the densely built city centers drive people to move into the suburbs. Furthermore the change in customer needs and lifestyles, partly due to the increase in incomes enhance the suburbanization (compare 3.3.1 and 3.3.2.1). This trend is mainly pushed by young people and families, with increasing needs for individual living space, but also the working class who cannot afford living in the town center. Even the upper and the middle class value the better living environment in the suburbs. Housing improvement in the city centre is more expensive than a new house outside in a suburb. Since an immediate proximity to work is not necessary anymore due to risen mobility, a child friendly and green environment and a linked high quality of living gain more importance (compare 3.3.1).

Furthermore low land prices incentivize companies to relocate there industrial production and office activities to the outer city. Housing-suburbanization and increased mobility makes decentralized sales or distribution in big shopping malls in the suburbs profitable for many branches. [180][187][169, pp. 1-9][208, pp. 1-14]

Emerging Asian countries with their high number of megacities follow the trend of suburbanization. The difference is the larger scale of these cities and the more intense progress of suburbanization. In Beijing „of villas built from 1999 to 2003, 98.3% were in the suburbs (65.9% in the outer suburbs) [186, pp. 11-13]." megacities have a large number of specific problems. Among these are a general high population density, in some cases with extreme levels and uncontrolled high spatial expansion. Often the most populous areas are shifted away from the city cores. Still suburbanization in Asian megacities is typically not leading to a decay of their centers. The concentration of population within these remain very high. [169, p. 4] [186, pp. 11-13]

Impact on Urban Mobility

Empirical analysis proved an instant positive correlation between the rate of car ownership and the distance of the living area from the city core. [197, pp. 1-30] Moreover there is a connection between the area of residence and variables like distance travelled per day and the rate of car ownership. This rate is influenced through emergence of new ways of lifestyle that are indicated by suburbanization. [208, pp. 201-203] Public transportation is strongly affected by suburbanization. The more dispersed a city is and the lower its density of demand for transportation, the lower is the competitiveness and efficiency of public transportation. This results in a low share of the mobility market.

Politics and city planners try to take countermeasures against suburbanization. This is because suburbanization is highly inefficient in terms of transportation and land consumption. Their aim is to make city centers more attractive and incentivise people to move back into the city centers. Among possible measures are city tolling, traffic and environmental restrictions, subsidization of urban living. The inefficiency in transportation partly occurs in an increasing number of commuters and extended commuting distances. The resulting high pressure on urban traffic is leading to traffic congestion. Higher costs for providing transportation grids and infrastructure and public transport will accrue in the future. [208, p. 1-18]

3.4 Conclusion

Enormous social transitions such as population growth, urbanization, demographic change and shifts in customer needs will widely impact urban mobility

development. Although these differ regionally, major global trends can be described. A growing middle class with higher luxury needs and an aging society that wants to stay mobile have to be served with customized mobility solutions. With rising GDP per capita, people become more environmental and health aware. Therefore, combating pollution and improving air quality and safety will become more important, especially in those cities with an emerging middle class.

Global population growth will occur mainly within cities. In fast-growing Megacities, traditional transportation will hit its limits. In conclusion, demand is rising for new technologies and concepts with higher capacities.

Suburbanization and clustering cause a trend towards individual transportation, which is the most congesting and unsustainable way of travel. To minimize impacts on the environment and air quality, measures need to be found to deal with these effects. City planning will become even more important to tackle related difficulties.

Cities will be competing in attractiveness for inhabitants. Therefore new measures to evaluate quality of life are necessary. GDP per capita will not remain a valid source of quality.

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4 Chapter 4
Political & Legal Trends

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Governments spend much effort on adjusting urban mobility solutions to major developments like the increasing urbanization and the need to reduce emissions.

The current car-centric approach is suffering from insufficient road systems and causes environmental problems. Therefore, governments worldwide foster other mobility solutions to reduce car traffic.

Particularly, public transport infrastructure is expanded to accomodate ever growing passenger numbers. At the same time, governments seek to increase the capacity of the current road infrastructure through intelligent transportation solutions and traffic control. To reduce the environmental impact of individual traffic, the use of cars and trucks, especially of those which are not environmentally friendly, is more and more constrained. Furthermore, the governments are competing in an international technology race. To win this competition they are promoting new technologies through research funding, subsidies and privileges for users of the new technology. This is especially the case for technologies related to e-mobility.

In addition, governmental regulations and policies shape the markets substantially. In many cases, governments take a steering role to mediate between technology, industry, and the market.

4.1 Introduction

The political and legal aspects define the market and the framework for urban mobility. In the field of transportation, governments often act as mediators between the interests of industry, customers and technology. In addition, public transportation and traffic infrastructure are mostly owned by the state, giving it further power in this topic. Governments have two main ways to influence urban mobility. First, they can define the rules through legislation and regulation. Second, they invest into traffic infrastructure.

Due to political reasons, the direction of governmental action is always intertwined with societal demands. As a consequence, the impact of political decisions on urban mobility cannot be regarded in an isolated way. It is therefore crucial to have a closer look at the interfaces between political intervention and customer needs. Another interesting interface is the interaction between governmental decisions, technology and the market. Governmental projects can act as the driving force for innovation and market change. While regulations and policies have a large influence on the market, state investment in R&D and public transport can promote sustainable technologies and promising new ideas. These measures are often part of a long-term strategy. In the long run, governments strive to make their cities more attractive for companies and to offer a high quality of life to its inhabitants, for example through good traffic infrastructure.

The approach of this report is as follows: First, the status quo in the key sectors of legislation and state investments will be analyzed. Based on the status quo, current trends will be observed and examined. The chosen trends are expected to have a major impact on urban mobility within the next five years. In the conclusion, the implication of the observations will be discussed.

4.2 Status Quo

To identify current trends, a close look at the status quo of the key fields of government action is necessary. The following sections are going to analyze the legal situation and the influence of state investments. First, the implications of environmental policies on urban transport are discussed. Then, the existing regulations concerning the safety of road users will be outlined. The next section describes concerns and regulations about data protection and privacy regarding the collection of personal data in traffic control systems. After that, governmental investments in urban traffic infrastructure are pointed out. Next, available research funds and subsidies are introduced and the degree of regulation and deregulation in urban transportation is analyzed. The last section concludes with a look at traffic control measures that are implemented by municipalities for more efficient usage of the current infrastructure.

4.2.1 Environmental Issues

Climate change is one of the key issues of today's society **??**. As more than 80%
of global greenhouse gas emissions originate from cities, the urban environmental
policies play an important role in slowing down global warming [320, p. 25].

In Europe, the emission limit for all kinds of vehicles is regulated by the Euro
1 to 6 standards [278]. The implementation and enforcement of these directives
differ from country to country [274][359, p. 43]. Germany and the United
Kingdom (UK) established environmental zones to comply with the emissions
limits. There are different national regulations for entering environmental zones,
e.g. in Germany it is necessary to notify that the vehicle has an acceptable
emission level, whereas in the UK allowance to enter depends on daytime
[308, 366]. Another EU directive for renewable energy binds all members to
reduce greenhouse gas emissions of fuels by 10% [271, p. 2]. Most states reach
this goal by introducing E10[1]. In Sweden E85 is in common use, which requires
cars with adapted engines [333]. A summary of current and planned average
$CO2$ emission levels for passenger vehicles is provided in figure 4.1.
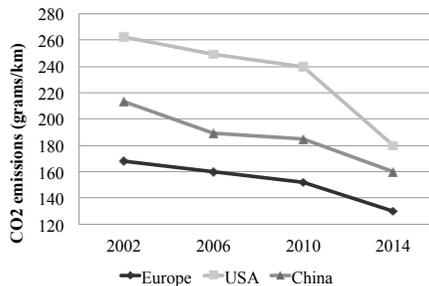
Figure 4.1: Passenger vehicle fleet average $CO2$ emissions
Source: Adapted from [263, p. 5]

Environmental laws in the U.S. still do not match European or Chinese
standards, but are getting stricter since the change of government. To give
an example, from 2016, only new vehicles with an efficincy of 14.5km per litre
will be authorized. As 60% of all transportation related greenhouse gases are
emitted by heavy vehicles, a significant reduction of the $CO2$ emission in the
U.S. is expected [246]. Since the oil crisis in the 1970s, the production of fuel
with ethanol reduces oil dependence. Through special governmental support
like tax savings since 2005, America is the largest producer of ethanol fuels with
an annual production of 49bn liters[294].

China is the world's largest emitter of $CO2$ with a share of 21.5% [262]. But
due to its strong agricultural sector, China has a severe interest in minimizing the

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[1]fossil fuels combined with 10% of ethanol

greenhouse effect [318]. As a result, China set its first nation-wide fuel economy standards for vehicles in 2004 [298, p. 1]. Chinese regulations become aligned to European Standards. Since 2010, the Euro 1 to 4 equivalents "National Standard 1-4" were legally enforced [249]. China was the first developing country to publish an action plan on climate change [326]. One important aim of this plan is to reduce $CO2$ emissions per unit of GDP by 40% to 45% until 2020 in comparison to 2005 [264, p. 22]. In some cities there are additional restrictions. In Hong Kong, for example, only taxis with a liquefied petroleum gas engine are permitted [258][266, p. 1].

4.2.2 Safety

In 2004, 1.2m people died as a result of a traffic accident [354, p. 1]. This leads to traffic injuries being one of the top ten death causes and the primary death cause of 15-29 year olds worldwide [354, p. 3]. 91% of all traffic fatalities occur in emerging countries, which have only 48% of the world's registered vehicles [354, p. 11]. Several countries lack policies for basic safety measures like speed limits, drunk driving and seatbelt use.

To give an example, nearly a third of all fatal accidents in China result from aggressive and high-speed driving [350, p. 11]. Concerning urban traffic, only 29% of all nations enforce a speed limit of up to 50 km/h in urban areas while allowing local authorities to reduce speed limits further [354, p. 20]. In contrary to that, seatbelt laws have been adopted by nearly all countries at national or subnational level. About half of these countries require all vehicle occupants to wear seatbelts [354, pp. 24-25].

Especially in developing countries, pedestrians often share the roads with motorized vehicles. This fact is caused by the lack of basic infrastructure like pavements or lighting [354, p. 16]. In order to protect pedestrians, special infrastructure has to be created. In Sweden, the Vision Zero Plan comprised a speed limit of 30 km/h in built up areas [378, p. 10] as well as building pedestrian lanes and tunnels [354, p. 17].

4.2.3 Data Protection and Privacy

Information collected and stored in ICT services could also be used for purposes other than envisaged. These include the surveillance of individuals and monitoring of public places, possibly infringing the privacy rights of road users [237]. Consequently, the implementation of traffic control systems in the EU, the U.S. and China is often accompanied by the creation of policies to protect privacy and limiting the amount of retained information [257, p. 19].

In the EU, personal privacy is defined and protected by Directive 96/45/EC. This directive regulates automatic processing of sensible data and is implemented similarly in most countries of the EU [355, pp. 13-14]. In Germany, the use

of Automatic Number Plate Recognition (ANPR) Systems has been limited by Federal Constitutional Court Act in 2008. It prohibits storing information of number plates beyond their processing [245]. In GB, data collected by the national ANPR network may be saved for at least two years according to the Data Protection Act. Collected data may be analyzed for intelligence and used as evidence, including real-time access for the police [336].

Current regulation in the U.S. is state-specific. In some states, traffic control systems are allowed to collect and store data indefinitely. This led to major misuse of the traffic tracking system in 2005, when a police sergeant accessed confidential databases to gather information on an individual because of personal reasons [265]. To address problems like this, the State of California released SB1268 'Electronic Toll Collection Privacy' in 2010 which limits the storage of personal information to six months [292]. The use of traffic control systems is not restricted to governmental agencies [299].

China lacks a specific law to protect citizens' privacy in traffic control systems. The Bejing Municipal People's Government announced in Februrary 2011 that they plan to track cell phone users in order to control the city's traffic [248]. In addition, some taxis are equipped with microphones and cameras. The gathered data is stored for one month [284].

4.2.4 Infrastructure

Urban transportation infrastructure is the backbone of economic growth. With increasing quality and expansion of this infrastructure, the mobility of people is facilitated.

In emerging countries, the majority of people use non-motorized transport (NMT) [348, p. 63]. This situation is treated by the UN and the individual states by projects which improve conditions for NMT [300, p. 60] and funds that focus on urban roads [300, p. 79]. But also increasing efficiency of existing facilities and the introduction of signal systems enable further capacity and safety regarding transportation infrastructure [300, p. 85]. A major issue in fast developing countries is the necessary high budget for transportation infrastructure which amounts to US$2,4tr in China. 90% thereof is reserved for road construction [335]. In Shanghai, an extension of the metro system is indispensable. The number of passengers serviced by the Shanghai metro system increased sharply from 2000 to 2005 with an annual increase of 37% [259, p. 56]. State investments in infrastructure can also be used to directly reduce poverty. If poor districts are equipped with public transportation and the people living there own the land, the value of their property enhances. Hong Kong, Singapore and Tokyo already successfully implemented this approach [255, p. 3].

In developed countries political efforts regarding transportation infrastructure mainly focus on sustainability, congestion prevention, safety and efficiency.

Member states of the European Union invest in public transportation and in projects that facilitate the use of NMT to fight congestion problems and decrease emission [363, p. 21]. The project "Transport for healthy urban environments" of the EU demonstrates the pursuit for a common fight for sustainable public transportation. [251, p. 12]. Sustainability in Europe is of high priority as 72% of the European population have lived in urban areas and economic activity is clustered in cities [251, p. 3]. To push environment friendly technologies, the German government supported the installement of 922 public charging stations for electric vehicles [302][330].

4.2.5 Research and Subsidies

Subsidizing the R&D for electrical cars and batteries is of top priority for the governments. In 2010, Germany introduced the National Electric Mobility Platform, providing €500m [285] for market preparation and introduction of battery-powered vehicles [281]. The U.S. administration provides US$2.4bn [369, p. 2] for the development of electrical cars and supports the car manufactures Ford, Nissan and Tesla with US$8bn of low-interest credits [368].

Most of the EU members established national support programs for electric vehicles for customers through state subsidies and VAT reduction [339]. The U.S. House of Representatives passed legislation granting tax credits ranging from US$2500 to 7500 [369, Sec. 1141] for plug-in electric vehicles. Also the Chinese government announced a trial program to provide incentives of up to US$8786 for a private purchase [386]. An overview over the current financial incentives for buyers of electric cars can be found in figure 4.2.

Supporting alternative fuels can help to become independent of oil imports from the Middle East and to reduce CO_2 emission [312, p. 1]. The member states of the EU promised to substitute 10% of transport energy by renewable sources by 2020 [340]. The Global Subsidies Initiative yet identified a significant decrease in subsidies in 2008 compared to 2006 [226, p. 9]. Currently, alternative fuels in the U.S. benefit from significant subsidies and tax incentives. The U.S. Department of Agriculture announced to provide for up to 75% of producers' costs of starting production of biomass crops [367, p. 3]. Yet the dependence on a source of funding sensitive to political fluctuation is unsustainable [315, p. 25].
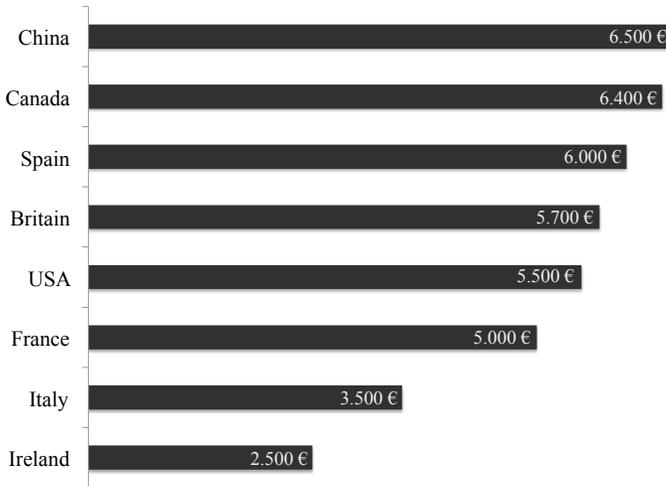
Figure 4.2: Financial incentives for electric cars in selected countries
Source: Own illustration, adapted from [260]

4.2.6 Competition Law

The role of the private sector in providing transport infrastructure facilities
and services increased in recent years [244][268, p. 7]. This emphasized the
need for effective regulation and regulatory institutions due to the limitations
of competition for the market and existence of natural monopolies [347, p. 98].

PPP is a worldwide phenomenon [364, p. 9] and throughout Europe public
transportation services experienced privatization [225, p. 1]??. Hong Kong has
even privately owned and operated bus transportation with no direct subsidies
or grants provided by the government [343, p. 10]. They are self-financed and
self-sustained under a well regulated framework with a competitive market
structure [303, p. 2].

Since the 1990s, competition in the taxi market has been strongly deregulated
in the European countries [295, p. 7]. The regulatory framework consists of
entry, quality, quantity and fare restrictions [295, ch. 2]. An increasing number
of OECD countries removed or loosened supply restrictions on taxis. The results
of these reforms have been positive for customers, with reduced waiting times
and increased consumer satisfaction [325, p. 9]. Countries like Ireland and the
U.S. had a massive increase in numbers of vehicles due to deregulation [325, p.
10]. The private hire vehicle[2] industry has decreased in size after the barriers to
entry in the taxi market were removed [324, p. 37]. Due to the drop in quality

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[2]Vehicles licensed for private hire cannot ply for hire neither can they advertise, display, or
otherwise imply, that they are for hire.

and excess supply, Ireland and the U.S. introduced some re-regulations [277, p. 47,50].

4.2.7 Traffic Control

The overuse of the existing traffic infrastructure leads to congestion, which wastes time, fuel and money, as well as to additional pollution [254]. For example, 35% of Bankok's gross city product is lost in congestion [329, p. 673]. Urban traffic authorities take various measures to control the traffic infrastructure, especially the use of roads for automotive traffic. These measures include charging for the use of roads, improving public transport, increasing parking charges, and zone-access control [323, p. 244].

There are three concepts of road pricing: Corridor pricing[3], distance-based pricing[4], and congestion pricing [257, pp. 9-15]. Congestion charging systems are used in several major cities, e.g. Singapore and London, to reduce car traffic and reduce congestions and emissions by charging for entering the city center by car [328, p. 10]??. The profits from charging for road use can be invested in traffic infrastructure [328, p. 68].

Low Emission Zones with access restriction for vehicles with high emissions [306] are in place in many cities, especially in Europe [328, pp. 127-163]. In order to limit freight traffic in city centers, trucks are often not allowed to enter the city center in rush hours or even all day [328, p. 34].

Another common way of traffic control is the dynamic adjustment of traffic lights to traffic conditions [311, p. 1]. In order to improve the efficiency of current road infrastructure, lanes are dynamically reversed (reversible lanes) [240, p. 1] or reserved for vehicles with multiple passengers (high-occupancy vehicle lanes) to encourage carpooling [296, p. 1].

The issue of traffic control is particularly important for large cities in developing countries, as the rapid rate of motorization and population growth by far exceeds the growth of transportation facilities [329, p. 673]. Many forms of traffic management that are used in developed countries are hard to implement in developing countries because of weak driving discipline [329, p. 675]. In addition, congestion control systems using advanced technology are costly and thus do not fit in the tight budgets of developing countries [329, p. 675]. Instead, major cities like Mexico City employ usage restrictions for cars to limit traffic. For example, some cars are only allowed to drive on certain days of the week, based on the last digit of their number plate [379]. Also, some regions employ user charges (i.e., high tax on car purchase) [329, p. 683] to limit the speed of motorization.

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[3]Charging for the use of a single road.
[4]E.g., charging per kilometer of road use.

4.3 Trends

Based on the findings in the status quo, current trends in governmental regulation and state investments will be identified. In a time horizon of five years, these trends are expected to shape the urban mobility sector. Although the market for public transport is increasingly deregulated, most parts of public transportation are still controlled by the government.

The first section therefore describes how policy makers adjust public transportation to societal changes. Next, an insight on how governmental authorities are going to promote new technologies in urban transport is given. The subsequent section examines the trends in the field of Nonmotorized Transport and Urban Freight Traffic. Finally, the evolution of regulations and policies in the context of environmental issues is discussed.

4.3.1 Societal Demands on Urban Public Transportation

In democracies, politicians are motivated to satisfy their voters to remain in office after the next elections. Reactions to societal trends help reaching this objective. The following chapter explains four upcoming political focus areas, transportation for elderly people, increasing capacity of urban public transport, mobility problems of the poor, and upgrading the quality of urban mobility.

4.3.1.1 Augmenting Facilitation of Access to Public Transportation for Elderly People

As people's life expectancy grows and birth rates decrease, a large part of the world's population will be older than 65 years **??**. As they have special needs regarding urban mobility **??**, politicians are expected to react adequately concerning the adaption of urban mobility.

One reaction is the World Health Organization (WHO) setting guidelines for public transportation for global age-friendly cities (see appendix 2). The WHO now launches projects to convert these guidelines into action on a local level [352, p. 2]. More age-friendly communities will join the initiative and further research will be conducted [352, p. 74]. This network approach is also pursued by Eurocities, which is a co-operation of many European cities that claims inter alia a common European framework for the ensurance of elderly people's urban mobility [344, p. 3] [269, pp. 12, 68]. Another initiative on European level is AGE, which contributed to the EU's Road Safety Action Plan 2011-2020 to focus attention on the importance of security and accessibility objectives[222, p. 2]. Projects on a national level will be launched by initiatives like the Canadian Urban Institute which aims at putting the mobility needs of elderly people on the political agendas [247] or the initiative of the mayor of London that supports pensioners, e.g. with free access to public transportation [304].

Impact on urban mobility

The efforts of politics to support pensioners will be recognizable by policies that enforce their needs in public transport but also changes in the infrastructure will be observable, like more reserved seats in public transportation. The existing guidelines by the WHO will be implemented by numerous initiatives, like Eurocities and AGE. Short-time projects like the free access to public transportation for elderly people in London ensure that the topic of mobility for the ageing society will play an important role on the agendas of political discussion.

4.3.1.2 Increasing Capacity of Urban Public Transport

The percentage of urban population is increasing rapidly **??**. Consequently, for example, London will have to face an increase in public transport demand by 28% until 2025 [359, p. 34]. Measures that target these developments are focused on increasing the capacity of public transport and on renewing existing transportation infrastructure.

Extensions of public transportation will be implemented to handle capacity problems. A US$129bn strong U.S. budget for the restoration of America's economic competitiveness will finance additional road capacity [374]. The transportation will also be extended in Beijing. Here, metro lines will be lengthened to 560km in 2015 compared to 270km in 2010 [232, p. 2]. A further development of infrastructure is the construction of hubs to bring together different routes and transportation networks. This linkage needs an institutional framework consisting of rising awareness and capital spendings for infrastructure [383, p. 117]. China's twelfth five-year plan for 2011-2015 includes high investments in infrastructure. Xiamen, a coastal region in southern China, starts this plan by constructing 116 new roads in 2011, like arterial roads and trunk roads [385]. Further three urban rail transit lines and eight public transport hubs will be built [384]. The Asian Development Bank suggests the development of bus rapid transit (BRT) systems in China, as they provide additional transportation capacity for a relatively low investment. Additionally, BRT systems can be implemented within about five years as examples of past projects showed [231, p. 1]. In the UK, the London bus system will be heavily extended to satisfy the growing demand in the next years [359, p. 91].

Renewing and managing urban mobility infrastructure will help facing increasing urban population [359, p. 40]. Road capacity will be allocated to competing areas of the city and the road infrastructure will be renewed with new lighting and tunnels. A PPP will help with the renewal of the Underground until 2018 . The bus system will be brought up-to-date by employing hybrid technology [359, p.55].

Impact on urban mobility

Increasing capacity demand towards urban transportation is handled by a mix of extending, renewing and managing existing infrastructure. For example, current road and train systems are extended and new BRT lines systems and intermodal hubs built. As shown above, governments around the world prepare big budgets. This way, they cope with the increasing urbanization and the resulting growth in public transportation demand.

4.3.1.3 Stronger Policy Focus on Mobility Problems of the Poor

One of the aspects of social exclusion that defines urban poverty is poor people's restricted access to jobs and social services [300, p. 25]**??**. Thus foreign aid for transport investment is changing from pure economic profitability to real benefits for the poor regarding mobility possibilities [227, p. 1]. At the UN Millennium Summit in 2000 the governments pledged to cut the number of people in poverty in half by 2015, including recommendations for the transport sector to alleviate poverty [346].

In the course of the FIFA World Cup 2014 and the Summer Olympics 2016 in Brazil, the World Bank approved a US$485m developement policy loan. The local population and especially those who live in favelas will profit from these policies that improve suburban transit and connect the slums with the city [309][351]. As an example, Caracas connects the inaccessible slums of San Augustin with an aerial railway in order to provide access to the city for the impecunious [239].

Means of individual transport are an important lever for poor families to increase their standard of living [4.2.4]. The ownership of a bicycle can reduce the costs of daily commuting by saving bus fare and allowing to run a small informal business [261, p. 26]. Even by 2025, just 3% of households will own a car in China [300, 261, p. 2].

In developed countries, public transportation also plays an important role in poverty reduction. Low income citizens are the key beneficiaries of the London congestion charging scheme **??** in three different ways. First, traffic is reduced which allows increased bus speed. Then, 80% of the charge are used to improve public transit and 20 percent for road maintenance. Third, the funds which would normally be used to keep roads maintained can now be used for the poors' needs, like social housing and community infrastructure. This forward-looking approach will be a trend for developing countries, where car users belong to the highest income group [380, p. 6].

Impact on Urban Mobility

Providing mobility for the poor is active poverty reduction. By connecting the low income districts to the transportation network the demand for low-budget

transportation is increasing and poor citizens are able to commute beyond their districts. Providing for bicycles and pathways in emerging countries leads to more freedom and individual transportation for low-income citizens. With methods like the London congestion charging schemes inner traffic can be reduced and the revenues can be used to provide for more and better low-budget public transportation and better pathway maintenance. This could be an especially valuable method for cities emerging countries to close urban wealth gaps.

4.3.1.4 Upgrading Public Transportation to Suffice Increasing Quality Expectations

Basic goals of improving public transportation quality include meeting increasing quality expectations and convincing more customers to change from individual to public transportation [317, p. 6]. The quality of public transport service may be perceived differently according to the amount of already fulfilled needs **??**. Therefore, to avoid the misallocation of governmental investment, the status quo of the current infrastructure and the resulting customer demands need to be taken into account.

Within Europe, most public transport systems are able to suffice essential customer needs [321, pp. 113-126]. Consequently, while safety improvements remain within the top prioritized governmental investments, planned improvements measures often focus on energy efficiency and increased customer comfort in an integrated network [275, pp. 16-17]. The CIVITAS initiative hosts several ongoing projects to integrate sustainable technology in urban transport [338]. The City of London announced that they are going to increase customer comfort by implementing the current smart card ticketing system across all modes of transportation [359, p. 56]. As outlined in the 12th Chinese Five-Year Plan, China's investments in public transport are going to focus on developing the network coverage [384] and improving transport safety [350, p. 28].

Impact on Urban Mobility

In developed countries, customer comfort and convenience will play an important role when choosing the mode of transport. More and more state initiatives are going to target the increased environmental awareness in Europe, investing into green technology and high customer satisfaction. The CIVITAS initiative is funded by the EU to implement sustainable public transport strategies in cities throughout Europe in the near future. In London, the smart ticketing system has been shown to be very comfortable for its users and will be used across all modes of transportation. State investments in emerging countries will rather aim for increased safety and network coverage. In its 12th Five-Year Plan, the Chinese government states that it will invest in the development of road infrastructure until 2015.

4.3.2 Governmental Technology Promotion

The future of urban transportation is shaped by new technologies. In the next years, there will be two major trends that involve public decision makers in transport technologies. First, municipalities themselves employ intelligent traffic control systems to control traffic flows. Second, there is an international competition for technological leadership, accompanied by heavy research funding, especially in the field of electromobility.

4.3.2.1 Increasing Implementation of Intelligent Traffic Control Systems

As the usage of traffic infrastructure in large cities grows faster than the infrastructure itself [337, p. 1][329, p. 2], a more efficient use of the road system is necessary. Therefore, many states heavily invest in Intelligent Traffic Control Systems.

In 2010 Germany released its Action Plan for Intelligent Transport Systems (ITS), funding numerous traffic control projects with €300m until 2015 [241]. Many of these projects target safety and congestion reduction using automatic adjustment of speed limits, electronic road signs and use of shoulder lanes for traffic [242, 288]. The country-specific ITS plans are backed up by the 2008 EU Action Plan for intelligent traffic systems, which provides for coordination and acceleration of ITS implementation. One of its residual goals is assuring the interoperability of electronic tolling systems and funding research in cooperative systems [273, pp. 10, 13].

The U.S. Department of Transportation hosts a Joint Program Office (JPO) on Intelligent Transportation Systems [372]. Until 2014 €500m will be invested in ITS research, focusing on V2X cooperative systems and Dynamic Mobility Applications [370]. Additionally, the JPO established an ITS Tech-Transfer and Knowledge Resource Database platform [371]. Throughout this database, successful pilot projects have already shown the feasibility of ITS.

In San Francisco Bay Area several Changeable Message Signs were deployed before exits of transit stations, showing alternative travel routes based on highway and public transport travel times. The project showed a 10% increase in ridership of targeted train stations [319]. In addition, San Francisco is currently testing a dynamic parking space management system, which monitors and publishes the availability of parking spaces and adjusts the prices at the parking meters accordingly to reduce the search time for a parking space and to distribute parking cars more evenly [331]. Building on the congestion charging system already in use, Singapore ran a pilot project in 2007 to use a Traffic Estimation and Prediction System for forecasting traffic and adjusting the congestion charges dynamically to route the traffic [289].

As a next step, the use of Time, Distance and Place road pricing systems is possible. These systems aim to charge drivers variable prices for the usage of the road, based on the time, distance and place (and sometimes, on the CO_2

emission) of their journey. Currently, the British government funds several research projects for the necessary technology. [337]

Impact on Urban Mobility

The aim of all the measures mentioned above is to use the existing traffic infrastructure more efficiently by introducing automated, dynamic and interconnected traffic control systems. As more and more cities start to implement these solutions, intelligent traffic control systems reduce congestion, promote safe driving and thus lead to more efficient urban transport. Furthermore, the strong research budgets are going to promote even more innovative pilot projects and ideas.

4.3.2.2 Accelerated International Competition for Technological Leadership

The leadership race in e-mobility goes beyond car makers. It involves regions, nations and governments.

The Chinese automotive industry seemed to be fragmented [267, p. 15]. Foreign manufacturers such as GM and Volkswagen are dominating the domestic market [287]. Yet the government in Beijing is willing to spend massive support for prioritizing electric and plug-in vehicles. As they subsidize local governments and taxi companies in order to buy electrics and hybrids. In January 2011 the state council announced to spend US\$1.6bn over the next three years to provide aids to develop alternative fuels. China is already the world leader of lithium-ion batteries production, which is the key technology for new electric cars [356]. China is aiming to leapfrog the traditional automotive industry so to build up system and technology advanced technologies that allow them to skip the progress of the developed countries [282]. This spirit can also be seen in public transportation: Shanghai for example built a maglev train[5] with German technology that did not find a market in developed countries [334].

In the Electric Vehicle Index[6], China rose from rank six to five right behind Germany, caused by the shift of extraordinary improvements in general framework for electric cars in the last year especially in government programs. China has the best chances to break through to a leading position in electric car industy in 2011. [382]

The U.S. and EU are trying to counteract this development. U.S. President Obama announced in August 2010 US\$2.4bn in government grants to support the manufacturing of electric cars and batteries. [356]. The U.S. is spending by far the most for supporting R&D and infrastructure for producers of electric vehicles as seen in figure 4.3.

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[5]Magnetic levitation train or transrapid
[6]McKinsey and Wirtschaftswoche magazine

The EU provides for €4bn in loans for transport projects reducing CO2 emissions, as well as €500m in R&D funding [291, p. 6]. Still there is mayor competition also within the EU. Germany established the National Electric Mobility Platform, aiming at 1m e-cars by 2020. France's national strategy on e-vehicles differs from Germany but is leading in Europe. There is not yet a consensus at EU level and especially France demands for a unified European strategy [270].
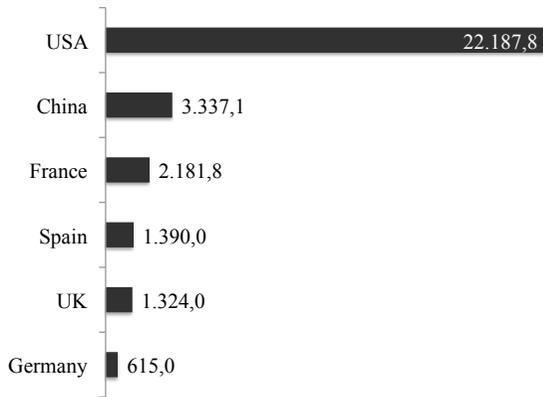
Figure 4.3: Subsidies for the producers of electric cars: Public support for R&D and infrastucture over the next five years (in million €)
Source: Adapted from [381]

Impact on Urban Mobility

Governments trying to win the race for the best technologies accelerates the integration of e-mobility in urban transportation systems. Through this process there will be more research in propulsion and battery systems, more investment in infrastructure and better standardization, leading to a joint responsibility of policy makers and industry stakeholders to solve the problems regarding mobility in the future faster.

4.3.3 Nonmotorized Transport and Urban Freight

Both non-motorized vehicles and trucks use urban road infrastructure that is often not suited for them. While Nonmotorized Transport (NMT) is increasingly fostered by governments through customized infrastructure, urban freight traffic is aimed to be reduced mainly through consilidation of shipments and better planning.

4.3.3.1 Increasing Facilitation of Bicycle Usage

NMT plays an important role in public transportation. Especially the use of bikes in cities will be a major issue of political projects within the next years. Reasons for that are partly different in developed and emerging countries.

The Bike 2015 Plan for the City of Chicago aims at integrating bicycle use in daily life by recommending concrete projects, plans and policies [314], like more bicycle-friendly streets [313, p. 15], law and enforcement and the set-up of bike parking sites [313, p. 17]. In London, an analysis of cycling potential policy identifies growth potentials in cycling [360, p. 8]. Further, framework-setting policies to make this growth happen are derived [360, p. 43]. The Mayor's Transport Strategy includes a 300% growth of the share of cycle use from 2% in 2006 to 5% in 2031 [360, p. 44]. This growth can be possible by removing barriers that keep people from using their bike, e.g. the lack of safety for bikers and insufficient facilities. The provision of separated bicycle lanes and enforcement would motivate infrequent cyclists to ride their bike more often [360, p. 45]. To convince non-cyclers, politics should provide parking spaces for bikes to attract young professionals who can imagine to cycle more [360, p. 46]. Bikes will continue to be the main mean of transportation in Asia [348, p. 63], because motorized vehicles will remain too costly for the majority [348, p. 152]. However, poor road surfacing and no separate bike lanes make biking increasingly unsafe. This makes clear that political guidance to reach an improvement of the safety situation for bicycle users is necessary. An augmentation of bicycle use might be triggered by China banning gasoline-powered motorcycles in more medium-sized cities [230, p. 37].

Impact on Urban Mobility

Policy supporting bicycle usage make urban transportation more eco-friendly and bicycling safer. Growth potentials in this sector will be recorded, if the biker's safety can be assured within the next years. A major role of government's will be to convince more societal groups to change their favorite mean of transportation to bikes. Hence it is expected that governments in emerging countries will improve basic street infrastructure for better traffic safety, while developed countries will improve bicycling comfort by implementing e.g. more parking space for bikes and separated bicycle lanes.

4.3.3.2 Increasing Efficiency of Urban Freight Transport

Freight transport accounts for 10-18% of urban road traffic and 40% of air pollution and noise in Europe [253, p. 2], and it is growing steadily [272, p. 11]. The reduction and centralization of inventory, especially in the retail sector, leads to more, but smaller deliveries [276, pp. 30-33]. Thus, efficiency of urban freight transport is declining [276, p. 50].

As trucks are often not fully loaded, the consolidation of freight transports is a suitable measure to increase efficiency [293, p. 17][253, p. 3] that "seems to be an emerging trend" [276, pp. 10, 66]. As consolidation is mainly driven by the transport companies themselves, the role of governments is to facilitate the process through help in setting up consolidation centers and favourable regulations [276, p. 79], especially limited access to city centers for trucks not part of the consolidation system [297, p. 74]. Public urban distribution centers, however, were not successful in the past [276, p. 80].

There are several concepts to coordinate the consolidation of loads. Goods can be transferred in suburban trans-shipment centres from large lorries to small vans to comply with access restrictions for trucks [316, p. 23]. These vans can be powered by more environmentally friendly technologies, especially electricity, due to their smaller size and shorter trips [316, p. 23]. Consolidation centers can also be linked to multiple modes of transport, especially road and rail, like freight villages, to facilitate intermodal transport [280].

On a related note, London and other cities in the UK employ Freight Quality Partnerships to bring together authorities, freight industry, their customers, and citizens to jointly develop solutions for urban freight transport problems [361][276, p. 66]. One example of the authorities working together with the industry is the retiming of deliveries to nighttime to avoid rush hours during the day [252, p. 69].

To increase the efficiency of urban freight distribution, intelligent transport systems, e.g. fleet management software, are used to improve the timing of deliveries and use the vehicles more efficiently by maximizing loads and avoiding empty trips [272, p. 12][250, p. 6][276, p. 36].

Impact on Urban Mobility

The improvement of urban freight transport relieves the urban road system from a part of the freight traffic. Urban freight transport efficiency can be increased by using consolidation centers. In addition, e-trucks can be used to reduce emissions and further improve the acceptance of e-vehicles. By advanced scheduling (e.g., rescheduling to nighttime), freight transport traffic can be kept off the streets during rush hours. As a result, road utilization is reduced and less congestion occurs.

4.3.4 Environmental Policies

There are two main directions in which environmental policies related to urban traffic are heading. On the one hand, environmental policies are increasingly standardized among countries. On the other hand, environmental regulations are becoming more and more strict.

4.3.4.1 Unifying International Environmental Policies

Due to the strong economic growth, emerging countries are mainly facing the same political challenges: as the number of motor vehicles is continuously increasing (e.g. in China at around 6% [341]) greenhouse gas emission rises dramatically, which in turn caused several new problems [375]. Infrastructure and laws have to be adapted in the next years, especially to protect public health against problems like decreasing urban air quality [238, p. 29-31]. Environmental awareness is more and more expected and encouraged. China is regarded as a pioneer for emerging countries concerning the legal environmental position. China already adapted, as first emerging country, most of European environmental laws and standards [249]. It can be expected that further emerging countries will follow this trend. Usually emerging countries are adapting european law with a delay of 5-7 years [234]. However, the U.S. decided to introduce their own standards [376]. The trend of an international unified legal position is additionally encouraged by the International Organization for Standardization, whose main aim is to develop and publish international standards [290].

Impact on urban mobility

Environmental policies will become internationally standardized. On the one hand, this leads to easier market implementation of new products in different countries, as different legal situations have to be considered less. On the other hand the advantage of different law situations cannot be used. Due to this process markets for the same product, such as new engine technologies, will converge internationally and cross border business will get more important. This will show an opportunity for producers of low-emission vehicles to find a growing international market.

4.3.4.2 Tightening Environmental Policies

The policy in emerging countries is permanently facing the trade-off between economic growth for additional prosperity and environmental protection [283]. Current environmental regulations are relatively lax or not existing as supporting growth is seen as more important. But due to rising environmental problems, especially city smog, a change in thinking has begun [238]. Environmental conscious policies will increasingly be encouraged and implemented [376, p. 5][322, p. 23][235].

A stricter environmental policy is also expected in developed countries. One main aim of the European Union is to reduce carbon dioxide at around 500m tones [279]. In 2015, the Euro 6 standard will come into effect, which is going to tighten emission standards for vehicles even further[307][278]. EU research

funding for renewable energies will increase[7].

Also in America, a change in environmental policy is expected. The U.S. president announced a stricter environmental policy and claims "combating global warming [as] top priority". One main target is to reduce carbon emission by 80%, below the level of 1990 [236, p. 1]. This will require a huge change in the current legal position, as America did not even sign the Kyoto Protocol, the biggest international agreement for the reduction of greenhouse gases [256]. The U.S. government already announced that "fuel economy standards [will increase] (...), while providing US$4bn for domestic automakers to retool their manufacturing facilities in America to produce these vehicles." Also a "National Low Carbon Fuel Standard (LCFS) to reduce the carbon in our fuels by 10 percent" will be introduced in the medium term [235].

Impact on Urban Mobility

The tightening of environmental policies, both in emerging and developed countries, leads to increased awareness for companies in the development of mobility technologies. As a result technology standards have to be improved to meet the given standards, while vehicles such as cars with older technologies will be increasingly repressed. This will lead to an open market with new players involved. To give an example, the demand for nonmotorized vehicles in emerging countries is going to increase, as new cars will be too expensive for a major part of the inhabitants.

4.4 Conclusion

Political action has influenced urban mobility heavily in the past and will continue doing so in the future. In the following, the key findings of this report will be summarized.

As more and more people move into cities, public transport systems need to be adapted to support higher capacity requirements. At the same time, the quality of public transport systems has to suffice rising quality needs to compete with individual transport. Facing an ageing society, this also includes accessibility for elderly people. Apart from that, public transport can also help to mobilize whole low-income districts in large cities.

As the current traffic infrastructure does not suffice for the rising traffic volumes, city administrations will employ Intelligent Transportation Systems to increase the efficiency of urban transport. Similarly, urban freight transport will be better planned and organized through cooperations between companies, government incentives and ICT. State involvement in and funding of research activities, particularly those related to e-mobility, will have a major influence on

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[7]e.g. EU: "7.Forschungsrahmenprogramm" with grant total of €54bn between 2007-2013 [243, p. 7]

where and how new mobility solutions will be developed. The growing influence of the bike as a mean of transport in urban areas in developed countries will continue, helped by custom infrastructure.

The legal situation concerning environmental policies will be aligned internationally. Thus, scientific and technological cross-border collaboration will be simplified and encouraged. The technology competition will push nations worldwide to invest into sustainable mobility technologies. Environmental awareness will also arise in emerging countries, resulting in stricter laws and green technology promotion.

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5 Chapter 5

Business Trends (Emerging Business Models)

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In order to complete the picture of present Urban Mobility Concepts, it is crucial to analyze current and emerging business models. Coming from public transit and combustion engine driven individual transportation, new technologies will foster future business opportunities in Urban Mobility. This work elaborates these business models, paying special attention to customer value propositions as the customers' acceptance is probably the most critical success factor. Covering the big topics mobility needs, communication technologies as well as environment and energy, business trends like personal rapid transit, carsharing and e-mobility are closely examined.

From this analysis it is concluded that the demand for individual and flexible means of transportation that compromise neither with environmental pollution nor with convenience rises.

5.1 Introduction

Every business case needs to have appealing use cases where it can be applied. Concerning the stakeholders, customers are attracted by value propositions like time saving and increased convenience, whereas shareholders aim to increase their profits with solid revenue streams that exceed costs. Urban Mobility is a crucial part of public infrastructure, as it can create locational advantages which affect potential tax incomes. The analysis of the business models focuses on use cases, customer value propositions as well as revenue and cost streams.

After the analysis of the current situation and upcoming trends concerning Urban Mobility in technologies, market players, customer needs and politics, this chapter will identify existing and emerging business models. In the same manner as before, the description of the status quo will be followed by an examination of expected trends and a conclusion.

5.2 Status Quo

The following section concentrates on the status quo of existing business models in urban mobility, divided into the main categories key transport services and supporting services.

5.2.1 Business Models in Key Transport Services

The presented business models in this section provide an explicit transportation service. Depending on their preferences and budget restrictions, customers can choose between owning vehicles or making use of them for a limited amount of time. The latter can be done either by renting vehicles or acquiring the rights to use them for single trips including public transport and taxis.

5.2.1.1 Ticket Based Fee Systems in Public Transit

In conventional short-range public transit systems there is a need for fast transportation of a high number of people during the day. Business models operating in this sector need to meet these requirements. Ticket based fee systems are widespread in public transit as from a customer's point of view they provide a straightforward and easy to use approach for payment.

In 2009, 9% of all rides in Western Germany have been accomplished by public transit. In terms of travel distance, this accounts for 15% of all transportation ways. This means that more than 480m kilometers of public transportation have been covered in a single year. [415, pp. 25] As the number of public transit users is constantly rising [468, p. 16], ticket based fee systems will not become less significant in the near future.

Over 75% of the revenues are created by season tickets [468, p. 17]. The customer benefits from discounts and not having to buy a new ticket prior to every trip. The operator, on the other hand, can tie the customers to their offerings and is able to make more accurate revenue forecasts which lead to improved planning security. However, it is usually also possible to buy single-ride tickets at affordable prices for people who infrequently use public transportation.

In addition to personnel expenditures, caused by a high number of affiliated system operators, material expenses for the usage and maintenance of transportation systems are the key cost drivers with an average 78% share of total cost [468, p. 28].

5.2.1.2 Selling of Vehicles

Cars   German households owned a total of 40m cars in 2008. 24.5m of these were used, 13.7m were new and 1.9m were leased. [435, p. 452] A private car is not only a status symbol but also provides the customer with flexibility and mobility. Revenues for both used car dealers and car manufacturers are mostly generated by sales with the particularity that car manufacturers also try to buy and resell used cars of their own brand. [411] Costs in this business are either the production and labor costs or the purchase costs of used cars. In Germany, despite of the rising maintenance costs of a car, its value is constantly declining. Two thirds of all new cars are leased instead of bought and cannot draw the estimated profit after three years of use. [444]

Bikes   In 2008, there were about 70m bicycles in German households. The average number of bikes per person has risen from 0.8 to 0.9 since 2002. [417, p. 60] The advantages of choosing the bicycle are environmental friendliness, health and fun [417, pp. 12-18]. In addition to the revenue generated by sales, most vendors offer service and reparation [413] or build customized bicycles [412]. The costs of manufacturing are rising due to increasing raw material and freight costs as well as ascending salaries in China, where most of the bicycle companies buy their components [464].

5.2.1.3 Loaning of Vehicles

The business model of renting vehicles allows the customer to only use a car when necessary and pay per trip, kilometer or gas usage. While one model includes the driving service (taxi), others require the customer to drive on his own. With included driving service, the companies' income depends on the kilometers the passenger wants to drive. The costs therefore adapt automatically depending on gas prices and labor costs [424].

Car rental agencies offer their cars without driving service. The customer pays per time, for fuel and often for insurance packages and other supporting services [430]. Costs for the company are labor costs and the acquisition of the

cars. Special target groups are tourists and traveling businessmen, as they do not want to abstain from individual mobility during their trip. [426, 403] The same business model applies to bike rental [437] and special vehicle rental like moving trucks [414].

5.2.2 Business Models in Supporting Services

As opposed to the previous section, this part describes current business models in surrounding areas of transport services. The first subsection concentrates on the provision of infrastructure, covering city tolling as a means to avoid congestion in urban areas as well as the business models behind traditional gas stations and parking space providers. The second part focuses on the provision of information, covering business models behind navigation systems, real-time traffic information, car pooling and cost comparison tools for different transportation means.

5.2.2.1 Provision of Infrastructure

Congestion Charging   Congestion charging or city tolling is a billing system for motorists travelling within a certain traffic area of a city. When London introduced this system in 2003, the city managed to increase the average speed of traffic moving through central London from less than three miles per hour to almost ten in 2008. Congestion decreased by 30% over the first year and as one result bus travel became more reliable. According to the technology used, cameras at entrances, exits and around the zone read car registration plates using automatic number plate recognition. [441, 459]

The scheme of city tolling in London is run by Transport for London, while several operations are sub-contracted to outside companies. Siemens Traffic Solutions is the provider and operator of the physical infrastructure, whereas IBM has been responsible for the charging system since 2009. The former administrator Capita stated that the annual revenues of administrating the charging system amounted to 56m Sterling. [410] Further cities having introduced city tolling to date are Singapore [443], Milan [450] and Stockholm [401]. Operation costs of city tolling vary from 10% of revenue in Singapore and 20% in Stockholm up to 40% in London [457].

Charging Stations   The Munich Yellow Pages include 160 entries in the branch of gas charging stations [447]. These facilities offer drivers 24/7 accessibility to necessary fuel for their individual rides. The revenue stream of gas station owners is generated by buying high amounts of gas at a comparatively low price and selling it in small amounts to the end consumer at the actual gas station facilities. Most of the gas stations provide further services like washing facilities and small shops or bistros. [404] In general, gas stations are organized in larger

international companies like Aral, Shell or Esso. Apart from the established petrol and diesel stations and the developing natural gas and hydrogen fueling stations [449, 399], there is an increasing number of electric charging stations in Germany, which will be further discussed in section 5.3.3.3.

Parking Spots   In terms of parking facilities, this report shall cover commercial parking spots in urban areas. Different forms of parking facilities are garages, in Munich amounting to 24 parking garages with a sum of 7400 parking spots, or specifically labeled outdoor parking zones [446]. Both work in the same manner, providing spots to park a car for some hours and charging a parking fee for this. A special offer is the renting of these parking spots for a longer time, annually or monthly. All these parking facilities together enable the end-user to get to the city without using public transport and to find a space to park their vehicle. Two of the largest parking garages operators in Europe are APCOA [402] and QPark [458]. Customers of these car park operators are inter alia local authorities, shopping centers and hospitals [421]. To simplify the search for free spots, cities use car-park routing systems, displaying the free spots in municipal parking garages and zones. One innovative idea of parking spots provision is realized by the UK start up parkatmyhouse.com, which enables property-owners to rent out their empty driveways and garages to drivers who need somewhere to park by managing the contact in between the two parties [454]. Further new possibilities in providing information on free parking spots will be discussed in section 5.3.2.2.

5.2.2.2 Provision of Information

Navigation Systems   Navigation systems provide the user with the fastest route to his destination. There are three kinds of navigation products: Portable devices, dashboard integrated systems and navigation applications for smartphones. Whereas portable devices used to be sold the most, smartphone-based systems are expected to account for most of the sales in the next few years. [452]

Navigation system providers such as the European market leader TomTom [391] have two most common revenue streams: Firstly, the company earns money by selling the navigation software and hardware. Secondly, further payments have to be made by the customer whenever he wants to update his maps. Subscriptions provide the customer with regular updates and value added services and the company with regular revenues. [398]

Real-time Traffic Information   Automotive navigation services can be enhanced by including real-time traffic information. For its service, TomTom collects traffic information from various sources including the location of mobile

phones and TomTom devices as described in 1.1.3.3.3[1] Taking traffic information into account provides the customer with three advantages: He saves times, the arrival time can be predicted more accurately and each user contributes to an overall reduction of the city's congestion. [388]

The provider of this service benefits from selling it on a subscription basis [398]. Third party cooperation creates further revenue streams and marketing opportunities. For instance, the radio station Antenne Bayern uses TomTom's real-time traffic information in order to improve its traffic announcements. [393]

Carpooling   Carpooling platforms help finding co-passengers for particular trips. Web services like mitfahrgelegenheit.de enable car drivers to offer their rides to the public. For instance, commuters can organize joint rides to distant work places.

These platforms earn money with online advertisement. Further revenue can be created by offering premium accounts based on a monthly fee which enhance the customer value, e.g. by hiding advertisement or unlimited access to user profiles. [387]

Cost Comparison Tools   Comparison tools help the customer find the cheapest means of transportation. Platforms like verkehrsmittelvergleich.de compare train, plane, bus, car pooling, taxi offers and other options. Intermodal transportation is included as well. As this service is free of charge, all revenues are created by provisions from partnering transportation companies and online advertisement. [418, 389]

5.3 Trends

The Trends section focuses on emerging business models in the time span of the next five to ten years. Originating from previous results, especially growing customer needs and global challenges, the covered categories are mobility needs, communication technologies as well as environment and energy.

5.3.1 Mobility Needs

In the context of urbanization the complexity of cities rapidly increases due to population growth, rising land consumption and infrastructure expansion. This section introduces Personal Rapid Transit and real-time routing - two upcoming mobility solutions that could meet arising challenges.

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[1]to be filled in when merged: cross-reference to topic 1 Technology Trends

5.3.1.1 Growing Opportunities for Personal Rapid Transit

Personal Rapid Transit (PRT) is a transportation system that operates on a network of automated guideways and uses small passenger cabins [400, p. 3]. As stations are located on side tracks, it is possible to execute point-to-point rides without the need of stopping at intermediate stations. Thus, PRT systems are similar to taxis although there is no physical driver needed; the system is steered automatically from control centers which guarantee an optimal velocity in order to prevent collisions or congestion.

Some areas, e.g. those with a sensitive nature, require a restrained use of space in order not to interfere with vulnerable eco-systems. As PRT systems are emission free and built above the ground, they require little base area and are a feasible solution for this field of application. [466] Another example is the usage of PRT systems to connect distant infrastructure elements, e.g. airport terminals [465]. Here PRT helps the user avoid long walking distances without having to incur the inconveniences of mass public transportation systems.

The usage of PRT systems has more advantages: Ideally there are always vehicles waiting in the station making the client independent from time schedules. PRT implements point-to-point transportation, which leads to time savings for the customer [428]. Another advantage of Personal Rapid Transit is the client's mantained privacy. A cabin usually accommodates not more than five individuals [419, p. 29] and as the travel destination is set individually, the user will be either alone in the cabin or together with colleagues who share his destination. This creates a more personal atmosphere compared to public transit or even a taxi ride, where an external driver is aboard.

Business modeling predictions suggest the existence of a trade-off between the ridership number and the creation of profit. If an operator focuses on maximizing profits, the charged fares are usually high and the number of trips low. If an operator focuses on maximizing ridership, the fares are lower and the number of trips higher. This becomes relevant if the system is state-run and profits are not the primary objective or in certain facilities such as airports, where PRT solutions could be offered as a value-added service. [419, pp. 38]

Revenues are created by fares. These could be raised with a ticket-based fee system or prices dependent on mileage or elapsed time. CAPEX cost drivers are the guideway construction and purchase of vehicles with a share of 33% and 26% of total capital cost, respectively. OPEX cost drivers are the maintenance of vehicles and write-offs with a share of 22% of total capital cost each. [451]

Impact on Urban Mobility

Personal Rapid Transit combines the advantages of individual rides with the advantages of public transit. Business models applied in this area have to focus on communicating these advantages to the customer and providing competitive price schemes. As soon as customers accept these offerings, PRT will lower
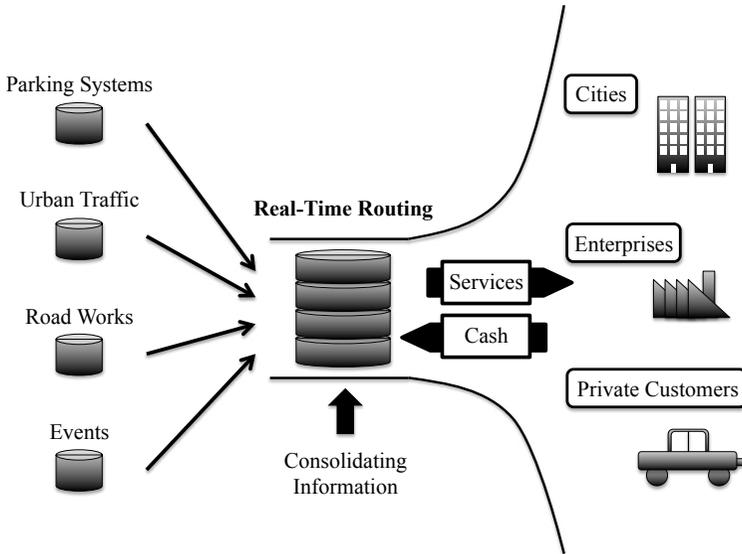
Figure 5.1: Real-time routing business model
Source: Own illustration

emissions and congestion by disburdening conventional streets without reducing average mobility convenience.

5.3.1.2 Expanding Implementation of Real-Time Routing Systems

Systems that help to control traffic flow and provide individual routing information are referred to as real-time routing. Data is collected from different sources such as parking space operators, highway guidance and traffic information systems as shown in figure 5.1. This data is transformed into useful and accessible information that can be provided for private or public use [462, p. 2].

By combining all available information related to urban traffic in an holistic approach, a more efficient and correct route guidance can be delivered to the customers. This information could also be used in traffic control centers to steer traffic lights, inbound highway traffic and parking guidance systems. Together with supporting measures from city traffic control centers, the end-user profits from improved, up-to-date traffic information. This can lead to significant time savings. [462, p. 3][431]

Business models that focus on real-time routing have to transform the collected information into attractive services that can be sold to customers in order to create revenues. One target group are city governments. Implementing real-time routing can support their city traffic control centers and reduce traffic

congestion as well as average journey times. In the long term this creates location advantages that might attract companies to the city. The costs of implementing real-time routing could then be covered by expected future tax incomes. [453, p. 3] Another option is to collect and process information as an independent service provider. The result could be sold to restaurant chains and similar enterprises with a delivery business. As well as the enduser, they could benefit from advanced traffic guidance services due to crucial time savings.

Impact on Urban Mobility

As complexity of overall city traffic management increases, there is a demand for information services dealing with these challenges. This creates opportunities for businesses collecting and processing traffic information. By cooperating with parking space or city tolling providers, these services will increase the efficiency of urban mobility and reduce average travel times as well as general congestion.

5.3.2 Communication Technologies

Since recent developments in mobile communication technologies enable vehicles to send and receive data, new use cases and business models are emerging. This chapter covers new safety solutions facilitated by vehicle-to-vehicle communication as well as infotainment applications utilizing in-car internet access.

5.3.2.1 New Upcoming Safety Solutions Arising from Vehicle-to-Vehicle Communication

As described in section 1.3.3.1[2], V2V technologies enable vehicles to communicate with each other. Car users benefit from this equipment for a number of reasons, most of which are related to safety issues.

A major advantage is the warning of upcoming collision situations as possible crashes can be detected by exchanging information about current positions, velocities and directions. After being notified by his car the driver can react and avoid an accident (see figure 5.2). [397, 448]

Furthermore, V2V and V2X communication allows for a better traffic flow. As car drivers receive information on the positions and activities of traffic lights they can adapt their own gas and break actions. This can also be applied to other situations like lane merging. Processing data regarding the number of lanes and the positions of nearby cars can lead to fewer stop-and-go situations. As a result the customer benefits from gas saving and a decreasing number of dangerous situations and simultaneously contributes to an improved traffic flow. [448]

Among other car manufacturers BMW, Ford and Audi have begun developing V2V technologies [394, 390, 397]. In order to promote the creation of a V2V

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[2]to be filled in when merged: cross-reference to Topic 1 Technology Trends
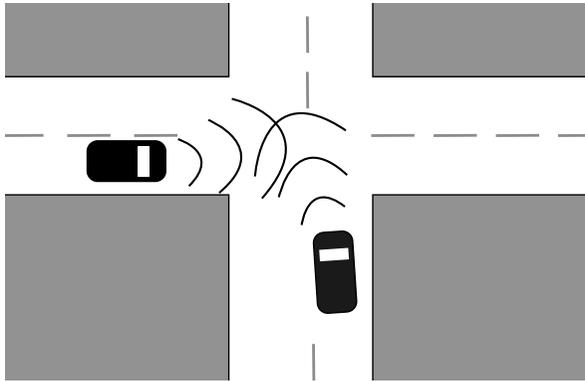
Figure 5.2: V2V Communication detecting a possible collision
Source: Own illustration

standard, the U.S. Department of Transportation collaborates with the Crash Avoidance Metrics Partnership (a coalition of automakers). Cars deploying this new technology are expected to hit the market within five to ten years. [463, 397]

V2V is built on the same wireless technology that is commonly utilized in homes or mobile phones, which leaves the costs for this safety enhancement particularly low. [397]

Even though V2V communication provides the driver with additional services, there are no direct revenues for the car manufacturer. However, those employing this technology well gain a competitive advantage as they are offering an additional value for their customers. [442] Further revenue streams can be generated by infotainment applications which will be introduced in section 5.3.2.2.

Impact on Urban Mobility

V2V communication results in a better traffic flow within cities which contributes to fewer CO_2 emissions. Furthermore, it helps reducing accidents, e.g. by collision warnings. Another way of increasing road safety can be facilitated by swapping data collected from various sensors. For instance, tools like a rain sensor, the ABS and an outside thermometer can give an indication of the road surface conditions. This data is sent to nearby cars whose drivers can adjust their driving behavior accordingly.

5.3.2.2 New Infotainment Applications Facilitated by

In-Car Internet Access

Information   Unlike V2V communication used for safety purposes, applications in the infotainment segment are often based on internet access. For instance, the passenger's e-mails can be downloaded onto the car's dashboard which is able to read messages out loud. Location based services facilitate further assistance, e.g. by determining the closest ATMs. Utilizing real-time data enhances the customer value, e.g. information about the availability of nearby free parking slots as well as directions leading there can be gathered. Any of these services result in time savings for the car driver. [390]

Entertainment   In terms of entertainment provision the customer value consists of a broad variety of applications. For Instance, personalized radio stations can be compiled by including content from various sources off the internet. In addition, the car's internet connection allows for surfing the web, either by using the built in dashboard or by creating a WIFI-hotspot for further mobile devices like smartphones. [390]

While basic services are offered free of charge and therefore generate no direct revenues for the car manufacturers, costs for the internet connection are expected to be covered by a flatrate plan. [395]

In order to further enhance the infotainment experience, additional media content or applications can be downloaded onto the car's system using an application or media store. For instance, third-party content based on the destination location can be displayed during the ride. This greatly expands the customer value and provides the car manufacturer with an additional way of generating revenue as they can charge the customer for the downloads. [390]

Impact on Urban Mobility

In-car internet access allows for information and entertainment applications. Many information services are especially valuable within highly trafficked urban areas as they help saving time and add value to the driving experience. For instance, this is accomplished by location based services offering directions to the closest point of interest or media stores offering personalized radio stations.

5.3.3 Environment and Energy

Looking into the future, apart from satisfying individual needs a further goal needs to be solving global problems like the shortening of resources and growing pollution. The section Energy and Environment introduces three emerging trends aiming at this goal, namely the increasing acceptance of carpooling and vehicle sharing, the growing e-car market as well as the facilitation of publicly available charging stations.

5.3.3.1 Increasing Opportunities for Carpooling and Vehicle Sharing

In the market field of shared vehicle usage two ways of sharing are distinguished. On the one hand the car owner shares it for certain trips or events but is still the only one who possesses the car (carpooling). On the other hand the car itself is shared as it is used by multiple customers (carsharing). [445]

Carpooling   As already introduced in section 5.2.2.2 the service behind carpooling concentrates on the information what passenger is suitable for a car owner's next trip. New carpooling businesses try to simplify pooling processes by using social communities [469] or websites combined with smartphone applications for ad-hoc-carpooling [396]. However, there is not much willingness to pay for the service provision on customer side. Therefore, a lot of revenue is created by online advertisement. [434]

The startup Zimride identified another revenue stream. They offer the customer a web portal as well as a Facebook application where the driver can choose his passengers from his listed friends or classmates. This service is free as long as there are less than 50 members of a certain company, school or university. After that Zimride contacts the network owner to offer him a subscription to their services. This idea seems to be well received as Zimride could already sign up 20 institutions, including Stanford University. [469, 434]

A similar strategy is to concentrate on whole companies which have to pay for the pooling service. They register all of their employees as passengers, who do not only trust each other more than they trust strangers but also have the same working destination. [438]

The costs of running a web-based carpooling service consist of software and development costs as well as labor costs. Some effort should be put into a safety strategy, for instance verification of each customer via bank account or a valid e-mail address. [438]

Vehicle Sharing   The concept of carsharing is an advancement of the traditional car loaning described in 5.2.1.3, as the renting process is now self-service. The fleet of rental cars is distributed over a city. To gain access to these rental cars, the customer uses his cell phone or a special membership card. [407] He pays per kilometer, via phone or via his membership card. The price covers all expenses, including fuel and insurance. [445]

Flexibility, comfort and money savings are the most important value propositions of this business model. Moreover, carsharing reduces congestion and is environmentally friendly. [416] The main revenue stream is the payment of the customer. Automobile companies can generate additional income by promoting their brand within carsharing platforms. For instance, Daimler is pushing Smart by running the platform car2go. [440, p. 7] [436]

Figure 5.3 shows the worldwide growth of carsharing until 2006. In the next

Number of Members   **Growth of Carsharing Worldwide**
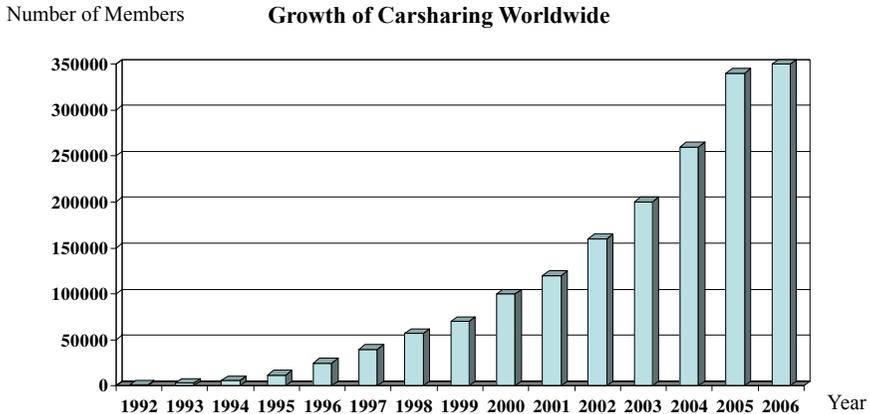
Figure 5.3: Growth of carsharing worldwide
Source: [460, p. 7]

years, increased carsharing education, impact evaluation and supportive policy approaches could help to develop and expand carsharing business even more. [461]

The sharing business model is also used for bikesharing in big cities like Paris or Munich [467, 406]. The start-up CityRide is trying to take this model a step further by constantly monitoring the environmental benefit of each ride and looking for partners who reward the customers with coupons or money. By this, they are trying to create a new revenue stream for bike sharing models in the long term. [420]

Impact on Urban Mobility

In order to reduce urban traffic and pollution it is necessary to change people's mindsets by convincing them that there is no need to own a car anymore. With more people making use of carsharing, bikesharing and carpooling the amount of private cars taking up parking spots and congesting the roads could be reduced. This would result in more efficient use of existing cars or alternatives like bikes and therefore less pollution.

5.3.3.2 Growing Demand for Innovative Business Models in the E-Car Market

The electrification of road traffic is accompanied by the market entry of new competitors for the traditional automobile industry. Not only new manufacturers are investing in that trend, but also energy and mobile phone providers. [440, p. 6] Three new business models for the e-car will be presented in the following:

Minimized Initial Costs   In a web-based survey of 1,042 U.S. consumers in the summer of 2010 44% stated that they would be "extremely" or "very" interested in purchasing a plug-in hybrid or allelectric vehicle. However, the intended prices of automobile manufacturers are slightly higher than the customers' conceptions. [456] One strategy to tackle this problem is to minimize initial costs for manufacturing and selling e-cars. For instance, the automotive company Coda builds part of their electric cars at a leased plant in China, outsourced the whole service department (contract with 75 Firestone retail locations) and works with a single dealership and several satellite stores, where customers can only test-drive one car. In this case the main revenue is generated by sales, while the production and service costs as well as the fix costs for big showrooms are kept at a minimum level. [429, 405]

Pay Per Use   In the pay per use model the customer does not buy the electric car by himself but merely pays per kilometer. This eliminates the problem of currently high prices for electric cars. [440, p. 6] Another value proposition is that the user's costs are not tied to changing gas prices but fixed. The income and costs for the e-car loaning company depend on their origin. If an energy provider uses the business model to increase customer loyalty the electricity usage is a direct revenue stream and the purchasing of cars would be the main expense. Simultaneously, car manufacturers produce the car for lower costs but will eventually need the energy provider as a partner. [432]

Focus on Service Provision   With energy and mobile phone providers entering the market, service provision could become one new core competence in e-mobility. The company Better Place offers such a model. They generate revenue out of a complete service package including battery-subscription, home charging stations, electricity-usage charges and 24/7 customer service. [409] The cost drivers in this business model are energy, production and labor. [433] Therefore, the consumption of electricity has to be taken into consideration. Partnering with energy providers becomes an interesting option. [440, p. 6]

Impact on Urban Mobility

Facing the energy crisis and environmental issues, finding an alternative to combustion engines is an important task. Even though the electric car is not an utterly new technology these presented business models show a new perspective on how the electric car could finally become a mass product. This would not only result in clean and quiet road traffic but also in a whole new system of infrastructure. It is likely that a growing amount of e-cars could either decrease the need for public transport or offer new possibilities for intermodal transportation. [422]

5.3.3.3 Spreading Publicly Available Charging Stations

The Cleantech Market Intelligence Firm forecasts that a total of 4.7m EV charging points will be installed worldwide during the period from 2010 to 2015. [455] To date, according to the European database of public and private charging stations for EVs LEMnet, the current number of publicly available stations in Germany is 922 [439]. About half of this number are stations from large operators like RWE, Park&Charge or Vattenfall, a quarter belongs to diverse companies and private businesses like restaurants and another quarter is in the hand of private individuals.[3]

The question arises who will become the leading provider in the business of electric charging stations. E.On and Vattenfall started fleet projects on e-mobility, first of which in Munich in cooperation with Audi, Stadtwerke Muenchen and Technical University of Munich, installing 100 electrical charging stations in 2010 [425]. The second mentioned, Vattenfall Europe AG, started a cooperation with the BMW group in Berlin in 2009, launching the shared project "MINI E Berlin Powered by Vattenfall" [427]. According to Martin David Ledwon, Vice President Government Affairs, Siemens AG, public charging stations up to 50 KW will find it difficult to refinance by selling electricity only as especially in the market build up phase traffic and demand are too little. Value added services like software updates for car system software, maps or local area advertisement could generate the remaining required returns. Concerning the role of traditional gas stations in the charging station infrastructure, Ledwon states:

> "Gas stations are considering business models around charging infrastructure already. They have the benefit of not depending on returns from selling electricity to refinance hardware investment and operating costs but would integrate new forms of fueling equipment in their business model based on generating income mainly from high margin sales of consumer goods. Whether they will develop this business by partnering with utilities or new service providers in the field of EV charging, remains to be seen."[4]

Businesses like super-markets could use the offer of charging up as a means to attract customers - like coffee shops already do with free WIFI [408]. Waitrose in Great Britain is counting on this by installing charging posts at their facilities [392], ECOtality does the same in some Best Buy stores in the United States [423].

Besides the simple provision of charging stations, there are many ways of creating businesses around this core service. With their application PlugShare,

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[3]Interview with Peter Zeller, LEMnet, 14.03.2011
[4]Interview with Martin David Ledwon, Vice President Government Affairs, Siemens AG, 21.03.2011

one Silicon Valley start up allows EV owners to browse a list of public and private charging stations and call or text members of PlugShare to ask for their private plugs. [408]

Impact on Urban Mobility

A strong and stable infrastructure of charging stations in cities facilitates the home-independent usage of electric vehicles. Even if people tend to charge their vehicles at home overnight or at their working place, it is of utter importance to secure a large network of charging spots in cities where electric cars are becoming vehicles of increasing importance.

5.4 Conclusion

Individual transportation services like Personal Rapid Transit, carsharing and car pooling become highly important as they are creating more flexibility and privacy for customers compared to conventional public transport. The substitution of e-cars for combustion engines leads to reduced emissions and a cleaner environment. This is implemented by innovative and well adjusted business models for e-mobility and the expanding network of publicly available charging stations. The usage of new means of communication, like vehicle-to-vehicle communication, is a core competence for improving quality standards regarding safety as well as infotainment issues. Due to these developments future Urban Mobility could become cleaner, safer and more individual.

The success of business models depends on customer's acceptance. Therefore besides the pure existence of convincing value propositions, they have to be communicated properly to the market. Whether the presented business models will convince the prospective customers or not remains to be seen.

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Part II

Scenarios and Business Ideas

6

Bundling and Integrated Services

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In cities, the growing adoption of Intelligent Transport Systems leads to large amounts of traffic data. Even smart devices carried by users throughout the city can tell details about the current traffic situation. The increase of congestions in the transportation infrastructure as well as the rising environmental problems are characteristic for current transportation solutions. To improve the efficiency as well as the comfort of urban mobility, new services will need to integrate this data from various sources in the urban traffic system. However, it is hard to access this data, often collected by different providers. In order to facilitate the implementation of efficient mobility services, data has to be provided in an aggregated and consolidated way.

In this report, three scenario for urban mobility in 2025 are described, mainly differing in the fields of privacy awareness, the public willingness to adopt new technology and the degree of integration of transportation systems.

Based on one of these scenarios, a business idea for a Mobility Data Cloud is developed. This is a platform to collect mobility-relevant data from sources like public transport providers and congestion charging systems in order to process it and sell it in custom packages to mobility service providers. By offering data from a variety of sources, this platform enables the implementation of innovative mobility services that can, for example, increase the efficiency of transportation, thus reducing congestions and emissions.

6.1 Introduction

One of the biggest challenges of urban mobility is to use the existing infrastructure more efficiently, as it often operates on the limits of its capacity, is congested, and creates environmental problems. A way to address this challenge is to create services that reduce congestion and improve intermodal transport. To achieve this task, these services will need to make use of mobility data. This data is currently collected in rising amounts in all modes of urban transport, but mostly not connected and used to further improve transport. As such services will have to integrate data from many different sources, they are called integrated services.

Often, these mobility-related services will not be implemented by the companies which collect the data. Therefore, it is important to bridge the gap between infrastructure providers and service providers. Infrastructure providers are the companies which have the possibility to collect mobility data, for example public transportation providers or urban highway operators. Service providers are the companies that use the gathered data to establish new services.

One example how the integration of data could be used is to enable more efficient and comfortable intermodal transport by sharing data between the mostly closed transport systems. Congestion information about the road system, usage levels of public transportation, schedules, and external data like events and accidents, or even the personal schedules of the users can be connected to dynamically adjust the different modes of transport.

In addition, all this information can be used to improve existing traffic systems and enables new transportation services. By providing users with more accurate, personalized traffic information, for example, the flexibility and comfort of transportation systems can be improved. More broadly, services that are not related to traffic can also be integrated, for example personalized entertainment services or advertisement in public transportation that adapts to passengers.

The connection of transportation systems can help to balance the transportation load, improve the efficiency of existing transportation systems and thus reduce congestions. Dynamically adjusting public transportation schedules can reduce the need for new infrastructure, as the current infrastructure is used more efficiently. As connected transportation services reduce waiting times and can help users to find the fastest route under the current traffic conditions, they significantly increase the level of comfort. Users are given better access to traffic information by using information technology.

However, there are several potential obstacles for interconnected services. For example the price of the necessary technological infrastructure, the fragmentation of the transportation market, the lack of cooperation between transportation service providers, and privacy issues when dealing with personal data can stand in the way of a successful implementation of such services.

The approach of this report is as follows: First, important factors that influence the bundling and integration of different mobility services are identified. Based on the three most important key drivers, three alternative, equally plausible future scenarios for urban mobility in 2025 are described. Building on one of the scenarios, a business idea in the field of bundling and integration of mobility services is developed. Finally, a conclusion is drawn to summarize the findings of the report.

6.2 Driver Analysis

In order to evaluate what will influence bundling and integrated services in urban mobility, drivers were identified and compared in regard to their impact on the topic and degree of uncertainty. Figure 6.1 shows the identified drivers in an impact-uncertainty matrix. The three key drivers privacy awareness, public acceptance and the degree of system integration with both very high impact and uncertainty are highlighted. In the following subsections, these key drivers and their possible developments in the future will be described in more detail.
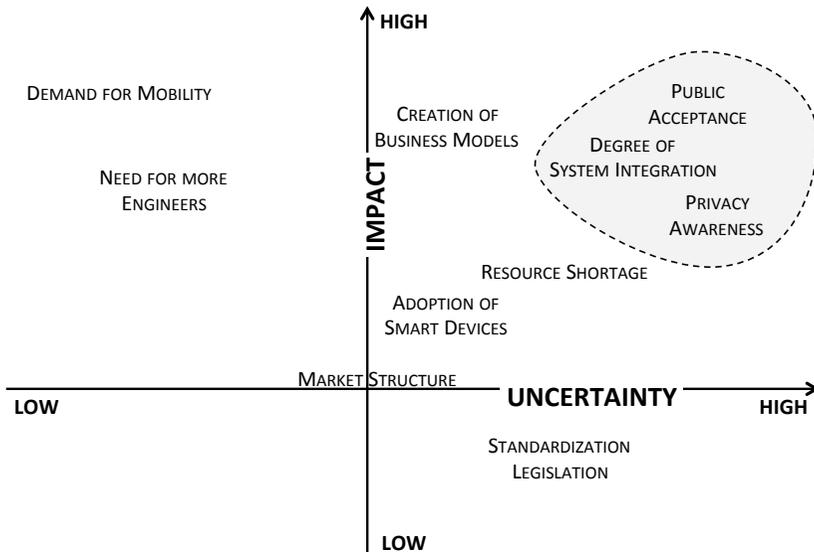
Figure 6.1: Map of drivers for bundling and integrated services
Source: own illustration

6.2.1 Key Drivers

In this section, the impact of the three key drivers on the development of integrated mobility services will be discussed. As it will be shown, their impact is very high, while the direction of their development is uncertain. The first key driver is privacy awareness, referring to the amount of private data that users are willing to share. Second, the public acceptance of new services will influence purchase decisions. Third, the degree of system integration defines how much the various mobility systems and other data sources are interconnected and share their data.

6.2.1.1 Privacy Awareness

Bundling and Integrated Services for improving urban mobility go along with the collection, combination and analysis of data in order to provide value-adding services. Due to the fact that this data often contains sensitive information about individuals like their position or social data, the willingness of the society to increase transparency in order to make these services possible will be crucial for their success.

Description   As described in the technology basic report 1.3.3.3, the technology in urban mobility will become more intelligent and interconnected in the future. Consequently, more data will be generated in urban mobility which will enable more powerful services than ever before. Besides traditional monitoring of machines and their functionality, the future data handling in urban mobility will allow monitoring of individuals, their needs and their route through the cities. Position data and movement profiles, camera images and social data are only a part of the information that individuals will generate in their daily urban life. In addition the information produced by vehicles, terminals and traffic management systems will provide the possibility to monitor mobility systems.

The more information these services combine and process, the higher is their value. This leads to the situation that if the government, companies or the end consumer want to benefit from these services, all users have to be willing to share information about themselves and therefore accept a certain degree of transparency. The variety and power of offered services and therefore their success in future urban mobility will largely depend on the privacy awareness of future societies. This might differ in terms of geographical regions, governmental systems or demographic and social groups. Thus, it is possible that new data-intensive mobility services will only be successful for specific consumer groups.

The impact that the privacy awareness of future urban societies could have on bundling and integrated services might also differ. The degree of data security and therefore the complexity of the used systems could vary, the kind of data that is generated and transmitted could be different and the providers of these services could be different companies and organizations. Also, the way

how privacy awareness could influence the future will not only lead to a single direction. On the one hand, governmental rules could be the main constraint, while on the other hand, the public opinion on services could be decisive of what these services may look like.

Possible Developments   Faced with the increasing generation, transmission and storage of data regarding the individual privacy in urban mobility, societies have to define their way of how to handle these privacy issues. In the following, two possible future developments, high and low privacy awareness, are described in more detail.

High: One could imagine a future in which most people really care about their data and are unwilling to share them, especially not with companies. This could have several impacts on the upcoming services. First, it is questionable if all the services that are technically possible could actually be realized, even if they could improve urban mobility. Privacy concerns of the end customer would lead to governmental rules which could make it impossible to implement data-intensive innovations. In addition, customers would just not use services that ask them for private data which they are unwilling to provide. Second, the security requirements for service systems would need to be much higher in the future, which would influence software development and data storage costs. Third, the collection of data to generate a certain information would be much harder because many actors in urban mobility will not share their data due to their high privacy awareness.

Low: In contrast, a world with a low privacy awareness will shape other services in urban mobility. Under these circumstances, more data-intensive services would be possible. Lower security requirements could enable a cheaper implementation, reduce costs for marketing and therefore facilitate market entrance for new services. No high-tech encryption technology would be needed in order to implement services that work with the personal data of their users. Furthermore the willingness of urban actors to share their private data will contribute to more powerful services. If people share very private data like their position or even their plans for the weekend, the urban mobility systems could work much more efficient than without this data. Therefore, the services would have access to a higher amount of data, enabling them to provide solutions that would not be possible otherwise.

The key differences between high and low privacy awareness are summarized in table 6.1.

6.2.1.2 Public Acceptance

Technology and services can only be successful if the market accepts them. Especially if a service involves a change of user behavior, the public acceptance of this service becomes even more crucial. Integrated services in urban mobility

Influence	High Privacy Awareness	Low Privacy Awareness
Data collection	Hard and more expensive	Easy and cheaper
Data security requirements	High	Low
Degree of personalization	Only low personalization of services possible	Higher personalization of services possible
Business models	Private data intensive business models impossible	Private data intensive business models possible

Table 6.1: Comparison of the influence of high and low public acceptance
Source: Own creation

could provide benefits for various types of customers, including governments, companies and end consumers. As they represent the market, their acceptance is necessary for the successful adoption of these integrated services.

Description To examine the influence of public acceptance on future developments, the impact on the adoption speed, the feasibility of innovative services, the amount of investments in data collecting infrastructure and the effect on customer values is analyzed.

For service providers, it is very important to be able to predict the success of possible mobility services. There are two major factors to influence this success: On the one hand, public acceptance influences the adoption speed of mobility services. On the other hand, it shows the feasibility of services that require change in the user's behavior.

As governmental decisions are always intertwined with societal demands, the public acceptance has a major impact on the amount of investments in infrastructure that collects transportation data. The availability of such infrastructure then enables the integration of the gathered data by new services.

Customer values play an important role in the purchase decision. On the one hand, the degree of public acceptance of new services is a good indicator for certain customer values. On the other hand, customer values can of course influence the acceptance of new mobility services. Customer values depend on subjective feelings and thoughts. In addition to the different interests of the market players, this fact contributes to making this driver a very uncertain one.

Possible Developments The public acceptance of integrated mobility services could either be high or low. The impact of these respective developments are described in the following.

High: High public acceptance of integrated services could speed up their adoption. Customers would be highly aware of the benefits of integrated mobility services and governmental investments would focus on sophisticated

Influence	High Public Acceptance	Low Public Acceptance
Service adoption speed	Fast adoption	Slow adoption
Innovative services	Highly innovative services are feasible	Only conservative services are feasible
Data collection	Intelligent, modern data collection infrastructure	Data collection infrastructure as a scarce resource
Customer values	Intense competition, personalized and interactive services available	Clearly defined customer value needed, focus on productivity, time and cost savings

Table 6.2: Comparison of the influence of high and low public acceptance
Source: Own creation

infrastructure to enable the gathering of mobility data. This development would support innovative ideas and creative services. As customers would be really eager to adopt all of these services, the top priorities of customer value would not be limited to increasing productivity as well as time and cost savings. Rather, mobility services for end users could also focus on being personalized and interactive. So while this development would help infrastructure providers in terms of large infrastructure investments, it would also result in an opportunity for service providers to find a market for their innovative business ideas.

Low: A development of the public acceptance for integrated mobility services to the opposite direction would mean a very slow adoption of integrated mobility services. It would be a very difficult task to convince customers to use these services, so the customer value would have to be clearly defined. Service providers would therefore have to concentrate on increasing the productivity as well as time and cost savings of their applications. Especially innovative ideas and services that need change in the user behavior would face heavy resistance. Public and private investments in data collecting infrastructure would stay low, so it would continue to be a scarce resource. These developments would therefore pose severe challenges for service and infrastructure providers.

The key differences between high and low public acceptance are summarized in table 6.2.

6.2.1.3 Degree of System Integration

The degree of system integration refers to the amount of information shared between infrastructure and service providers. As the feasibility of services which bundle and aggregate mobility data from various sources greatly depends on the availability of this data to the service providers, the degree of system integration

represents a key driver of the implementation of these services.

Description   To fully understand the impact of the degree of system integration on integrated services, a closer look at the major influencing factors and influenced aspects is necessary.

First of all, an important factor is depicted by the willingness to cooperate within the industry. Especially in the IT sector, standards are usually not set by governmental authorities, but by industrial associations. So it is up to the industry to bring forth common protocols and interfaces.

Another essential aspect is how data is stored and whether there is a common consolidation process for mobility data or not. This relates to the centralization of data storage and to the acceptance of centralized data storage technologies like Cloud Computing. A common consolidation process defines how fine-grained the access to mobility data could be, thus enabling possibilities in terms of implementing integrated services.

The degree of system integration is also influenced by the market structure in the sector of integrated services. Reasons for this include the high cost of infrastructure and governmental restrictions, for example in public transportation. There is also an interrelation with the availability of developer platforms for urban mobility applications, which would also help small companies to implement their business ideas.

Possible Developments   Future developments could lead to the degree of system integration being either high or low. The impact of these developments will be described in the next paragraphs.

High: A high degree of system integration could lead to a highly interconnected world of mobility services. If common protocols and clearly defined interfaces for mobility data are established, infrastructure providers might be willing to offer access to the data they collect and store. Services could use global mobility data to combine and aggregate it in a smart way. Data might be consolidated and stored in a centralized data center to ease the access to data for the providers of integrated services. This centralization of mobility data could help to set up developer platforms to foster new and innovative services, which in turn could lead to an intense competition of small businesses offering their mobility applications on various platforms. They should compete both on a global and a local level. While local solutions might use global data to benefit from worldwide experience, global applications could aggregate local data to create new services. This development could therefore offer opportunities for service providers as well as infrastructure providers.

Low: In contrast, a development leading to a low degree of system integration could result in a world of isolated mobility services. Due to a possible lack of a standardization process between the market players, efforts to come up with common protocols and unified interfaces would be very likely to fail.

Influence	High Degree of System Integration	Low Degree of System Integration
Cooperation in industry	High	Little to none
Protocols	Open and standardized	Proprietary due to the lack of standards
Data storage and consolidation	Centralized data storage and consolidation	Decentralized data storage, no consolidation
Market structure	Highly competitive global market	Local market, dominated by infrastructure providers

Table 6.3: Comparison of the possible degrees of system integration
Source: Own creation

Rather than sharing the data collected in urban infrastructure, companies might be eager to keep valuable data to themselves. Data would be stored in decentralized data centers and consolidation would fail because of the high complexity involved. The existing mobility services and applications would target a local, limited market that might rarely exceed the domain of a single municipality or region. Because of the high cost of infrastructure and the unwillingness to share mobility data in the industry, the market entry for new service providers would either be connected with huge costs or constrained to the single network of one infrastructure provider. Therefore, nearly no competition would exist in a fragmented market dominated by cost intensive, often state-subsidized infrastructure providers. Most of these providers would have hardly any competence in controlling the complexity of huge distributed data processing systems. While a development in this direction would slow down the implementation of bundled and integrated services, it would also show opportunities to come up with a data consolidation and aggregation service to create a platform for cross-system services.

Table 6.2.1.3 summarizes the impact of a high and low degree of system integration.

6.2.2 Additional Drivers

In the next sections, the development and impact of additional drivers will be discussed. Either the uncertainty of their development or their influence on the development of integrated mobility services is not as high as for the key drivers. The identified drivers are the Creation of Business Models, the Resource Shortage, the Adoption of Smart Devices, the Market Structure, Standardization & Legislation, the Demand for Mobility and the Need for Engineers.

6.2.2.1 Creation of Business Models

For the success of bundling and integrated services, well-functioning business models are necessary. If no viable ways to earn money from the integration of services and the data gathered in urban mobility systems are found, they can hardly be successful. As urban mobility is a very broad and complex topic with the possibility to integrate many different services, it enables a wide range of business models. At the same time, however, the complexity of the topic complicates the creation of business models.

It is essential for the new business models to give the organizations that implement the integrated services, as well as the customers who use them, a high enough benefit to outweigh the costs. The impact of business models on integrated transportation services is high, while it is uncertain if and when these business models will be developed.

6.2.2.2 Resource Shortage

There are two kinds of resource shortages that have a large impact on bundling and integrated services.

First, the scarcity of oil is a major driver for the topic of urban mobility in general. Higher oil prices would shift urban traffic to the cheaper and more efficient public transportation and making individual car traffic less important. This has direct implications for the integration of different transportation systems. The need for adding intelligent ICT technologies to existing and upcoming mobility systems will therefore increase in order to enhance their fuel efficiency. The future development of the oil price is uncertain and can be heavily influenced by major events, e.g. wars in oil-producing regions.

Second, the shortage of resources that are necessary for the production of high-tech products might slow down the technological development and massively increase the price of high-tech devices. These resources include the so-called rare earth elements, a group of metals which are very important for the production of computer chips and other high-tech equipment. As the main producer of rare earth elements, China, has massively constrained the export of these elements in the past, the future supply seems uncertain. The lack of rare earth elements could be a major obstacle for the development of Intelligent Transportation Systems and other IT-supported transportation services, which are essential for the bundling and integration of mobility services.

6.2.2.3 Adoption of Smart Devices

Smart devices will most likely play a key role in the spreading of integrated services, as they are the devices that enable the end users to access mobility-related information from everywhere. For example, end users may use a device

like a smart phone to plan a trip through the city or make a reservation for a shared car.

The widespread adoption of smart devices, however, is uncertain. Only if smart devices spread among all parts of the population, they can act as the mobile access device for information of transportation services. It is questionable if smart devices, which are currently used mainly by young and middle-aged people with higher incomes, will spread to the rest of the population. In particular, it is to be seen if smart devices will be developed that are easy enough to use for elderly people or that are cheap enough so people with lower incomes can afford them.

If smart devices do not spread widely enough, mobile access to transport information and transport-related services will be limited.

6.2.2.4 Market Structure

Bundling and integrated systems might often be added to or use data of existing or upcoming transportation systems. Therefore the market structure in the future urban mobility will certainly have an impact on the way how these services will look like and how successful they will be. So the structure of the market for transport systems and their integration strongly influences the diversity of these systems.

In a fragmented market, many different transportation solutions could coexist, making their coordination and communication a complex task. At the same time, such a market could lead to a highly competitive market enabling innovative ideas and services.

If there is only a limited number of players in the urban mobility market, the adoption of new services could be more difficult due to the fact that their monopolistic position enables them to stick to their outdated technologies. On the other hand, the successful adoption of new bundling and integrated services could be accelerated by the decision making power of big players. The data management of these services might then be less complex because the systems could be easily standardized.

6.2.2.5 Standardization Legislation

Upcoming mobility services might often contain interfaces between different mobility systems implemented by different companies or even different industries. Therefore reliable standards are necessary for these services to work. Historically, however, most standards in the ICT sector are set by the industry and its standardization organizations, rendering state action less important.

However, facing the upcoming challenges of reinventing urban mobility the state might enlarge its activity in ICT standardization in order to accelerate the adoption of integrated mobility services. The standardization efforts of the state are hardly predictable due to the fact that governmental decisions always

depend on voters interests, present potentates and different degrees of foresight. Also, it is questionable if future standards will be proprietary or rather open, and which role the state takes in this field.

6.2.2.6 Demand for Mobility

As shown in the basic reports **??**4.3.1.2, the demand for urban mobility is going to increase in the future. Therefore, the direction of this driver is not very uncertain, but more the dimension of its development. There might be cities where the demand for mobility increases to a high level within a short timeframe.

Such a demand could not be handled with the current use of infrastructure. Therefore, the existing infrastructure would have to be used in a more efficient way. Bundling and integrated services could be an integral part of the resulting action and so the demand for mobility could have a direct impact on the adoption and usage of these services.

6.2.2.7 Amount of Expert Engineers

Especially industrial nations have problems to find enough well-educated engineers to do the research which is needed to sustain their status as technology leaders. Innovation depends on the education and professional experience of engineers. If there are not enough creative and experienced researchers, technology will not develop in the expected speed and direction. Therefore the number of engineers and researchers working on integrated transportation services has an influence on the development of innovative products in that industry.

The amount of available engineers of a certain discipline is hard to predict. Emerging countries like China or India could increase their influence, investing in the education of young engineering talents. On the contrary, the trend of yearly decreasing numbers of students in the engineering fields in the western world could proceed. This would have an impact on the degree of innovation in the field of integrated mobility services.

6.3 Scenarios

Based on the identified drivers, three scenarios have been developed. They show how the world could look like in 15 years. Their perspective varies, depending on the dimensions of the key drivers. The first of them is "Race", picturing a world of isolated mobility data systems competing for expensive data. The second is "Slalom", a future which poses a huge amount of obstacles in terms of the adoption of mobility services. The third is "Free Flow", a world where mobility data is a cheap and highly available resource with a lucrative market.

6.3.1 Scenario 1: Race

As illustrated in figure 6.2, the following description is based on a scenario in which the public is very open to new technologies, the privacy of personal data is a large concern in the communities and the degree of integration in urban mobility systems is low. The scenario is called "Race", as several competing, not integrated systems are racing to develop solutions for the public that wants innovative solutions, but also cares about privacy.
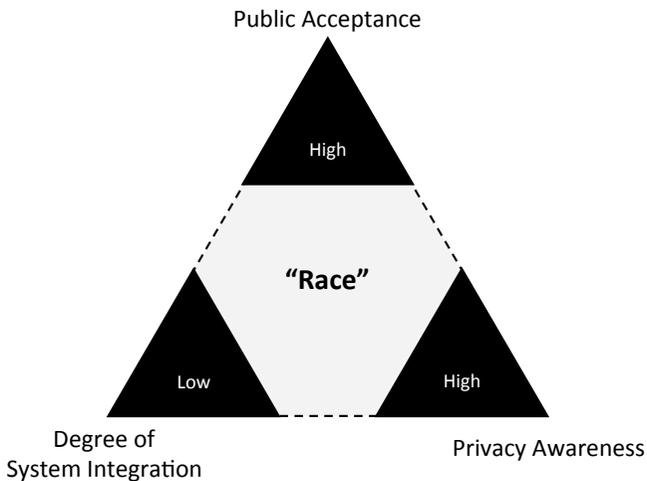
Figure 6.2: Key drivers for the "Race" scenario
Source: own illustration

6.3.1.1 Scenario Description

The technological developments during the last few decades had a major positive impact on urban life. Due to the high urbanization in the last decades, people now live in extremely crowded cities which result in many problems on daily lives such as mobility challenges, resource allocation and environmental damage. People clearly realize that innovative technological solutions can bring them concrete benefits. They are now aware of their needs and passionately request better solutions. By the help of generous subsidies provided by the governments, companies and research institutes can now employ very talented engineers to prepare wide portfolios consisting of innovative technological solutions coming into the market every year.

French press agencies have recently reported that a new kind of e-car has just been brought to the market by Renault which needs less resources, provides faster transport, and prevents congestion by using intelligent car2car communication technology. The demand for this product exceeds all expectations. Similar to other recent products launches, it was reported that many people stayed in front of the shops overnight in order to be among the first ones to be at the wheel.

Although this new solution forces people to change their habits of using combustion engine driven cars, like listening to an artificial engine sound, the majority of people do not even hesitate to adopt such a breakthrough solution, since they are aware that they can get serious benefits from these new technologies.

Furthermore, governments and state-owned organizations play a key leadership role in the promotion of new technologies among communities. Municipalities and state-owned organizations provide remarkable incentives to their citizens so they can afford new technologies, and at the same time come up with many projects to implement innovative solutions in the public themselves.

A short time ago, the public transportation authority in Munich announced that as a result of a large-scale renovation project, the public transportation network in Munich has been turned into a totally autonomous system which is controlled by a huge data center without any human interaction. The authority states that such an autonomous system can operate the network much more efficiently than human control. Therefore, the last few metro drivers in Munich have lost their jobs.

In contrast to the openness for new technologies, privacy is a major concern in public. People adopt new technologies very rapidly as long as their concerns about privacy are satisfied. They seriously care about the security of their personal data. More than 20 years ago, when Facebook created a new era for digitalized social platforms, people were extremely eager to share personal information on such social platforms. In 2010, there were almost half a billion people around the world who had made their full names, work, education and address details, friend networks and even phone numbers public.

However, in the last decade, a big scandal in the US shocked the whole world. It is now clear that the US government forced Facebook to share personal information of all of its users with the state authorities by claiming that this information was needed to identify criminals. However, it is also clear that US government exploited this source by monitoring all users from foreign countries without distinguishing criminals and innocents. Since such an approach had put everybody in a possible criminal position, people have become so sensible about the security of their personal information that they no longer share any more data than necessary, even when registering for a simple service. Therefore, people blame these platforms which track and store personal information for threatening their personal security.

Such social media scandals have also caused many speculations on other technologies. People really care about privacy friendliness of each and every device they use daily. They are well informed using private online newsgroups to read about experiences and myths. The New York Police is said to track the habitants via the GPS devices on their cars, while Deutsche Bank earns a lot of money by selling the contact information of its clients to advertisement agencies. Therefore, browsers and applications on personal computers or mobile devices that do not track and store any personal information have gained popularity.

Google is accused of tracking a huge amount of personal data and storing it insecurely. Since it does not react to such requests coming from the society and does not take any precautions, Google has lost its huge popularity which it used to have in 2010. GPS devices are used only if they do not share some set of location data of the user with any remote server or system. CCTV cameras, which were used to observe each and every corner in London and many other cities in the past, were exposed to strong opposition by the public after several scandals where CCTV cameras were misused for criminal purposes. Consequently, they had to be removed from the streets in many cities.

Additionally, there is a strong competition in all business areas. In order to keep their core competencies and increase market share, companies consider each other as real rivals. The number of patent lawsuits shows the degree of rivalry between different market players. Due to such serious conflicts and rude discussions in the press, the top managers of leading ICT companies such as IBM, Google and Microsoft have even hesitated to come together at the famous World ICT Fair in Las Vegas this year. Therefore, it is very hard to create a harmony between different players in the market. For instance, different companies installed smart parking lots in different locations in the San Francisco. However, due to the tough competition in the market, there is no communication between these smart parking systems. They are also not synchronized with the operation center of public transportation network.

Furthermore, due to the lack of standardization of various technologies, there are many incompatibilities between the technical infrastructure of different services. For example, the public transportation authority in San Francisco has a large data and operation center which collects data about the current density and performance of the public transportation systems in the city so that dynamic routing services can be provided for the inhabitants, choosing the best route and type of transportation for traveling through the city.

However, the public transportation authority's data services are not compatible with the data service of the taxi network. All taxis in the city are connected to a centralized network so that they can be tracked and monitored in this system. The density of both busy and available taxis in every location can be monitored, and this information can be used to estimate driving times and serve customers. However, due to the isolation between different systems and services, it is hard to create and provide value added services which make use

of harmonizing a variety of resources.

Concequently, it is clear that, in this scenario, there is a huge interest in the community for new technologies, providing a basis for potential growth. However, since privacy awareness is really high, there are some challenges for the companies that they need to tackle. Additionally, the degree of integration between different organizations is too low so challenges have become more serious. Therefore, such a market view presents a "race" for each player in the market.

6.3.1.2 Signposts

There are several factors to look at while deciding whether this scenario will turn into reality or not. One signpost is the release of breakthrough devices and services. Customers from all over the world do not hesitate to wait overnight in long queues to buy such products on the first day of release. Especially if such devices are released on a regular basis, the future will hint towards this scenario.

But at the same time, society may react differently to new products. Innovative products and services have to respect the privacy of the user. For example, some people could force the government to give them the opportunity to prevent companies from publishing pictures of their property online. Furthermore, illegal data trades between companies or even state organizations may apparently result in an increase in privacy awareness among the society. Therefore, if products would be evaluated based not only on their technology, but also their on respect for the privacy of the user, this will be a sign for this scenario.

Lastly, due to the collapse of borders between business fields and high level competition between companies, especially in information and communication technologies, the number of lawsuits tends to increase. If international organizations and governments cannot establish fair and effective patenting systems, patent conflicts might cause demolishing almost all relations and partnership opportunities between companies. To give an example, a large industry association could fail to set up a standard for sharing mobility data between their systems. The role of state-owned organizations in standardization and promotion of cooperations is also questionable. A strong state leadership might be a sign for this scenario.

6.3.2 Scenario 2: Slalom

In this scenario of the future, the public is hesitant to accept new technologies and considers them as too costly. Furthermore, the public is highly aware of privacy issues, strongly restricting the use of personal data. As the companies in this scenario join their forces and cooperate to overcome the obstacles of lacking public acceptance and a high privacy awareness, this scenario is named

"Slalom". The constitution of the key drivers in the Slalom scenario can bee seen in figure 6.3.
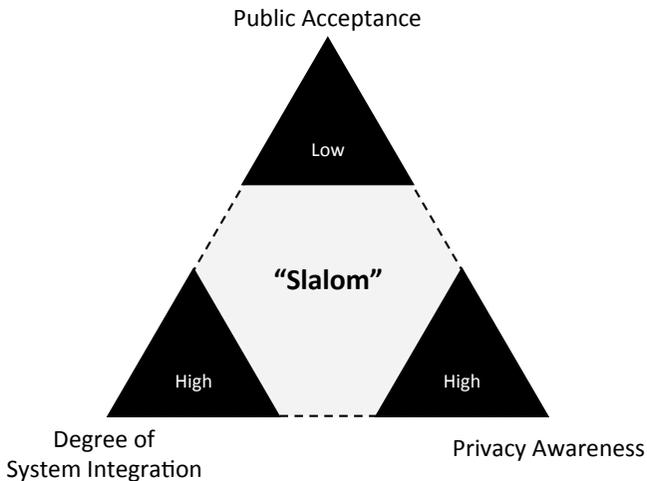
Figure 6.3: Key drivers for the "Slalom" scenario
Source: own illustration

6.3.2.1 Scenario Description

Like many other major cities, London in 2025 still has to deal with immense traffic problems. While the network for public transport was strongly extended in the last decades, including new underground lines and buses, the increase in population was even stronger, worsening the city's traffic situation. London has extended its congestion pricing scheme to a large part of the city with a dynamic pricing system to adjust prices to demand in order to control traffic flows in the city. At the same time, an intelligent parking control system was introduced in the city center, adjusting the parking charges according to demand and giving car drivers the opportunity to beforehand access information about the parking situation.

However, the rising number of cars in the city offset the increased efficiency of the road system. London's citizen are therefore disappointed of the new technology, they have to pay to access the city center by car, but are still stuck in congestions most of the time. As the traffic control systems in London use very advanced, but also expensive components, the cost of the system uses up most of the revenue generated by the congestion charges.

Rising oil prices, among other factors, have led to an economic downturn in most parts of the word, cutting into the infrastructure budgets of the cities. Prestigious, but costly intelligent transportation systems were cancelled in New York and Los Angeles, among other cities, as their utility was questioned by the public, referencing examples of intelligent transportation systems such as London.

Another result of the rising oil prices is an increased demand for public transportation, electric cars, and bycicles, which are also partly electrified. Many cities have expanded their public transportation systems, adding more metro lines, trams and buses. In Berlin, all bus stations now show real-time arrival estimates and predictions for travel times with respect to congestion and construction sites. Trips via all public transportation systems can be planned on a central online platform, also taking real-time traffic information into account. This information is not only provided by the buses themselves, also taxis in Berlin are required by law since 2020 to carry a GPS device to measure traffic speeds and transmit the data to Berlin's transport authority.

Electric cars have become popular especially in suburbs of larger cities, as distances there are not very long but public transportation networks are not as dense as in city centers. The high oil price helped to make e-cars more attractive from a cost perspective, but at the same time, the economic downturn resulting from the high oil price made consumers much more price-sensitive. Adoption of e-cars therefore falls short of expectations in countries that are hit particularly hard by the crisis. In 2018, all major car companies finally agreed on a worldwide standard for charging stations and electric plugs. Charging stations for electric cars can now mostly be found at private homes in the suburbs, but there are only few public charging stations in city centers. A number of supermarket chains offers free charging in some of their parking lots as a service for their customers.

In order to facilitate the building, maintenance and the recycling of key components for electric vehicles, especially batteries, a electric mobility standardization board was installed to create standards for these components.

Especially in Europe with its comparably dense cities, electric bicycles surged in popularity. With the growing adoption of e-cars, the price for batteries reached levels that also made electric bicycles much more affordable. Many companies now offer charging stations for their employees' e-bikes.

In France, there were plans to introduce a tolling system for all roads with variable prices depending on time, distance and place (TDP charging). However, as this system requires all cars to be tracked by the authorities, a public outcry about privacy issues stopped this tolling systems. Similarly, concerns about privacy have rosen worldwide. For example, in the United Kingdom, the number of CCTV cameras was reduced drastically after it was found out that the operating company had developed a face recognition software to track people, aiming to sell access to this data to private detective agencies and

whoever pays for it.

As a result of a number of major personal data-related scandals in the last years, people all over the world realized the value of their personal data, and thus are very hesistant to share their data with companies. Among these scandals was a large-scale theft of detailed customer profiles of a major online retailer that now leads to masses of unwanted personalized spam e-mail massages. Similarly, thousands of personal user profiles were stolen by hackers from the social network Facebook. This personal data was used to blackmail these users, threatening to publish compromising personal information. Finally, the widespread publication of location data in social networks allowed burglars to break into houses when the owners were not at home, making people also more sensitive for their location data.

6.3.2.2 Signposts

If more and more intelligent transportation systems projects, for example advanced city tolling systems, are cancelled because they are considered too costly by the public while not delivering the claimed benefits, this scenario is increasingly likely. Also, large demonstrations against new high-tech transportation infrastructure programs like maglev trains that finally lead to a cancellation of these projects are a signpost for this scenario.

Another sign for declining investments in high-tech infrastructure can be a drastically increasing oil price and a resulting economic crisis. This could be induced by a warlike situation in major parts of the Middle East or other oil supplying nations.

Events like major data leakages as described above and a resulting public uproar about privacy issues will also show that this scenario with high privacy awareness becomes reality, where people will be hesistant to let companies use their personal data.

Additionally, a market for transportation systems that is more and more consolidated and the establishment of new data and communication standards are a clear sign for increasing cooperation between the companies and their systems.

6.3.3 Scenario 3: Free Flow

In the following "Free Flow" scenario, many cities in Europe and North America are under complete data monitoring, which means that traffic, infrastructure and transportation data of a city is now transparent. This development is spurred by an ecosystem of people and governments trusting and investing in new technologies and by a broad willingness to share private data. In this world, companies have established common standards for communication protocols, thus enabling a world of total data integration. What this world exactly looks like and how it has developed like this, is described by following a representative

urban mobility user through his day. The dimensions of the key drivers are illustrated in figure 6.4.
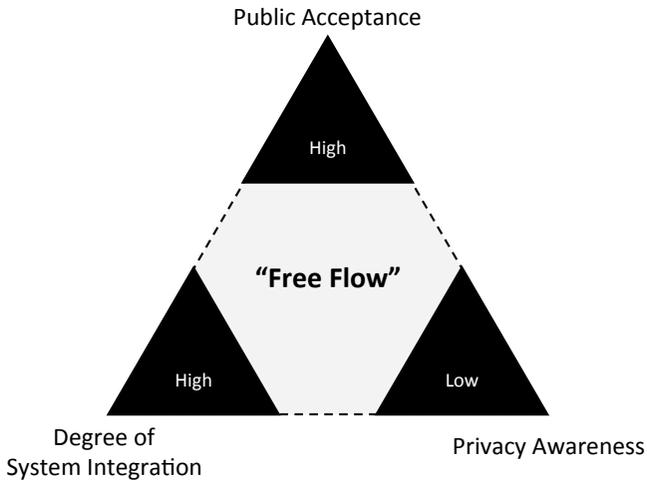
Figure 6.4: Key drivers for the "Free Flow" scenario
Source: own illustration

6.3.3.1 Scenario Description

Zee is a representative urban citizen. Together with his wive and his two children, he lives in a suburb of Cologne, Germany. He works for a market research institute in the city center. In order to get to his workplace, Zee does not actively need to choose a mode of transportation by himself, but his smartphone will automatically show the fastest connection. This connection often consists of different modes in a row, with real-time information about the changing traffic condition. When Zee leaves the door, his smartphone can tell him what time it is, what time he has to be at the stop of the transport modes he has to take and if he has to switch modes. A route for him could consist of first taking the shared bike that luckily got dropped off in front of his home and that the system knows about. After that, and as the system knows that Zee prefers routes where he has to switch only once, Zee hops on the tram which gets him directly to his office without any waiting time. The systems knows all this at once and without him having to enter a word as it extracts the information directly from Zee's digital calendar. It automatically starts arranging his transport connection in advance.

Zee's location data, his personal calendar with all appointments, address book, social network accounts and public transportation time schedules are all wirelessly conected to a traffic monitoring system. It can provide Zee with reliable traveling route information. Zee has never been too late at work since he started using this system.

Many different data providers have closely cooperated in order to bring such a system to the market. The ICT industry and municipalities have agreed on various standardized protocols enabling a free flow of data. Zee works in a market research institute that aims to collect shopping data to improve their customers' advertising. Many people earn a small amount of money by being part of Zee's market research institutes' network, contributing their shopping preferences instantly as their shopping bags identify goods via radio frequency identification (RFID) and transmit the data to a research institute. The hype for the RFID shopping bags, as shown by an increase in Google search results from 5000 to five million in six months, shows that people love to share their data and have recognized the value of making data available to the public.

Intermodality is the dominating concept in urban mobility, all modes of transport – e-cars, trams, buses, e-bicycles, e-scooters and trains, segways or trucks - can wirelessly communicate and interact with each other and exchange data about, for example, location, destination, deviation from the scheduled times and about the capacity load. All modes are seamlessly integrated and their data is stored in central data centers in the cloud. This way, Zee and other customers can make a well-informed decision.

Today, Zee decides in favor of public transportation. As he scans his e-ticketing chip at the metro station, his bank account is automatically charged the individually computed ticket price. With this paying process, Zee's traveling data, such as his transportation mode, travelled distance and environmental friendliness of the medium as well as frequency of traveling overall is wirelessly transcribed to his online mobility identity profile. Data bundling has helped a lot to achieve efficient ticketing, to increase sales, to improve the attractiveness of public transport, and to make it less dependent on governmental subsidies.

Traveling is another aspect that has been influenced by integrated data systems for two reasons. First, traveling between European countries has become more convenient. Scheduling, pricing and technical data are now shared between vehicle operators across borders, which now provides customers easy access to, for example, all European car sharing networks in one platform. It implies a mutual recognition of the customers, car categories and tariffs as well as a technical convergence of the reservation centers and chip cards. This means that Zee can use one single booking system and would receive one single monthly invoice via his local car sharing operator. This development was again possible because ICT companies, car manufacturers and especially transport system providers and governments have created a large integrated network over the last fifteen years with many common interfaces. However, Zee feels a bit

uncomfortable that companies from other countries with different privacy laws also have access to his data.

Furthermore, cars have massively lost their importance for long-distance trips. On his last trip to Barcelona, Zee left his apartment in Cologne with his luggage, and the integrated service he accessed through his smartphone knew where he wanted to go and told him which modes to take. In his case, first an e-car of a car-sharing platform to the city border of Cologne was allocated for him. From there, he took a train to Paris, where he had to switch to another high-speed train that took him to Barcelona. Data bundling allowed him to pay only once, namely at the end of the trip, with his e-ticketing chip. The other plus about this service for Zee was that he could instantly leave his apartment in Germany without looking up any travel data, as the system informed him via push messages as it got the data from his calendar entries.

When Zee arrived in Barcelona, the service provided him with an e-scooter which was automatically rented for him for the duration of his stay in Spain. As Zee frequently chose e-scooters in the past when the weather was nice, the adaptive learning system could predict his choice of transportation modes. However, Zee does feels uncomfortable when somebody else makes decisions for him. For example, when he spontaneously meets a friend and wants to take a taxi together with her, the system might already have reserved an e-bike for him that he now has to cancel.

The nightlife in Barcelona showed another side of bundled transportation data. Due to the integration of data from social accounts, sensors from street signs, cameras from parking lots and sensors in cars measuring seat occupation, for instance, there are services that can always tell exactly how many people want to leave which club, bar or event at what time and need to be picked up to be brought to another place. Intelligent party bus services send their buses according to demand and notify all guests about which bus they have to take. Zee appreciates this personalized service as he never has to wait in line. Such specialized services have turned out to be a big market opportunity for start-up companies.

Last summer, Zee took his family to China. When they landed in Shanghai, they were genuinely impressed by the city. It was very futuristic, with skyscraper all across the city center. The Chinese government massively invested to make Shanghai a role model. Actually, many of the new mobility services that Zee knows from Cologne were piloted there. Currently, there is even a pilot project where all people from one part of the city are constantly tracked via their mandatory smartphones to create motion profiles in order to analyze traffic streams. For Zee, this is too much of surveillance, and he thinks that the systems in his hometown works fine without this personal tracking.

Zee rented a car to explore central China for two weeks. On his trip, he was reminded that smart traffic systems are still a thing of developed countries and megacities. In rural China, he was surprised that he had not been so dependent

on a car for more than five years. And even though there was not very much traffic in the rural areas of China they visited, they still managed to be stuck in enormous traffic jams several times. When they landed in Cologne again and entered the maglev train to the city center, Zee was happy to not have to care about planning his tour anymore.

A benefit in the Free Flow world is that transportation has become significantly more efficient and more comfortable in various fields of mobility due to seamless data integration and many personalized services, at least in developed countries and large cities. This has been made possible by people adopting new technologies very quickly. E-vehicles, for example, have long outgrown the early adopter phase and their share has risen dramatically over the past years. Local and national governments as well as the EU brought together all relevant actors and speeded up the implementation of standards. In addition, governments and local authorities have massively supported the electronic movement with subsidies, thus letting the customer feel the value of new technologies, not the costs. Industry cooperations with a high agreement on standardization in the process for data collection and processing have also contributed to the way the city and its transportation looks now.

Furthermore, privacy awareness of people is very low. Politics has followed the open data movement among the population, which is why there remain only few laws about privacy and data collection, usage and storage, especially in the developing countries and in Asia. In Germany, for example, data is still collected anonymously but also widely shared and data security solutions for the shared data are very sophisticated. A few years ago, Zee was concerned about his data, but he accepted that the benefits of sharing data by far outweighed his loss in privacy. Especially when the first integrated transportation systems came to the market, however, many people shared his opinion. It took more than five years until the public discussion about the privacy issues calmed down, when the success of the integration became more and more visible.

The data sharing trend made it attractive for ICT companies and engineering conglomerates to put more emphasis on the collection and use or sale of data that is generated by their hardware devices, e.g. parking meters, and thereby creating a new revenue stream. People also actively contribute their data. In a recent market study, more than three quarters of the participants said that the new individualized services enrich their quality of life.

The transparency of the fully monitored city can also be seen in the real-time tracking information of the vehicles in the freight transport chain. Freight tracking services help delivery companies in reducing costs by decreasing the number of tours required. Tracking and tracing of goods is possible by using RFID technology, thus leading to higher reliability of off and on-trip information and a better traffic flow. Integrating location data of freight vehicles into traffic control systems allows a better information management towards the customer about which road or which transport mode to take.

Car services, for example taxis, are in use almost non-stop. A system has been established that allocates certain taxi companies to certain areas and always sends the nearest taxi to the customer. This led to a significant decrease in the number of cars on the street. Similarly, a taxi can pick up more passengers on the way if they entered a destination in their smart phone that is en route. Passengers are notified right away when the taxi will be there and how much it will cost, based on the exact distance and computed proportionally to the distances traveled by each passenger. This service is enabled by location data sharing and fosters capacity load balancing through the co-operation of different taxi services. Zee enjoys this taxi sharing a lot, as he regularly meets interesting people on his trips. However, others preferred the times when they were alone in a taxi and pay the drivers extra fees not to stop for additional passengers.

Apart from personal traffic management, general traffic management itself has also become more efficient and interactive. All vehicles have sensors attached to them, are tracked by GPS and connected to the Internet. The thereby enabled communication has fostered the collection, processing and exchange of data between vehicles, people and buildings. A ubiquitous information exchange is taking place in a cooperative urban mobility control network.

First of all, different intelligent systems and services have ensured that cities are almost congestion free. For example, Zee almost never waits on traffic lights in the morning rush hour when he takes a shared car. This has been achieved by dynamically adjusting traffic light green times to the amount of traffic. Assisted route guidance and congestion charging systems have also made their contribution. They dynamically adjust the congestion charges according to traffic conditions and route cars around congested roads.

Furthermore, parking guidance services inform drivers about free parking spots and garages. People have the option to reserve parking spots ahead, leading to less congestions because people who knew that they would not get a parking spot at a certain time have started taking public transportation regularly.

The dynamic allocation of lanes, using emergency lanes during peak times, has further supported a balanced demand management and the minimization of congestion by aggregating location data.

Apart from less congestion, in Zee's world there are also less accidents, which led to transportation becoming more safe and secure. Vehicles use technologies like vehicle-to-vehicle and vehicle-to-x communication systems. This means that vehicles know about other vehicles' location, speed and number of seats occupied. Sensors and cameras detect potential collisions between two vehicles and warn both drivers. Intersection accidents, for instance, do not occur anymore. Self-driving cars even react autonomously. Zee's vehicle, for instance, was able to tell his daughter's school that he will be late for pick-up as he left the office too late. Zee's vehicle is also able to share technical data, for example the condition of the tires, and report it to a car workshop. In most Asian cities, vehicles also

interact with boardwalks, passengers, roadside infrastructure and local traffic control systems.

In general, the tracked data also includes traffic pattern analysis, road surface diagnosis and urban environment measuring, for example air pollution. Over the time of a day and depending on the traffic situation in a certain street, Zee experiences various tariffs when he looks at the road tolling fee deducted from his bank account. With this dynamic tolling system, urban mobility has also become more ecological as individual car use has been reduced. In Zee's hometown Cologne, the revenues from the tolling system are invested in the suburban train infrastructure, which made Zee and many of his neighbors sell their own cars.

Another point is that in Zee's world, transportation in urban areas has become greener and cleaner with less pollution and less noise. The comparison of the data aggregated from sensors like individual driving behavior, environmental data and critical limits on vehicles and roadside data was decisive for the introduction of the congestion charging system. Real time e-ticketing via smartphones has recently reached 80% of the population. People started rethinking about their behavior and are now adapting it.

Apart from tickets and much improved urban transport, successful car sharing platforms were the other reason why the high rate of car ownership has plummeted, which has had a positive impact on green life in cities. The location of these cars is tracked and can then be made available to all carsharing members. As this has worked out friction-free, people more and more feel the benefits. Recently, when a political party in Europe proposed to stop car-sharing programmes because they would violate privacy, a nationwide demonstration wave against this party's proposal started.

Sensor- and WiFi communication between environmental data, transportation vehicles and municipalities lets the customer know when the daily pollution limit has been reached. Then, a higher price will be charged to the customer's credit card. Efficiency also led to less pollution due to increased use of public and shared transport, an increased share of bicycles and a significantly lower car ownership rate than just a few years ago.

To sum it up, in this world vehicles can communicate with other vehicles of any mode, with passengers and drivers, with the roadside equipment, traffic signs, base stations, across national borders and to passengers and bicycles. Technical, legal and political regulations have experienced a harmonization of mobility systems and become cooperative. The car has basically been reinvented due to electric drive, wireless communication services and enriched on board entertainment possibilities. Many people and institutions like to share their data and many new services have come into existence.

Figure 6.5 shows the political, economical, social, technological, legal and environmental events from the past and possible future headlines.

Political Economical Social Technological Legal Environmental
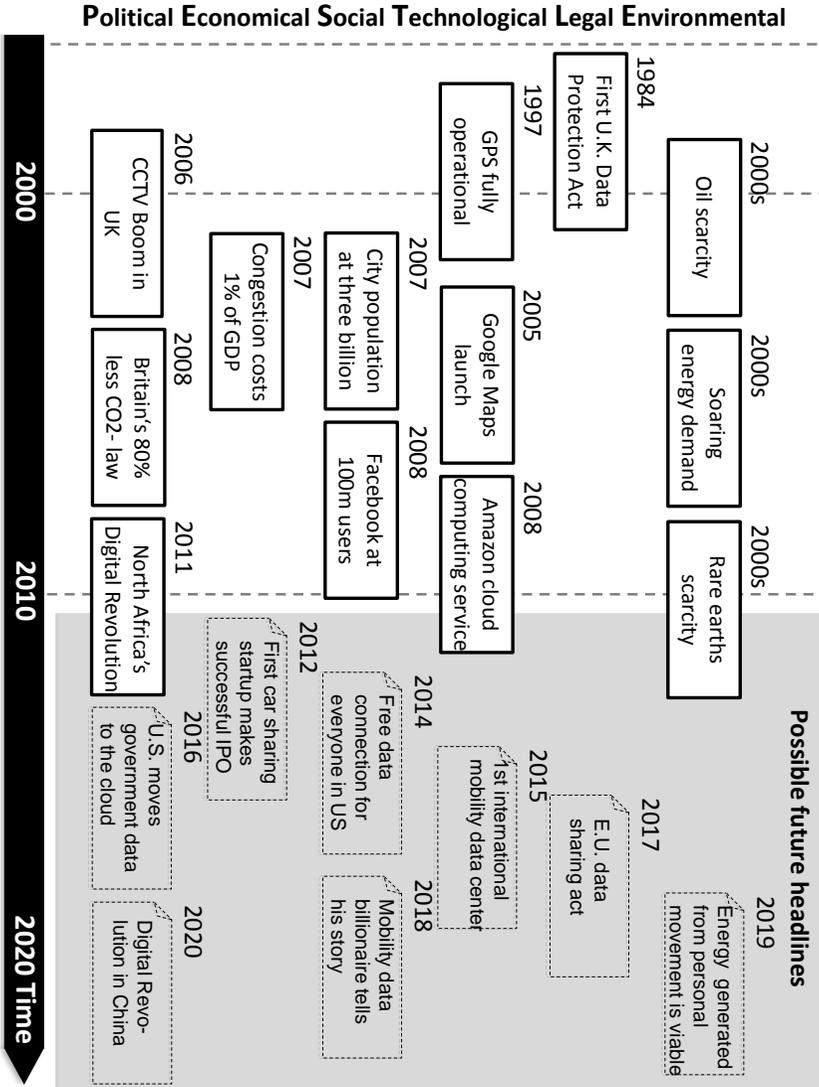
Figure 6.5: Timeline for past events and possible future headlines
Source: own illustration

6.3.3.2 Signposts

Several signposts that you can see in figure 6.5 could be hinting towards this scenario. A huge market for integration technologies, like cloud computing or smart grids, will support the vision of this scenario to enable a network of integrated services. For instance, governments could move their data and administration services onto a cloud computing service. This would not only be a strong sign for the feasibility of these technologies, but also show that they favor the idea of integrated mobility environment.

Cross-industry partnerships can further strenghten this tendency. They set up standards, protocols and interfaces which are crucial to establish a framework to bundle and integrate mobility data. An ICT company could provide data hosting to a public transportation authority, which in turn allows to publish parts of the data for service developers.

Certain societal reactions can show further willingness to accept new technology and to share data. In so-called "digital revolutions", protesters organize via social networks to demonstrate against their autocratic regimes. Like in North Africa in 2011, the power of social networks will make it possible to achieve long desired governmental changes. People share their data, media and opinions, paving the way towards this scenario. Over the time, they gain faith in the power of personal transparency and continue to broaden the amount of data they share. In several cities of the world, terrorist attacks and crimes could be prevented by cameras installed in and around transportation facilities. This way, each individual could contribute to the security and safety of the society worldwide. Further signposts show a strong belief in the power of the society. For instance, crowd based product development contests could lead to a big wave of innovation in urban mobility and offer a chance for startup companies. As a result, success stories about the "data millionaires" and about the first and successful IPO of a car-sharing company could then encourage people to show an even bigger openness towards new technologies and services that involve aggregated information. Goverments could even start to give incentives like providing every citizen with a smartphone to spur the spread of innovative mobility services. This would result in a facilitated implementation of traffic management services that use tracking data.

Another signpost paving the way towards the Free Flow scenario could be that turning kinetic energy from moving people and also the use of energy from the vibrations vehicles generate on streets is finally feasible. The age of nuclear energy generation is over and a way of sustainable energy supply has been found. This research result could motivate people to really believe in and adopt innovative technologies.

6.3.3.3 Value Maps

As shown in the scenario description, new traffic control systems and mobility services are established. They are enabled by the collection, aggregation and processing of urban mobility data, increasing the efficiency of personal mobility and traffic management. But to understand the decisions of certain stakeholders, it has to be analyzed which values they strive for. That is why the possible attributes of integrated services need to be connected with their respective values for different stakeholders. First, the perspective of the end customers is examined. Then, a closer look at the industry perspective is taken.

Customer Perspective

Figure 6.6 points out the attribute-value mapping from an end customer perspective. The following paragraphs detail the attributes and their corresponding values for end customers.

Integrated mobility solutions can increase the safety of several transportation modes. This would lead to a lower number of accidents and a less dangerous traffic situation. Road users can therefore have the feeling of security, they are relieved from stress and are more relaxed while driving.

Next, another attribute may be the environmental friendliness of integrated mobility services. They could for example raise the awareness for environmental issues. As of today, living healthy and caring for the environment is seen as a prestigious and respectable activity. This fact goes along with a healthier environment, which lets city dwellers perceive a high quality of life.

Seamless entertainment systems can offer the user an interactive and entertaining mobility experience. Services can also be personalized and tailored to the specific needs of an individual. If users are able to actively influence and individualize their service experience, they can focus on their very own needs. These services therefore give the user the feeling of being and control and, in addition, they are fun to use.

Another aspect refers to the time and cost savings that can be enabled by new mobility services. Time savings can be induced by shorter traveling times and higher reliability of schedules, enabling better planning options and offering spare time to invest. Cost savings result in financial freedom, which could eventually have an impact on one's social respect.

Attribute Value Map – Customer Perspective
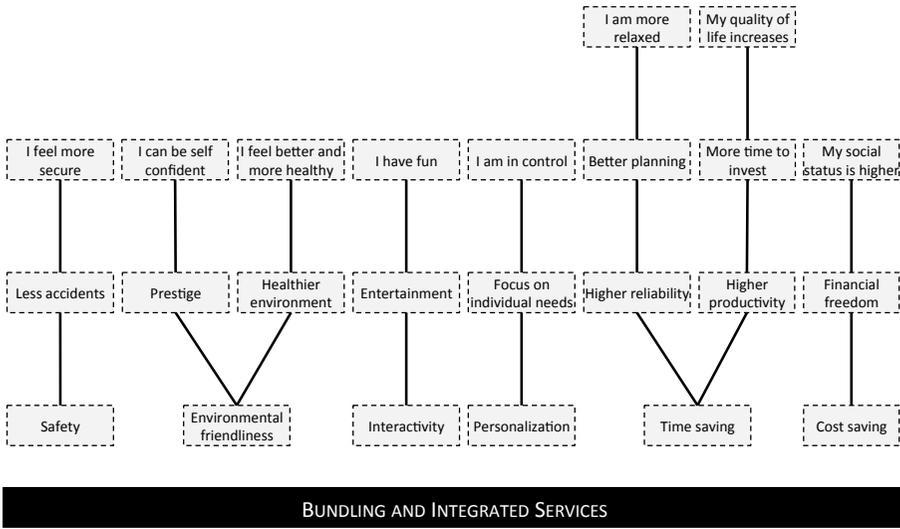
Figure 6.6: Attribute value map - customer perspective
Source: own illustration

Industry Perspective

Figure 6.7 describes the attribute-value mapping for the industry sector. The following paragraphs will take a closer look at the driving values of companies using mobility services.

First of all, the industry benefits from integrated mobility services in terms of new technological opportunities. By using those opportunities, new markets can be created or the competition can even be leapfrogged. Both options lead to competitive advantage and growth opportunities.

A second attribute might be the high knowledge about customers. As more and more customers are willing to share their preferences and experiences when using mobility services, better targeting and advertising methods become feasible. This effect can be valued with respect to higher revenue and less marketing costs.

Being aware of customer needs is an important factor to achieve high customer satisfaction. Great mobility services result in a better brand image, leading to a high company value. In addition, high customer satisfaction means less customer complaints and thus lower service costs.

Integrated mobility services enable a highly efficient use of existing infrastructure. This relieves companies from the heavy investments in new infrastructure or could even make some existing infrastructure obsolete. The saved money can then be reinvested.

Attribute Value Map – Industry Perspective
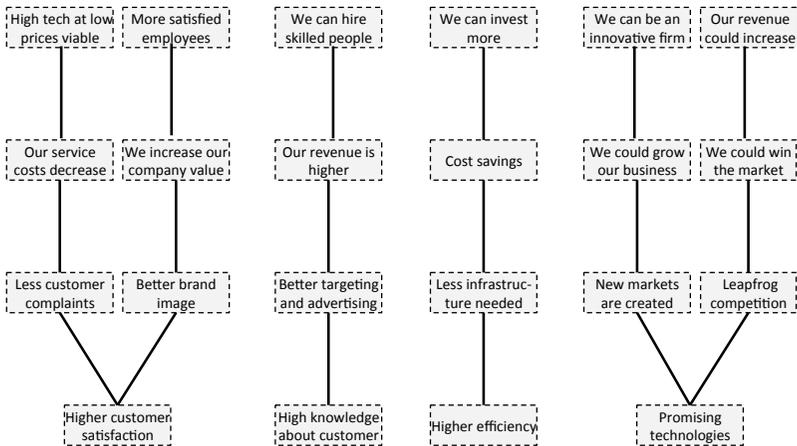
Figure 6.7: Attribute value map - industry perspective
Source: own illustration

6.4 Business Idea: Mobility Data Cloud

As the description of the Free Flow scenario shows, urban societies will be highly interested in new technologies and will at the same time not be concerned about how their private data is handled. This future situation, especially when opposed with a picture of isolated data hubs and problems in matching transportation demand and supply, provides a basis for new possibilities in the exploitation of data generated daily on the urban mobility ecosystem. Therefore, there are various possibilities to collect different kinds of data, process and enhance them and to combine them with each other in order to provide effective solutions for emerging urban mobility problems. A product, called Mobility Data Cloud
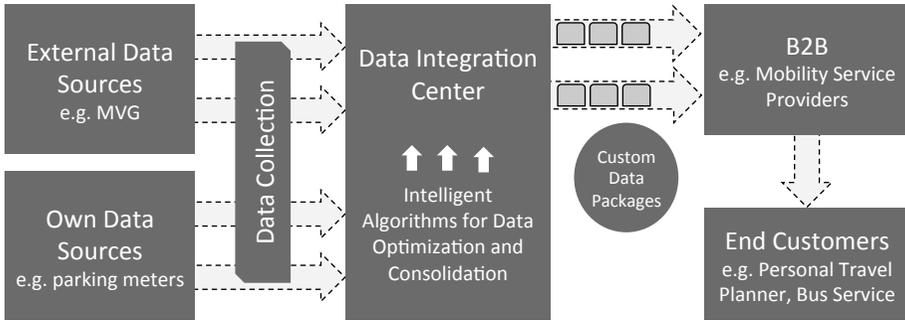
Figure 6.8: Business model "Mobility Data Cloud"
Source: own illustration

(MDC), is proposed to be a gateway between the infrastructure and service providers of mobility systems. The MDC aims at integrating both parts of mobility systems in order to create a harmony for enhanced solutions. Besides enabling smarter and more innovative services for the end customers, the MDC aims to provide several opportunities to transform mobility infrastructures in the cities into a more intelligent and interactive environment.

6.4.1 Business Model

The field of bundling and integrated services in terms of urban mobility data includes various specialized traffic and transportation management services and products for the end customer. The enabler of all these end products is a product idea called the "Mobility Data Cloud" (MDC) which will be presented in the following paragraphs and is illustrated in figure 6.8.

The Mobility Data Cloud represents a two-sided hub. On the one hand, it serves as cloud-based data storage and hosting platform for infrastructure providers like transportation services and traffic management providers. On the other hand, it offers customized data packages to service providers who can employ them for innovative products. This is possible because the Mobility Data Center does not only integrate and aggregate the external data from the infrastructure providers, but also data from isolated services and from the company's own hardware equipment that is installed in the urban mobility environment. The data is aggregated, consolidated, processed and then stored in a database. It can be accessed as an on-demand service in the cloud.

The unique selling proposition of the Mobility Data Cloud is that it establishes the link between mobility service providers and infrastructure providers and that it thereby is able to give the collected data a higher meaning by means of processing. The MDC is a new service business model which is characterized by a new combination of hardware, software and traffic data. Furthermore, a new

pricing model in the transportation provider segment is introduced. Another feature of the MDC is the way how its software is distributed among the service providers.

In the following sections, the functionality and different aspects of the Mobility Data Cloud business model will be exemplified by a possible B2B customer from the Service Provider side namely by a traditional bus company. The methodological approach of exemplifying the business model can be found in Osterwalder (2009) [470]. This transportation service provider enhances its service by integrating bundled information from the MDC and by thereby opening a new service branch which targets participants of big events.

6.4.1.1 Customer Segments

As the Mobility Data Cloud enables two services, data storage and data warehousing, it also has two main customer segments that can overlap.

On the data storage, hosting and maintenance side the customers are infrastructure providers. This includes transportation service providers like MVG in Munich, municipalities, urban highway operators, car- and bike-sharing companies and parking lot operators, for instance.

Customers from this segment currently have their data stored on their own servers, which is costly, time intense and not scalable, especially considering the urbanization trend and growing amounts of data coming with it. Infrastructure providers want their data to be securely stored, accessible at all times, analyzed and available for internal optimization processes. Furthermore, from the perspective of the Free Flow scenario, infrastructure providers focus on their core competency, which is for instance the operation of their transportation network. Therefore, the MDC addresses customers who could save money by outsourcing traffic data to the cloud and enables them to focus on their main business.

On the data warehouse side, the customers are service providers and big companies that can internally make use of integrated urban mobility data packages. These business customers can order a certain set of data and create a service out of it that they then can further distribute to their business or end customers.

The service providers can further be divided into three sub-segments that can separately be addressed. The first and most important segment are the local municipalities that want to optimize the traffic flow in their city, offer synchronized and real-time transportation information to their inhabitants and decrease environmental problems. The second customer section among the service providers are big travel and transportation companies, including freight companies, the telecommunication industry or travel services that want to reach or keep a leading position in the market by offering innovative services that are enabled by the MDC data sets. The third customer segment are start-up companies that try to fill a niche in the market.

The MDC is especially interesting for start-ups as it is a platform that integrates information from various sensors, cameras, the Internet, smartphones and infrastructure equipment. It includes position data, traffic data, schedule data, statistical, weather, machinery and communication information. Therefore the MDC not only gives established companies the chance to bring innovative solutions to the market that were not possible before but also for new companies the opportunity to fill a gap in the market or enter a new market.

The bus company mentioned as an example before, could be a customer of the MDC. It could for example offer an intelligent event bus organization as a smartphone application. One could imagine that such a company would need a data package of GPS data from the buses, the traffic conditions, and destination data from the smartphones of the event visitors.

The key point concerning the customers of the Mobility Data Cloud is that it is multi-sided, with customers being able to play different roles. This means a broad basis for possible revenue streams which are further described in part 6.4.1.5.

6.4.1.2 Value Propositions

In general, the Mobility Data Center enables new mobility services and helps its customers to enhance their services. Both customer segments benefit from the MDC's data services.

Six main values are created for the infrastructure providers. These are performance and optimization, scalability and flexibility, security, and cost reduction. Performance refers to the highly scalable cloud computing service and to efficient network management. Cost reduction refers to the advantages of outsourcing non-core activities. An increase in security is due to the fact that the MDC service provides its customers with high-tech data security solutions.

In addition, the MDC represents the opportunity to create an additional value stream for the infrastructure providers. For those who want the MDC to share their data, it gives its customers the opportunity to earn money with their data. If their data is used in a data package sold to the service providers, they participate in the revenues of this transaction.

The service providers experience value-added from cost reduction, risk reduction, a higher customer satisfaction and scalability. The higher customer satisfaction is a result of convenience and better usability created by an easier and faster interaction with the transportation network. It is furthermore reached by customization which means the ability to provide individualized services for subscribers, as well as by accessibility that is the connection to a unified service which combines different sources of data.

Combining all of these different sources was not possible before and can now be the steppingstone to being an innovative company on the market. The pay-per-use payment method additionally provides the MDCs customers with
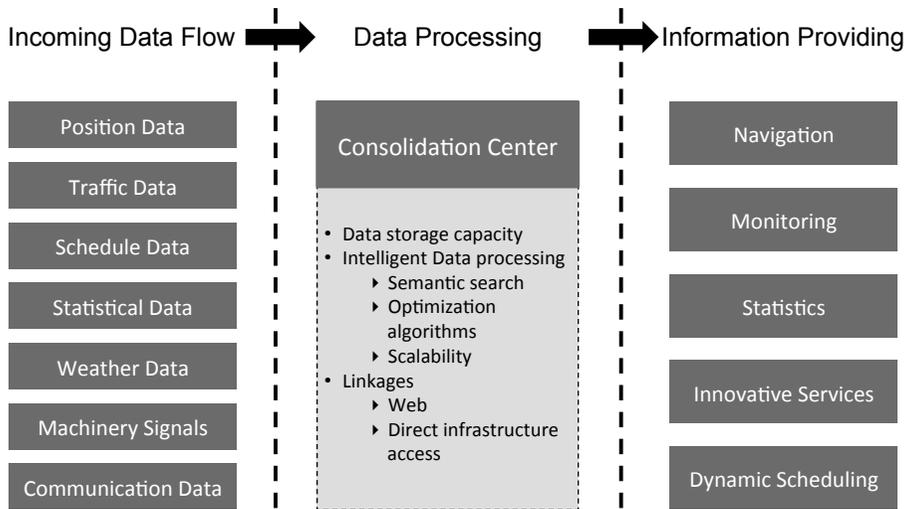
Figure 6.9: Data flows to and from the MDC
Source: own illustration

cost transparency and planning security due to variabilization of costs which can lead to a competitive advantage.

The product is an evergreen product as the data renews itself automatically and the user's data version gets updated automatically. Furthermore, as the data set offering process is standardized and the data interfaces accessible at all times, customers are very flexible and can quickly adjust their own services by expanding their data set with little interaction involved. The data flows to and from the Mobility Data Cloud are depicted in figure 6.9.

A case to exemplify the value propositions of the Mobility Data Center is the event pick-up company for efficient transportation mentioned in part 6.4.1.1. A big issue for bus companies is the public acceptance of their service. Many people consider taking the bus their last choice, for trips as well as for daily transportation. Buses tend to be overcrowded, uncomfortable, not safe especially for elderly people and unreliable in terms of their arrival times. Another problem public bus services face is the motivation of the bus passengers to pay. Checking everyone costs time and decreases the service quality which is why many bus drivers do not do it. Both aspects lead to lower revenue for the companies so that the full revenue potential is mostly not reached and municipal subsidies are necessary. Therefore, by offering a new individualized bus business model for events, supply and demand can be matched and adjusted to certain target groups as for example event and party goers. This is why in the case of the bus company the biggest benefit from using the MDC service is

customer satisfaction. You can imagine an iPhone booking app that is provided with a direct billing service. The pickup ticket fare is automatically deducted from the user's bank account. The bus company thereby misses less revenue and saves time as passengers do not need to be checked. Customers are more content with the bus service due to the fact that the predictions about pick-up and arrival times are precise as the service that the bus schedule is based on has the consolidated information of weather data, traffic data and position data combined in the background. This could mean the end of usually overcrowded transportation after events and present a benefit to the customers. Furthermore, the bus company can upgrade their customized data package from the MDC and thereby their own service offer. They can subscribe to additional statistical data and optimize the precision of the prediction times, for instance. Besides this option, once information is rented from the MDC, the bus company saves money as it does not have to pay for updates but gets updated automatically for the time of subscription. In the end the cooperation with the MDC lets the bus company more effectively manage the way to meet their strategic goals.

6.4.1.3 Distribution Channels

As described in section 6.4.1.1, the Mobility Data Cloud addresses two different customer segments. On the one hand, the infrastructure providers are large companies with a complex decision-making process. On the other hand, the service providers are supposed to be highly agile small to medium-sized startup companies. Therefore the channels to sell to each customer segment differ in how potential customers should be approached.

From the infrastructure providers' perspective, moving parts of its IT infrastructure to a managed hosting service is expensive and risky. Such an important decision would be made only by the top level IT management. The main decision factors in this process are the professionalism of the offering company and the decision makers' trust in the brand. These facts help to understand that to sell this kind of service, a skilled sales force with established contacts and co-operations is needed. They have to encourage infrastructure providers to implement this platform, using the brand and the reliability of the platform provider. In addition, the sales force should also consult municipalities so that local authorities can be reached and encouraged to share their resources with the platform and motivate local infrastructure platforms to do the same. Especially if legislation concerning the processing of mobility data is set up, consultants need to be in place to steer the law making process in a favorable direction.

A multinational engineering conglomerate has such a sales force at disposal. It is their preferred way of approaching new customers and maintaining customer relations. As they also provide parts of the existing hardware to the infrastructure providers, they know the systems and protocols and can provide

consultancy to implement the platform.

Customers on the Service Provider side of the hub need to be approached differently. These companies are small businesses and startups which create and provide mobility services for their respective customers. Therefore, the platform provider needs to support and take care of these small companies. One possible way to reach them and teach them how to make use of the resources offered by the Mobility Data Cloud is to organize technology fairs or publish in relevant magazines. Another option is to launch contests looking for new business models, as they both stimulate competition and spark the interest of new developers. Also, a developer platform should be set up to facilitate the communication to and between service providers. With this platform, service providers can acquire the necessary knowledge for innovative mobility services.

Multinational engineering conglomerates are not known to be very agile in terms of contacting small businesses.The target group for their engineering products consists of large industry corporations. That is why they heavily rely on their sales force to sell products. But in this case, with the target group of small and medium enterprises, such a direct channel is not feasible anymore. Instead, they have to come up with a new marketing strategy to attract possible customers, using the above mentioned opportunities to connect with service providers. However, they do not have the necessary experience to fascinate developers at technology fairs or to create engaging developer platforms. It would be either possible to build up this crucial know-how, or to form a strategic partnership with a player who is already known for its expertise in communicating with small ICT companies.

In the case of the event pick-up company, an article in a business magazine could spark the interest of the manager of a traditional bus company. As a result, he sends two of his employees to a technology fair, where consultants show them possible implementation options. They convince the manager to invest into this new business model, and finally cooperate closely with the Mobility Data Cloud provider to create this new service. Via the developer platform, they find skilled engineers to develop the software needed by them.

6.4.1.4 Customer Relationships

As seen in part 6.4.1.1, there are mainly two groups of customers. On the one hand, the infrastructure providers that contribute the main part of the aggregated data and, on the other hand, the service providers that use the data in order to create value for the end customers. Both of them need a certain kind of support in order to ensure the functionality and quality of the services enabled by the Mobility Data Cloud.

The relationship between the MDC and the infrastructure providers has to be an intensive and personal one. The infrastructure suppliers are not only data suppliers, but also customers of the platform. Due to the fact that the

operator of the mobility cloud is highly interested in the data the infrastructure providers are able to offer, it has to take care that the data flow from the infrastructure system into the cloud occurs without any difficulties for the infrastructure providers. This requires especially in the establishing phase to the cloud, but also during the whole operating time, consultancy and technical support. Imaginable are MDC-technicians that help to connect the systems of the infrastructure providers to the MDC in terms of hardware adoption or individual installations of interfaces to the infrastructure systems.

The MDC also stores and manages the data of the infrastructure providers. Therefore, a close collaboration will be mandatory to achieve a fluently running system. In order to guarantee such an intensive assistance to them, the employment of account managers is necessary. They should be responsible for approaching new providers and taking care of the relationship with them. Additionally, the platform should be able to guarantee an extremely high availability and a 24/7 emergency plan for potential technical problems.

The relationship with the service providers is a different one. Due to the probably large number of different service providers, they cannot be approached individually. However, in order to encourage them to use the platform to create innovative solutions, a developer platform is created that enables communication and also technical consultancy in a support center. Such platforms are already successfully used in many fields of software development. A special kind of interface that provides all data gathered by de MDC where the developers are able to work creatively and freely on new solutions and services will improve the quality and the degree of innovation.

Communication is a crucial point: The service providers will be the group that gets direct feedback from the end customer. Therefore, they are the ones to create visible innovation and create the demand for new functions and resources. This will push the platform in terms of new ideas for innovative bundling and integrated services. In the case of the event transportation service, the developers of this company would be able to create an innovative smartphone application easily with the help of the developer platform. All the data they need for the App is easy to acces, automatically updated and guaranteed available.

6.4.1.5 Revenue Streams

The revenue streams to and from the Mobility Data Cloud are depicted in figure 6.10. It is a business principle that multiple revenue streams decrease the business risk and the risk of failure. Therefore the business model around the MDC includes different revenue streams from the two customer segments, which are represented by the two inner circles in the figure.

The left side of the graphic shows that the MDC service enables Infrastructure Providers to push their data onto the platform and that it creates an interface between their own network and the platform. For these consulting services, they
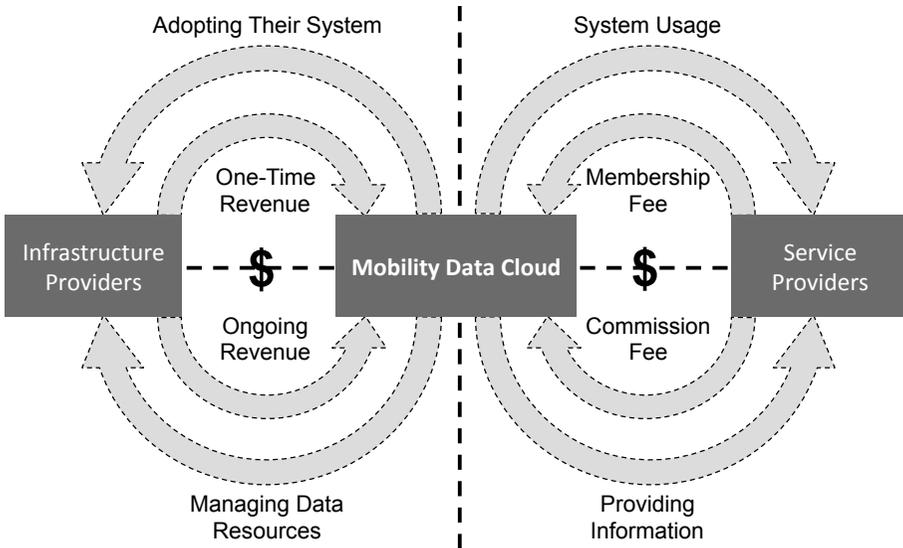
Figure 6.10: Revenue streams to and from the Mobility Data Cloud
Source: own illustration

will be charged a migration fee which represents a non-recurring revenue for the MDC. Infrastructure providers can furthermore employ the MDC service to have their data resources and services managed in the computing center. This includes hosting and maintenance services. The infrastructure providers can therefore outsource their IT costs and the MDC generates another revenue stream for the platform.

The right side of the graphic shows that all Service Providers pay a certain one-time membership fee that serves as an entrance fee to be able to use the system. After that the customer pays a subscription based fee for the indivdual data set they choose. In addition, while providing services to their own customers, the service providers pay a commision fee by sharing their revenue from these services which use mobility data. A share of this revenue is given back to the infrastructure providers to recognize their data supply. The different service provider customer segments mentioned in part 6.4.1.1 are charged different prices according to a price discrimination scheme. Customized and on-demand data sets which are individually combined according to certain customer criteria require a higher price than standardized ones which are directly available over the developer platform. Furthermore, it is worth mentioning that the MDC is a scalable business as adding new data sources and increasing computing capacity can directly lead to a business expansion.

In the case of the event bus service, the revenue streams are again multi-sided.

The bus company pays the one-time fee to become a member and to have access to the database. In addition, and depending on whether it decides for a customized or a standardized data package, an ongoing fee incurs which can be compared to a subscription based payment model. For the bus company one could imagine the amount of the fee depending on the size of the information set and a transaction-based fee depending on the number of applications sold. There could also be a money stream flowing to the bus company if other service providers can make use of the data provided by the bus company to the MDC.

6.4.1.6 Key Resources

To establish and maintain the Mobility Data Cloud, several key resources are required. The most important physical resource is the data center which serves as a hardware basis for the cloud computing service offered to infrastructure providers. This relates to the need for a high-end IT infrastructure to suffice the contracted service level agreements. Especially in an initial setup, the use or even the deployment of sensor networks owned by the MDC provider might enrich the capabilities of the platform. For instance, a sensor network deployed in a city by the MDC provider could give detailed information about the congestion in this area. Later, as more and more infrastructure providers share their data, the use of own sensor networks might not be necessary anymore.

The intellectual resources aim to improve the platform operator's options to sell the services. As similar services may be offered by competitors, these resources are needed to gain a competitive advantage. First of all, strong co-operations and partnerships with municipalities and infrastructure providers are required to promote the use of the platform. The MDC cannot be established without their willingness to share mobility data. Therefore, a strong brand image in terms of engineering capabilities supports the sales force during their work. Even if the MDC is finally set up with running services, the operator still has to come up with new innovative solutions to aggregate and process mobility data to secure the competitive edge. Patents on this know-how could then strengthen the market position even more.

Of course, personnel is needed to develop the platform, keep it running, and make sure its service is promoted. The platform software is implemented by a group of software engineers and architects, who also take care of new features and the used technology. They closely cooperate with the IT infrastructure team, which is responsible for the availability of the service, emergency backup plans and ensuring system performance. In the sales department, account managers keep in contact with businesses and try to promote and sell the product. Also a service center needs to be set up to provide technical consultancy to business partners.

6.4.1.7 Key Activities

Using the key resources identified in section 6.4.1.6, the following activities describe the main tasks to create the value proposition, distribution channels, customer relationships and revenue streams. Initially, the platform has to be implemented. This includes not only to set up the hardware, but also to design and implement the software. Pilot customers on both sides of the platform help to define requirements like availability and performance agreements. Interfaces have to be set up to enable the communication with data collection infrastructure as well as to provide a simple protocol for service providers. In this process, co-operations with other hardware manufactures should be established. To facilitate the communication to and between service providers, the developer platform has to be implemented.

Later, technical activities evolve around managing the data flow of the platform and developing new features. The data may also be analyzed in order to come up with new meaningful ways to optimize the desired output. It is important to listen to customers, as they may have special needs and good ideas.

Other activities are mostly focused on attracting new customers and maintaining customer relationships. Infrastructure providers have to be approached and convinced to become customers of the data storage service or share their data on the platform without the full migration of their data to the MDC. Then, they need to be consulted in migrating their data onto the platform. Service providers get inspired by engaging technology fairs and the developer platform. For experienced developers as well as newcomers trainings and workshops are offered. Infrastructure providers are supported by their account managers, while service providers can benefit from the excellent technical support center.

6.4.1.8 Key Partners

The Mobility Data Cloud is a highly complex system that requires knowledge and experience in several disciplines, but also contacts and intelligent marketing to be successfully adopted and operated. Such a platform combines aspects of software and communication engineering with infrastructure industry products. The realization of such a business idea is also a huge challenge from a management perspective. The large number of players involved and their different interests will require persuasive efforts and coordination between them. To make the wanted change in end user behavior possible, strategic partnerships need to be formed.

It is imaginable that either a ICT company or a industry conglomerate could create the MDC. The competencies of both will be needed in the adoption and the maintenance of such a platform. Both company types will face the challenge to complete the required competencies in order to be able to operate it. Therefore, several partnerships will be necessary. In the following, the most

important ones will be outlined.

The first group of partners are the players in urban mobility that possess a broad access to interesting data which could be used to set up new integrated mobility services: Urban highway operators, operators of traffic management systems, car sharing companies, and many others. Besides them, telecommunication providers might also be interesting for the data collection side of the platform. It will be crucial to reach agreements with these players to get access to their data. Possible benefits for the partners in terms of data collection could be that parts of their IT infrastructure could be cost efficiently outsourced and that they themselves are able to provide better services to their customers. If infrastructure providers are not willing to cooperate, another option to get their data would be to buy it.

If an industry conglomerate operates the platform, there might be a gap in data processing knowledge due to the fact that this discipline is not a core competence. Therefore partnerships in this area could also be valuable: Cloud computing providers could bring their knowledge into a strategic partnership, meaning calculating center maintenance and scalable computing solutions. Software development companies could be valuable for the development of intelligent algorithms that process the collected data before delivering it to the service providers. ICT companies could help support the creation of mobility data standards.

As seen in section 6.4.1.4, there will be a high degree of collaboration necessary to enable the service providers to create high-quality services. Therefore also the actual customers for the platform will be partners. For example, smartphone manufacturers or even small ICT startups will need a assistance in terms of technical support or implementation of customized features into the MDC. Providing high quality assistance to the service providers should also be of interest for the platform operator, as the services and solutions of these providers are crucial for the success of the platform. Thus, the platform operator should be eager to help the service providers to come up with valuable and innovative services.

Finally, municipalities will play a key role as a partner in data collection as well as service distribution because of their broad involvement in transportation systems, investment decisions and legislative constraints.

For each of the services that are enabled by the platform, a different data flow in terms of collection, processing and distribution of data could be necessary. Therefore, different partners might play a role for the realization of a certain service. For the event transportation service, the scheduling of events in the city, the current traffic situation, the availability and position of its own transportation vehicles and the distribution of this information to the end user are the most relevant aspects. Apart from partners that help to process the data, the municipalities, event management businesses, taxi companies, urban transportation providers and the actual event bus company would be partners

for data collection. The event transportation provider that creates the user access to the data would be the partner on the service provider side of the platform.

6.4.1.9 Cost Structure

The cost structure of Mobility Data Cloud consists of three cost levels: Research and development, implementation, and operation.

First of all, a large effort must be spent on a research and development process that is aiming at enabling the technology for such a comprehensive system. During this process, the main costs are personnel, software and hardware expenses. In order to develop complex integration algorithms, many engineers and researchers are necessary. The salaries of the research and development team represent the biggest part in development costs. Developing the platform and necessary algorithms will take remarkable time and energy so a very talented development team should be employed. The success of the system strongly depends on the capabilities that the software brings. Therefore, if there occurs a need for longer time and more talented engineers during the software development process, the resulting costs should not be avoided. Secondly, during the development process, the research team hardware to test and implement the expected system. Therefore, besides the personnel and software development costs, there will also be continuous costs to facilitate the know-how creation process.

Furthermore, during the development process, there is the possibility that the research team may need to use existing algorithms, methods or products which are protected by patents of different companies. Therefore, it should also be considered that there might be unexpected costs triggered by intellectual property rights. Municipalities and state organizations might decide to authorize only a few companies for mobility data centers in the cities of the future. Therefore, they might hold auctions to sell licenses for such a business. In this case, license fees could represent another source for costs.

Once the mobility data cloud system is developed and published to the market, there are also some necessary expenses for the implementation of the MDC. For the data center, there are setup costs for the servers and processing units. Then, these devices should be connected to the networks of the business partners. The data flow between infrastructure providers, the MDC and mobility service providers that use the platform must be tested. In case of any incompatibilities between the MDC database interface and existing infrastructure providers, there will also be a need for modification of the software and hardware. Therefore, the hardware and personnel costs during the implementation and start-up process are another major part of the cost structure.

Besides the development and implementation costs, there will be some costs during the operation of the system as well. First of all, maintenance and security

of the data center is one of the most crucial parts during the operation. The maintenance of the data center creates mostly personnel cost. The data center should be protected against any physical threats, as the data center may be vital for the functioning of a city's traffic infrastructure.

Secondly, a group engineers will be responsible for continuous performance and development of the system. Since there will be a strong collaboration with infrastructure and service providers, they should work on consulting and supporting the partners as well as taking care of the system internals.

Besides all these costs for technical activities, the marketing and sales activities for encouraging infrastructure providers to integrate their networks to the data center and promoting the opportunities among service providers are another part of the costs. In addition, the developer platform for the service providers also requires ongoing attention by the MDC operator. These costs occur during the setup as well as during the operation. As one main contributor of data are the municipality-owned public infrastructure providers, lobbying efforts might be necessary.

Lastly, since the infrastructure providers share their databases with the mobility data cloud, they should be paid a compensation for their contributions to the data cloud. Therefore, a certain part of the revenue that comes to the MDC from service providers should be given to the infrastructure providers. This revenue share will represent an ongoing part of cost structure.

6.4.2 Scenario Robustness

The success of the Mobility Data Cloud business idea depends on many different factors and characteristics of possible scenarios in the future. Since each of the scenarios is equally plausible, the robustness of the Mobility Data Cloud against all scenarios and their different key driver characteristics needs to be examined.

Scenario "Race": According to the characteristics of scenario "Race", it is very likely that new services provided by Mobility Data Cloud would create an attraction in the public. People would realize the benefits that they can get via the cloud quickly so they will easily start testing and adopting the new services offered to end customers. Due to the high public interest, the initial reaction time will be short and demand is expected to be high, like for many other products and services coming to the market.

Such a big interest in the public will inevitably attract many companies and push them to take a part in providing mobility services to consumers. Small and medium-sized companies will not hesitate to employ more software developers and marketers to develop new innovative services to exploit the cloud. Big companies will also try to keep their position in the market by enhancing their core competences with the functions offered by the cloud.

There will be a large number of new services which use the cloud and are developed by third party companies. The capabilities and functions provided by these solutions will exceed the expectations due to the contributions of different parties. Therefore, the importance of the Mobility Data Cloud is expected to increase rapidly. Under these circumstances, such a centralized integration system might easily have a fundamental backbone role for initiating a new market.

This fundamental backbone role has already been proven as some public transportation authorities have turned all their infrastructure and system management centers into autonomous systems. Since there is no human control in public transportation systems of many cities, the data processing and integration systems has become the major part of all mobility systems in cities. Therefore, it has become easier to integrate different systems and offer harmonized services.

At such a frustrating race between service providers, one of the biggest challenges that the companies will face is to satisfy privacy expectations of people. Despite having a great interest in new products and services, people faced many privacy scandals related to social networks, so they are now demanding services that do not misuse any private data. Therefore, companies should spend more time and resources to make their services privacy sensitive and increase the data security in their data centers. This requirement may increase the costs and limit the profit margins.

One of the most important success factors for the Mobility Data Cloud is the level of integration between different players in the market. The more companies cooperate, the easier it is to connect their systems to create innovative services. Therefore, the Mobility Data Cloud can create higher benefits for consumers. However, in scenario "Race", the degree of system integration is defined to be low. It is stated that there are serious conflicts between companies so nobody wants to cooperate on joint projects and services. Furthermore, the market is very fragmented, making it hard to reach a consensus.

In such a case, it will be extremely hard, even for a conglomerate, to bring different players together and convince them to contribute their data to such a mobility cloud. Therefore, integration efforts would simply be expected to fail and the resources of the mobility data cloud would be extremely limited.

However, the mobility problems will continue to emerge. Municipalities and state organizations will still feel responsible for providing effective and integrated solutions for their inhabitants. Therefore, the best solution is to encourage municipalities and governments, instead of the conglomorate itself, to play an independent leadership role to establish consortiums, bring different infrastructure and service providers together, and enable enhanced solutions for their citizens in order to solve emerging mobility problems.

Even though business players cannot manage to come together and cooperate, state authorities can establish data processing and integration centers on their own and legally encourage other players to contribute to their infrastructure.

In this case, instead of establishing the mobility data cloud privately, selling such systems to municipalities and state organizations could be a good solution to run this business idea.

Scenario "Slalom":   In the second scenario, called "Slalom", the introduction of the Mobility Data Cloud faces several problems. The global oil crisis led to a strong reduction in infrastructure spending. Therefore, Intelligent Transportation Systems, one major data source for the MDC, were only introduced in some major cities that were not hit very hard by the economic crisis. In addition, only public transportation vehicles and taxis are equipped with positioning systems in some cities, but no private cars. Therefore, there is not much data available to analyze traffic streams on the roads.

However, the rising oil price has strongly increased the importance of public transportation, as using a car of one's own has become too expensive for many people. Analyzing traffic streams in public transportation is much easier, as the operators routinely track all their vehicles.

In this scenario, it is likely that the Mobility Data Cloud provider has to pay for all data that it gets from other companies and especially municipalities, as they need to create as much revenue as possible by themselves due to their tight budgets. This can have a strong impact on the business case for the Mobility Data Cloud, which may have to restrict itself to only the most profitable services with the cheapest data.

Additionally, in this scenario, the low public acceptance for new products or solutions might represent a problem for the Mobility Data Cloud. The low acceptance will cause service providers to earn smaller amounts of revenue and therefore lower the attractiveness of the Mobility Data Cloud. As less money is invested in new technologies and high-tech transportation infrastructure, less data is available that can be used in the Mobility Data Cloud.

On the positive side, however, the economic crisis and the following cancellation of many infrastructure projects has led to a consolidation in the infrastructure provider market. The remaining companies have realized that they need to cooperate in order to be able to succeed. They realized that too strong competition will make it impossible for all of them to be successful in the face of the obstacles. Therefore, already some standards to link different transportation systems exist, making it easier for the Mobility Data Cloud to collect and process the data.

The growing success of e-cars and especially e-bikes in this scenario can also offer opportunities for the Mobility Data Cloud. For example, the smart linking of these vehicles with public transport as well as the provision of charging station data are promising application fields. The customers that bought those e-vehicles can be assumed to be more innovation-friendly and are therefore an interesting target group for new mobility services enabled by the MDC. This and other niche groups of end users are the most promising potential

customers for services based on the Mobility Data Cloud. The relationships to the companies providing services to these customer groups should therefore be even more intensive.

Privacy is a major topic in the "Slalom" scenario, as data scandals have reduced the willingness of people to give their private data to companies. Therefore, services that use personal data would no be used by large parts of the public. In addition, data security is very important. Moving all data to the cloud is therefore not an option, an own data center with strong security measures is necessary. Data security is a key field of knowledge in this scenario. Even better data protection could be achieved through stronger cooperation with the governments and the municipalities, for example through legislation.

In this scenario, the Mobility Data Cloud would probably not be successful in developing countries such as China which are hit particularly hard by the economic crisis, as infrastructure spending is reduced and the environemt is not very supportive for such radically new solutions.

To conclude, the Mobility Data Cloud can harmonize different mobility service and infrastructure providers despite the bigger privacy concerns, the worse availability of data, and reduced infrastructure spendings due to the economic crisis. Through better cooperation among companies and between companies and the municipalities, these obstacles can be overcome. However, many services based on the Mobility Data Cloud that would be possible in the "Free Flow" scenario cannot be employed in this scenario due to the restrictions mentioned above.

6.5 Conclusion

Many new services can be enabled by using aggregated and consolidated mobility data. The efficient use of existing infrastructure is very important for the future of urban mobility, and the exchange of data between traffic systems is essential to reach this goal. By providing better, more accurate mobility-related data to the end user, and also by integrating other services like personalized advertisement or event agencies, urban transportation can be improved.

The key factors that currently influence and will influence the spreading of integrated mobility solutions in the future are, firstly, the willingness of people to adopt new technology and change their behavior, secondly the public awareness of privacy issues and the willingness to contribute data, and thirdly the degree of integration of the different systems, including the willingness of the companies running these systems to cooperate.

In one of the three developed scenarios, called "Free Flow", the public is open to new technologies and willing to accept a reduced privacy level if the general public benefits from the additional information. As companies in the transportation sector cooperate to link their transportation networks, urban mobility is strongly improved. In such a scenario, new technologies and large

amounts of data connect different modes of transport with the users and among themselves, creating a new travel experience.

A business idea that fits perfectly into this scenario is the Mobility Data Cloud, a common platform for the mobility data that facilitates the connection between various transportation systems. The role of the platform is to collect all relevant data about traffic conditions from transportation companies, municipalities and others, process and combine this data and finally sell custom data packages to other service providers.

The business idea also fits into the other two scenarios, but faces larger obstacles. The resulting interconnected transportation systems can be much better coordinated and adjusted to the actual travel demand. Furthermore, the collected data can be used by other companies for new services building on the common platform.

For example, a bus company could use the Mobility Data Cloud after major events. It could use the information about the travel destinations of the people who attended the event, for example entered through a smartphone application, and combine it with current traffic information to provide buses on-demand for people with similar destinations.

The Mobility Data Cloud requires the collection of large amounts of data, which often requires costly new technology. Therefore, the business idea is better suited for developed countries with at least partially already existing data collection infrastructure. However, a common traffic data platform can also deliver benefits with less, more basic data. It definitely would help to reduce the traffic problems in quickly growing megacities in developing countries.

To conclude, the integration of different mobility services is a promising approach to improve urban mobility. The interconnection and exchange of information between the different traffic systems is necessary for these integrated services. A common mobility data platform as described in the business idea is a promising approach to this challenge.

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7 Infrastructure Provision

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Due to rapid environmental changes and urbanization, just to name two megatrends, the urban mobility infrastructure faces the crucial challenge to improve and modernize its functioning, being a main pillar in supporting the evolution of society. In this sense, it is of utmost importance to think of directions in which uncertain drivers such as environmental awareness, political input and technological progress can evolve, while taking also into account the influence of indubitable factors like demographic changes or social needs. The interaction between such factors gives birth to a lot of possible future scenarios, out of which this report details just three. They offer a broad overview of the changes in the road and rail infrastructure, the energy distribution network, tolling or parking.

Although there is an omnipresent need for improving urban infrastructure, the future will demand different competencies from cities in developed economies than from those in developing ones. Those in the first category will need to implement new technologies in the already existing infrastructure and, in the case of economic difficulties, reach this goal with minimum expenses. Cities in developing countries need to develop in a sustainable way and balance a low public environmental awareness with effective measures in order to bridge the gap between them and economically mature societies. The goal will be to integrate smart and versatile technologies that will tackle pressing issues regarding infrastructure. A modern future urban mobility infrastructure will imply less congestion, faster travel time and massive use of eco-friendly means of transportation. The business idea *Avanti* attempts to improve the urban traffic flow, additionally collecting revenues for the municipalities, by implementing an innovative, dynamic and fair system for administrating toll and parking fees.

7.1 Introduction

Infrastructure plays an essential part in urban mobility. All modes of transport depend on it in order to function properly. However, although it is part of everyday life, it is probably one of the most overlooked aspects. The human mind is so used to this element of urban mobility, since it is so established and integrated and its development usually is minimal, that only major changes are perceived by the everyday user.

The biggest challenges it faces, among others, are the integration of the new technologies with the old technologies and vice versa, as well as the slow but gradual replacement of legacy systems, the acceptance by the everyday user and its sustainable planning. So for example one issue which is of high interest regarding infrastrucutre is the integration of the existing traffic management system into a new personalized payment system concerning tolling and parking.

The following report describes three scenarios based on a number of drivers, that give an outlook on possible developments of this vital part of urban mobility. First, the driving forces are identified in section 7.2. They consist of key drivers that have different impacts on infrastructure provision which are outlined according to the different dimensions they can take, as well as a number of additional drivers. Then the three scenarios which range from "Bridging the Gap", a chaotic world, over "Mobility takes a Backseat", a slightly more structured world, to "Conservative goes Innovative", in which infratstructure solutions work and are accepted in society sare described in section 7.3.

Finally, a business idea called *Avanti* is introduced in section 7.4. It aims to reduce congestion and pollution within cities as well as a more efficient usage of parking spaces, while generating revenue for the municipality.

7.2 Driver Analysis
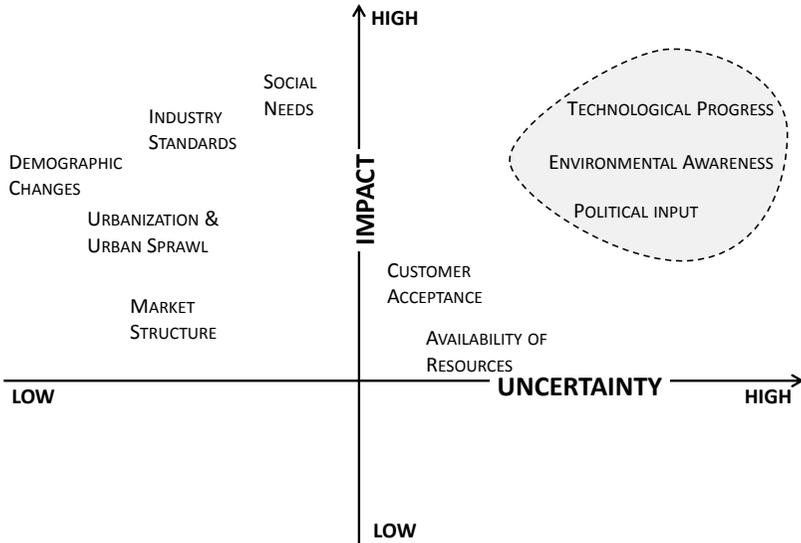
Figure 7.1: Map of drivers for urban mobility in infrastructure provision
Source: Own illustration

The following section introduces the ten most important drivers that will shape the infrastructure provision in urban mobility within the next years. While there are four certain drivers, since their development is considered to be reasonably predictive, six drivers with uncertain outcome are also identified. Of these, the ones with the highest impact and the highest uncertainty are considered to be key drivers as seen in figure 7.1. First, the key drivers will be outlined, followed by short descriptions of the additional drivers.

7.2.1 Key Drivers

Three key drivers regarding infrastructure provision were identified: The environmental awareness of the citizens, the political input that is provided and the technological progress. All three share the characteristics of having a high influence on infrastructure provision, but also being very uncertain. Thus, an explicit description of them as well as the dimensions in which they could evolve is given hereafter.

7.2.1.1 Environmental Awareness

Description   Environmental awareness is a key driver which influences infrastructure provision in an indirect way. Customers have a particular attitude towards environmental topics such as waste and recycling, air pollution or greenhouse gases, which determines their way of using means of transport or energy resources. These usage patterns will then shape the infrastructure needs and thus the market, as the municipalities want to provide a traffic network and energy supply which fulfills these needs. The way patterns and consequently the infrastructure will develop, depends on different aspects.

First of all, the level of demand for a sustainable traffic infrastructure should both avoid damaging the eco-system and provide a more enhanced traffic network. The essential question therefore is if people will accept rising prices or any other disadvantages like stricter regulations for such an infrastructure.

Secondly, the way in which people respond to different kinds of price developments of energies will be important. Once again, there is a trade-off between eco-friendly energy supply and ecologically harmful but cheaper alternatives which evokes the question of acceptance.

Thirdly, the degree of adoption of new eco-friendly technologies will heavily influence infrastructure provision. The number of users of new propulsion technologies like EVs and smart devices will determine how far infrastructure has to be modified, specifically how much sense and value an implementation of new features like charging stations would have. This third aspect has various possible outcomes that are further influenced by the acceptance of state regulations or subsidies for these technologies.

Fourthly, one has to consider the reversed situation: How high is the level of pressure from the population on authorities to find more eco-friendly ways for commuting or delivering?

Finally, one should not forget that this key driver can rapidly change its dimension and thus its influence following a natural disaster or another event.

Possible Developments   There are two broad dimensions viewed in this report, namely high and low environmental awareness, that are explicitly described in the following.

High environmental awareness: People would react very lively to environmental changes which they face due to natural catastrophes or media coverage. Consequently, the demand for a more sustainable infrastructure as well as more efficient and eco-friendly energy would highly increase. Vehicles powered by electricity or hydrogen would see mass adoption, therefore completely changing the city landscape, e.g. streets and gas stations. Citizens might endeavor to adopt stricter regulations or even call for higher investments to fight environmental problems. Cities providing sustainable infrastructure and environmentally pleasant inner cities would gain more and more attractiveness and thus face

immigration and a high growth in population. Furthermore, activities from both citizens and media to convince other people to use eco-friendly technologies would accelerate environmental awareness and thus make it an elementary way of thinking for most of the population.

Low environmental awareness: People would not bother too much about environmental topics. This is due to different reasons in different population segments which however could complement each other in a coherent way. Some people might be preoccupied with other financial issues like job, housing or education problems. Consequently, new, ecological technologies might be too expensive and thus the adoption rate would not be high enough to enforce significant changes in infrastructure provision. Moreover, people would also not demand better ways for commuting because they prefer investments to be allocated in other fields like education or social services. Although being annoyed by long travel times and being aware of the problems of climate change, many people would only care about the costs of transportation, therefore using ecologically harmful but cheaper vehicles. Some people might not be aware or would just not care about the consequences they have to face. Besides, frustration and a loss of confidence in new eco-friendly technologies could atrophy the trust in improving the current state, e.g. if they realize they cannot oppose climate change alone while others do not care at all or hear about accidents caused by new eco-friendly technologies. All these aspects might lead to a very low environmental awareness, giving priority to other problems and issues people are more concerned about and thus have to be tackled.

7.2.1.2 Political Input

Description   Due to the fact that infrastructure provision is the responsibility of state institutions and municipalities, the second key driver is the political input. Politicians can influence infrastructure provision by undertaking a variety of actions. Two of the most important tools are regulations and subsidies. Political engagement towards infrastructure improvements depends on the need for change and on the affordability of investments in this area. Next to general trends such as demographic changes, the effort put into infrastructure adjustments could be influenced by the geographical location of a city, as some areas are more affected by the consequences of climate change or urbanization. Developing countries might have different priorities than developed countries. Even though there is also a need for infrastructural improvements, some cities might have to focus on education issues or preventing crime. Thus the level of political input depends on the level in which other areas demand investments as well. The degree of success is further influenced by the amount of cooperation with companies and other municipalities, as well as the opinion of the citizens.

Possible Developments The following sections cover developments in the political framework. Possible consequences of a high and low input towards infrastructure provision will be described.

High political input: In case of a high involvement the government and municipalities feel a great responsibility towards infrastructure provision. In terms of regulations, public authorities could restrict or ban the usage of particular technologies, e.g. ICE vehicles, within cities. This would lead to low emission areas or completely car-free zones as well as the promotion of public transit usage. Another option could be city tolling for vehicles which would reduce the number of private cars within the city and therefore would improve traffic flow. Next to regulations, political objectives might be reached by subsidies. Private investments by citizens could be subsidized, for instance when purchasing e-cars or installing renewable energy creation systems at home. By funding public research centers or supporting joint ventures which push disruptive technologies, the evolution regarding urban infrastructure might happen more rapidly. In order to have a deep impact, regulations should be implemented in a strict way and on a large scale, therefore requiring regional, national or international agreements. Further progress would be enabled by establishing associations between public institutions and companies. This could provide a setting in which costs and responsibilities for new projects are shared and standards are discussed. In order to make faster progress, municipalities could increasingly exchange know-how concerning experiences in new infrastructure projects. Public transport services might be privatized in order to foster competition resulting in better and more diverse services. This could lead to an increasing usage and a demand for infrastructure expansion.

Low political input: If public infrastructure is a low priority for the government, long term projects for new systems that demand extensive funding would be postponed or abandoned. One would only see maintenance and improvements in existing infrastructure where absolutely necessary. As no new projects would be introduced, the existing means for mass transportation would only be expanded in order to provide mobility services for a maximum capacity. Thus there might be more buses on the streets and as many metro trains per line as possible. Further consequences of low political engagement would include the lack of subsidies and regulations aiming for eco-friendly ways of transportation. If neither the production nor the usage of hybrid vehicles or e-cars is supported, both the technological progress and the affordability would decrease. As a consequence, there is no immediate need for adjustments in infrastructure. Differences between municipalities or states could arise, resulting from a shortfall of cooperation and agreements. Opinions of decision makers might change as elections or other political issues come up, contributing to an inconsistent sequence of actions. For instance, low-emission zones could be established and shortly afterwards abolished. As not much political effort is put into this topic, it would be easy for lobbyists of existing mobility providers to

strengthen their position and prevent progress. All in all, the lack of political engagement could lead to the prevention of technological progress and consumer adoption as a whole.

7.2.1.3 Technological Progress

Description   Technological progress is a key driver which influences infrastructure provision in a direct way. It is understood as the improvement of an existing technology or the development and implementation of new and innovative technologies. These products can be either pulled or pushed into the market. A product is pulled, when a need arises in the market that is not filled, and therefore a development needs to occur. A product is then developed that fulfills these needs. A product is pushed, when a company has an innovative idea that they place into the market. Due to these aspects different economies have different levels of technological advancements as well as speed of development.

Challenges technological progress faces are security issues that come with new technologies, cost reduction that has to happen for this technology to become accessible to the everyday customer and the integration of new and old technologies, or the complete substitution.

Possible Developments   The dimensions viewed in this report are fast technological progress, medium technological progress and slow technological progress.

Fast technological progress: In case of a fast technological progress events have occurred in order to push technological progress. The faster the progress is, the faster innovations are marketed and the higher the adoption rate for new infrastructure technologies is. Since the technologies in this dimension are being rapidly developed, the projects would be implemented on a large scale where the direction depends on the city and its needs, e.g. the focus may be on individual transport infrastructure or on railway-based systems. Investments in research and development (R&D) are high, e.g. for fast rail systems for commuting, a multiple layer underground rail system or an extensive use of smart grids and decentralized energy concepts such as self-sustainable buildings, e-car charging possibilities and renewables at home.

Medium technological progress: This implies that new advancements are being made in technological fields that are not deployed immediately and there are only few early adopters. Investments in R&D would be sustained, however, since the infrastructure solutions would still be expensive, the municipality would continue to rely on traditional ways for electricity supply, meaning innovative solutions such as smart grids or extensive usage of renewable energies would not see a mass adoption. Also, car manufacturers would strive to raise the accessibility and affordability of electronic vehicles, making their share constantly rise. However, due to all of this, the existing infrastructure would still be needed greatly, although public infrastructure systems would adopt new

technologies, that are more eco-friendly.

Slow technological progress: This implies minimal technological improvements. It may be due to either a low priority of infrastructure projects with the government, meaning few incentives for companies to push technological progress, or companies generally struggling to find innovations and keeping up with the pace of time and the needs of the citizens. The products that the companies do produce, would turn out to be too expensive for the infrastructure providers to invest in and they would therefore remain with old established technologies. Continuing to use conventional methods would also entail less advanced solutions being developed that concentrate on avoiding congestion and traffic accidents. Therefore safety in traffic would remain a key problem. Possibly the expansion of the public transport system, where maximum capacity has not been reached could help distribute the masses of commuters, although it would mean more buses and metro trains per hour as possible.

7.2.2 Additional Drivers

There are further drivers that have an impact on the future of infrastructure provision. However, in contrast to the key drivers, they are either less important or less uncertain when it comes to the development of urban infrastructure.

On the one hand, there are drivers like market structure, availability of resources and industry standards which are closely related to industry issues. On the other hand, drivers such as customer acceptance, urbanization and urban sprawl, demographic changes and social needs shape the future of urban infrastructure rather from the customer side. Both sets of drivers have in common that they impact infrastructure provision indirectly, as it is explained in detail in the following.

7.2.2.1 Market Structure

Infrastructure provision is influenced by the market structure which describes both the number of competitors producing the same goods as well as their market share. In this report the degree of cooperation between public institutions, companies and research centers is also considered. The market itself is shaped by the citizens' requirements, so their needs and behavior have an indirect impact on the market of infrastructure providers. For instance, urban infrastructure providers react to the citizens' usage of bicycles, e-cars or public transport resulting in the expansion of existing components or the replacement by new solutions.

Traditionally, primary infrastructure components are built by few large scale companies who split the market between themselves. They are public goods and require high financial commitments with respect to development, implementation and maintenance, thus also the financing is managed by the public sector. As few large companies have dominated the market, they possess the most know-how

and are most likely able to come up with solutions for future requirements. If radically new concepts are needed, there will be a chance for start-ups or existing companies with a different background to provide infrastructure subcomponents, therefore changing the market structure. However, this change could turn out to be insignificant if the dominating players adopt fast and maintain their expert status.

Municipalities are expected to increasingly partner up with different commercial infrastructure providers in the future in order to share costs and reduce investment risks, while gaining less profit out of successful infrastructure investments. If public transport services were to be provided by different companies, competition between these companies would also be encouraged, thus leading to a faster progress in terms of improving public transport services.

7.2.2.2 Availability of Resources

Another driver that impacts the future of infrastructure provision is the availability of resources. In this case resources mean natural resources which are not available in an unlimited amount. As a consequence of an increasing world population and a rising demand regarding quality of life, more resources than ever are needed. The availability of resources affects many aspects of infrastructure as they are needed in a broad range of areas. For instance, different resources are both employed during the construction of roads and railways and used for powering any means of propulsion technology, e.g. in form of gasoline, electricity, or hydrogen.

As the availability of a resource decreases its price increases. If, for instance, the price for gasoline becomes too expensive for the everyday car driver, e.g. a commuter, the need for more affordable energy sources rises. This challenge can be solved by powering the development of vehicles utilizing electricity. Consequently, changes in the infrastructure are needed as gas stations have to be replaced by charging stations for e-cars. Further concepts like charging at home or at work arise and require additional adjustments regarding the infrastructure of a municipality. Progress in this area could be slowed down due to a rising worldwide demand for electricity resulting in high costs for energy consumption if more efficient technologies cannot be implemented. As a result, municipalities might strive for independent electricity creation which also leads to changes in the infrastructure.

7.2.2.3 Industry Standards

Infrastructure is further driven by industry standards. Standards are considered to be established norms or requirements for technical systems. They can be developed by single institutions such as companies or regulatory bodies as well as by associations, unions of several companies operating in a related environment and state institutions. The general goals of the creation of standards include

compatibility and interoperability, as well as quality and safety. In addition, technical norms can provide independency from single suppliers. For the customers, standards contribute to an easier buying decision as one rather spends money on a product which is guaranteed to work with complementary goods. On the contrary, the lack of standards might hinder customers from purchasing which leads to a lack of revenues, therefore further R&D investments are delayed, thus progress is prevented. However, if there is only one player offering a certain product, a de facto standard can be established due to market domination.

In terms of infrastructure provision, technical norms are a crucial aspect for the establishment of new means of transportation. Depending on the number of market players offering a similar product and the political involvement, norms or de facto standards are developed. They are necessary for gas or charging stations, e.g. regarding the size and shape for plugs. It is also important to agree on the kind of energy that is provided, meaning gasoline or electricity as well as the specifics of the gasoline mixture. Moreover, agreements are required for communication services which are enabled by V2V or V2X technologies. For instance, there need to be compatible hardware components for sending and receiving data as well as protocols in order to exchange information. Further standards gain importance in the area of energy supply as smart grid concepts become more popular. For many cases the involvement of the state is needed which then often leads to a faster development of norms and therefore an earlier implementation of infrastructure solutions.

7.2.2.4 Customer Acceptance

Another aspect influencing infrastructure provision is the customer acceptance, which generally can be described as the willingness of the customer to buy a product or service. This willingness depends on various factors, including usability, costs, individual needs and marketing. As normally the citizen does not invest in infrastructure components but rather in individual or mass mobility services, this aspect impacts infrastructure in a very indirect way. Similar to the influence of industry standards or environmental awareness, customer acceptance directly impacts the success of products which shape the requirements of infrastructure provision. Consequently, depending on the uncertain acceptance and adoption rate of new individual vehicles or bike sharing offerings, the surrounding infrastructure must be adjusted. In case of a high customer acceptance, sharing and charging spots have to be established, whereas a minimal customer acceptance does not require such a change.

7.2.2.5 Urbanization and Urban Sprawl

Additionally, urbanization and urban sprawl impacts infrastructure provision. Urbanization describes the movement of people from rural areas to cities in hope

of a higher quality of life and better job opportunities, resulting in an increasing population and physical growth of cities. Urban sprawl means the spreading of suburban areas in the outskirts of a city, among other things resulting in an increasing number of commuters.

If there are more people in a larger area, the demand for transportation will rise. Congestion problems become worse, requiring an improvement of transportation services and infrastructure. In terms of city planning, less centralized approaches with smart traffic solutions might improve congestion issues. This can be accomplished by splitting a city into districts while providing shopping centers, jobs and further services in each district. This way people have fewer reasons to travel long distances within the city but rather stay in the district they live in.

7.2.2.6 Demographic Changes

Furthermore, infrastructure provision is influenced by demographic changes. Demographic data represents the characteristics of a population, including specifics about age and gender. Citizens of different demographic segments require different mobility solutions. As the worldwide population of the elderly is growing, new mobility solutions regarding accessibility, individuality and safety are needed. This has an impact on the overall infrastructure: for instance, more centralized and decentralized systems focusing on safety have to be implemented. Concepts which combine the low costs of public transport and the easy access of individual transport, e.g. Personal Rapid Transit, could be established as a result of a changing society with different needs.

7.2.2.7 Social Needs

Lastly, infrastructure provision depends on the needs of the population. Needs can be ranked, ranging from essential to luxury needs, whereas different customer segments have different needs. Depending on the income, customers are able to afford different kinds of products, therefore choosing different products in order to satisfy similar needs. Additionally, social needs vary enormously, based on a person's attitude and age.

In terms of mobility this results in different degrees of attractiveness for certain means of transportation depending on the citizens' characteristics. The most popular transportation ways then shape the surrounding infrastructure. The growth of the middle class in fast developing countries would probably be accompanied by the rising usage of private vehicles. Thus, road construction has to keep up somehow to avoid intense congestion problems. If the number of poor people increases, public transportation would be important as they could not afford private means of transportation.

7.3 Scenarios

The following section presents just three of the multiple scenarios that could describe the urban mobility landscape in 2025 with respect to infrastructure provisioning. They are shaped by the strong influence of the key drivers, analyzed in section 7.2.1, as well as by the evolution of additional drivers, presented in section 7.2.2. The scenarios are characterized by a particular configuration of the dimensions of the three key drivers and their interaction creates unique problems and raises specific challenges in each scenario. It is interesting to note that, while the first one focuses on a developing economy, the latter two consider the situation of a developed country and have almost the same initial situation. However, the latter two evolve very differently and the 2025 urban mobility status is shaped by specific events that shape the evolution up to the described final situation. These events are noted in the "Signposts" section of each scenario.

7.3.1 Scenario 1: Bridging the Gap

The following section describes one of the possible scenarios regarding the infrastructure of urban mobility. The name "Bridging the Gap" is a reference to the case of a developing country that tries to rapidly build infrastructure for its cities in order to have economic growth and attract investments, thus approaching the state of evolution of other nearby developed economies. The particular projections of the key drivers described in the previous sections are observable in figure 7.2. The technological progress has a medium dimension, the political input is high, while the environmental awareness is low.

7.3.1.1 Scenario Description

The following scenario unfolds in 2025 in a city of significant dimensions, with at least one million inhabitants, in the heart of a developing country, e.g. in Asia or Africa.

   When looking at the current state of the city, one can only be amazed at how much it has changed over the past few years. Although the resources are limited and the demands high, much has been done to improve the general quality of life here and in other urban areas throughout the country. When walking down the once dusty city centre, one can not miss the electric buses that arrive on time or the small number of taxis that have eco-friendly propulsion. Many people make a living with small commercial activities, but they are struggling to survive now because of the new regulations for freight transportation. There is a system now to distribute goods all over the city using electric-powered vans, as part of a strategy to reduce air pollution. To further achieve this, old and polluting cars are banned from the city centre and some of the transportation is done here using the underground metro system. There are only two subway

Technological Progress

Medium

"Bridging the Gap"

High   Low

Political Input   Environmental Awareness
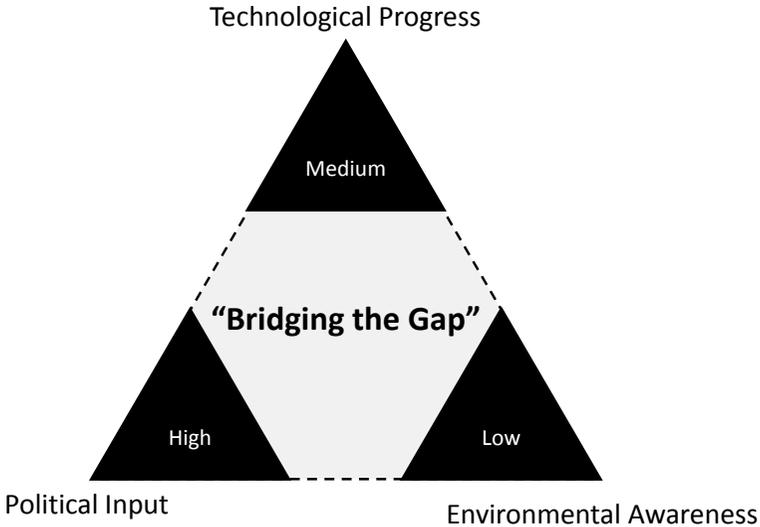
Figure 7.2: Key drivers of the ccenario "Bridging the Gap"
Source: Own illustration

lines and the trains are always full because of their limited number. The authorities plan to build more underground lines in the years to come to cope with the ever-increasing number of commuters but the current network is still a big achievement in a city where a decade ago people needed a car to get anywhere. Now, due to the high tolling tax, few people use their cars in the middle of the city which is the cause of a lot of frustration and protests among the high number of poorly educated citizens. To counterbalance this, there are underground parking spaces, but they are not sufficient to cope with the increasing number of cars and the fact that the normal citizen is used to using their car under any circumstances. It is hard to raise environmental awareness and change mentalities here, hence people are always disagreeing with "green" measures that affect their habits. The fact that investors are attracted to the city and create jobs makes the protests less vocal.

Above ground, public transportation is also going green. The buses have electric propulsion, and they have a special lane to drive on. They are coordinated by the newly installed intelligent traffic management system which is old news for the developed countries, but here it is doing wonders to stabilize the traffic flow. Combined with the allocated lane, it helps the buses to be punctual, a thing that citizens here always envied European or Japanese public transport systems for. This system handles the signaling throughout the city, based on collected data from multiple sources. However, it does not communicate to

vehicles and thus does not offer them routing information to avoid traffic jams. Unfortunately, there are not enough buses to sustain the daily necessities of this fast-expanding city, so many people use bicycles. They enjoy a dedicated lane on some wider roads, but on narrow streets and outside of the city there has not been room to build special pathways, so riding them on car lanes is somewhat dangerous. The prices for the services are rather high compared to the local buying power, but the high cost of all the crucial projects, such as the high-speed commuter train line or the huge underground parking on the outskirts of the city have to be compensated somehow. Yet, there are still some infrastructure projects that were started some time ago and are still not finished because of the high expenses, the most notable being a ring road and the extension of the underground subway system.

The average suburb commuter also notices improvements in his daily life. After a long period of construction, two new train lines have been inaugurated recently, which allow people to access the jobs in the city more easily. The trains arrive twice per hour and are always very crowded, but they have raised the overall value of the area where there were once slums and the crime rate was high. A payment system is used to buy tickets from ticket machines and on-the-fly payment with smartphones is also possible, yet most people still cannot afford such a device and Internet services for it.

Following the trend from developed countries, electric vehicles and, to a smaller extent, hydrogen-powered ones are starting to gain popularity, despite being seen as rather strange and expensive for normal citizens.The average citizen here still buys combustion engine cars, even though the government has subsidized eco-friendly means of transportation. There is a small network of charging stations for these, but the traditional fuel distribution stations are still dominating the market.The charging stations are distributing solar energy as this is easy to collect in this area. Hydrogen distribution is lagging behind because it has required more expensive investments. The energy production is still centralized and heavily fossil fuel based, but authorities are making efforts to increase the share of renewable sources and also extend the distribution infrastructure.

7.3.1.2 Signposts

For the infrastructure projects described in the scenario to have a chance of becoming a reality, a first signpost could be represented by the acquiring of power by a new political force that has to make a firm commitment towards developing a sustainable infrastructure. Investments in this sector would have to be significantly larger than what they are in other sectors of the economy. Incentives for buying eco-vehicles and the extension of the charging infrastructure could probably lead to a wider adoption of these environmental-friendly vehicles. If the projects will be implemented in partnership with private companies, thus

sharing costs and responsibilities, more projects could be done and the overall progress could be faster.

A possible second signpost that leads to the outcome of this scenario is represented by the frictions and tensions which are likely to appear regarding the utility and cost of the public measures. These will happen between citizens that have a low degree of environmental awareness and authorities which push reforms that are not popular e.g. city tolling and car-free-zones. People have certain activities that depend on urban mobility and if the measures taken, for example banning cars in the city center will cause them financial problems or if the services will be too expensive, there could be acts of hostility to keep the status-quo or demand shifting of investments. The authorities would feel forced to concentrate on other areas such as production or industry, to create more jobs and regain popularity. In addition, they will most likely try to attract investors in the rapidly developing city, thus reducing unemployment and stabilize costs by delaying infrastructure projects or using cheaper technology to implement them.

7.3.2 Scenario 2: Mobility Takes a Back Seat

The following section describes another possible evolution of the future concerning urban mobility infrastructure. "Mobility Takes a Backseat" refers to the situation of a developed economy which is faced with financial problems and cannot afford significant investments in the infrastructure of its cities. This scenario is influenced by low political input and low environmental awareness as well as a slow technological progress. The projections of these key drivers are observable in figure 7.3.

7.3.2.1 Scenario Description

This massively extended, overcrowded city is experiencing its worst period right now, since the financial crisis massively hit the country ten years ago. The city that was once a thriving metropolis now struggles to tackle urbanization and urban sprawl with minimal investments in mobility infrastructure.

The average citizen of this city uses public transport, which is very crowded because there are too few train lines and just a few new ones have been built in the last five years. He usually takes the subway because the network was extended very much before the financial crisis. His work colleagues that live outside of the city use the commuter trains, but the travel conditions have been degrading constantly. Rails are seldom repaired and thus the travel time is unbearably long. The same happens in the inner-city with trams. Some of them are even lacking some windows due to many acts of vandalism.

Those who want to travel around the city must be patient, because congestion is everywhere. When using the road infrastructure, the average driver sits in a long queue and is tempted to use the bus lane, like most of the people who are
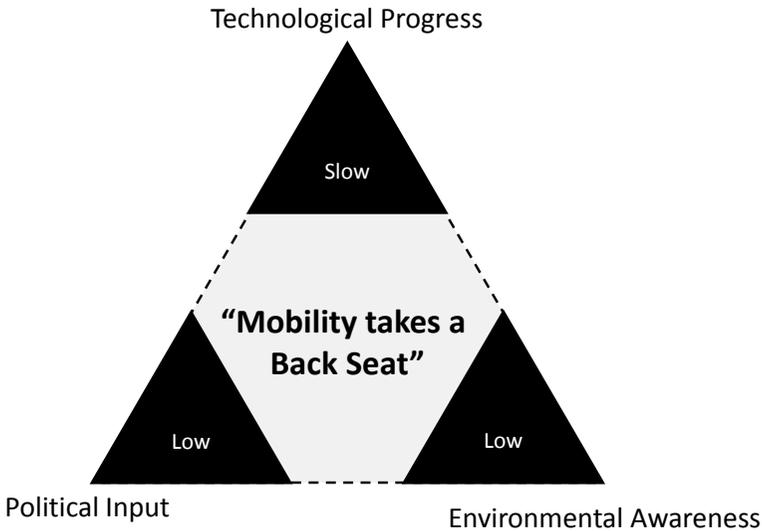
Figure 7.3: Key drivers of the scenario "Mobility Takes a Backseat"
Source: Own illustration

desperate to get to work on time. Too few additional roads are being built and one can only remember with regret a news headline from not too long ago that stated "Ring road construction postponed for another five years". From time to time he takes the bus, which often doesn't make a difference since the bus is also sometimes blocked in the same congestion because nobody seems to care that buses have their own lane. To pay for mass transportation services, one usually uses their smartphone because it is convenient and cheap. Some still remember the innovative payment system that was implemented a few years back, in which sensors from the smartphone would track the exact distance that a customer used the public transport system. It was only used for six months because, given that most people had financial problems, they were trying to trick the system and pay less that they should have.

The average citizen drives an ICE vehicle. He cannot afford an electric- or hydrogen-powered one because of the financial difficulties and because their price has gone down too slowly in the last years. He also regards these new technologies as dangerous because there have been some explosions of cars with hydrogen propulsion and even hydrogen charging stations, killing dozens of people. A buyer of such premium lacks the opportunity to charge them comfortably at home, thus he has to drive several kilometers to the nearest electricity charging station, and on his way he passes by at least three gas

stations. The energy production is still centralized and although more and more renewable sources are used nowadays, the government has just decided that no more investments will be made in the e-energy sector in the next years.

While driving around the city, he is always annoyed by air pollution that is a constant problem because of frequent congestion. He hates being stuck in traffic, but the concerns that he has about keeping his job in these times of economic uncertainty are more pressing. Some positive changes were made some years ago to the signaling and changeable lane system. He would like to see some additional improvements being made, but the authorities just concentrate nowadays on repairing the existing infrastructure and keeping up with the increasing urbanization. His car features vehicle-to-vehicle communication possibilities, but the lack of standardization in this technological sector means that he can only exchange information with just a few other cars or intelligent traffic lights. Therefore, road safety is still a big issue and the traffic flow is not improving sufficiently. A significant reason for this is that the municipality can only process a limited amount of traffic data and cannot access information from the cars themselves because of strict privacy rules. The traffic system has been hacked a few times, so everyone is now strictly against the sharing of data, but this is creating opportunities for start-ups and big companies alike to come up with advanced digital security solutions.

7.3.2.2 Signposts

This scenario is mainly impacted by the low political input regarding infrastructure. There could be several reasons for this. One signpost could be a financial crisis in several European states, where the European currency would undergo a severe test. In the worst case such a currency crisis within the EU could lead to the failure of the Euro. Consequently, the unemployment rate would rise and the demand for consumer products would decrease, again resulting in a reduced number of orders for businesses. So in general, there probably would be an unstable, flat economy. As a result, the government would most likely have a strong focus on saving jobs and improving the economy. Other areas including disruptive infrastructure concepts, however, would not be considered as important. This development goes hand in hand with a shift in government spendings, meaning fewer public investments for subsidies and research with respect to infrastructure. Thus no new concepts like city tolling or other smart systems for traffic flow improvements could be provided by the municipalities and there would also be much fewer contributions in road or public transit maintenance. If people are afraid to lose their jobs, their environmental awareness will not exactly decrease, however it will be a low priority. As a consequence people will probably rather buy cheaper combustion engine cars than expensive, but more eco-friendly cars.

Another major signpost would be the loss of trust in new technologies. This
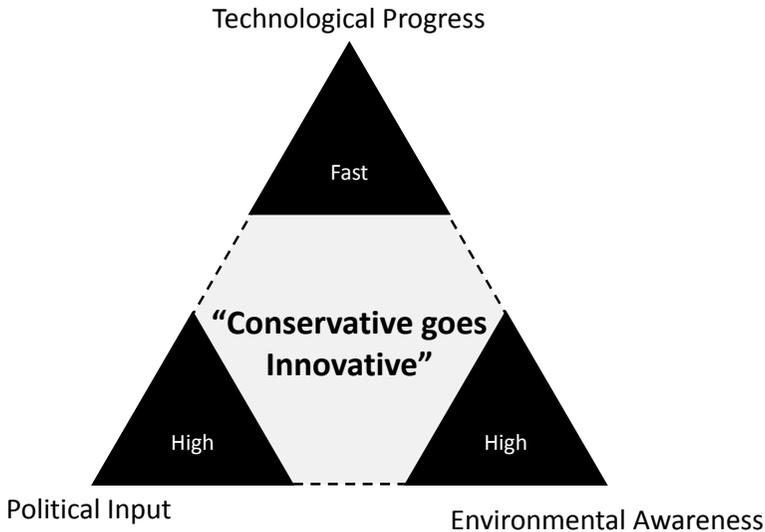
Figure 7.4: Key drivers of the scenario "Conservative goes Innovative"
Source: Own illustration

could happen due to accidents involving emerging energy or data processing concepts. If a megacity's ICT system were to be hacked and if therefore unauthorized persons were able to control traffic lights and dynamic payment systems, people would lose trust in infrastructure components employing digital technologies. Moreover, if there were accidents due to hydrogen powered vehicles resulting in injuries or even deaths, not only would they lose trust but also fear new technologies. Next to the better affordability, this will probably be another main reason to keep using the well established ICE cars and public transit. Another consequence might be the rising demand for implementations which are conducted in a safe and secure way.

7.3.3 Scenario 3: Conservative Goes Innovative

"Conservative goes Innovative" is the third scenario regarding the infrastructure of urban mobility. It describes a conservative city, e.g. a Western world capital with several million inhabitants that have had a complete change of heart and therefore has gone innovative. This implies in particular that the environmentally pleasant interaction between the population, the economy and the state has led to a high environmental awareness, fast technological progress and high political input as it can be seen in figure 7.4.

7.3.3.1 Scenario Description

It is the year 2025. Over the past fifteen years the city has become more attractive to businesses, which have built sites in and around the city, due to major improvements in urban infrastructure described, among others, in the following. Therefore, the number of jobs has increased drastically and more people have moved to the city and the surrounding suburbs. The desire to work at home and to be more flexible has become a necessity and more companies have accepted this and integrated it into the everyday work life of their employees over the years. An overview of past events that have shaped the infrastructure as we know it today is depicted in figure 7.5. To get vivid insights of how the city and especially the infrastructure looks like, a day in the life of a business man is described throughout the following sections.

Tom, 40, living in the suburbs with his wife and two kids starts his day fairly early today. Although he usually works from home, which has become very common and reduces the need to travel, today is an exception. He has a meeting in the inner city and needs to get there somehow. However, the question arises which of the many possibilities should he make use of?

Of course, he could take the personal rapid transit (PRT). It was originally only planned for the airport - city center route, but has been expanded and is now being built all around the city, due to its increasing popularity. It does not even have to stop at intermediate points, and therefore is one of the fastest ways to travel above ground, while offering a high degree of comfort. In the less frequented areas there is just a pair of rails for each direction, some still under construction, but in central points already many lines are bundled together to keep up with the ever-increasing need of citizens to move into the city as fast as possible. However, getting to the inner city without intermediate points or changing has its price. PRT is still an expensive option to get around the city so that it is still used foremost by people who put a very high price on saving time.

As he is not under time pressure, Tom thinks about taking his e-car, parking it at one of the many parking spaces across the inner city belt and walking the rest of the way, as the headquarters is located in the small inner city zone which was declared to a private-vehicle-free zone three years ago.

Driving an e-car can sometimes be a rather fast way to get to the inner city boundary, as congestion has decreased over the last years because of many regulations which have taken place, e.g. extra lanes for e-cars and hydrogen vehicles. Tom still has the specific news headline in mind: "Lanes only for emission-free cars - eliminating access to city for people who cannot afford them". Despite this small improvement, congestion remained a problem for the citizens and commuters as the megatrend urbanization continued, especially in the attractive city Tom lives in. Therefore it is no surprise that the municipality also decided to massively expand the public transit system to pull their weight in reducing congestion in 2020. The following referendum to enlarge the metro

system was affirmed positively by the inhabitants, although investment costs were very high. Not only the pro-government media celebrated this decision as a breakthrough in people's mindset concerning environmental awareness.

Remembering that his wife needs the e-car today, Tom checks with his smartphone whether there is one of the public e-cars or e-bikes available. The next sharing point would just be 100 meters away from his home. Travel time would be nearly the same, just slightly longer as they are not as comfortable as his private e-car. The last and also cheapest option would be the previously mentioned public transit system with the tram or the metro which allow access for people of all income brackets, e.g. the second class pass allows travelling within the city for only a small amount of money per month, consequently overcrowded at any time. However, first class is available for a small extra charge. It provides comfortable seats and latest news update via TV screens. Furthermore, these means of public transport are also modern, equipped with energy-efficient technologies, and very secure. The headline "Municipality spends another 5% of the budget for expanding the video surveillance and security in public transits" Tom reads when passing a newspaper shop, just confirms his impression that the municipality does strive to provide an excellent transportation network.

Although the first class is also overcrowded in the morning rush hour, he decides to go by metro because he likes the vital, colorful and diverse going-on as well as the many shops and services around the stations. Tickets for each route and duration can still be bought at ticket machines, but also on the way via smartphone debiting your bank account automatically. Not wasting any time, he takes a single ticket paying with his smartphone when entering the metro. During the travel time, he thinks of all these positive metro and tram developments that would not have been possible to this degree if the municipality had not pushed the privatization of public transit operators, who highly compete among each other to get as many passengers as possible. All of a sudden, Tom is jolted out of his thoughts by a ticket inspector. Briefly showing his smartphone with the respective ticket file in the "GoTicket" application, he exits the metro and heads to the office building, again deep in thought: "When will they install the latest technologies, so that ticket inspectors can identify fare dodgers just by passing by and receiving signals either from smartphones or the small chips on the tickets? Implementation wouldn't be that expensive, would it?"

Although Tom appreciates working at home, he always looks forward to having meetings with the business team in the newly built headquarters. Beside the architectural beauty, the smart energy system, which coordinates the energy supply, is a unique characteristic of this technologically advanced, eco-friendly building. Being built with polymer layers that integrate solar modules and having the most efficient geothermal technology, it is almost autonomous in energy generation. Besides, excellent insulation and smart sensor systems,

which equilibrate indoor and outdoor temperature and thus minimize energy consumption by adapting the right temperature by heating or cooling, as well as windows, curtains and shutters, that open and close automatically depending on the weather, provide an energy-efficient and comfortable working environment. Obviously, there were some buildings which followed the same approach considering energy-efficiency, but this headquarter has been the first without major technological problems when it was implemented. Its beautiful architecture in combination with the integration of the latest technology and its optimum location in the inner city next to the famous park made it the newest sight of the city attracting even more tourists.

Tourism has increased a lot in the past years as the city succeeded in being a model eco-city with various green zones and the latest eco-friendly technology considering sustainable infrastructure and buildings. Therefore it was possible to climb up to and defend the first place of the Quality of Life in Cities Index gaining many international grants as a pioneer eco-friendly city.

After the first session of the meeting is done, the sunny weather tempts all team members to have their lunch break in the park, a wonderful green zone installed five years ago when public transit in this area was moved below ground. The only vehicles one can see are bicycles and some electrically driven, noiseless vans which supply restaurants and shops with necessary goods. Routed on particular tracks they allocate the goods that have been ordered online the day before to the respective storage places of the shops. An automatic routing system calculates the shortest ways according to the received orders, so load is distributed efficiently and transportation costs are minimized. Moreover, sophisticated sensor systems and video cameras avoid crashes between single vans or with pedestrians and are able to report attacks and crimes on vans as well as in the surrounding area to the municipality, so that police can act immediately.

After deciding on a lovely restaurant in the middle of the park to have lunch, the team members' conversation promptly ends up in a discussion about the charging stations and the latest headline "Where can you still get gasoline in the city?". The overall opinion in the group is that it is incomprehensible as to why some people still drive cars with ICE. Some can put themselves in the position of those people, as they had not been able to convert to e-cars up until recently as well. On the one hand the advantages do not outweigh the cost factor of buying a new e-car and on the other hand they consider the amount that they contribute to pollution with their ICE cars to be insignificant since they do not need them very often. The consensus of the team members is that one can only hope these people will see the error of their ways rather sooner than later, although the ever decreasing number of locations where you can get gas, as well as the continuously rising gas prices will probably force the rest of the doubters to relent in the end. The conversation then shifts to the charging infrastructure. Only few gas stations are left and the solution to integrate relic

gas stations into the new and improved infrastructure by converting them to electricity and hydrogen charging stations is deemed to have been the ideal move of the government. The possibility to charge the e-car at home has also made life easier, which immediately shifts the conversation to the smart grid. While some prefer to have a self-sustainable household, being an active part of the smart grid by feeding excess electricity to it, others only use the connection to it to obtain their electricity from centralized renewable utilities, such as offshore wind parks and solar energy farms. The first approach makes use of the "Feed the grid, earn money!" option. This famous headline was a topic of many discussions a few years back. Although feeding the grid does not make the user a millionaire, many households not only keep costs at a minimum but also gain a much needed financial support after reaching the break-even point of the investment. Others, who decide for the second approach, either prefer to not or just simply cannot invest an initial huge amount in their autonomous energy generation, but are then not able to earn some money.

Independent from the approach, a smart device installed in every home allows easy access to the options and a customization of the settings how energy supply should be arranged as well as an overview of the current energy status at home and what the consumption has looked like in the past hour, day, month or year. This overview can also be segmented by different devices if the user wishes. The application "HomeEnergy" for smartphones, is a new development, only two years old, and provides remote access to software installed on the smart device at home and its functions. A quick glance at his smartphone app "HomeEnergy" tells Tom hat he or his wife left on the lights in the kitchen as well as the heater in the bathroom and with one click per device he switches them off from his remote location.

Once the meal has been finished and the conversation has subsided, the group requests the bill in order to pay. Since the city traffic management is not the only one who offers a holistic mobile payment solution to their customers, they can pay their food and beverage bill quite simply with the "CityShopping" app on their smartphones, which has even made payment per person possible. Restaurants and shops decided around a decade ago to align their payment solutions in order to gain as much information about their clients as possible. At first privacy laws and issues were a hindrance until security concepts were established enough to ease all the users worries and avoid breaking the privacy laws. Now shops can customize their offers and therefore avoid a superfluous storage of goods, hence minimizing their storage and delivery costs.

After having finished the second session of the meeting, Tom leaves the building and decides to have a relaxing walk to the border of the outer city in order to then use one of the e-car sharing services which provide a huge fleet of e-cars. Taking one of the last ones - they are highly in demand for the evening rush hour - and unlocking it with his smartphone, he starts his way home. The fee which depends on the electricity consumption is depicted on a

fare meter. Tom is in a very good mood when he is driving through the streets heading towards the highway - listening to his favorite music (as the car radio just synchronized with his Internet music profile) while seeing that the ride will cost less than average because electricity market supply outnumbers demand at the moment. "Nice that competition among car sharers is so high that they offer fees depending on market prices!"

Besides the fun aspect, driving your car has become very comfortable as you do not have to worry about car accidents anymore since the new city traffic security concept was installed last year. With the help of the high-speed data processing vehicle-to-x communication is enhanced, so that speed limits set by the traffic management center cannot be exceeded and crossing red traffic lights is not possible because the car would brake automatically if you try to do so. Furthermore, sophisticated sensor systems recognize every object in front of the vehicle forcing it to break or even to stop if necessary.

Slowly approaching the suburb where he lives, he takes a look at the digital displays above him. They show the current approved speed limit, which is adjusted regularly, depending on the density of traffic on the roads, as well as the nearest car sharing drop off parking lot with available spots. The suburb has three of them. Once he has dropped off the car, he takes out his smartphone, checks again the available bikes around him, but then opts to have a wonderful evening walk home, listening to his music.

7.3.3.2 Signposts

From today's perspective, in order for the previous scenario to take place until 2025, major changes have to happen. Mostly these changes have to do with the state becoming more ecological. For this development it is crucial to have governing parties which have their main focus on environmental topics combining them with a sustainable economic and population growth. Thus, if more and more states start electing parties with eco-friendly programs, the developments in infrastructure provision will change to more ecological solutions and be more rapid. Since this radical political change is very unlikely to happen without any pressure to do so, a green movement in the population is needed, protesting for more green solutions in order to protect the environment, thus forcing the government to "go green".

One signpost could be the initial action of an institution to reduce CO_2 emissions significantly in order to tackle climate change and to position itself as leader in ecological thinking. One can think of international institutions with a high relevance such as the European Union launching an international competition, where the top ten greenest cities with the most efficient energy supply and green infrastructure solutions will be rewarded. The massive media coverage this competition evokes is enormous - it dominated newspapers' front pages, tv and internet news over months. On the one hand, the institutions would

Political Economical Social Technological Legal Environmental

1900 2000 2020 Time

1830
Asphalt road construction

1925
Traffic regulations

1940
Usage of private cars

1940
Gas station infrastructure

1940
Public transit

1940
Tolling for bridges

1940
Parking spaces

1955
Public transit

1980
Intelligent Traffic Management

1985
Public Transport privatization

1997
Hybrid taxis (NYC)

2000
Bike/Car sharing

2001
Environmental Protests

2005
V2X communication

2010
Stuttgart 21

2017
"Lanes only for emission-free cars"

2021
"Feed the grid, earn money!"

2023
"Where can you still get gasoline in the city?"

2025
"Municipality spends another 2m € for expanding the video surveillance and security in public transits"

Possible future headlines

Figure 7.5: Timeline of events relevant for infrastructure provision
Source: Own illustration

achieve their aim to enhance environmental awareness among the population. On the other hand, this leads to increasing popularity of its participants, which automatically become more attractive tourist destinations, just as these model cities had hoped for. The competition solely requires the solutions to be shared in the end. This leads to a fast progress and adoption rate throughout most of the international, also before unknown, municipalities.

Another, even more dramatic signpost could be a new, disruptive study about climate change. It gives reasonable explanations that climate change is caused by the high CO_2 emissions exhausted since the industrialization and has an even more sweeping effect in the future if nothing is done to limit the consequences. Even a former opponent would have to agree on the approach and results the studies show. In contrary to the first signpost, this time not an institution but the reaction of people would lead to a huge "green movement". Demonstrations and protests would be as dramatic as the effect itself and would force governments to act very quickly, not only on a national level, but also globally. Strict international treaties on CO_2 emissions would be signed to show that the government of every nation cares about their citizens' concerns.

Once the government takes action, infrastructure projects would be pushed. Besides, efficient traffic and vehicle concepts such as car sharing and bike sharing also could become more widespread. These proactive actions then would accelerate the measures taken by companies and private households, which have not been environmentally aware before this signpost, to reduce waste and pollution even more. In the end, an overwhelming share of the world's population could have completely changed its mindset concerning environmental issues.

A last signpost could be the number a high concentration of natural catastrophies in a short period of time. In the beginning, only a few nations would have to struggle with the consequences of these events. However with the occurrences of catastrophes becoming more frequent, reconstruction and assistance costs would rise, thus there also would be the pressure to react on environmental issues globally sooner or later to avoid setbacks that obviously have a negative economic effect, too. Compared to the previous signpost, awareness grows rather indirectly and more slowly by experiencing the state of emergency. Depending on level of the education and comfort, the initial activity could also come from the state's side in this case. Nevertheless, actions which would take place would be very similar to those mentioned in the previous signpost.

7.3.3.3 Value Map

Providing an improved infrastructure creates a number of values for a municipality which in turn create additional values for either the municipality itself, its citizens or other stakeholders. The core values discussed in the following can be viewed in figure 7.6, which represents the value map regarding infrastructure
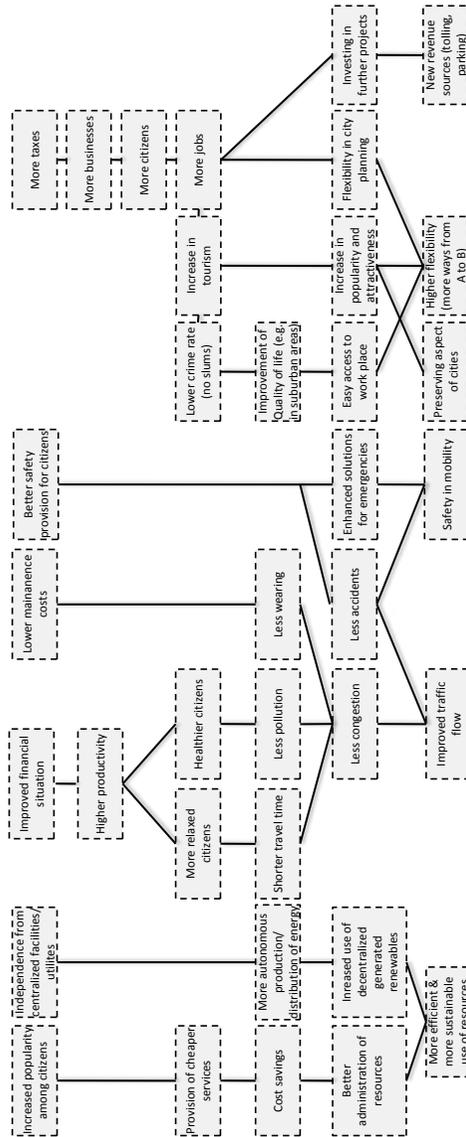
Figure 7.6: Values derived from building infrastructure, perspective of a munici-
pality

Source: Own illustration

provision from the perspective of a key player, the municipality.

One of the main values of an improved infrastructure is the more efficient and sustainable use of resources. This could happen due to a better administration, resulting in cost savings and thus cheaper services. For instance, lower prices for using the metro could be offered to the public, increasing the popularity of the municipality. A second benefit of efficient and sustainable use of resources is that it could lead towards a larger usage share of decentralized generated renewables. As a result, a more autonomous production and distribution of energy would take place in the city and therefore the city would keep these activities independent from centralized facilities.

Additionally, an improved infrastructure provides an improved traffic flow and therefore decreases congestion. Decreasing congestion, meaning less stop-and-go traffic, has an impact on the wearing of roads and vehicles. Aside from this, less congestion entails less pollution which provides a healthier environment for citizens to live in. Traveling through a city or an area with less traffic implies a shorter travel time and consequently increased average speeds in traffic compared to the values seen today in large European cities [471]. A healthier environment, inhabited by healthier citizens, and providing shorter travel time, leads to more relaxed citizens, increasing the average productivity of a person and overall the quantity of work being done in the city. The municipality benefits because the productivity increase reflects itself in an improved general financial situation of the city.

Regarding the improvement of the infrastructure, an important aspect is the safety of everyone using it. Safety in mobility implies less accidents and improved means of evacuation in case of disasters. These aspects contribute to a general sense of safety felt by the citizens, thus an increase in the quality of life.

For a city that possesses a cultural and architectural heritage, a main value is the preservation of the appearance of the city. Keeping a city's appearance intact has the effect of increasing its attractiveness, making it a sought-after destination for tourists that appreciate the unmodified architecture. Naturally, tourism can be a significant revenue source for the municipality.

To add to the previous points, another value can be considered the higher route flexibility. This improves the ease of access to one's workplace, therefore giving citizens ample choice for their preferred living situation, be it in a suburb or the city center. The improvement of quality of life is connected with the crime rate of a city, the increase of the former dictating a decrease in the latter. In addition, tourists will appreciate the multiple possibilities of getting around when visiting the city, thus generating more revenues. Increasing the flexibility of the average citizen by implementing more ways to get from point A to point B also positively impacts the flexibility in city planning. Office buildings, as well as housing can be placed nearly anywhere, without the worry that people will have difficulties commuting. This aspect will increase the value of the city

Figure 7.7: The *Avanti* Logo
Source: Own illustration

in the eyes of investors, who will create more job places within the city.

New revenue sources generated through, for example, city tolling and parking fees, allow for further investments in projects for the city. This creates a virtuous circle because, combined with the improved travel flexibility, businesses desire to benefit from this trend and follow suit, building new locations in or around the city, depending on the aforementioned aspects, and in turn generating more revenue for the city in form of taxes.

7.4 Business Idea: *Avanti*

Avanti is a system that enables dynamic pricing for tolling and parking within cities. It is sold by a large scale infrastructure provider to municipalities and aims at improving their congestion, pollution and financial situation. Value propositions for the municipality, revenue streams for the selling company and further aspects of the business idea are detailed in chapter 7.4.1, whereas a description of the product itself and how it works for the average citizen is given in the following. The name *Avanti* (Italian for forward) and its logo (see figure 7.7) stand for the improvements regarding congestion and the municipality's financial situation.

Vehicle owners can either opt for static or dynamic pricing with respect to parking and city toll fees. In case of static pricing, citizens pay a predefined fee per hour for parking using conventional parking meters and per day for the city toll. As there are no tolling barriers around the city as there are on some highways, vehicles and therefore their owners are identified using cameras and automatic number plate recognition (NPR). These systems are already implemented in various cities (see section **??**).

In case of dynamic pricing, vehicle owners are required to register and to place a location transponder in their car in order to facilitate positioning and thus benefiting from lower fees for parking and tolling (see figure 7.8). Registered users pay per kilometer for the city toll, with the kilometer price depending on the current congestion on the specific road as well as the CO_2 emission of the car. This means that citizens can lower their payments by using less frequented streets or by taking the car during a less crowded time of the day and by using eco-friendly vehicles. Users pay per minute for parking, with the price depending on the attractiveness of the parking lot and the size of
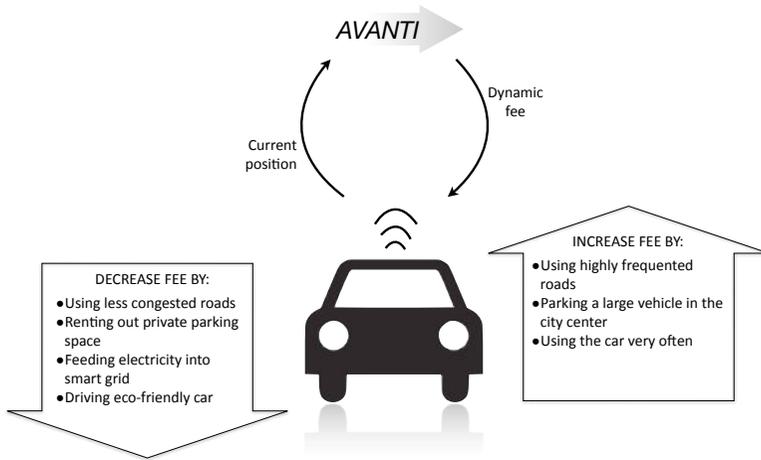
Figure 7.8: Overview of the way *Avanti* works for a registered user
Source: Own illustration

the vehicle. Therefore people who do not park their car in the inner city but rather at a metro station further away pay less as well as people using small and eco-friendly vehicles.

Citizens can further reduce their costs or even earn money by renting out their private parking spaces while not occupying them themselves. These private parking spaces are registered and treated like regular public ones, resulting in a higher number of publicly available parking spots. Similar to this is the opportunity of lowering parking costs by feeding electricity from your e-car into the public smart grid while parking on a dedicated parking lot.

In order to compute individual prices for registered users, their vehicles must be tracked, e.g. utilizing global positioning and mobile network access. Payments can be done in numerous ways, for instance by monthly bills, prepaid accounts or daily credit card debiting.

7.4.1 Business Model

To give a complete overview of the business model behind *Avanti*, a detailed description of nine key building blocks is provided in the following. This reference framework was proposed by A. Osterwalder and Y. Pigneur [472] and illustrates the relationships between the company that develops the product and the customer and how the whole business intends to generate revenues.

7.4.1.1 Customer Segments

The specialized product *Avanti* aims to reach one specific customer group, municipalities, which are responsible for providing a sufficient urban infrastructure for its inhabitants and commuters. Targeted by the value proposition to solve traffic and parking problems, as seen in section 7.4.1.2, are especially megacities which significantly struggle with these issues.

Potential customers can be segmented into municipalities without a tolling system and only static parking fee solutions, and municipalities which already have smart traffic management solutions, like a tolling system or an enhanced parking system that is not personalized yet.

Since this product offers a personalized payment solution for parking and tolling in urban infrastructure, a rather small but not widely accessed promising market can be entered. In order to leverage the first-mover advantage, a primary goal should be to first conclude contracts with as many traffic management centers of megacities as possible. Successful implementations could then serve as a model to attract smaller municipalities as a new customer group for the product.

7.4.1.2 Value Propositions

To underline the value that *Avanti* has for the customer, it is vital to state what kind of problems the municipality is facing with respect to infrastructure provision.

First and foremost, the most obvious and burdening problem is congestion, mainly determined by the fact that a large number of people use the same route at the same time. This results in a series of negative effects, including pollution, angry citizens or road wearing. Secondly, municipalities charge static fees for parking, missing the opportunity to support the usage of eco-friendly vehicles. Also, too few private parking places are integrated in the public system, contributing to inefficiency in the use of space. Finally, municipalities do not sufficiently exploit the toll system in order to generate additional revenue streams.

The product *Avanti* is seen as the solution that tackles each of the aforementioned problems and it has several key advantages that make it stand out amongst similar systems. It is foremost a long-term solution, designed to be supported and improved continuously. In addition, it is characterized by a high scalability, being suitable for a small city and a metropolis alike. Its core feature relies on dynamic and real-time tracking of vehicles, analyzing this data and calculating the fees, which constitutes a significant improvement of the current status of urban infrastructure. In addition, *Avanti* is scalable and adaptable to the city's needs and economic power. It can be implemented in a metropolis and a small city alike, while remaining a considerable income source for the municipality and a competitive advantage over other cities in attracting

investors due to better traffic conditions. Last but not least, its high degree of automization offers the benefit of reducing personnel costs.

The two aspects of the *Avanti*, tolling and parking, each have some specific advantages in responding to the needs of a modern urban infrastructure. A dynamic toll fee will lead to less congestion, since the people will feel encouraged to detour when going from A to B. The improved traffic flow will lead to an increase in the average travelling speed in the city and a reduction of pollution. The radical shift from the current static fee is favorable for environmentally aware citizens, who will feel that authorities are on the right track to promoting eco-friendly means of transportation or reducing freight traffic to counteract congestion. A major advantage of tolling is that it will create an additional revenue stream for the cities which do not yet benefit from such a system.

The implementation of a dynamic fee system for parking can be an additional method to promote environmentally-friendly cars because propulsion will be a factor when calculating the parking fee. It also leads to a better utilization of existing space, since location additionally influences the price. Largely contributing to this efficiency aspect is also the inclusion of private parking spaces in the public system. Lastly, adding extra services like electricity charging lets the municipality involve its citizens into the smart grid.

All of the above stated aspects illustrate how the integrated personalized tolling and parking fee system strives to solve the problems faced by the municipality. Next to extensive experience and technical expertise, the improved traffic flow, the increased attractiveness and the new revenue sources are all convincing aspects for choosing the company's solution.

7.4.1.3 Distribution Channels

As the complexity and customization of *Avanti* obviously does not allow an indirect distribution, an own sales force is the most important aspect when it comes to marketing the product.

Awareness   Because of the small customer group, there are only few reasonable options to raise awareness about the holistic solution the business concept *Avanti* offers. Targeted addressing of those responsible for the municipality through direct contact channels, e.g. personal talks, could be an approach to propose a first meeting where the business idea is presented. Lobbying by staying in touch with municipalities or using already existing contacts is another option to have a chance to present *Avanti* to the customer.

Evaluation   If interest is aroused in the first meeting, a workshop with a specialized consultancy team of the company is offered in order to help customers to evaluate the value proposition. This no-cost workshop, including a more

detailed presentation, clips of prototypes or existing implementations and further information literature, should finally convince the customer to buy *Avanti*.

Purchase As the contract is jointly developed with the provider so that it fits the particular needs of the municipalities, an official appointment, that also can be announced publicly, for signing the contract for *Avanti* is arranged.

Delivery The respective hardware components of the business concept are delivered with an internal installation service. If desired by the municipality, it could also be sent with goods delivery services, so that installers who collaborate with the city management could do the implementation. Software components are delivered and installed by the company's service team.

After sales Providing a post-purchase customer support is vital for *Avanti,* as it is a complex, data-based business concept. Options for different channels of maintenance support could be phone-based services, coachings in situ, access to online platform data or 24/7 services that provide quick assistance if major problems within the system occur, as it is explicitly described in the section 7.4.1.4.

7.4.1.4 Customer Relationships

In the following paragraphs the customer relationships towards the municipality that are important for this business model are explained.

Personal assistance and self-service Due to the small number of potential customers, the personal assistance and self-service relationships are of utmost importance and are the main focus, whereas the other relationships have a supporting and extending function. First off, this relationship contains a direct support channel which is the first step to take in case of an error. It will help evaluating whether or not the problem is easily solved. If it is a problem of greater complexity, a maintenance team will be needed. The municipality can either choose to have their own personnel to maintain the system or hire a team or company of maintenance workers. However, as a maintenance worker for the implemented system, attending trainings in order to properly take care of the system is unavoidable.

Automated services Belonging to the supporting services, there is an automated service which is part of the *Avanti* software system. The sole function of this automated service will be to monitor the entire system. Depending on the occurring error, it gives warnings accompanied with detailed error messages. It will also predict the time and location of the next hardware failure, in order to shorten the breakdown span of a link in the system.

Communities and co-creation　Lastly, in order to gain the support of the citizens, which is important to the municipality, advertisements specific for each city will be necessary in order to raise awareness about the citizens' opportunities to lower their costs. Online communities would be beneficial as well, allowing citizens to give feedback, by voting for or against other users' ideas and comments. Giving the people a platform where their concerns and ideas can be heard, also allows the municipality to react accordingly.

7.4.1.5 Revenue Streams

Revenue streams can be created either by one-time or ongoing payment flows, both possibilities being illustrated in Figure 7.9. Hardware components are categorized into one-time revenues, as they have to be paid once and then need to be installed in order to run *Avanti*. On the one hand, there is hardware such as positioning devices, servers and cameras for NPR bought from suppliers. All of them could be sold with an extra charge on the price the suppliers demand, since some efforts have to be made to establish the buyer-supplier relationships (see section 7.4.1.8) and to then provide the respective amount of hardware the customer needs. A discount could be given if a high number of such hardware components is demanded. On the other hand, there is hardware which could be produced by the company itself because of the already existing knowledge of a large-scale player. Besides, add-on features like smart grid plugs for parking lots as well as the access system to the grid could be offered by the company. In contrary to the purchased components, a higher price could be demanded for these since nobody else would offer this hardware.

Although there are some profit opportunities just mentioned in the hardware paragraph, the largest part of revenue streams can be realized with ongoing payments for software licences as well as for maintenance and service. Software packages for the personalized parking fee or tolling system are licensed for a particular period of time. In order to continue using *Avanti* after this timeframe, the customer has to obtain another license. Further revenues can be gained with value-added services, like coachings or 24/7 services demanded by the customer, as well as access to support hotline services or to the online platform data.

Furthermore, two different financing solutions are to be offered. The first, called "Pay Everything, Get Everything", is rather self-explanatory: the customer has to pay all hardware components as well as the software packages and maintenance support he demands, but also gets all the money which is charged by the commuters. The second, "Step by Step", is a leasing model. The company rents all hardware components for free, whereas software packages and maintenance support still have to be purchased. The profit gained by the municipality then has to be shared until the municipality has repaid the hardware investment. This provides an advantage for municipalities that cannot afford an high initial investment, but want to have *Avanti* installed.

One-time revenue

- Positioning devices
- Servers
- Cameras
- Parking equipment

Ongoing revenue

- Software licenses

Profit margin
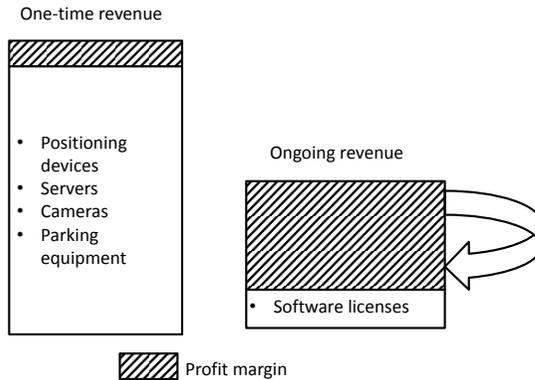
Figure 7.9: Revenue streams for the *Avanti* system
Source: Own illustration

7.4.1.6 Key Resources

Developing, implementing and maintaining this product requires numerous resources which have to be assembled. Some resources are acquired from suppliers and partners, others are owned or produced by the large scale infrastructure provider itself.

In order for the system to be installed, several key physical components are needed next to obvious existing components like roads and parking spaces. These consist of highly developed and widely available elements, most notably cameras for number plate recognition, location data receivers and mobile network transmitters for the transponders as well as servers and further IT equipment for the software and databases. These components can be considered off-the-shelf products, meaning they do not have to be specially produced and can be obtained by suppliers. Also included in the required physical resources are the citizens' private parking spaces which are rented out while the owners do not need them themselves.

In terms of intellectual resources, the software managing the dynamic pricing is to be developed by the system provider itself. Although possible, this task should not be outsourced as it is of high strategic importance to the product and the company. In case of a joint development or maintenance with a foreign company, privacy issues might arise due to different privacy regulations. Another crucial intellectual resource is a database of all registered vehicles and their owners from a partnering state agency. Depending on privacy laws and the citizens' attitude towards this issue, getting access to such a database might be

difficult or not even possible. Furthermore, the usage of local mobile networks and GPS or a similar positioning system is vital for the transponders to receive and send data.

Regarding financial resources, routine processes for financing can be applied. Finding investors is not necessary as this product is expected to be developed by a large scale infrastructure provider.

Finally, human resources are the key for this project to be successful. Employees in charge of selecting, approaching, consulting and negotiating with municipalities are needed as well as personnel responsible for the software and hardware. Additionally, staff from the municipality is required to check for citizens abusing the system. Service and maintenance could be either handled by employees of the city or the company itself.

7.4.1.7 Key Activities

In order to create the value proposition stated in section 7.4.1.2, earn revenues and maintain the customer relationships, there are some key activities that must be completed. These are clustered in three key focus areas: Production, problem solving and platform/network.

Production   To bring *Avanti* to the market, the hardware and the software will have to be provided. The hardware has to be acquired from equipment manufacturers. Some parts like sensors, electronic panels or smart grid equipment are already produced in-house and their usage in the tolling and parking system will lead to cheaper development costs for the company. Software is the most important part of *Avanti* and its development is a key activity in order for our product to bring the promised benefits for urban infrastructure. This demands prototyping, iterative development, testing and continuous after-sales support.

Problem solving   A series of concrete activities will need to be executed in order to make sure the customer's problems are professionally dealt with. Firstly, research has to be done about the cities and the tolling and parking infrastructure needs analyzing, since some already installed components could be leveraged e.g traffic information and congestion sensing. The municipality would need to be closely consulted about their specific needs and requirements, so that *Avanti* could be adapted to fit these needs. After development of the needed software, several trial runs will be made and feedback collected. Deployment will be gradual to ensure a smooth transition to the new tolling and parking payment system. After installation, assistance will be given in case of malfunction and further improvements will be made.
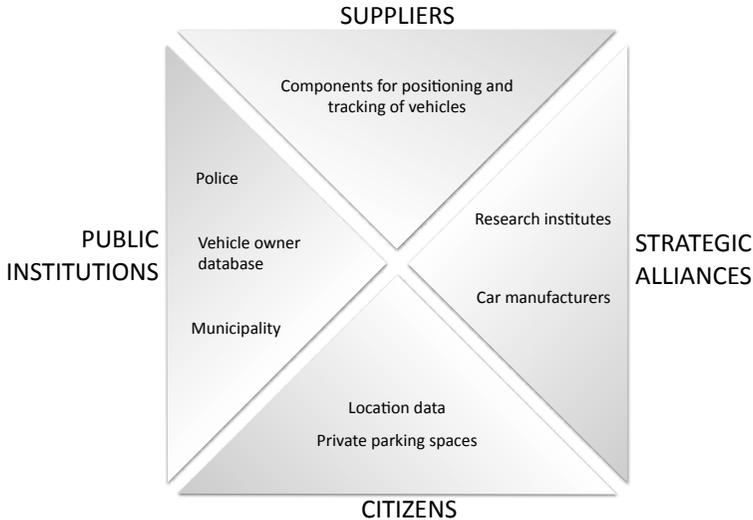
Figure 7.10: Overview of the key partners involved in the *Avanti* system
Source: Own illustration

Platform/Network   A communication platform between cities that use the *Avanti* system will facilitate the exchange of best practices and additional ideas regarding infrastructure. For the tolling aspect of our solution, it is also important to facilitate the transition of a vehicle from one city to another within the same country if the two cities agree on fees. No additional transponders will be necessary in this case.

7.4.1.8 Key Partners

In order for this system to be realized, working with several partners is mandatory. This includes collaborations with suppliers and public institutions as well as alliances with non-competitors. An overview is given in figure 7.10.

First, buyer-supplier partnerships need to be set up in order to obtain common hardware components, including cameras and GSP receivers. The company benefits from extending its own capabilities since it may not know how to produce e.g. cameras. This way the company does not need to manufacture every part by itself. For the installation of the hardware within the city, partnerships with local companies can be established. Furthermore, partnerships with mobile network providers as well as possibly licensing the usage of a positioning system are crucial as they allow for realizing the functionality of the transponders which is the basis for computing the dynamic prices. By sharing the infrastructure, both parties lower their costs and benefit from economy of scope effects. Additionally,

partnering with universities or other research institutions can contribute to improving the product. This can be accomplished by exchanging know-how and experiences regarding areas like real-time routing, high speed data processing and large scale data base systems. They can bring new algorithms and advancements concerning these areas.

In order to ensure the intended usage of the system by the citizens not using a transponder, local authorities have to check for people cheating or abusing the system. If the municipality is convinced to reach its goals regarding pollution and congestion using this system, it will most likely be easy to delegate this task to the local police. As they are already in charge of managing all things traffic and as they are respected among the population, the police is probably the best choice for this job, rather than personnel form the *Avanti* provider itself. Next to the police, another public partner is needed in order to make the system work for not registered car drivers, e.g. occasional visitors from different cities. Number plates recognized by the cameras need to be linked to the name and address of the vehicle owner in order to send bills there. Therefore a database of all licensed cars and their owners is required from the respective government agency.

In addition to partnerships with public institutions, a close collaboration with the citizens is necessary for renting out private parking spaces while the owners do not occupy them themselves. This incorporates offering incentives and promoting the benefits for the participating users.

By establishing strategic alliances with car manufacturers, transponders can be pre-installed in vehicles. As a consequence, the system provider gains an easy way for the citizens to obtain and use the transponder, whereas the car manufacturers benefit from the ability of offering vehicles including even more services.

7.4.1.9 Cost Structure

A big part of the revenue is formed by the costs of production. They include costs for creating and delivering a value, as well as maintaining a customer relationship and generating revenues. In the following the various costs included in the parking and tolling system *Avanti* will be detailed.

Fixed costs   Costs, such as the rent or value of the manufacturing sites, as well as salaries for standard personnel and all costs concerning software and software updates are accounted to fixed costs. The latter two include salaries of the software development team and the needed hardware.

Variable costs   Variable costs are made up of costs per hardware devices bought from the market, the salaries of the personnel training the maintenance teams, as well as costs per resources needed to produce other hardware items

needed in either the parking or tolling system. Hardware bought from the market, first of all depends on the size of the municipality and describes all parts the provider of the infrastructure system does not produce on its own, which could be e.g. video cameras and standardized plugs for the smart grid. Other resources needed to implement the system are the controlling software as well as salaries for the employees installing, building and supporting the system throughout its lifecycle and hardware produced by the company.

Economies of scope   The company behind the product is a large scale company which provides a variety of products concerning infrastructure among other things. Therefore the know-how which has long been established in the area of software development for traffic management systems and the general build up of large scale products will both benefit the product development.

Economies of scale   Concerning economies of scale, the most obvious benefit is buying components on a large scale, resulting in a cheaper price per item. Other than that, the production costs of components of the provided tolling and parking system can be decreased by producing them on a large scale.

7.4.2 Scenario Robustness

In order to evaluate the robustness of our product, the benefits and downsides of such a system will be described in the following with respect to each of the three scenarios.

When it comes to the main scenario, "Conservative goes Innovative", the company selling a system for dynamic pricing benefits from the high dimensions of the key drivers. A high degree of political input has already lead to measurements dealing with pollution issues, for instance appointing street lanes specially to e-cars or subsidizing citizens that purchase eco-friendly vehicles. However, even though the increasing usage of e-cars results in less pollution, it does not solve any congestion problems at the same time. Besides, after numerous public investments in infrastructure provision, concepts contributing to gaining new revenue streams are welcome. *Avanti* is a plausible solution for tackling the mentioned congestion and budget issues. Moreover, it can be attractive for e-car owners that are eager to contribute to the public smart grid, since they have the opportunity to lower their parking and tolling costs by feeding electricity into the grid while occupying public parking spaces. Due to the fact that the population is characterized by a high environmental awareness, people might be especially motivated to detour or find out about alternate routes. This could be accompanied by an extensive usage of an online community dedicated to the exchange of hints and experiences with respect to exploring the best routes and parking spots.

On the downside, many citizens have started working at home, while others have begun using the personal rapid transit on a regular basis. These developments already contribute to pollution and congestion reduction, so this might be an indication of a lower need for a system like *Avanti*. Additionally, it cannot be used by the municipality as an incentive for the citizens to purchase e-cars rather than combustion engine vehicles, since most of the inhabitants already own eco-friendly ones.

In terms of the other scenario dealing with a capital city in a developed country, "Mobility Takes a Back Seat", there are also several aspects emphasizing the need for a system like *Avanti*. However, due to a few striking arguments, the realization of such a project can be considered very unlikely. Starting with the facts that stress why a system for dynamic pricing is beneficial for the municipality, a crucial factor is the intense amount of congestion within the city. As the better part of the citizens own ICE vehicles rather than e-cars, this point becomes even more important with respect to emissions and pollution. *Avanti* could serve as an inducement for the population to use and purchase more eco-friendly ways of transportation. Another vital aspect in favor of this system is the serious financial situation of the municipality in this scenario. New ways of generating revenues are highly appreciated, something that a city toll can provide.

Opposed to that, the low priority of improving the mobility infrastructure due to economical events is marked by minimal public investments in this area. People also struggle with their jobs and their private financial situation, making the government focus on other projects that are considered more important. Additionally, the loss of trust in new technologies has lead to strict privacy laws, making individual vehicle tracking almost impossible. As a consequence, it seems unlikely to see this system happen in this scenario.

Finally, in terms of the third scenario, "Bridging the Gap", the robustness of this product is mainly determined by the impacts of the political framework and urbanization. The high political input aiming to decrease pollution has lead to the fact that old and polluting cars are already banned from the city center. Next to this, the government already offers incentives to its citizens for obtaining e-cars. Therefore, the need for *Avanti* does not seem to be high at first glance.

However, since people continue to buy combustion engine driven vehicles and since the increasing number of commuters stimulates congestion, a system like *Avanti* might be useful to the municipality in this scenario. This is supported by the fact that a city toll with static pricing as well as great amounts of public parking spaces already exist, representing the optimum conditions for implementing this system. This is especially due to the fact that the population is frustrated by the additional costs of a city toll, so dynamically computed prices illustrate a good opportunity to lower costs. The government can further benefit from generating revenue by charging for the formerly free parking spaces,

which on the other hand most likely leads to dissatisfied citizens. The success of this project in this scenario also depends on whether its realization is postponed or abandoned altogether despite its advantages due to high expenses, just like other undertakings in infrastructure provision.

7.5 Conclusion

The evolution of urban infrastructure will be one of the main pillars for changes in the urban mobility landscape in the next fifteen years. This process is shaped very much by a series of drivers, and the specific combinations of their dimensions leads to diverse challenges concerning infrastructure provision. There are several directions in which technological progress, environmental awareness and political framework can drive the future of this sector. These will be further influenced by some more certain tendencies with less impact, the additional drivers market structure, availability of resources, industry standards, customer acceptance, urbanization, demographic changes and social needs. Taking all these factors into account, the three scenarios presented in section 7.3 attempt to give a detailed insight into how the multiple facets of infrastructure evolve in developed as well as developing countries, the latter situation being illustrated in the "Bridging the Gap" scenario. It is essential to note that specific events can steer the same situation towards different outcomes, for example a financial crisis severely changing the investing priorities and the citizens' concerns in the "Mobility Takes a Back Seat" scenario. In contrast to this, the "Conservative Goes Innovative" scenario unfolds itself in a booming economy.

To find an opportunity for a business idea in the infrastructure provisioning market, core values for municipalities are essential. In that sense, the *Avanti* system is looking to reduce congestion and pollution throughout the city, provide a better utilization of space and offer an additional income stream for the city. Authorities can benefit from the personalized toll and parking fee system directly through these revenue streams, or indirectly through an increased city attractiveness for citizens, tourists and investors. In addition, it is essential to note that *Avanti* is an additional way to incentivize the use of eco-friendly vehicles in the city. The robustness of the system to the described scenarios is remarkable, as *Avanti* would be just as suitable for a developed city, where congestion and pollution need to be handled, as well as for an fast evolving city which needs to finance further investments.

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8

Chapter 8

Mass Mobility

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The future of mass mobility depends on the development of three key drivers. The first key driver is Energy Prices. This driver reflects the current level of energy prices. The second key driver is Ecological Policies. It determines to what extend politics support mass mobility with subsidies and laws in favour of this mean of transportation. The third key driver is City Density. A very urbanized city usually has a high density. A widespread city with a lot of people living in the suburbs has a low density.

A variation of these key drivers leads to different possible scenarios. Two first scenarios are Chaos City and Market Decides. The third scenario Green World is the one that is focused on most within this article. As in this particular scenario Energy Prices are high, Ecological Policies are high and City Density is high, this is the perfect environment for the implementation of innovative mass mobility solutions. The demand for public transportation is high as energy prices are high and governments support these means of transportation. Therefore, cars are not allowed in inner cities and public transportation takes over.

In the scenario Green World, a need for innovative mass mobility solutions arises. An invention that could evolve out of this need is the Travelator. The Travelator consists of two or three walkways with different speeds that are arranged adjacent to each other. Passengers can jump onto the slowest lane and crossover to faster lanes in order to bridge larger distances. The advantage of this new transportation mean is that the system is emission free and no stops at intermediate stations are needed. Therefore, the Travelator could be a widespread mass mobility solution in the future.

8.1 Introduction

Mass mobility will continue to play an important role regarding urban mobility. Moving many people at once is a lot more efficient than private motorized transport in terms of energy consumption, number of transported passengers and environmental friendliness. Moreover, mass mobility ensures social equity and efficient use of public resources. With a growing worldwide population, space and therefore congestion issues will arise if mass mobility solutions are not integrated properly. [476, p. 1]

Three key and several additional drivers have been determined to forecast urban mobility scenarios with respect to mass transportation. By altering the dimensions of the drivers, three different scenarios have been developed. These scenarios are presented in detail, with a focus on the main scenario Green World. In all scenarios, mass mobility and its implementation into the city structure are of vital importance.

To counter upcoming social challenges that already have been stressed in the first part of this book, it is necessary to also develop new technologies. In chapter 8.4 a mass mobility solution is presented, which is applicable in dense city centers with a low percentage of private vehicles.

8.2 Driver Analysis

Drivers are important to predict developments in the future. Some drivers can be referred to as key drivers. These are most essential to develop scenarios. Key drivers are those that have a high impact and a high degree of uncertainty. In Figure 8.1 the three key drivers Energy Prices, Ecological Policies, and City Density are brought into context with the degree of impact on mass mobility and uncertainty. The first part of this section will further introduce these three key drivers. Other drivers are referred to as additional drivers. Seven additional drivers will be presented in the second part of this section.
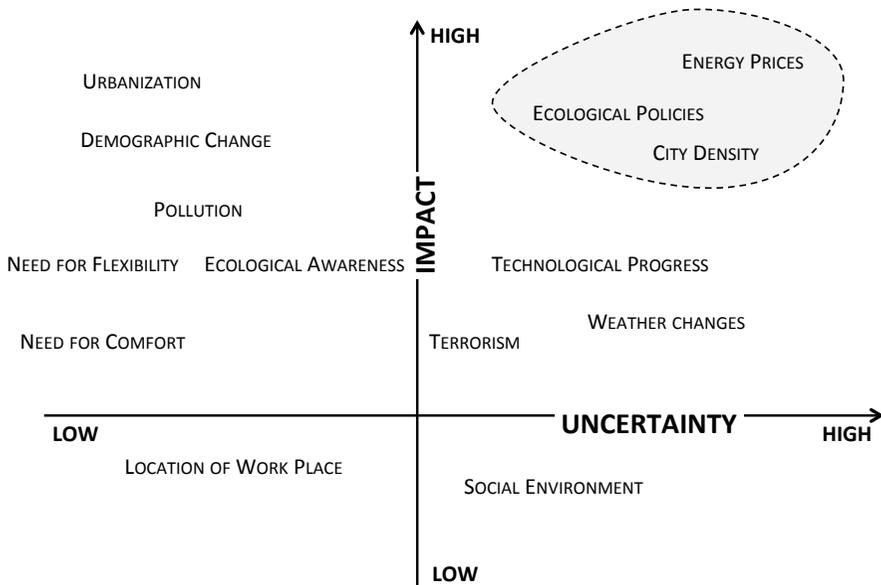
Figure 8.1: Impact-Uncertainty Matrix of drivers for mass mobility
Source: Own Illustration

8.2.1 Key Drivers

Within mass transportation, the three key drivers are the development of energy prices, the introduction of ecological policies such as subsidies for public transportation systems, and the density of cities in connection with urban policies and population growth.

8.2.1.1 Energy Prices

Description   When considering the possible development of mobility in the future, the price of energy is a key driver. Demand for energy is rising constantly due to the rising world population and social changes such as the development of a worldwide middle class. At the same time, all resources are scarce. Especially primary fuel reserves are limited and fuel production can not be increased much further. One idea to decrease energy consumption could be to increase the usage of mass mobility. Means of mass transportation can carry a lot more people for the same amount of primary energy than personal transportation.

Possible Developments   It is uncertain to which degree and how quick the prices will change. This is illustrated for Low Sulfur Crude Oil in Figure 8.2. Although the Energy Information Administration of the United States proposes

a reference price until 2035, it still states that very high or very low oil price developments could be possible [473]. This results also out of uncertainties whether non-OPEC states will provide their oil also to other countries [473]. Therefore, two dimensions have to be considered, one with high and one with low energy costs.

Annual Average Price of Low Sulfur Crude Oil
Real 2009 US-Dollars per Barrel
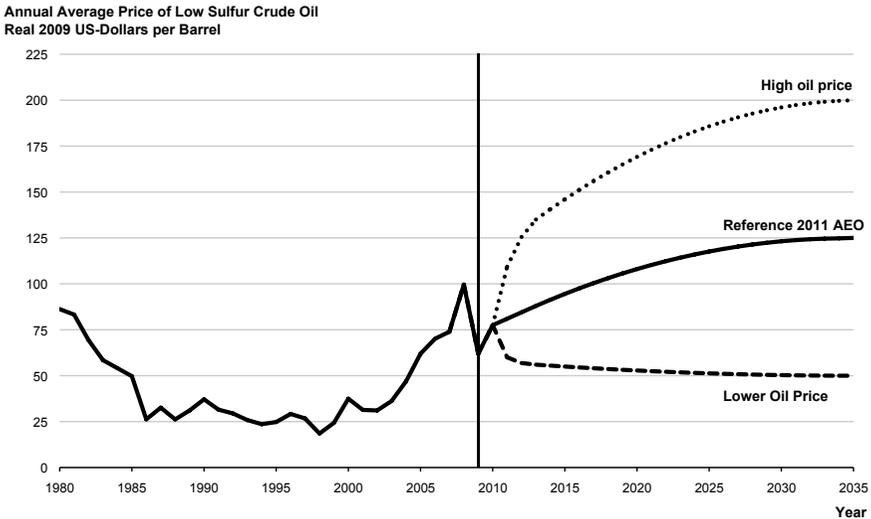
Figure 8.2: Different possible developments of oil price
Source: Own illustration adapted from [473]

High Energy Prices: This dimension refers to an exponential or breaking increase in prices. The development of this dimension depends inter alia on the demand side. This means that prices will rise when energy demand of emerging countries keeps rising and also developed countries continue their high demand for energy.

Another role plays the supply of energy. As stated above, if non-OPEC states will not provide their energy to other countries, a higher price is inevitable. If no new sources of fossil fuels will be found, then supply can not meet demand as well as old sources will be running out.

Governments on global or national level could enforce new energy policies such as the introduction of exhaust taxes or subsidies for certain types of green energy. This furthermore results in higher Energy Prices. Introduction of emission certificates could also have significant impact on Energy Prices. Whether emission trading occurs nationally, supranationally, or even globally, an increase in costs for energy producers and therefore also an increase in prices

will be the result.

Some countries with high primary fuel reserves are politically unstable and therefore fuel supply is to some degree a fragile system. A crisis in such a region could result once more in higher prices for primary fuel.

When Energy Prices are high, even without policy regulations the need for mass mobility in cities rises, as less energy per traveler is consumed here in comparison to personal mobility when e.g. driving cars. Furthermore, other energy sources such as renewable energy could be used, as mass mobility solutions are often using electricity instead of combustion engines.

Low Energy prices: This dimension refers to a moderate increase, stagnation, or even decreasing of Energy Prices. This dimension occurs if energy demand increases slowly and new primary energy sources were found. Some countries and companies are already researching in mining for these fuels in the deep seas or even underneath the polar ice. If successful, prices might stay comparably low to the dimension stated above.

New technologies in terms of improving efficiency of energy consumption could slow down price increases as well. The dimension "low Energy Prices" could result in less support for means of mass transportation unless policy makers support the usage through incentives and the construction through subsidies.

8.2.1.2 Ecological Policies

Description   Ecological Policies are measures that are raised by legislation in order to regulate the mass transportation sector. The legislation could result from national laws but also from supranational agreements such as EU directives.

In order to be relevant for this driver, guidelines have to benefit mass transportation directly with subsidies or by granting competitive advantages to mass transportation operators such as a simplified approval procedures for the building of infrastructure elements. However, regulations that favor means of transportation that are not considered as mass transportation are also relevant. These regulations raise opportunity costs for users of conventional transportation means for switching to mass transportation and will have a negative impact on passenger numbers of public means of transportation. Therefore, all measures affecting mass mobility are influencing the driver Ecological Policies.

Possible Developments   The driver Ecological Policies has two dimensions which are referred to as "high" and "low".

High Ecological Policies: High Ecological Policies means that a high degree of support for mass mobility is provided by legislation such as a lot of subsidies. The following situation is an example for high Ecological Policies: The EU enacts a new directive that supports the EU-wide implementation of mass mobility

solutions. National governments are forced to convert the directive into national law and start to heavily subsidize mass transportation operators. Framework conditions for such businesses improve and more mass mobility companies are attracted to invest into mass mobility. Competition in the mobility market increases and ticket prices decrease. Therefore, opportunity costs of not using public transit rise and less people will possess personal means of transportation such as cars. Due to declining economies of scale, the total costs of ownership of personal means of transportation rise and therefore opportunity costs rise even more what leads to a spiral. Such situations are driven by high Ecological Policies.

Low Ecological Policies: Low Ecological Policies means that such policies are not existing. In fact, it is possible that they are not only not existing, but that the majority of policies favor rival transportation means. If those policies predominate, the driver Ecological Policies would also be considered as low. Low Ecological Policies can be described the following way: As a new way of manufacturing high-performance batteries at a significantly lower price point has been discovered, the production of e-cars becomes fairly cheap. The government sees the future of Urban Mobility in these small and emission-free vehicles. Therefore, manufacturers are heavily subsidized and mass transportation becomes less important. As it becomes cheaper to own an e-car, the opportunity costs of using alternative means of transportation such as public transit rise. Due to the process described above, this spiral is self-enforcing. As mass mobility becomes less important, this situation is a blueprint for low Ecological Policies.

Ecological Policies are an important driver of mass mobility as they could decide whether public transit will be a future mean of transportation at all. The unpredictability of political development makes it even more important to take into consideration different possible outcomes of this uncertain driver.

8.2.1.3 City Density

Description   Regarding the key driver City Density, it can be distinguished between urbanization and suburbanization. These terms are used to describe the development of urban areas. Urbanization can be defined as an growth of urban areas. This means, that more and more people move from the suburbs to urban areas. The population density of the city is getting higher. Suburbanization describes the opposite. People move from urban areas to the suburbs, so that the population density of the outskirts is growing. Population density is an important driver of mass mobility. Table 3.2 shows that the density in urban areas will increase worldwide until 2015. However, it is estimated that the annual urban growth rate will decrease in value from 2015 to 2020.

Possible Developments   The key driver City Density has two dimensions - high and low. The dimension of City Density changes in response to several reasons.

High City Density means increasing urbanization, so that an efficient public transport network is needed. Urbanization can be caused by higher economic opportunities in the city. Cities can be regarded as a place that centralizes services, jobs and wealth. Most of the businesses are located in urban areas, as well as entertainment places and other services, like medical services. Therefore, the job opportunities are better and especially the elderly move into inner cities considering the better medical care. Moreover, living in urban areas can also be attractive to younger people due to the better quality of education, such as renowned universities. Due to the high population in urban areas, the social community is much more diverse than in rural areas, so that socializing is easier. Cities with high density are faced with the problem, that traffic is high and space is low. Therefore, space saving solutions for mass mobility have to be realized. Research has shown that private cars consume 24 times more space for a passenger, and therefore more road space, than a bus. This leads to the fact, that in cities with high density, a high need for mass transportation systems occurs. [477, p. 5]

Low City Density means that the trend leans towards suburbanization. In this case, the requirements for public transportation systems are different and mass mobility solutions are less needed. Suburbanization can be caused by high rents and land prices in inner cities. Furthermore, the quality of life in urban areas is lower than in rural areas because of pollution caused by industries and traffic congestions. In particular young families with children move to rural areas, where land prices are lower and the need for more individual living space, such as a private garden, can be fulfilled. Cities with low density are faced with the problem that the population is widespread and therefore, mass transportation systems could not be efficiently realized. The lower the population density, the lower is the efficiency of public transportation.

8.2.2 Additional Drivers

In addition to the described key drivers there are several other drivers that also influence urban mobility in the future. The difference is either their impact is not that high compared to the key drivers or they have a less uncertain effect on the future.

1.2.2.1 Technological Progress   Regarding the driver technological progress, the uncertainty is not that high. It is obvious and logical that there is going to be some technological progress concerning mass mobility. Looking at the past we can observe that the speed of technological progress increases but it is uncertain how fast and how strong this progress will be. Governmental subsidies

in research, the number of unexpected groundbreaking inventions and the acceptance of new technology in the population will be crucial for this progress. Furthermore it is hard to predict on which of the specific topics research is going to focus in the future and as a result where the most innovations will arise.

Technological progress has a high impact on urban mobility as it can basically influence all matters within urban mobility. Among those are production and operating costs, speed and efficiency of public transportation as well as the environmental friendliness, just to name some to them.

1.2.2.2 Terrorism   Terrorism is a very uncertain driver, as it highly depends on political stability and international relationships as well as prevention of terrorism. Therefore the origin and the targets of terrorism have a high influence. It can be prevented by providing a higher and better education and living standard to countries where terroristic organizations are located but also by increasing control and surveillance in regions that have a high risk of becoming an aim for terror attacks.

If terrorism becomes a more relevant issue in western countries as Europen countries or the USA in the future, it will increase security requirements, as surveillance or even bullet or explosion-proofed public transportation systems. Furthermore, demand for public transportation might decrease as public transportation has been among the main targets of terror attacks in the past and the customers might not feel safe anymore.

1.2.2.3 Changes of Weather and Natural Conditions   Climate change makes weather more extreme. The increase of hurricanes and floods, storms or blizzards, and other extreme weather phenomena can already be observed now. Moreover, climate regions are changing. All over the world the average temperature has been rising significantly and many countries struggle against drought or record breaking summers. Again, the further development is hard to predict as scientists still argue about the dimensions of the consequences of climate change. International agreements and national environmental policy and regulations will determine the emission of greenhouse gases and the dimension of the climate change in later years.

Climate, weather and natural conditions have a high impact on urban mobility regarding comfort, safety and reliability. Mass transportation has to supply air condition in hot regions, heating in cold regions and to be flexible to heavy weather changes among the according seasons. The transportation grid and the transport process have to be insensitive against extreme weather phenomena as storms and floods and ensure a safe locomotion. Moreover, demanding tasks will be to avoid delays and failures of connections in times of blizzards and heat waves.

1.2.2.4 Social Environments and Needs   The change of social environments and needs are strongly correlated. If the society changes, its needs change equally. Depending on politics and the resulting development of national and global GDPs, social fallback systems, taxation and health systems, society will change differently. Reasons for this change are population growth, demographic change and the gap between rich and poor. Moreover, other events or problems such as natural disasters, shortage of recourses as oil or food, as well as economical crises could have an impact on welfare and the society. The gap between rich and poor is currently increasing but the prospective development is hard to predict.

Changes in society and the consequential change in customer needs highly influence the way in which public transportation is provided. Rich regions want comfortable transportation and are able and willing to pay a higher price. Therefore, private transportation or low scaled public transportation (like e.g. PRT) might rather be used than mass transportation. In poor regions this expensive type of transportation can hardly be afforded. Customers simply want to get from A to B; hence there would be a need for very basic mass transportation. An ageing society would have an influence on the means of transportation. The transportation in an older society has to be very easy to reach and compatible for people that are not good at walking.

1.2.2.5 Ecological Awareness   Ecological awareness highly depends on education, welfare, culture and politics. Education is important because the requirement for acting sustainable is to be aware of the consequences of your actions and what damages the environment. People usually first try to satisfy their very basic needs, so they try to ensure their survival. Only then they have the capacity to act sustainable so increasing welfare also increases the ecological awareness. This is also because welfare enables people to use more time for education. Furthermore, cultural habits and politics influence the behavior towards our environment. As environmental problems increase and become more visible in our daily live there is a common development towards environmental friendly behavior. However, with an exploding world population and short running resources it is unclear how long and how many countries and people can afford environmental friendly and sustainable politics and industries.

Naturally in an economy the demand influences the supply, so if customers only want sustainable and environmental friendly transportation, industry is forced to provide such transportation. So with increasing ecological awareness, the city population in the future would probably use the more efficient and environmentally friendly public transit or the bicycle rather than cars that are run with combustion engines. Furthermore with increasing environmental awareness, environmental parties are gaining power in the governments and are able to assert regulations that are unpopular and lower the short term living quality but increase the long term living quality. Examples for such regulations

are city tolling or emission and combustion taxes. If ecological awareness would decrease in the future, the population would probably not take care of the sustainability of the chosen mean of transportation. The decision for a mean of transportation would be made on other criteria and probably not be in favor of the sustainable but inflexible mass transportation. Also rather parties that assert only little environmental regulations would gain more power.

1.2.2.6 Development of Private Transportation   Private transportation can develop in different terms and directions. For example, more efficient technologies might lower production and operating costs and reduce energy consumption and pollution. Therefore it might make private transportation more attractive. Furthermore, new business models or ways to organize transportation, for example car sharing, can occur and ease the problem of congestions or make private transportation more affordable and sustainable. Again the direction of the development towards new business ideas and technologies is somewhat clear but the extent of the trend is hard to forecast.

The effect on mass transportation on the other hand is very clear, as people can only use either private or public transport. If the demand for private transportation increases more than the general demand for transportation, the demand for public transportation will decrease.

The same applies for the opposite development where private transportation isn't that attractive. The result would be that public transportation is increasing.

1.2.2.7 Location of Work Place   Home office and internet or home shopping eases some people's daily life. The degree of implementation differs from country to country. The development of home office and shopping is very hard to predict as it is subject to various and variable factors as degree of welfare or different cultures. Without any doubt both decrease the need for transportation. People tend to order their shopping from their home and often do not necessarily have to leave the house for working. This development has its limits as not every job and every shopping is compatible with home office or internet shopping.

8.3 Scenarios

Regarding the key drivers the following section describes three interesting scenarios for urban mobility in the year 2025. In all scenarios different developments of the key drivers lead to extreme situations and cause big challenges for mass transportation. Therefore the first scenario shows a chaotic world where governments have a laissez-faire politic and the energy prices are very low. The second scenario describes the same situation but with high Energy Prices and finally the third scenario describes in detail how a sustainable environment friendly city with high energy costs and a high density could look like.

8.3.1 Chaos City

We write the year 2025. The world has changed drastically, problems that already occurred in the very beginning of the 21st century have increased and new problems have arisen. What does the city life in this world look like and how has mass mobility adapted to the past developments? The following scenario tries to give an answer to these questions and describes a polluted world with a low City Density, high Energy Prices and low Ecological Policies.
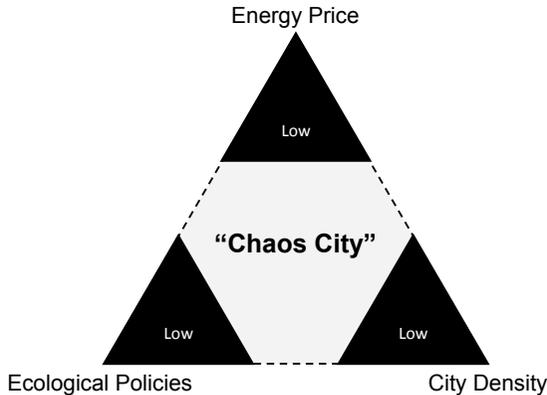
Figure 8.3: 3-Key-Driver-Figure Chaos City
Source: Own illustration

8.3.1.1 Scenario Description

It is the year 2025. We are living in a highly polluted world that heats up constantly. The world's governments could not agree on strong united contracts to save the environment. Emerging countries do not want to be deferred in their energy and raw material usage compared to the industrialized countries that have already been polluting and exploiting resources for centuries. Besides that, industrialized countries are not willing to renounce a part of their high living standard. Due to a selfish and not much foresighted population, politics is characterized by liberal parties and little regulations. These developments shape the urban life and structure. In the all types of cities, there are only negligible subsidies for public means of transportation, which are used very little due to high prices, a bad coverage or availability, and an atrophied public transportation infrastructure. The little usage even pushes the prices further and makes public transportation even more inefficient.

Energy Prices remain very low due to low taxation from governments on combustion energies and very loose environmental regulations. New energy sources such as Shell's deep-sea mining of methane hydrate, Antarctica glacier

oil production, and other methods that gain new oil sources also keep Energy Prices down. As prices are very low, not much money needs to be invested in research and new technologies by governments and the industry. As there are still plenty of oil and methane sources around the world, there is no mandatory need for alternative energies. Almost every vehicle in the city, no matter if public or private transportation, is still run with a combustion engine. In addition, the urban population sees no need to change from affordable private transportation to mass transportation, as Energy Prices are low. Mass transportation is actually not used by masses and therefore very inefficient and expensive.

Especially in most European and American cities, population density decreases quickly due to a shrinking population in the city. In Asian cities, people leave the congested and polluted city centers where health problems such as lung cancer, heart attacks and allergies are increasing. Thousands of commuters travel into and out of the city every day. There, the centers are packed with highways that have up to twelve lanes to deal with the rush hour. High space consumption for traffic infrastructure pushes land and rent prices. Besides that, city centers are not as dense populated as before. In the suburbs, it is still possible to have a comfortable life, as the environment is not that much destroyed. There also is more space as in the city centers that are packed with streets and industry buildings and offices, therefore rents are still affordable. As a result, people also tend not to live where they work. Most business and industry districts are loud, highly polluted and very dense due to an exploding world GDP that leads to a constantly growing industry.

The cities become a clustered patchwork and a widely spread puzzle. The occurring high need of the population for transportation results from the distances that have to be traveled every day, in order to reach their workplaces and other destinations. This variety of dispersed destinations can hardly be served adequately by public or mass transportation while providing low prizes. Mass transportation is also not that flexible so most people take their car.

8.3.1.2 Signposts

There are several events that could lead to such a scenario. Just as the deepwater horizon accident, the tragic nuclear accident in Japan might be as soon forgotten as it happened. Worldwide many nuclear power plants will be built then and the deep see could be covered with oil platforms. Furthermore, it might happen that the polar caps become ice free in summer. This would enable the mining of their oil resources.

Moreover, new technical progress will shape our future, for example deep sea mining of methane hydrate could be possible soon. The future also highly depends on the success of international environmental agreements as the next Kyoto protocol. If they fail, it will represent an enormous setback for conservation. Looking at China the most influential parameter is the further change

of the governmental system. If liberal, democratic movements as, the jasmine revolution are not tolerated by the government and stop violently, the world is one step closer to the described scenario.

Moreover, Europe and America might struggle in catching up with the exploding economical growth of emerging countries. As a result, people fear to lose their high living standard and green parties probably would not make it in the parliaments. These are further on dominated by liberal parties. The model of the emission certificate trading in Europe also could come to an end as many companies might struggle to be competitive against the low cost Chinese and Indian companies.

8.3.2 Market Decides

Due to high energy prices and insufficient ecological policies in the year 2025, the provision of mass mobility depends on the market. As using the car is too expensive for the majority of the population and an efficient public transport network is not supported by the government, the market has to find new solutions or create new business models for mass mobility by itself.

The specific developments of the three key drivers in the Market Decides scenario are depicted in figure 8.4.
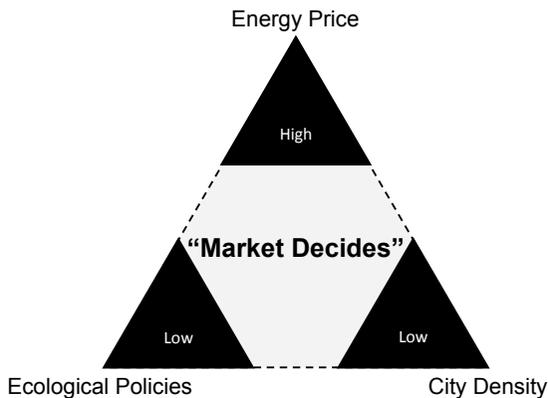
Figure 8.4: 3-Key-Driver-Figure Market Decides
Source: Own illustration

8.3.2.1 Scenario Description

It is the year 2025, somewhere in central Europe. The country is suffering from a serious energy crisis. In view of diminishing fossil fuel reserves, the challenges associated with the climate change and the high degree of dependence on energy imports from the Middle East and the CIS States, the energy prices

exploded. The government did not take forecasts and prognoses seriously and did not support renewable energies, so that energy sources such as wind power, biomass and solar energy have a very low market share. Furthermore, the severe ecological and socio-economic consequences of the nuclear disaster in Chernobyl as well as in Japan resulted in the closing of many nuclear power plants.

The mostly conservative government did not see the potential of energy efficient vehicles and therefore did not support the development and successful implementation of advanced vehicle technologies such as hybrid and electric vehicles. Thus the environmental impact of internal combustion engine vehicles could not be reduced. An efficient public transport network is urgently needed, but as a consequence of the last economic crisis, intensified by a political crisis, the offering of state benefits has been limited. Without adequate financial resources, an efficient public transport network could not be subsidized by the government and therefore not successfully established.

Due to the declining population in the industrialized countries, the population density is low. Sub-urbanization predominates. No alternative to cars with internal combustion engine exists, therefore, the inner-city pollution is high. Riding bicycles or walking longer distances is avoided by the majority of the population. People are afraid of health problems due to the high fine-dust and ozone pollution in city centers. Therefore, a large part of the inhabitants of the city decided to move to the suburbs. However, the majority of businesses and industries are established in the city center. The city is confronted with the everyday problem that thousands of commuters have to travel from and into the city. Working from home is enforced more and more. School and university institutions are raw, due to the widespread population and the difficult locomotion. E-learning services have been developed, to allow students to learn at home. Real-life meetings are mostly avoided. Meeting friends and establishing new relationships is done mainly virtually, that means via social networks or 3D video conferences.

Due to the fact that the population is spread out widely and destinations differ considerably, public transportation systems could not be efficiently implemented. The car would be the most flexible and fastest transportation, but considering the high energy costs, it is too expensive for everyday use. The population needed new solutions for mass mobility, but was not supported by the state. The market had to create new business models by itself. However, the implementation costs of a new infrastructure are very high, precisely because a huge area has to be covered, for example with long rails or underground tunnels. Therefore, private investors or joint ventures only offered conventional mass transportation with low set-up costs such as bus services. Decisive criteria of new business models were efficient and energy-saving solutions that can be implemented flexibly, also if demand is low. One developed approach is car sharing. The main advantage is that there was no need to built up a new expensive transportation grid as roads already existed. Intelligent traffic management systems assist in organizing

mass transportation efficiently and flexible.

8.3.2.2 Signposts

There are several events that could lead to the described scenario. After the tragic nuclear accident in Japan in 2011, the number of green party supporters could increase. However, this political development could be economically unsustainable. For that reason, conservative parties are likely to take over the power. The closing of nuclear power plants could be one success of the short rein of the Green Party. The conservative party would rather concentrate on handling the economic crisis and disregard the global climate change. Therefore, no new ecological policies would be implemented, no new energy-saving technologies would be subsidized and no efficient public transport system would be established. As no other technologies could have been supported by the government, mainly vehicles with combustion engines could be used. As a result, the city would struggle with high congestion within the city because there would be no efficient alternatives to cars. Developing countries probably would not accept the trade of emission certificates, hoping for an economic recovery - by any means. Therefore, European countries would not implement them too, because they struggle to be competitive against the low cost Chinese and Indian companies. Due to the high energy costs and the lack of resources, the only rescue would come by private investors or joint ventures, who could invest in the development of new business models like car sharing and other energy-saving methods, as well as flexible transportation systems.

8.3.3 Green World

The Green World scenario results out of the development of the three key drivers: As Energy Prices are very high, it is unfeasible for the majority of the population to own or use a personal car as it would just be too expensive. Because of high City Density, the streets are also congested and it would not only be expensive but also very time consuming to use cars. Politics around the world have understood these problems and are trying to find solutions in order to solve them. Public transit systems are a reasonable answer to these problems, as they are able to transport a lot of people without emissions or with a very low emission level. In the following it is described, how the city Shanghai has found its own solutions to the arising challenges in the Green World scenario.
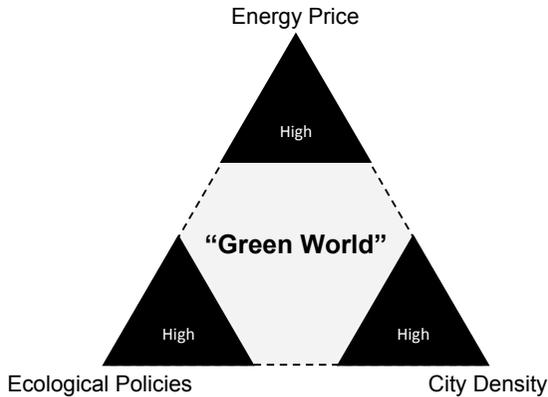
Figure 8.5: 3-Key-Driver-Figure Green World
Source: Own illustration

8.3.3.1 Scenario Description

In 2025, Shanghai is a true megacity. Over 40 million people live in Greater Shanghai. As available living space is rare, the City Density is very high in order to be able to provide an accommodation to everybody at an affordable price point. Highrises shape the cityscape and spacious apartments have become extraordinarily expensive. About ten years ago, the traffic situation was horrible. As personal cars were very popular as status symbols and more and more inhabitants were able to afford those personal means of transportation, the streets became very congested. In addition to the inner city residents, a lot of commuters from the surrounding suburbs commuted in and out of the city every day. Due to rising overall congestion, traffic jams and accidents became more frequent and at some days it was very difficult to estimate the travel time that would be needed to reach the desired destination. A public transit system existed but it was not developed enough and did not suit the needs of a megacity such as Shanghai. Therefore, even if the inhabitants did not want to use their car, public transit was not a possible solution to them. The current government needed to come up with a solution to this problem.

Energy costs are very high in Shanghai in 2025. After several riots in oil producing states, the political leaders of these states failed to regain the control over the situation and Saudi Arabia is in civil war for over five years now. This situation led to a lot of insecurity and uncertainty in the markets and the trade with future contracts on energy sources became highly speculative. As the majority of Shanghai's population heavily depends on gasoline due to the circumstances described above, the high oil price is a disaster for Shanghai's economy. As a result, the available income to be spend on consumer goods significantly decreased, because gasoline was just so expensive but nevertheless

was necessary to buy it in order to use the car. The climax of this development was reached, when car-free Sundays had to be enforced in order to deal with oil supply bottlenecks. The population noticed these nuisances and started to put politics under pressure.

Green reform forces immediately jumped on this train and started to develop alternative mobility concepts that would reduce the dependence on individual cars as well as oil and shift the focus to public transportation means in order to reduce congestion. It started with the introduction of city tolling combined with environmental zones. Old cars with high emission levels were not allowed in the inner city at all and those car holders had to pay very high tolls. As the emission thresholds and city tolls were raised over time, more and more inhabitants did not use a car anymore. Five years ago, the government decided to take a radical step: Since the Car Prohibition Act of 2020, all cars are banned from the city center, as shown in Figure 8.6. Exceptions are only made for police and ambulance vehicles. Logistic deliveries that can not be processed using public means of transportation need a special approval from the responsible government agency. Private individuals are only allowed to use personal vehicles if they have a permission that is granted on a case-by-case basis if it would be out of proportion to not allow the usage of a car in an individual case.

Due to these developments, the need for effective means of transportation is high. A mix of different mobility solutions tries to address these challenges. The subway system has been expanded with five new lines and average waiting times have been halved since 2015. Conventional public transportation means such as buses, trains and trams are still in place and the railroad network has been extended consistently. Beside these mobility solutions, two more innovative means of transportation are very wide-spread in 2025. The first is Personal Rapid Transit (PRT). A dense network of PRT stations has been implemented throughout the city, so that the next station is 400m away on average. This allows the inhabitants to take advantage of this fast and straight-forward transportation method as there is no need to stop at intermediate stations and congestion occurs very rarely because the vehicles are automatically steered by a control center. Another advantage of PRT systems is, that there is no driver needed. Passengers can therefore use the travel time to work or relax in a convenient and private environment. PRT systems do also allow rescue forces to transport injured persons to the next hospital in a very fast and efficient way, if there is a station next to the accident. Otherwise, the free streets usually also allow for a fast emergency transportation.

However, due to the high demand for mass mobility services, a lot of effort was put into the research of potential future ways of transportation. This was heavily facilitated by high state subsidies in favor of mass mobility solutions. Several new innovative means of public transportation resulted out of this incentive scheme.

These new transportation means disburden the whole inner city by a large

degree and make living much more comfortable. This effect is also fortified by the increase in air quality. As cars are not allowed in the city anymore, they can not pollute the air, too. The perceived living quality benefits heavily from the cleaner air and kids enjoy playing in small nature parks that have been built on places, where former traffic installations have been. But not only kids benefit from this development. The number of respiratory diseases decreased significantly over the last years and the medical system could shift its resources on the fight against other diseases. Health services have thereby become better and the inhabitants of Shanghai have the highest life expectation of whole China.

During the last 15 years, Shanghai has changed drastically. Coming from a city which heavily depended on cars and a population that lost hours of their day having to wait in congested streets, the government decided to take some drastic steps. Now, after years of heavy subsidies in favor of ecological technologies, Shanghai is a car free city. Efficiency increased dramatically and inhabitants profit from a cleaner and healthier environment. The high City Density has been levered successfully in order to create a public transit system that is optimized for a high number of people and short distances. The omission of several streets and intersection points made it possible to free a lot of space that was used to build new living spaces and plant trees. After all, Shanghai heavily profited from the development of the last 15 years.

8.3.3.2 Signposts

Civil wars could get out of control in several oil producing countries. This would lead to a lot of uncertainty in the market what influences Energy Prices. Energy Prices could then raise to new exorbitant levels, and government would have to react and issue extensive policies in favor of ecologically friendly technologies.

A world-wide emission certificate trade system could be enforced, so that world emissions can be monitored and reduced over time.

The demand for cars could decrease significantly due to severe taxes on emissions and heavy city tolls. Some car manufacturers would then go bankrupt, others are able to initiate an enormous turn-around by changing their product line-up towards mass transportation vehicles. Vehicles with combustion driven engines could be prohibited in a lot of cities. Due to the need of reducing congestion, in some cities no cars are allowed at all.

Researchers all over the world could shift their resources towards the development of new innovative public transportation means to solve the arising mobility challenges. Governments then support these attempts heavily.

Urbanization could increase as more and more people move from the suburbs into the cities. Big slums develop around the inner city areas that accommodate the underclass that can not afford to live in regular housing areas. Highrises could dominate city centers and inhabitants live together very closely as there
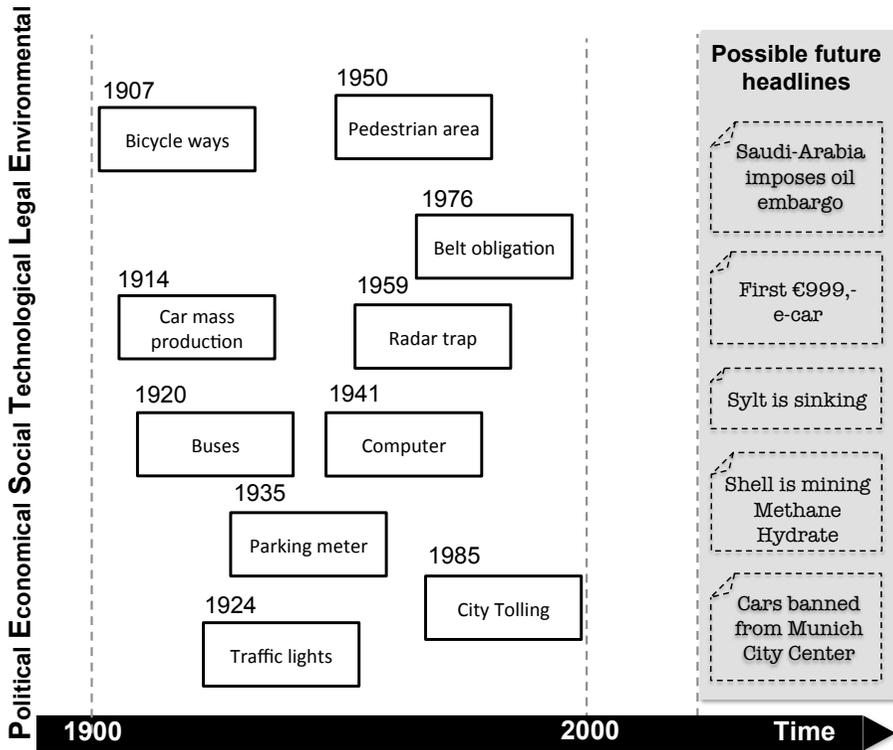
Figure 8.6: Timeline
Source: Own illustration

is a lack of living space.

After several severe natural disasters, conservative and liberal political parties could have lost the trust of society. Under economists a consensus is achieved, that the state is obliged to intervene into society with Ecological Policies in order to prevent market failure. The Green Party could have an overwhelming majority in parliament and then dominates politics.

8.3.3.3 Value Map

As new needs come up in Green World due to the car prohibition, new challenges arise, too. Nevertheless this situation also leads to benefits that are granted to inhabitants, such as less congestion and accidents on the streets. Figure 8.7 gives an overview over those effects.
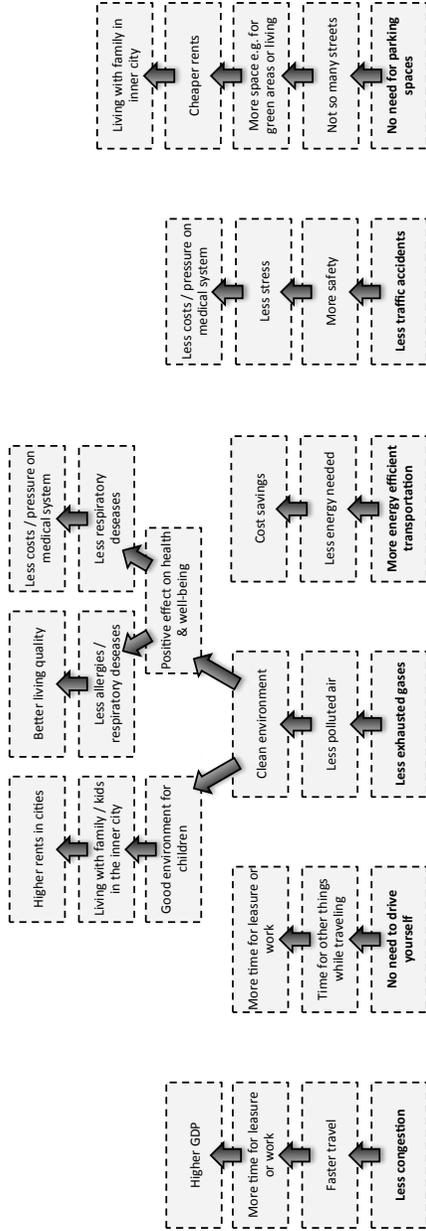
Figure 8.7: Value-Map
Source: Own illustration

8.4 Business Idea: The Travelator

The Travelator is a new mass mobility solution that is able to deal with a great number of passengers without creating emissions or congestion. The installation consists of two or three walkway lanes that are located directly next to each other and are operating with different speeds. The slowest walkway is operating with about four kilometers per hour, the medium one with eight kilometers per hour and the fastest with twelve kilometers per hour. A passenger can hop onto the slowest lane and then cross over to faster lanes in order to speed up. If he wants to disembark he just crosses back to the slowest line and jumps off. At certain times of the day where the need great, an assistant is traveling on the walkway to help all people in need, so that disabled and elderly people can use the system safely. Besides that, every 100m there are gaps in the slowest lane. This helps people in a wheelchair to enter the walkway without having to enter from the side, as this would create difficulties. In order to increase overall travel comfort, it is possible to install seats on the fastest lane. For a better understanding, these descriptions are illustrated in figure 8.8.

A roof protects customers from unpleasant atmospheric conditions such as rain. Thereby the walkways are protected from corrosion. If the sun is shining, the roof can be opened.

This system fits into application areas that request an usage underground or above the ground and is ideal for the bridging of short and medium distances in the inner city, e.g. between metro stops or shopping areas. It could also make sense to implement it as a circle around the inner city. As the risk of someone stumbling and falling off the walkway persist, safety is an issue. However, the speed difference between adjacent walkways does not exceed four kilometers per hour and the fastest walkway is either protected by a wall on the open side or even more walkways are added so that the fastest one is in the middle. Due to this and the fact that plastic materials are used to build the walkway instead of metal, minor injuries can not be excluded but the risk of those is kept to a minimum.

In future scenarios in which cars are prohibited, there is a need for alternative transportation means. The Travelator is very flexible and therefore a great supplement to other means of transportation.
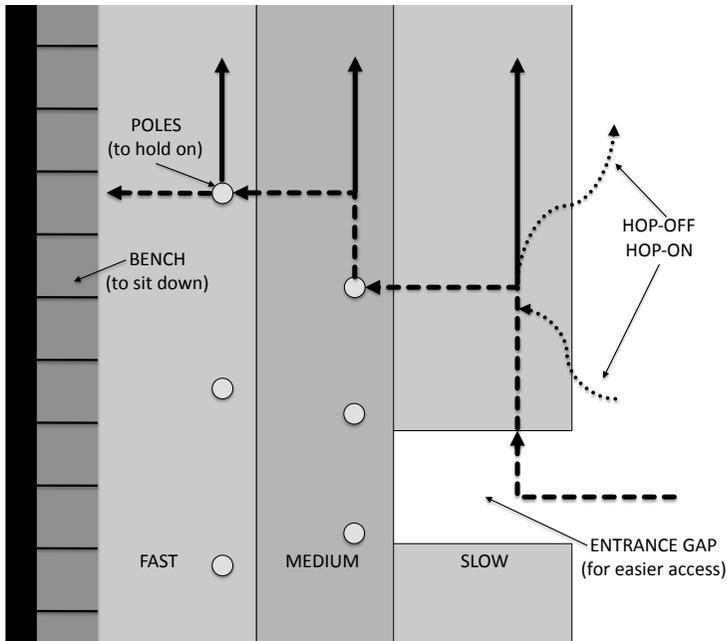
Figure 8.8: Travelator product draft
Source: Own illustration

8.4.1 Business Model

To transfer the idea of the Travelator into a business model, a structural approach was applied. This helps to have a common ground for further discussion and presentation. In this case, the business model generation approach of A. Osterwalder and Y. Pigneur is followed [475]. Thus the proposal is analyzed with respect to nine essential building blocks in the following part. These are customer segments, value proposition, distribution channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure.

The Travelator was especially designed to meet the needs of cities in the Green World scenario. As cars are not allowed in inner cities, the necessity for means of transportation that are emission free and capable of transporting great numbers of people arises.

Figure 8.9 shows the Travelator value chain. The proposed business model takes over the parts system planning, research and development and product sales. Production, construction, and maintenance aspects are carried out by key partners that have specialized in the respective fields. However, these actions have to be managed and supervised by the company providing the Travelator

system. External maintenance personnel has to be trained to become specialized within the Travelator system.
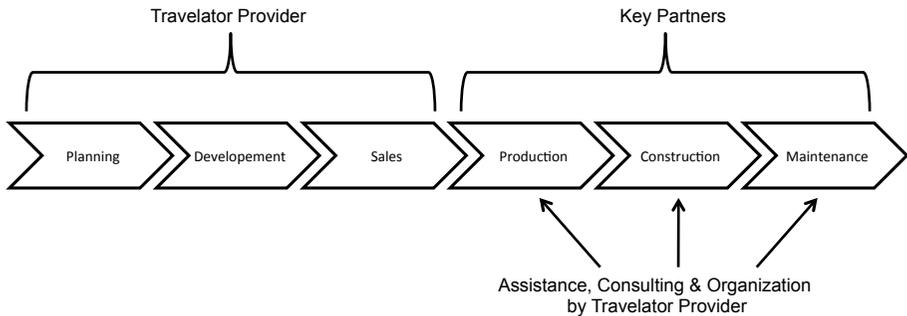
Figure 8.9: Travelator product value chain
Source: Own illustration

8.4.1.1 Customer Segments

Within the scenario Green World, the focus lies on public transportation. Almost everybody has to use means of mass mobility, as the number of cars is very restricted. The Travelator can transport a great number of people at once and is therefore an ideal method of mass transportation.

The actual end-users of this product are the cities' inhabitants. They are either living within the city centers, or are visitors or commuters. The system can be used especially by those people who have to travel between underground stops or over medium distances of about three kilometers. However, the main paying customers are municipalities since the end-user is not charged for the usage of the Travelator. The ministries decide which means of transportation are implemented into the city structure. In conclusion, the product is designed to be used by the city citizens but the actual customers buying the system are public authorities or large private investors and should thus be addressed.

The product has to be attractive for all groups of city inhabitants in order to be attractive for the policy makers. Politicians need the votes from the majority of mass mobility users to be reelected. Therefore it is important to also look at end-user segments, although they are not the paying customers. A special concern is put on elderly and disabled people, as well as people with trolleys. As these user groups have to be integrated, special means of access are necessary. These reasons were the driving factor to introduce an easier access to the slowest lane.

For public authorities the advantages of the Travelator include lower set-up costs compared to underground lines. As this service can increase the attractiveness of a city's transportation system and even of the whole city, this

could be an incentive for companies or skilled employees to move to a certain city. Public authorities could thus increase revenues from taxpayers. Due to the fact that this technology is best integrated in very densely populated areas, cities with a high population density, as present in the Green World scenario, should be addressed first.

Besides municipalities, organizations that have to handle large spaces and big crowds such as airports, train stations or even shopping malls are a further customer segment.

Summing up, the two main customer groups are city governments and other institutions with large properties. Although end-users are not a paying segment, they do have a great influence and are a main decisive factor for the paying customers.

8.4.1.2 Value Proposition

For end-users, a lot of value is created through this product. The Travelator is a method of transportation within the inner city that gets people to their destination quickly. This system has a lower maximum speed than e.g. underground trains, however, the competitive advantage considering time consumption results out of other reasons. By running above ground the users do not have to walk to the next underground station, which always consumes time. Boarding and disembarking is possible everywhere. As the Travelator also does not have to stop for people to get on or off, it saves again valuable time. Additionally, there is no waiting time necessary, as it is possible to enter the system at any moment. A comparison of time consumption of traveling by underground train, Travelator, and by foot is shown in table 8.1. The distance chosen to compare these means of transportation is three kilometers, which corresponds to those distances where the Travelator is very efficient and should be implemented. The results show that the Travelator is the quickest method of transportation with a distance of around three kilometers or less. On top of the traveling speed, the user could increase his speed while walking on the fastest lane. Through this even higher time savings are possible.

Underground	*Time to use underground for 3km:* $15,5\,\text{min}$ Average speed of underground system: $3\,\text{km} \div 33\,\text{km/h} \approx 5,5\,\text{min}$ [474] Time to and from station: $2 \times 4\,\text{min} = 8\,\text{min}$ Estimated average waiting time: $2\,\text{min}$
Travelator	*Time to use Travelator for 3km:* $15\,\text{min}$ Speed of fastest lane (3 lane configuration) is $12\,\text{km/h}$: $3\text{km} \div 12\,\text{km/h} = 15\text{min}$ *Time to use Travelator for 3km while walking on it:* $10,6\,\text{min}$ Speed of fastest lane plus walking speed: $12\,\text{km/h} + 5\,\text{km/h} = 17\,\text{km/h}$ Time needed: $3\text{km} \div 17\,\text{km/h} \approx 10,6\,\text{min}$
Walking	*Time to walk for 3km:* $\sim 30 - 45\,\text{min}$

Table 8.1: Time savings for end consumers
Source: Own creation

Another value proposition for end-users is, that unpleasant walking or traveling underground can now be avoided. When it is raining, customers are protected through roofs on top of the lanes and therefore do not have to carry umbrellas. The Travelator furthermore is very easy to use. Travelers who want to get to their destination as quick as possible can use the fastest lanes. Others, such as elderly people and also visitors of the city can just drive along the slowest lane and enjoy the view. Furthermore, the Travelator can be installed where conservative means of public transportation are ineffective, e.g. on short distances within busy city centers. Therefore, end-users can benefit from additional opportunities of transportation.

City authorities, which are the actual customer group that the Travelator would be sold to, get a transportation device with far lower investments than for example underground transportation. Direct costs are also lower as there are no drivers necessary. Indirect costs such as maintenance expenses are lower since the infrastructure is less complex. Therefore, big money savings for public authorities are a definite value increase. Furthermore, easy modes of transportation and a well working system can attract further companies and skilled employees, which will pay taxes to the city. Through this, cities could increase their revenue streams. As the Travelator could also be an interesting way to get around for tourists who want to visit the city center, more visitors could be attracted.

The system could also be sold to airports or shopping malls. Here the owners receive a system that offers again different advantages compared to conservative people movers. Thus, these institutions could create a comparative advantage over other malls or airports.

Concluding, the main value gains are better time efficiency and more comfort for the users as well as less investment and operating costs for the authorities.

8.4.1.3 Distribution Channels

To bring the idea to the market, presence on international industrial trade fairs is important. This creates public and private awareness for the product. Establishing key partnerships with large players in the escalator or moving pathway industry could also be helpful to raise awareness and to use their existing marketing and distribution channels.

In the scenario Green World, authorities strongly support public transportation through policymaking and subsidies. Therefore, the main addressees for selling the Travelator are city governments. It would be one possibility to sell the product by itself. Public-private partnerships and several financing options should be considered here. On the other hand, selling a product-service bundle that includes the product, energy costs and maintenance services is plausible and can enable long-term profits. To convince politicians and sell the product in this market, lobbyism plays an important role.

Private institutions such as airports, rail stations, or any company with big premises can also be addressed to sell the product. In this case other distribution channels are necessary. Lobbyism becomes unimportant and instead the companies should be addressed directly or again on trade fairs.

8.4.1.4 Customer Relationships

Travelator system providers will not operate the system themselves but sell it to municipal authorities, shopping malls or airports. As not the end-users but the municipalities are the main customers, it is important to establish good relationships to them. Usually, a few municipalities are responsible for the majority of revenues. It is therefore important to foster good relationships to these key clients. In order to do so, Travelator providers employ experienced key account managers that are responsible for a small number of clients. Through this communication strategy, the relationship to municipalities is very good and intense.

Travelator systems are operated with a high degree of automation as not even a driver or other workers are needed to carry on with the mobility service. The communication with the end-user is therefore generally low and to build up customer relationships is difficult. The fact that end-users do not pay does also make it difficult to establish relationships to them.

However, as disabled and elderly people might struggle to use this mobility service due to the sudden acceleration while entering the walkway, a relationship will be established with this target group. In intervals an assistant is traveling on the walkway to help all people in need to use the system safely. Everybody who wants to use this service just has to wait for the next assistance. In addition to that, attempts to create an atmosphere of help and assistance are made. Signs which encourage people to help others to crossover to other walkway lines are positioned in steady distances. Over time this leads to the establishment of
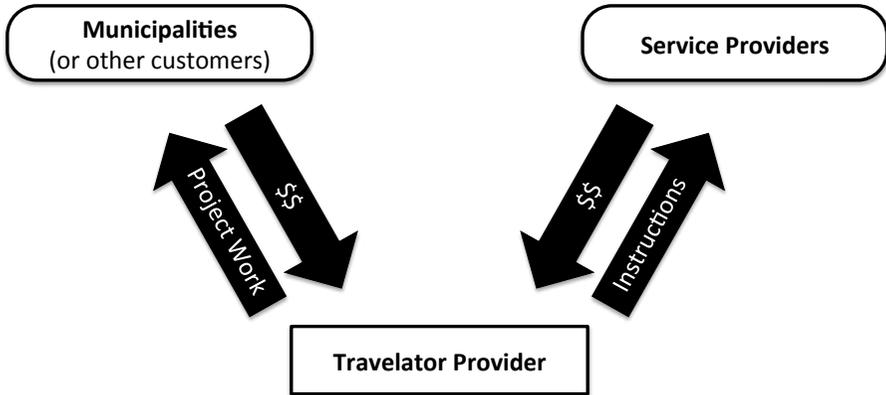
Figure 8.10: Revenue streams for the Travelator provider
Source: Own illustration

a culture of help between Travelator users. By implementing these measures, the overall acceptance of this service rises and more people will feel comfortable using it. This also influences the direct customers, e.g. municipalities, as they will not buy the system if their users are not satisfied by it.

8.4.1.5 Revenue Streams

End-users do not pay for the Travelator. Therefore there is no direct revenue stream created here. Travelator system providers rely on the revenues that are created through selling their system to customers, e.g. municipalities, as can be seen in Figure 8.10.

The planning and engineering of the Travelator requires a high degree of specialisation and experience as the Travelator solution needs to be adapted to individual use cases. Therefore the major revenue stream results out of the project work for every Travelator. Thereby customers pay for these services that are provided to them.

A second revenue stream is located in the aftersales area. Third party maintenance specialists are instructed and can be booked by municipalities for a commission.

However, municipalities might be able to create indirect revenues out of their investments in Travelators. Due to their implementation, the infrastructure of a city improves and becomes more efficient. This creates a location advantage that could attract companies to the city who would have to pay commercial taxes to local authorities.

8.4.1.6 Key Resources

Intellectual Resources   An important intellectual resource are patents on all inventions, which have to be secured. These inventions should also be secured, if they are not used at all, as these ideas might otherwise be used by competitors. For example, a patent application for the three walkway lanes that are located directly next to each other and are operating with different speeds, should be filed, as well as for the installation of seats on these lanes. Furthermore, official permits from the relevant authorities for the construction of the Travelator have to be obtained.

Physical Resources   The design of the product must satisfy the required factors, i.e. the product must be safe as well as reliable, quickly to be installed and enable cost savings by increased economies of scale and learning effects. Therefore, the installation of the product has to consider safety aspects, reliability and quick finalization.

Human Resources   Partners, who are familiar with the production of moving walkways, as well as suitable manufacturers have to be selected and quality has to be assured by external monitors. Specialized engineers have to collect ideas and design the product. Sales activities and the alignment of the installation with operation activities of the customer have to be performed by project managers with technical and marketing expertise. Craftsmen or service companies are responsible for installations, maintenance and repair and need to receive specific training. Furthermore, permanent product improvement has to be ensured by a constant contact of project managers to customers and to the design team.

Financial Resources   Services and advice for planning, engineering, economics calculations, technical dimensioning, installation, social activities, training and safety analysis for the construction of the Travelator are very expensive. For this purpose, either high start-up funds or advance payments of future manufacturers will be needed. Financing of ordered production has to be provided by down-payments of customers and bridge-financing of banks or by deferred payment to manufacturers. Maintenance and repair will be financed through regular service fees from the customers. Financing for technical developments and sample production has to be provided from regular cash-flow within yearly planned budgets.

8.4.1.7 Key Activities

Outsourcing of Production   Strategic partnerships with manufacturers and construction companies, specialized in the implementation of moving walkways, have to be established and contracts with all partners have to be concluded.

The product will be implemented by business partners, however, Travelator experts will support and consult them during the whole implementation process.

Training and Support   Due to the fact that the Travelator is an innovative and complex product, trainings for companies have to be provided, so that the Travelator can be successfully implemented and maintained. To achieve the objective to convey the social responsibility for handicapped people, elderly or children in order to enable them to access the Travelator smoothly, social activities have to be taken. These activities may include advertising campaigns as posters, but also the employment of qualified personnel who travels in intervals on the walkway, assists handicapped passengers and serves as a possible role model for others as well.

Product Enhancement   The product has to be permanently improved by the constant contact of project managers to customers and to the design team. Furthermore, the market and the competitors have to be observed permanently as well.

Marketing   Due to the fact that the product has to be accepted by users and the safety of use has to be guaranteed, convincing marketing and sales campaigns have to be conducted, as well as active trade-fair participations.

8.4.1.8 Key Partners

Travelator providers focus on their core competences that are the in 1.4.1.7 described key activities. Such are planning, construction and distribution of the new moving pavement solution. Therefore close partnerships are necessary to enable production, construction, maintenance and operation of the Travelator.

As the production of the Travelator is similar to the production of current moving walkways, it would be valuable to outsource the production to a company that has already lots of experience and know-how in the production of similar products. Therefore, a technology provider as Thyssen Krupp would be a potential candidate. This partner could provide the costly infrastructure that is necessary for the production and support the planning, research and development departments with their experience.

As the implementation or maintenance of Travelator systems are not covered by the proposed business model, a maintenance company has to be found that has to be trained in the necessary technical details so that it can be imparted to the customer. Maintenance providers would also represent an interesting financing option as they could be charged for the impartation of new customers.

All in all, the Travelator provider can be relieved from unnecessary duties. He would be allowed to focus on developing and distributing new mobility solutions

in the field of moving walkways. With the help of the key partners, he would join and provide a whole mobility service including maintenance.

8.4.1.9 Costs

This business model is highly cost driven. The idea is to provide the service as cheap as possible as there are no direct revenues from end-users. There are fix production costs for one lane that are similar to the costs of existing moving walkways multiplied by three for the three lanes and with higher cost for the stronger engine and the higher quality of the material, as it has to operate at a higher speed than the currently used moving walkways.

The operating costs split up into maintenance, personnel and energy costs. Personnel costs can be divided into management costs and research and development costs. The management costs in this case highly depend on the market share of the company and should start very low and increase with the growth of the Travelator provider. Research and development costs can be steered flexible but should be a major cost component, as it is the core competency of the provider and the major criterion for the success of the company.

Maintenance costs for materials and new parts that need to be exchanged depend on the market share of the Travelator and the area covered. It should be financed by the investor that buys the mobility package.

Energy prices highly depend on the speed and length of a band and not so much on how many persons are transported. Therefore the energy consumption of the Travelator is similar to the current energy usage of a moving pavement but will be more efficient in the future. On the other hand in the scenario Green World energy is more expensive. Currently the average daily costs for the power consumption of a busy escalator are around 28 € for electricity [SR3-jann-escalator-energy-cost]. However, the energy cost will be paid by the customer.

8.4.2 Scenario Robustness

The Travelator technology fits extremely well into the Green World scenario. Due to the fact that Energy Prices are high and using the car is quite expensive, there is a strong need for efficient mass mobility solutions. Furthermore, City Density is high and public transportation systems are subsidized by the state. The major advantage of the Travelator is the possibility of hopping on and off whenever the passenger wants to. This facilitates considerable time savings and a clear increase in convenience for the user. A disadvantage is that the realization of the Travelator implies high investment costs.

Market Decides   Considering the Market Decides scenario, the dimensions of the three key drivers are different. Energy Prices are still high in this scenario,

but City Density, as well as Ecological Policies are low. Due to the high Energy Prices, an effective mass transportation solution is urgently needed, but the government does not offer any support. Therefore, the high investment costs that are implied with the realization of the Travelator have to be covered by the market. One possibility would be the integration of the Travelator by private investors or joint ventures. However, buying the Travelator is quite a high investment and earning money is very difficult. Nobody can really ensure that only passengers with a valid ticket use the transportation system. For this purpose, special entry points would be necessary. However, this would cancel the big advantage, which allows passengers to get on and off the Travelator whenever they want. Furthermore, investment costs in the Market Decides scenario would be much higher than in the Green World scenario because City Density in the Market Decides scenario is very low if a full coverage wants to be achieved. Suburbanization predominates and the population is widespread. Therefore, the whole public transportation system would have to be very dense and the moving walkways would have to be very long. Thus, integration costs would increase a lot.

The only possibility to successfully realize the Travelator in the Market Decides scenario would be, if private investors or joint ventures find another way to make money. Because high Energy Prices and the development and implementation of advanced vehicle technologies such as hybrid and electric vehicles were not supported by the government, cars and buses are also very expensive. Trains, underground railways and trams are the only already existing means of transportation. Compared to these vehicles, the Travelator could be operated cheaper, and therefore would be a better alternative, even if special entry points for payment have to be integrated.

However, if entry points should be avoided and revenue has to be guaranteed, there still is the possibility to inspect the passengers' tickets randomly. One approach could be producing tickets with RFID chip. Users of the Travelator would have to pay a monthly fee. Fare evasion could be prevented by the installation of hidden scanners and a picture will be taken if a passenger is using the Travelator without a valid ticket.

Nevertheless, the realization of the Travelator technology in the Market Decides scenario poses many challenges. Therefore, it is more probable that the market will develop other business models, such as car sharing.

Chaos City   Looking at the scenario Chaos City, the City Density is very low and many people live in suburbs. Therefore the Travelator would be very costly to implement. The production costs to set up a Travelator grid are high, and for a very widespread city a large surface would have to be covered. Although Energy Prices are low in this scenario, there would be high operating costs to provide the service to a huge area as an immense amount of energy would be needed. Also the maintenance would come at a high price, because a longer

length of Travelators simply is more susceptible. Not only is the technology costly in such an environment, but also very inefficient and unsustainable as only a few people would use it at a time and the running costs of the Travelator depend to a high percentage on how fast it operates and the length of a lane but not that much on the number of passengers transported.

In the considered scenarios there is a lot of congestion in the inner city because everyone uses his car. Therefore a high percentage of the city area is covered with streets or transportation infrastructure. Consequently, land prices are very high and there is not much space that would be suitable to implement the Travelator.

This again would make the technology in such a city very expensive. Furthermore the question would arise if there is a demand that is high enough to justify the high operating and production costs of the Travelator. Inhabitants of the Chaos City scenario are very used to internet, home shopping and to work from their homes. Otherwise they go shopping in huge shopping malls that are located in the outer suburbs where land is comparably cheap.

Furthermore, there is a very low support from Ecological Policies and very few regulation in this scenario. We are facing governments that make very liberal politics. Therefore there is no city tolling or a car-free city but the streets are congested and city centers are polluted and not a comfortable place to walk around. In this city there are very few pedestrian zones. As there are no subsidies for public transportation, cooperation with the government is not very likely. The biggest issue for the business idea would be to find a partner that is interested in financing the costly infrastructure and to find a place where the demand for such a mean of transportation is high enough.

The only thinkable place such a system could be successful would be in the described shopping malls, airports or other private premises where long locomotion distances have to be taken and where private transportation or vehicles in general are not a possible solution. A way to market the technology would be to offer a set-up and maintenance package to a private investor.

Concluding, in this scenario the Travelator would not be impossible to implement but not a very feasible mean of transportation.

8.5 Conclusion

Mass mobility will be of major importance in the future. However, how exactly it will be implemented is subject of the development of three different key drivers that were identified. Ecological Policies reflect the support for mass mobility that is granted by policity makers. City Density describes how close people live together in the city. Energy Prices state the current level of energy costs that is determined by the market. These drivers will have a major impact on mass mobility. In the scenario Green World the circumstances are ideal for the implementation of innovative and energy efficient means of public transportation.

As no cars are allowed in the hypothetical inner city of Shanghai in 2025, the existing public transit network has to be expanded and new mobility solutions invented. The Travelator is a product idea that would address the challenges that come up in the Green World scenario. This innovative idea is able to transport a great number of passengers without direct emissions or congestion. Therefore, it can solve the mobility needs of a mega city such as Shanghai where no cars are allowed. If the drivers develop differently, as in the Chaos City or Market Decides scenario, other solutions might be needed in the future. The stated signposts in the scenarios give hints how the future might evolve.

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9 Personal Mobility

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The term personal mobility in context of this scenario report covers the transportation of individuals in urban areas in the year 2025. A driver analysis of the most influencing forces for individual movement emphasizes the three key drivers Mass Adoption, Political Framework and Disruptive Technology. Based on different possible upcoming dimensions of these key drivers and with the smaller impact of seven additional drivers, three scenarios are created: *Car Free Zone*, *Road Runner* and *Sharing*. The latest is chosen as the main scenario for personal mobility.

Sharing stands for a future scenario in which carsharing becomes one of the most important means of transportation for personal mobility. The carsharing business adds flexibility and efficiency to the city's traffic system but lets individuality of vehicles disappear. This lack is filled by *carsonalize*, a service offering carsharing operators the possibility to expand their carsharing business and individualize every user's driving experience. Its features include an automatic setting of seats and mirrors, the access to favorite music, the provision of individual routing and the implementation of a customer loyalty program in form of a rewarding system. While this business idea is based upon and especially suitable for a widespread carsharing industry, it is still imagineable for a situation in which carsharing is only one tiny part of transportation since it offers significant value to the end user of carsharing.

9.1 Introduction

Personal mobility deals with all means of individual transportation within urban areas. Currently the most common technology within this segment is represented by motorized vehicles. As fuel is getting more expensive and environmental problems are arising, finding new mobility concepts for personal mobility and improving existing ones is getting increasingly important. Environmental awareness is more and more expected and encouraged, but also necessary as can be seen by increasingly extreme weather conditions. This in return forces current technologies for personal means of transportation to adjust to customer needs and required ecological changes. Here different possible developments, which affect the success of existing and new concepts, are possible. The first two sections of this chapter describe several directions the future of personal mobility can evolve in. Three key drivers as well as seven additional drivers influencing the development of personal means of transportation will be explained shortly with a special emphasis on possible developments they can provoke. The consideration of each driver is depending on its impact and its uncertainty concerning personal mobility. Based on specific developments of the drivers, three scenarios will outline how the picture of personal mobility could look like in the year 2025.

The third section will introduce the business model of *carsonalize*. This business model is based on the third scenario *Sharing*, in which carsharing is the major means of personal mobility in the city. To give a clear and structured description of the business idea the technique of Canvas according to Osterwalder and Pigneur with its nine elements is used.

9.2 Driver Analysis

In order to build scenarios of urban mobility in 2025, drivers which shape these scenarios have to be analyzed. The following sections discuss the most important drivers with the highest impact on personal mobility. Figure 9.1 shows these drivers in an impact-uncertainty matrix and marks the three key drivers *Disruptive Technology*, *Mass Adoption* and *Political Framework,* which are further explained in section 9.2.1. The following section 9.2.2 describes seven additional drivers.
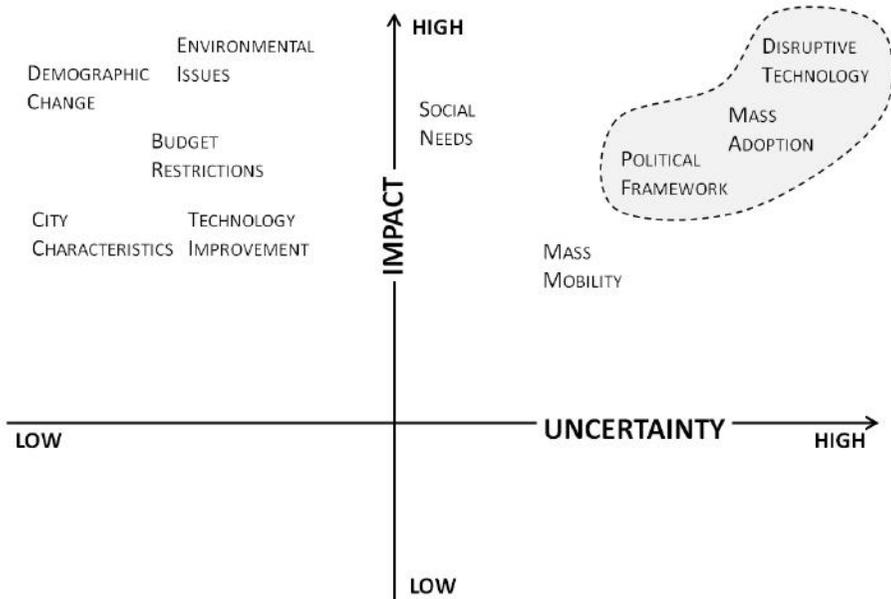
Figure 9.1: Impact-Uncertainty Matrix of personal mobility
Source: own illustration

9.2.1 Key Drivers

The key drivers of personal mobility concepts are characterized by a high impact and simultaneously a high uncertainty. The latter makes different developments possible whose impact will be highly influencing urban mobility. In this section the three key drivers are explained and an outline on possible developments is given.

9.2.1.1 Mass Adoption

The behavior of the mass is an important criteria to measure success when new products are launched, new services are offered or new governmental rules are created. The mass influences how big the revenues for a product or a service will be by paying or not paying for it. In terms of political decisions it is also the mass that gives its feedback to the politicians by re-electing them or not.

Description   The term mass adoption includes two main building blocks of people's mindset when certain changes in their direct environment occur. Firstly, it means acceptance and describes the change of people's opinion to a new condition and their tolerance. Secondly, it includes modification of people's

behavior due to new conditions in their environment and new products changing their daily life. In the following possible developments that occur due to different dimensions of mass adoption will be explained.

Possible Developments   There are two possible dimensions of mass adoption that influence further developments of the status quo, *high* and *low*:

high: The better part of the population in a city is accepting and also adopting new conditions in their political, technological and social surroundings. They agree with it their surroundings and also make physical use of new technologies and obey new political laws.

low: The majority of the people do neither accept nor adopt their habits to the new development and its conditions. They disagree with the situation and would like to experience a change in it instead of adopting to the current situation.

The development of mass adoption is highly dependent on the development of social needs. For instance, the growing demand for flexibility in people's life could lead to a high mass adoption when a new flexibility promising technology for urban mobility is launched. The need for clean living surroundings and therefore a clean cityscape could support political decisions like the introduction of city tolling (compare section **??**).

Privacy and people's evaluation of their own needs in terms of privacy play a huge role for the adoption of the mass. The development of privacy as a social need is rather uncertain, since opinions stating that privacy of every individual needs to be protected could easily be turned down by the upside consumers are getting out of this, value added services that make life a lot easier and more convenient. This could for instance be new devices or services using private data to gain knowledge about current positions of road users in a city's traffic system in order to suggest the best and fastest routes in real time.

In the context of personal mobility, privacy does not only cover the protection of data but more trivially the privacy protection in terms of having a ride from A to B as a single person without the presence of strangers. The influence of people's desire for comfortable rides is still uncertain. Will people reject new transportation means that offer high flexibility leading to enormous time savings when the demand for comfort is not satisfied? Or is it that in a world where time equals money the need for comfort is shrinking to an unimportant size?

Apart from analyzing the coherence in between social needs and mass adoption it is also important to consider mass adoption's influence on political decisions or technological innovations and the other way round. Regarding the example that government decide for a congestion zone in a city, the population could actually accept it due to their environmental awareness and are forced to adapt it since it is a governmental law set up to guide the development of personal mobility. Government could due to people's adoption either broaden the congestion zone or increase the fee that needs to be paid when entering the zone by car. This

spreading of city tolling would not work out that easily if people did not accept it because their environmental awareness was too low. This is one example for the interplay of two key drivers and an image for how network effects occur.

All in all, people's mindset and their desire of their own personal mobility are an uncertain driver with an undeniably high impact. This becomes especially interesting when evaluating new developments coming from other drivers like the political framework or disruptive technologies. Mass adoption is a key driver when regarding possible scenarios for personal mobility in urban areas.

9.2.1.2 Disruptive Technology

Urban mobility has always been and still is dependent on technology developments and improvements. From the bicycle to the modern software controlled electric vehicle, disruptive and new technologies constantly influenced personal mobility. Depending on what kinds of technologies there are and which are adopted by the mass, the possible shapes of personal mobility vary intensely. Therefore disruptive technology is one of the most important driving forces for personal mobility.

Description　It is important to differentiate between new technologies that offer new solutions or alternatives for current mobility concepts and those improving or supporting existing technologies. Supporting and improving could mean increasing efficiency of existing machines, adding new features or providing better infrastructure or supportive services for conventional means of transportation. Given that existent technology is well-known, such alterations are more predictable and certain and therefore not considered a key driver in this analysis. Innovative or disruptive technologies on the other hand are very uncertain and thus a key driver for the future of personal mobility.

Possible Developments　Considering the driving force of this key driver, the two dimensions of disruptive technology are *no* or *yes*:

no: There is no disruptive technology influencing personal mobility. It is most likely that the additional driver improving technology becomes more important (compare section 9.2.2.3).

yes: A disruptive technology has been developed and is entering the market. The eventual impact of this new technology is dependent on people's acceptance and their budget restrictions (compare section 9.2.2.5). Some early adopters are always open for new technology but profound changes in behaviour need a broad mass acceptance. Therefore it is also possible that there is disruptive technology, but the low mass adoption thwarts the impact of the driver.

The possibilities for new innovations are vast. Emission free means of individual transportation as well as improved mass transport solutions would meet the great challenges of current urban mobility, namely pollution, congestion, safety

and sustainability. If the acceptance and adoption of new ways of transport are high, the impact of these developments will be immense.

If a new engine technology, neither running on fuel, electricity nor hydrogen, was introduced, urban transport would produce less emissions and save oil resources. Thus pollution and sustainability problems were solved. The use of cars implementing this new engine technology would increase drastically and mass transport could lose its importance. This could lead to a whole new standard of transportation, as people prefer flexible individual transport, if there are no more environmental disadvantages. A result of disruptive technologies could also be that there is no differentiation between public and private transport anymore. Personal Rapid Transit for example could offer the possibility of docking private cars to the network and thereby making use of the infrastructure and minimizing street traffic (compare section **??**).

Even inventions in fields that are not directly linked to mobility, e.g. biotech or energy generation, could have a high impact on how people reach their individual destinations. Regarding human physique, it is imaginable that devices improve certain abilities such as walking speed or strength. The concept of mainly using some sort of vehicle for individual transport might change radically and bikes or cars could become redundant.

9.2.1.3 Political Framework

Political framework in this chapter includes all policies of the government that have an influence on personal means of transportation. Possible measures could be national and international subsidy programs as well as EU-directives that need to be converted into national law. Due to groundbreaking scientific innovations and a changing environment, the political framework in emerging and developed countries is continuously changing and can differ from country to country. For the development of new technologies, knowledge about the political framework in a specific country is of crucial importance as policy can influence either in a positive or negative way. All regulations and directives, which directly influence personal mobility, such as environmental requirements or financial aid programs, effect the characteristic driver.

Description The characteristics of the political framework depend on the leading political party as well as the opinion of the public majority. The political framework sets the external conditions for the personal mobility business and has a major impact on its development. Thus it is important to classify if the political framework is intervening or indifferent in terms of personal means of transportation. Intervening can either mean supporting or preventing personal mobility. Supporting would be that the market for personal mobility is affected positively by the legal situation. Special subsidy programs could increase the importance of the personal mobility market and lead to additional growth.

The opposite situation consists of a political framework that is preventing the market for personal mobility. This could be the case if regulations are set up, which tighten the legal position for personal mobility in order to increase living standards for the population. As a result the business for personal motorized mobility could get harder and the market for mass mobility and non-motorized vehicles, like bicycles, could increase significantly. An indifferent political framework means that neither supporting nor preventing guidelines are set up towards defining optimal transportation means. Liberal politics that trust into the self-enforcing powers of the market could stand for such a position. Thus, every business model operating into the mobility business has to create revenue streams that exceed costs without the help of public subsidies. As the state does not get involved as a corrective, solutions that are not optimal from an ecological point of view could take over due to moral hazard. As a result pollution and congestion could even increase compared to the current state.

Possible Developments The driver political framework is characterized by two dimensions. A political framework can either be *intervening* or *indifferent*:

Intervening: Guidelines have a great impact on the personal means of transportation since governmental restrictions define new rules for either individual users, whole businesses or a city as such. Most of the time, all of these players need to accept the regulations defined by the government and adapt their habits to it. Only in rare cases people's opposition to a new law or regulation can actually change decisions that have already been made.

Indifferent: Governmental influence on the mobility business is very low. Thinkable is that general regulations are in effect, but special guidelines for supporting private mobility are not set up. As a result the advantage of different legal situations cannot be used and the enforcement of certain technologies concerning private mobility is mainly depending on the market adoption.

The political framework of a country plays an important role in the development of the personal means of transportation. As the government permanently has to react on changing economical and ecological requirements, the development of the political framework is not predictable. This makes it even more important to focus on the political framework. On the one hand individual transport technologies can be particularly encouraged by the government. On the other hand the government could make personal mobility redundant.

9.2.2 Additional Drivers

In this section important additional drivers which influence the scenarios for personal mobility are described. These drivers are either less important or less uncertain than the key drivers which have been described in the section before. Nevertheless they shape the developed scenarios in addition to the key drivers.

9.2.2.1 Mass Mobility

Mass and personal mobility have always been and still are highly influencing each other as people can only choose between those two modes of transport to date. The usage of mass mobility highly depends on wealth of the person and availability and features of the mass transit system itself in terms of flexibility, comfort and safety. Urban areas generally create wealth as there is more labor provided than in other areas (compare section **??**). Inhabitants have the need for flexibility and independency and therefore many decide to buy a private vehicle as soon as they can afford it. In addition, clustering in cities leads to high distances between work and living areas. Often the public transport system cannot adequately cover all the individual travel routes and dispersed areas which have to be linked (compare section **??**). This leads to high individual transport in cities and less usage of mass transport. As a result, the congestion problems in dense and populous cities are enormous. By using mass transport people are able to move more quickly even during rush hours and save travel time. Moreover using mass transport can save money especially when energy prices are rising. In the end the good ratio of advantages and disadvantages of mass transport could be stronger than people's need for individual trips.

However, with this growing dependency on mass transit, the traffic of personal transport shifts to the mass transport system. The increasing number of customers makes adjustments, enlargement and concentration of service necessary. New ways of mass transport could be a solution to solve problems like the lack of safety, comfort and flexibility of existing systems. Thus new and better ways of mass mobility would highly influence personal mobility.

All in all mass mobility has a rather high influence on personal mobility. Furthermore changes and developments of both modes of mobility have to be taken into consideration which makes the uncertainty of the driver rather high, too. The dependency on each other makes it hard to predict how both means of transportation will develop in the future.

9.2.2.2 Social Needs

Different social needs influence people's decisions and actions in terms of their mobility. Several needs support a decision in favor of personal transportation as among others flexibility, time saving, comfort, safety and privacy.

The need for flexibility is important because a private vehicle offers individual travel routes to every destination in the city. The use is independent from time schedules and possible at any daytime. This leads to a great degree of comfort caused by less unfavorable circumstances of depending on schedules and fix transportation networks. The individual route moreover implies time saving as one does not have to wait for the departure or has to change at stops. Comfort is furthermore gained by the high privacy in a private vehicle. People have the need to keep a natural distance between individuals and feel uncomfortable

if they have to spend time being close to a number of strangers. In personal transport this is not an issue. This privacy also leads to a better feeling of security. In mass transport social layers, which are normally separated by areas of living and working, collide. This situation causes a lot of security problems for wealthier layers as well as very young, elderly and disabled people. The need for safety drives people to personal transport to escape this lack of security especially in the night.

In conclusion social needs have a high impact on personal mobility because they strongly influence the development of new ideas, business models and technology and their adoption in society as well as what means of transportation a person chooses. Most social needs, especially the basic ones, are anchored in people of all social layers and do not change much over time. Higher needs like comfort and luxury needs are different within each social layer, culture and individual and their development is hard to predict. Taking both aspects into consideration the certainty of this driver is moderate. (compare section **??**)

9.2.2.3 Technology Improvement

The improvement of existing technology has a rather high impact. It can drive the people towards or against personal mobility. In case an existing technology was improved, personal mobility could rapidly increase especially when this new solution solves an existing problem like emission production or congestion. An example is the electrical vehicle which would be adapted by the masses as soon as it is affordable. Then many people do not need to use public transport due to environmental friendliness anymore and turn towards personal mobility. Moreover technology improvement can postpone the need for new technologies. If existing technology was improved and problems were reduced, the need for a solution would decrease. On the other hand, the lack of improvement would drive the need towards an disruptive technology influencing personal mobility or even towards new modes of transportation. In some cases the improvement of established technology influences the adoption of new technology e.g. in matters of affordability or mindsets. The combustion engine is still further developed although it produces emissions in contrast to the electrical power trains. Nevertheless the development of new technologies for electrical vehicles is progressing slowly. Moreover electrical vehicles are not adapted by the masses yet, due to an existing technology which is much more affordable.

It is rather certain that existing technology is steadily improving as it always has been. Moreover the features of a technology often dictate if and how the technology can be improved.

9.2.2.4 Environmental Issues

Environmental issues caused by traffic as pollution and shortage of resources influence urban life. Emissions cause smog and the inhabitants suffer from

health problems caused by bad air. Due to the growing number of inhabitants in urban areas worldwide (compare section **??**) traffic has grown and needs more energy. A great amount of resources have been burned up so far and they are constantly getting less. This affects personal mobility as fuel prices increase and people decide for other transport solutions to save money. With growing problems, the environmental awareness of people worldwide increases. They change their habits in terms of personal mobility e.g. by using the bike. Many also use mass transport to cover greater distances. Thus environmental issues can cause a change in social needs which again influences behavior. In parallel to these needs and the behavior of the society, the government is influenced by environmental issues. This topic has a high impact on political decisions and restrictions as well as on laws coming into place. This impact is emphasized by the interplay of voters and government.

In sum environmental issues have a high impact on personal mobility. However, they only have a moderate certainty. This is due to the rather certain scarcity of resources but the unpredictable progress in technology. It is unsure if, when and to what degree personal mobility can gain independence from these resources. The use of alternative energy already started but the degree of use is uncertain for the future and depends on technology progress and financial aspects.

9.2.2.5 Budget Restrictions

An important influencing driver for personal mobility is budget restrictions of companies, government and private persons. These restrictions can influence the outcome of personal mobility in the future at several points. The budget restrictions of companies form a bottleneck for new ideas, technology and products as the possible research and development depends on the spendable budget. Governments can less invest in infrastructure changes and subsidize mass transport due to budget restrictions. In addition new political ideas are often not realizable due to missing state money. The end customer has not only the power to decide what product he uses but is also bound to his spendable budget.

Thus new modes of personal transport can be too expensive for producer, infrastructure provider and costumer. For instance batteries for electrical vehicles are very expensive because of rare resources. Moreover many infrastructure changes are needed to provide charging possibilities. This influences the development of personal mobility because people further use ICE cars or turn to mass mobility as both possibilities are cheaper.

The certainty of this driver is high as money has been and will always be the bottleneck for changes in personal transport by companies, government as well as the end customer. But it is uncertain how big the influence will become in the future and how many projects will be cancelled due to budget restrictions.

9.2.2.6 Demographic Change

Demographic change is closely related to social needs as these strongly depend, amongst others, on age. Therefore an aging population causes significant changes in personal mobility needs which need to be considered in mobility solutions of the future. The growing group of elderly has new needs in accessibility, security and service of personal transport as they might not be able to drive by themselves anymore. These needs can be satisfied with new technologies like e.g. self-driving cars. An aging society and therefore the demographic change has a high impact on personal mobility and the certainty is also high, especially in developed countries (compare section **??**). Nevertheless it is influenced by balance of birth, death rates and migration streams.

9.2.2.7 City Characteristics

City characteristics as density, space and level of development shape the solutions of personal and mass transport. Technologies and transport services depend on the respective characteristics of cities. It is crucial whether there exists a given or an emerging infrastructure. Developed cities often have a difficult, slow and expensive process to change the traffic infrastructure. Developing or new emerging urban areas offer the possibility of efficient planning of infrastructure for personal and mass transport. All in all city features have a rather high impact on personal mobility.

In developed cities the cityscape is more or less given and will not change significantly within one decade. But also in developing cities constructions are planned early and decisions are made in advance. The process of infrastructure shaping is in general rather long and slow. This leads to the fact that city features are a certain and even guidable driver.

9.3 Scenarios

After having analyzed important drivers for the future of urban mobility, three scenarios for the year 2025 will be discussed in the following. These scenarios emerge from different variations of the key drivers and are further influenced by the additional drivers. These three scenarios are equally plausible since the development of the key drivers is uncertain, which makes it impossible to judge what development for the future is most probable. However, the third scenario is chosen as the main scenario and will be the basis upon which the business idea in 9.4 is developed.

9.3.1 Scenario 1: Car Free Zone

The scenario *Car Free Zone* is driven by a highly intervening political framework, a low mass adoption of the system of rules and no disruptive technology regarding

personal mobility (see figure 9.2).
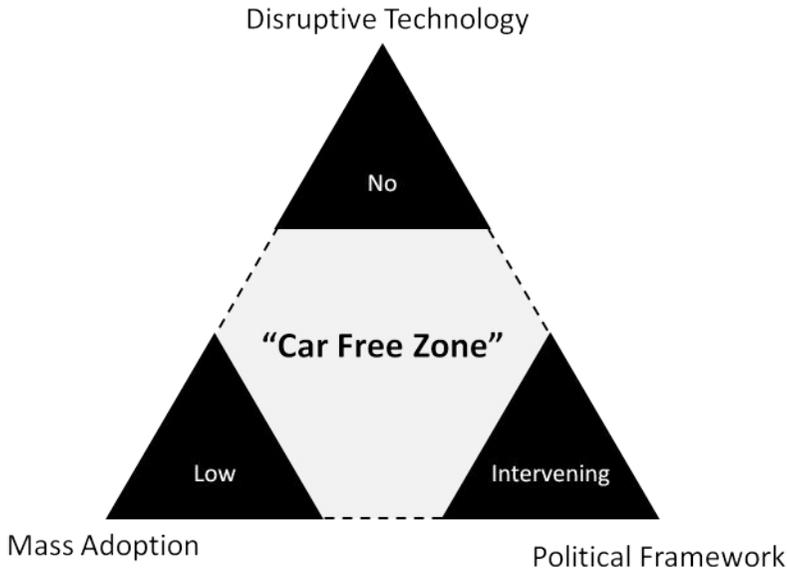
Figure 9.2: Key drivers of the *Car Free Zone* scenario
Source: own illustration

9.3.1.1 Scenario Description

In the first cities worldwide governments have decided to ban motorized vehicles from urban areas. The city center is a car free zone and surrounded by a zone border. Within people have to use mass transport or non-motorized vehicles such as bikes. Thus problems such as city smog or noise emission are minimized. Especially due to rising environmental problems and increasing congestion, governments were forced to implement this concept to guarantee acceptable living conditions.

This new model was firstly introduced within Beijing. One of Beijing's inner ring roads functions as a border for the car free zone within the city center. European cities adopted this structure, often by using parts of the former city wall to define the zone. Car free zones can be entered via different kinds of changing points. The most common kind of changing points is characterized by large and optimized park and ride stations, as many people have to be transported during a day. The parking houses offer optimized and efficient storage for the great amount of daily-parked cars and adjusted ways for the passengers to enter the public transport stations. High-speed moving walkways are implemented to increase the speed of passenger transport to prevent overfilling and a better

comfort in the park and ride stations. Moreover intelligent solutions provide information about leaving mass transportation vehicles and manage a better passenger flow to shorten waiting times. Nevertheless the changing points became a bottleneck in the urban traffic flow. Especially congestion problems within and next to the changing points lead to high waiting time especially in rush hours.

Another type of changing points allows authorized vehicles to enter and leave the car free zone. Although private personal transport is banned, emergency vehicles e.g. those of police, hospitals and doctors have permission to drive in the inner city. Also transportation services such as freight transport and taxi services can get a license for the zone. Furthermore private persons can apply for a temporary permission for reasonable matters like relocation or freight transport for business. All these permissions for public, economic and private usage differ in duration and price.

Freight transport to destinations in the car free zone is made possible by several ways. At big changing points heavy goods can be delivered and are transported by freight transport services to a destination within the zone. These services are offered by commercial and public transport companies, which use special freight vehicles. Public freight transport is less flexible but included in a special seasonal ticket. For light goods mass transportation vehicles provide additional space for freight and offer quick solutions to load and unload it.

The majority of traffic in the city center is caused by people riding bikes. Elderly and disabled people often use bikes with electrical engines, three wheelers and motorized wheel chairs for better safety. Due to the infrastructure change, biking in general got safer because there is less danger of having accidents with faste motorized vehicles and a developed and broad lane structure with different speed lanes for bikers. Moreover biking is more comfortable than as e.g. a great network of bike parking spots has been built up. Motorized vehicles like buses and other vehicles with permission have to use specially signed lanes. Signed lanes are easy and cheap to install because they can be implemented on existing streets. Altogether a significant change of the existing infrastructure was not necessary.

Due to the implementation of car free city centers environmental problems such as city smog decreased significantly within urban areas. As a result living standards have increased and the behaviour of inhabitants in means of mobility has changed drastically. On the one hand public transport improved due to high governmental investments. Together with progress in technology these investments made e.g. the introduction of emission free buses and faster means of transport possible. On the other hand social needs, like comfort and flexibility, are neglected as cars are banned from city centers. Especially time loss due to congestion around changing points and constant dependence on timetables generates public dissatisfaction. The population struggles with the new regulations and as a result countermovements arise. Along comes the

need for privacy and security, which is threatened by a forced use of public transport. Normally different social layers are quite separated due to their social environment and their working place. Within public transport all social layers collide which causes a lot of security problems. Especially wealthy people feel the lack of safety compared to driving their own car. Therefore, constantly high investments are made to improve the security system of public transport.

Apart from that the system has to be improved even further, especially by optimizing processes at changing points to minimize the currently high congestion. The mass transport system has been expanded and made denser compared to the time before the car free zone. Busses and trains run more frequently to decrease waiting times and to cover the high number of passengers. Moreover additional stations have been installed to guarantee low distances to the mass transport system from all positions in the zone. These changes were mostly financed by the city using tolling and parking fees. All those ongoing improvements are supposed to guarantee adequate availability and flexibility but cannot yet compete with former personal mobility solutions. Therefore new technologies like personal rapid transit systems have been installed as they offer advantages of personal transport like privacy, security and flexibility but are designed for the masses. It remains to be seen how these systems will turn out regarding efficiency and customer satisfaction in the future.

9.3.1.2 Signposts

In cities all over the world traffic increases due to growing urbanization and wealth of their inhabitants. With more wealth the number of people driving private cars is growing steadily. As smog density becomes higher because of pollution, the municipalities need to start limiting emission and congestion problems. This is realized by steadily growing tolling zones and fees. Nevertheless the concept of tolling is not successful enough and does not reduce traffic and emissions significantly.

The infrastructure cannot be adjusted fast enough to the increasing amount of cars due to slower building processes. The high amount of traffic causes congestion especially in the rush hours and as a result travel times are immense. The scarcity of resources leads to steadily increasing energy prices. These facts result in a higher usage and dependency on mass transportation in urban areas.

The revenues of tolling are mostly invested in an improving the mass transport system as it is an environmentally friendly and very efficient mobility solution. With the better availability of mass transport many inhabitants abstain from owning a private car. In addition many use other individual transportation such as bikes to stay flexible.

The municipality bans personal motorized traffic from the city center due to immense traffic problems as well as unbearable environmental issues and living standards for the inhabitants. As the mass transit system has been constantly

improved and extended, it can cope with the high number of passengers.

9.3.2 Scenario 2: Road Runner

The scenario *Road Runner* is driven by a disruptive technology in the area of personal mobility resulting from a high intervening political framework that invests a lot of funding in research and development. This new technology is highly accepted and implemented by the population, hence there is a high mass adoption of this new technology (see figure 9.3).
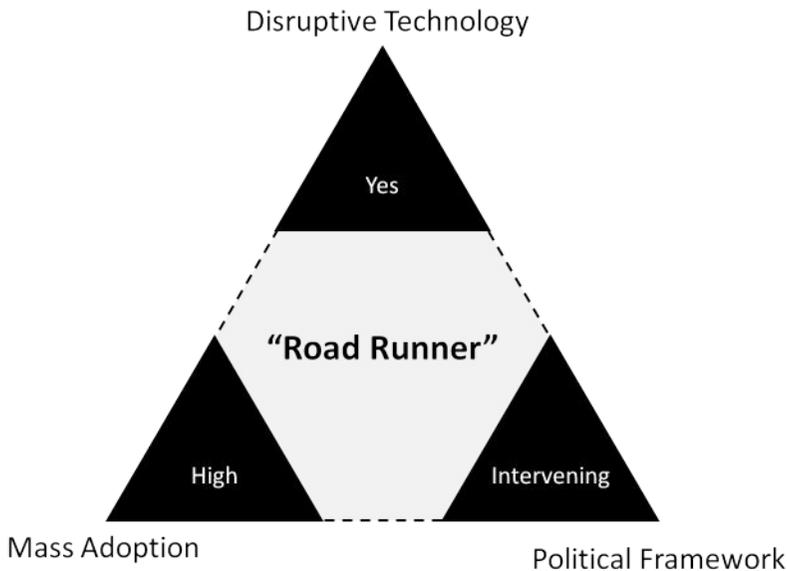
Figure 9.3: Key drivers of the *Road Runner* scenario
Source: own illustration

9.3.2.1 Scenario Description

Shanghai, due to its strong economic growth, has become the world's largest city. The transportation system is highly advanced and new technologies are permanently tested to minimize problems that arise from the expanding population. Governmental investments in existing infrastructure are encouraging this trend. Lately a revolutionary new technology called the Road Runner has been implemented. It offers a completely new way of short distance traveling within urban areas by overcoming common means of transportation thanks to high speed and flexibility and therefore replaces existing technologies.

The great success of the Road Runner is mainly based on its convenient and flexible way to use. It is light weighted, rather small and offers a faster way of traveling than riding a bike. As the Road Runner is something like a new kind of shoe type with additional mobility support, it also can be transported and stored easily, as it even fits into a backpack and therefore makes storerooms, such as garages, unnecessary. Annoying searches for parking spots are history and as traffic decreases no more time is wasted in congestion. Further, this new technology is quiet and easy to use and therefore improves the quality of personal mobility. Additionally, the Road Runner is an environmentally friendly means of transportation, which does not cause any emissions and thus is suitable for cities facing environmental problems. As a side effect cityscape improves as traffic decreases and additional space emerges due to abandoned parking space. However, since the Road Runner is only optimized for single person usage and short distance traveling, it leads to a decreasing social interaction as conducting small talks or making phone calls while using is not possible.

Since its market implementation the Road Runner experienced a massive adoption. Triggered by high maintenance costs for cars and rising expenses for public transport, a constantly increasing number of people switch to this more affordable new technology. Due to its low price the Road Runner became the main means of transportation for the majority of the population in between the age of 16 and 65 years. As body movement is necessary to use the Road Runner it is not suitable for disabled, the oldest and very young persons. Thus common methods of traveling such as cars or public transport are still in use. However, the usage of these common mobility solutions got unpopular for personal mobility and the main purpose of these transportation means changed. In contrast to Europe where cars are primarily used for personal mobility, in Shanghai they are mainly used for the transportation of heavy goods. Therefore, the demand for cars decreased drastically within Shanghai isince the Road Runner as motorized vehicles, such as cars or motorbikes, are not used for personal mobility anymore. New business opportunities emerge, while existing industries like the automotive market decreases sharply. Especially the intervening political framework had a huge impact on this development. Due to massive governmental investment in personal mobility, scientific progress has been encouraged and led Shanghai to be the world's most innovative city concerning urban mobility.

To allow a safe usage of the new Road Runner technology, Shanghai had to adapt its infrastructure and political framework. Existing streets transferred into fully developed walkways and new traffic regulation systems had to be invented. Former parking spaces turned into green zones to improve the cityscape. But nevertheless, as Shanghai was the first city to implement the Road Runner, the government is not able to react fast enough to the on-going change in the area of urban mobility. Now the streets of Shanghai are characterized by a small number of cars, taxis and buses with an optimized and efficient traffic flow. In

comparison to highly congested European cities this is a large improvement. People using the Road Runner can easily enter and continue their trips by mass transport. Hence, as the Road Runner technology is particularly suitable for short distance traveling, the Chinese government decided to improve and expand the public transport system for long distances. In order to safe money systems for short distances were reduced as its usage strongly decreased. Altogether the quality of Shanghai's mobility transport system has increased highly since the implementation of the Road Runner. Although its introduction went along with high costs, especially concerning the high investments in research and development made by the government, problems such as health issues due to high CO_2 emissions in urban areas or wasted time in congestion can now be handled more easily. Currently Shanghai is the only city using this technology, but further big cities like London or Munich started to adopt their infrastructure to be able to introduce the Road Runner shortly. Since this process is not completed, in Europe the Road Runner does not have a street permission yet especially due to security problems. However, as this technology requires huge governmental investments like changing the existing traffic regulation systems, in the first phase the Road Runner will not be implemented in emerging countries like Africa.

9.3.2.2 Signposts

Due to an increasing number of cars and further urbanization both in emerging and developed countries, cities are becoming more complex. Hence the challenge to have safe and efficient road traffic gains importance. Especially in densely populated areas like London, Berlin or New York congested city centers are a major problem. An expanding middle class further enhances this challenge as buying a private car gets affordable. As a result pollution increases and thus health problems, such as Asthma and bronchial infections become common diseases. Furthermore the traffic in urban areas gets particularly bad. Congestion determines the usage of mobility and as a result the desire of the population to strengthen the mobility system increases.

As real time routing failed due to privacy issues, the government shifts mobility away from urban areas by massive investments in the public transfer system. Additionally, worldwide underground street systems are created in urban areas to reduce pollution. Streets with five to seven tracks become normal.

As an economically rational alternative to motorized vehicles is not found yet, city life gets more and more unattractive and generates general public dissatisfaction. Parties supporting environmental awareness are increasingly popular to the voters. Special government campaigns like massive subsidy programs for research work in the field of personal mobility are set up to stop this development. As a result the business of personal mobility experienced an immense growth. Finally, out of this development a disruptive new technology,

the Road Runner, occurred which is firstly implemented in Shanghai and is considered a great success.

9.3.3 Scenario 3: Sharing

In the third Scenario for 2025 *Sharing*, mass adoption is high and the cause for a flourishing carsharing business (see figure 9.4). There is no disruptive technology but a massive growth and development in terms of e-mobility. The political framework in the beginning is indifferent. However, as the growing carsharing market offers a lot of profit on the one hand and might decrease customer numbers of public transport on the other hand, the dimension of this key driver might eventually shift.
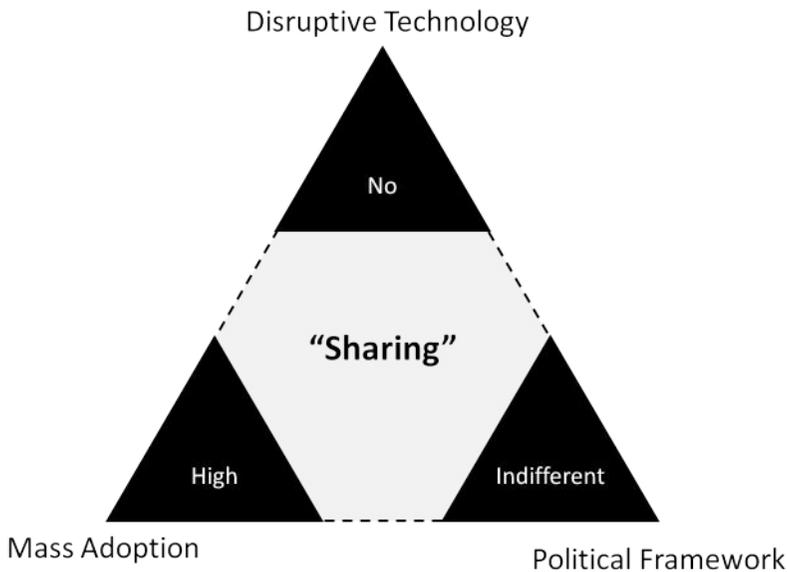
Figure 9.4: Key drivers of the *Sharing* scenario
Source: own illustration

9.3.3.1 Scenario Description

The cityscape of a traditional European city like Munich has become the playground for sharing of vehicles in 2025. Bikesharing and carsharing is established in people's minds and has become a feasible transport solution in cities. A big part of cars driving in the city especially all cars belonging to carsharing companies are electric cars, whereas the amount of ICEs steadily

decreases. Nevertheless, there is still a share of ICEs in personal mobility that is not to be neglected.

Apart from the different engines, there is a huge difference in designs and shapes. While combustion engine cars look the traditional way, new forms of e-cars are conquering the market. The design of shared e-cars has adapted to the special needs of carsharing companies. There are cars with only two wheels and others with the established four wheels, but all of them are able to turn their wheels into all directions to make for instance parking very easy. Moreover, they are fitted in terms of plug ins and of shape to the charging stations that serve as parking stations for the publicly available carsharing cars and are easily stackable in multi-level-parking slots. Another improvement is that modern electric cars can be linked together and form a train of cars. This way of driving is called *cars-in-a-row*. The connection is mechanical and electrical, thus only the first car has to be steered while the energy used is coming from all the connected cars and batteries. The collection of many shared cars at-a-time, for instance when they need charging, becomes very easy.

Regarding park and charge facilities, the city owns a wide spread public charging infrastructure that allows e-car owners and users to charge their car at almost every street corner, at traditional gas stations, which have adapted to new electrical charging stations, or at parking lots of for instance supermarkets. The latter works in a similar way as carsharing parking spots, the car is charged while it is not in use by its owner or one temporary user. In terms of park and charge spots being part of carsharing platforms this allows for a steady use of shared e-cars due to constantly charged batteries.

As there are many cars in the streets and congestion is still a problem, the city now has an established and dense car2car and car2x communication network. Most of the car manufacturers sell this service as standard with their products and all carsharing companies include this in their e-cars. This vast network makes road safety an established feature in the city and has decreased the number of accidents significantly. The new communicative car provides the driver with a multitude of information. It has various sensors to predict upcoming accidents, difficult weather conditions or congestion. Moreover the car's internet access offers new infotainment possibilities such as directions to the nearest free parking spot. The intelligent car constantly exchanges data, not only with other cars, but also with the adapted intelligent environment. Real time routing is installed all over the city. The wide collection of data helps to control traffic flow and provides individual routing information. For the people driving through the streets this means that they are informed about congestion, road works or certain events blocking the streets and are offered different routes. This is especially helpful for food delivery services as they now need very little time to deliver warm meals to the customer. The city uses the bundled real time routing information to steer traffic lights, inbound highway traffic and parking guidance systems. Urban traffic is cross-linked and communicating all

the time.

A growing number of pilot projects that employ self-driving e-cars for carsharing benefit from the available intelligent infrastructure. They enable carsharing for the elderly and for the increasing number of people without driver's licenses. The self-driving cars rely upon the intelligent and communicating infrastructure and are so far causing significantly less accidents than human steered cars. However, these self-driving cars are still in their testing stage and therefore the main business in carsharing is based upon cars which need a driver.

The public transport system is still important. Many people do not want to or are not able to drive a car themselves and frequently use the established mass transport system. Others make more sporadic use of it, in case of bad weather conditions or when they go for a drink. While subways and light rail transit have been powered by electricity for several decades, buses have finally caught up and become e-buses. They use the charging possibilities at each bus stop and therefore do not have any range problems. Apart from this, public transport has not changed or expanded considerably since 2011.

The governance has not changed drastically either. There have been a lot of adaptions to ongoing changes especially concerning infrastructure and public transport, but at the moment it is yet to be seen if the government will start intervening or stay indifferent towards the new shape of personal mobility. Apart from installing and establishing real time routing, the municipality heavily expanded the city's bicycle infrastructure, in order to support an environmentally friendly means of transport and decrease congestion. There is a citywide network of bike lanes, including an optimized regulation system based on traffic lights as well as real time routing information. By that, the government backs up the growing bicycling culture within the city.

Regarding freight transport and emergency-services both electric and ICE vehicles are used. Especially smaller businesses fear the necessary big investments for owning electric vehicles. Some even switch to shared vehicles to save money. While emergency-services like police or ambulance appreciate the advantages of intelligent, connected e-cars and real time routing offers, bigger companies still oppose the effort to change their means of freight transport and rely on their existing and conventional ICE vehicles without car2car or car2x communication.

As already indicated, urban mobility is characterized by a booming car- and bikesharing industry first of which uses e-cars as the actual transportation means and second of which makes use of the vast governmentally supported bike infrastructure. The actual road users in cities have changed their mindset to usually borrowing and not owning a vehicle. As a result owned cars become a rarity especially under young citizens and lower income classes. Although owned bikes are still wide spread under the city's population, bikesharing is an important business especially for tourists visiting the city and citizens using the bikes for spontaneous trips.

This sharing industry contains a one-digit number of providers competing for

customers but trying to match their platforms in a way that offers customers the highest amount of flexibility. Every single provider tries to distinguish from its competitors by implementing unique selling propositions that promise higher numbers of more frequently using customers. Some of them for instance offer real time carpooling as an additional service and approach flexible and sometimes not as prosperous users like students. There are carsharing platforms with luxury and extravagant sportive cars that include seat heating, massage units and the most up-to-date technologies. These high-class companies approach mainly people who care a lot about comfort or prestige. On the other hand, there are carsharing companies with the target group of students offering low prices and trying to catch them as frequent users. However, all companies make use of the city wide implemented real time traffic routing and provide the car user with up-to-date congestion information.

Going along with the change of people's mindset and the shared use of cars is the problem that people tend to care less about the condition of the cars, since they are not their property. Carsharing companies struggle to cope with vandalism and people soiling their vehicles.

The carsharing system itself in terms of the organization of getting the cars into the park and charge pick-up stations is already advanced. The normal case of a road user making use of carsharing platforms is like the following: He picks a car up at a random station of a specific carsharing operator and drives to the station that is closest to his destination. In case he actually parks this car from company X at a station that belongs to company Y he needs to pay a small fee. This fee is implemented to prevent overwhelming chaos in the distribution of cars in the car park stations. The wide spread and very dense charging stations network allows for flexible rides with the suitable station at the end of the journey. There is an obvious coherence between the companies with the densest park and charge infrastructure and the highest number of customers. Carsharing users can easily find the stations closest to their current location and also their final destination and decide for a specific company by inquiring their real time electronic map on their smart phones.

In case the user does not park the car at a station but on an ordinary parking spot he also needs to pay a fee in order to prevent too high fragmentation of the network. However, the possibility exists and lets users become even more flexible. A huge problem is that the majority of customers is not willing to charge the e-cars because of the comparatively big time effort, especially because charging is already included in the carsharing price. To prevent cars from standing around in the streets with an empty battery, e-cars from carsharing companies only run until 10% of the battery charging is left. The customer gets a warning about the current state of the battery from 20% downwards and is asked to find a parking spot or a charging point within the next few kilometers. The car automatically locks when the 10% margin is reached and when standing on an ordinary parking spot without charging. It cannot be used by customers

anymore. Personnel of the company is informed about the empty cars via a network map that indicates all current positions of used and not used cars. They can still use this car and drive it to the closest station to guarantee recharging. This process is further simplified by the cars-in-a-row principle that was pointed out earlier. Still the amount of empty cars filling-up public parking spaces is growing and carsharing operators struggle to keep their cars together and fully charged.

Concerning self-driving cars the method of sending the car to the closest station when reaching the 10% margin has already been implemented into the pilot projects and is right now in a test phase. This could allow companies to shorten the personnel needed to rearrange locations of free parking e-cars.

Considering the different possibilities of using the carsharing and bikesharing infrastructure as well as alternative means of transportation, there are different points of view resulting in different shapes of personal mobility.

A few years ago the majority of commuters did not benefit from the booming carsharing industry. As the park and charge stations concentrated and still concentrate within the city-center, they did not have the possibility to use shared cars for the ride home from work. Therefore big companies reacted by opening their own carsharing platforms for their employees. Today, most of them have a great fleet of company owned e-cars stored at a central park and charging station at the companies headquarters where employees can pick up a fully loaded car for the ride home and park their cars at arrival in the mornings. Employees with a very long travel are provided with home charging stations to reload the car over night. The cars serve as advertising vehicles displaying the company's name and their progress to e-mobility. Recent studies show that this solution turns out to be worth the effort for companies, as most commuters arrive at their working place less stressed and in a better mood than if they had used public transport

The majority of students and young adults are bike users. Most of them own a private bike, but some of them rely on bikesharing, as they live in the city center and use bikes only sporadically. For all students the big choice of carsharing is very attractive because they normally cannot afford to buy a car. Even though most of them are not frequent users, they sometimes need a car or other vehicle for shopping, transport of large goods, moving or in case of bad weather conditions. They also benefit from the competitiveness of the carsharing market and the affordable prices going along with this. Still, in a students every day life use of public transport in addition to bicycling is common.

Regarding families two ways of adapting to the new mobility solutions are visible. Wealthier families, especially those living in the suburbs, still rely on a private car. They make use of it quite often to get into the city, for shopping and for holiday trips. The share of privately owned electric cars is still low. On the other hand there are the families living inside the cities and those with a lower

budget. Both have decided for carsharing as a good alternative to a private car. They do not have to make a big investment but only pay an affordable price for the use of the vehicle. Moreover, they can easily switch between a big car for family trips and a sportive two-seater for a parents-only trip. Nevertheless many of them also use public transport for daily trips.

School classes or other large groups make intense use of the *cars-in-a-row* principle. In comparison to former bus trips, the linked e-cars are very easy and spontaneously obtainable and can be adapted to the size of the group. Only the driver of the first car needs to own a driver's license. The other cars just follow and can be fully occupied with children. The system is flexible in the amount of cars combined in a row, it ranges from two cars that are connected until roughly ten cars in a row, depending on the number of passengers. In sum, excursions become more spontaneous and cheaper and schools organize a lot more of them. But also private persons and families make use of *cars-in-a-row* for parties or special events and trips.

Although the carsharing infrastructure and its navigation system is on an advanced level, there are still a number of problems that need to be solved within the next few years. One problem in traffic flow is congestion due to the amount of cars in the streets especially during rush hour. The situation has improved but has not been solved since the implementation of real time routing.

Another big issue at the moment are the growing privacy concerns of society due to real time routing and car2x communication. Although they benefit a lot from it, people worry that their everyday life becomes too transparent. Especially the real time electronic maps tracking shared vehicles rise mistrust among users. Law and politics also have not yet been able to provide people with more security in terms of data crime and abuse.

Despite the named problems and concerns the market of carsharing is thriving and profitable. It remains to be seen if one of the current market players will prevail and crowd out the others or if the government will start intervening by either entering and supporting the carsharing market or on the contrary trying to re-establish and strengthen conventional public transport.

9.3.3.2 Signposts
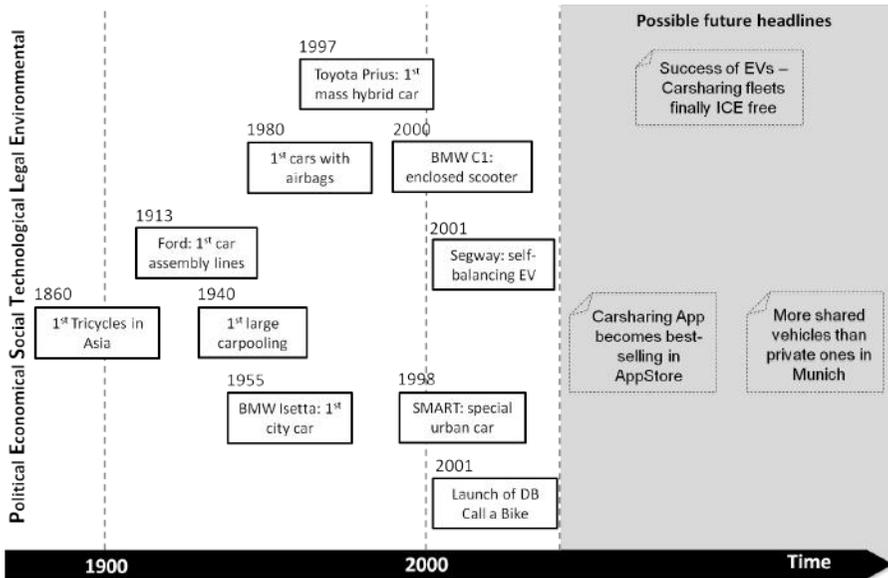
Figure 9.5: Timeline and possible future headlines
Source: own illustration

There are several signposts that could indicate that urban mobility is leading into the direction of the *Sharing* scenario. First of all, a carsharing app that offers all available carsharing cars around someone's position could become bestselling app in the appstore 9.5. As a result more people would use carsharing as a means to travel within the city and other means like using a taxi or a privately owned vehicle would decrease.

A further event that leads towards the presented scenario is the publication of sales figures revealing that car manufacturers have, for the first time in history, sold more vehicles to carsharing industries than to private persons.

The sales of vehicles and cars for private ownership would shrink and the number of shared cars in a city could overtake the number of private ones. In the upper scenario this city is Munich. More than half of the cars within Munich's street would belong to carsharing operators and people using carsharing could find these cars at every corner in the city.

The existing carsharing companies who have used at least some ICEs in their fleet could change to electric cars only. This would expand the concept of e-mobility within the city. Moreover research and development in the field

of e-mobility could be expanded and receive more and more acknowledgment. This would be accompanied by growing manufacture of e-cars and a developing charging infrastructure.

Another signpost for the scenario is the improvement of existing bicycle infrastructure all over a city. Riding a bike in the city becomes safer and more comfortable as there are new traffic lights and signs for bikers as well as a dense bike lane network.

The implementation of real time routing to tackle congestion problems is also a clear signal for the upcoming of the scenario. Infrastructure is adapted and car2car communication able cars go into serial production to make use of the new information services and expand its network effect.

9.3.3.3 Value Map

Figure 9.6 shows the value map belonging to the third presented scenario in this chapter. It is tailored to the actual user of personal mobility, the consumer. The level on the bottom shows outer circumstances that should be given by a service, a product or a system of rules surrounding people in a system of urban mobility, since these are the desires people wonder about when deciding for a product or service. It is privacy, flexibility, efficiency, individuality and environmental protection, making no claim to be complete. The level most on top is a collection of resulting inner desires that could be fulfilled if the products and services that offer the overall wishes like privacy and individuality are implemented in a successful way.

One example is the way from flexibility to better performance and a broader horizon. People who gain flexibility become independent since they do not depend on strict timetables or restricting rules. They decide upon when and where to travel to and choose their means of transportation according to the best fit. This guarantees mobility in terms of freedom of time and place. People have more possibilities when to start their journey, e.g. in the middle of the night, and do not rely on intermediate stations only but can choose their destination freely. This leads to the mentioned better performance since they work when they want to work and enjoy the leisure time when and where they want to, with some outer restrictions of course. The broader horizon also comes from more possibilities since people's minds get opened for many new styles of life.

In the scenario of *Sharing*, it already has been mentioned that privacy could be a concern. This does not mean the privacy sprouting from single rides which is described in the value map and which obviously is fulfilled, but the privacy built upon data protection. Since this is already a big topic in 2011, there is room for hope that this will not cause concerns in 2025 any more due to solutions that might be found in the near future.

Besides flexibility the outer desire to be and live effectively is absolutely fulfilled in the scenario. Efficiency describes the fact that cars shall not stand

around unused but be used for the better part of the time. Privately owned cars are not efficient at all. Shared cars on the other hand are used by a plethora of consumers and therefore reach a significantly higher status of efficiency. In sum, this saves money for the consumer who can spend it on much nicer purchases than an unused car. The desire of inhabitants to live in a city where environmental protection is pursued is fulfilled due to the growing amount of electric instead of combustion engine driven cars. It promises more motivation and enthusiasm in people's life since their prospects of the future develop in a much better way when thinking of a sustainable future. Moreover, they can actually rely on a longer and healthier life in a clean city, which makes motivation and enthusiasm an even more important topic.

Although the scenario already fulfills a number of desires that are collected in people's minds, there is still room to improve, especially in terms of individuality. Carsharing cars look all the same and people do not feel like driving in their own car when borrowing one. This effectuates one important source of gratification in the scenario *Sharing* and is one basis to develop new business ideas upon.
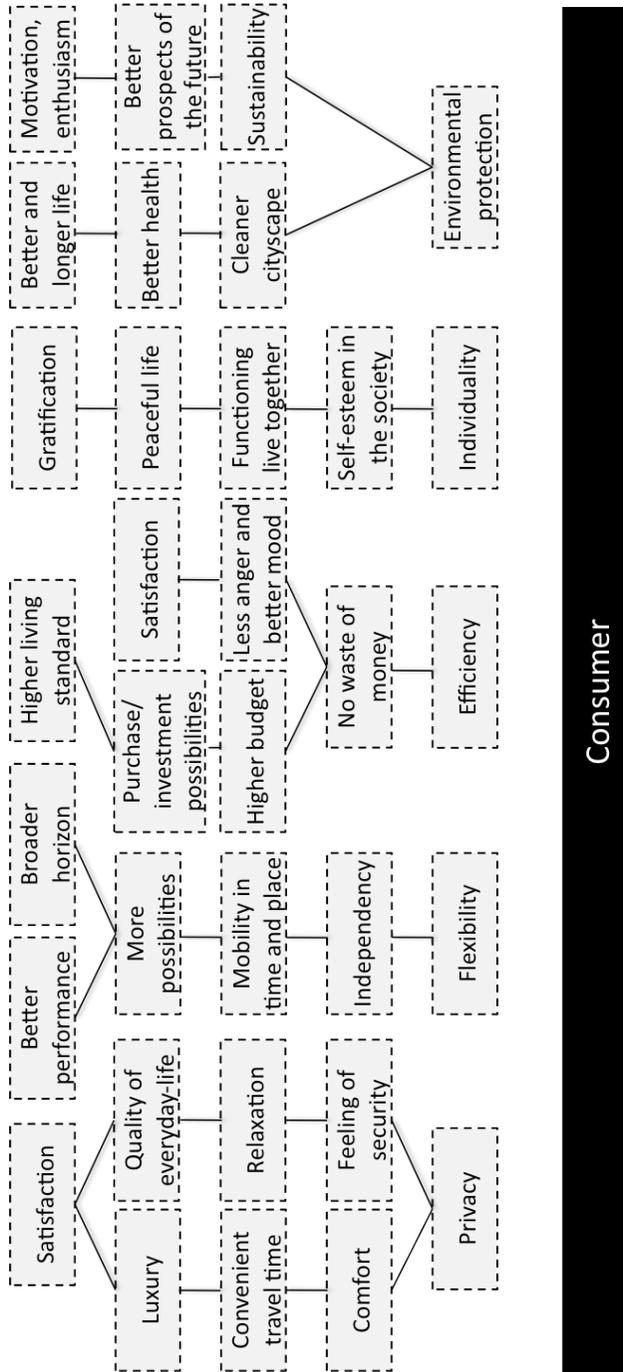
Figure 9.6: Attribute value map - *Sharing*
Source: Own illustration

9.4 Business Idea: carsonalize

The scenario *Sharing* has a flourishing carsharing industry. This kind of mobility offers new possibilities to strengthen flexibility and efficiency in terms of urban transport. However, the component of individuality is neglected. *Carsonalize* is a service which allows for more individuality when using shared cars. The description of the business model will be followed by an analysis of the nine elements of the Canvas model, a tool for describing and evaluating business models by Osterwalder and Pigneur [481].

9.4.1 Business Model

The business model behind *carsonalize* is a user system sold to carsharing operators to add value to their core business by personalizing their carsharing fleet. It is based on individual user accounts providing the end users with individual features during their rides. Once registered a free account the end user can benefit from personalizing features in cars of all participating carsharing operators (see figure 9.7).
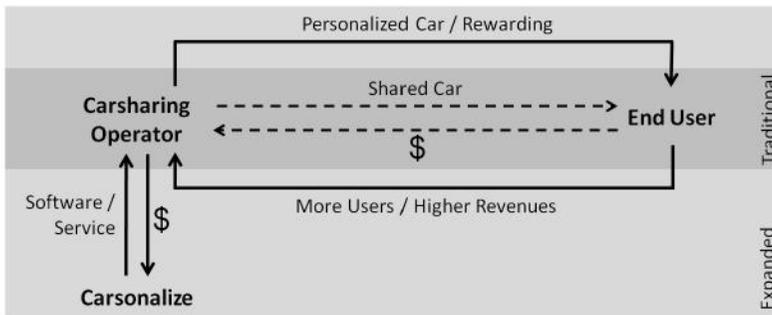
Figure 9.7: Integration of *carsonalize*
Source: own illustration

As the carsharing cars are not owned by the drivers but borrowed for single trips there is no personal driving experience so far and customers see the car they are using as a completely neutral device. Moreover, it is necessary to adjust the car before every single ride. Individual carsharing accounts change this due to personalized features which include individual settings of the car (e.g. mirrors, seat, steering wheel), a personalized entertainment system, customized routing and access to a mobile office, which can be synchronized with the user's calendar, e-mails and contacts (see figure 9.8).
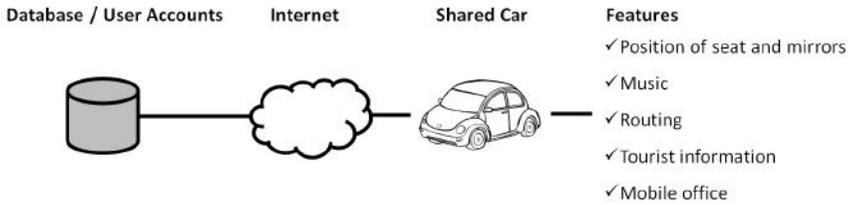
Figure 9.8: Personalization by *carsonalize*
Source: own illustration

Carsharing users can register for free as an end user of *carsonalize* and get an account in the web portal. This portal is linked to the cars of all participating carsharing operators and available during the ride. Users can log in via internet from a computer or mobile device and save their entertainment preferences or favorite routes. When entering the car they merely need to login and have access to all features they want to use. The car adjusts automatically to the saved settings in the account. This provides the end users for example with individual navigation to their favorite places and with favorite music due to personalized radio or saved libraries.

The actual customer of *carsonalize*, the carsharing operator, pays for the availability of this service in his car fleet. Carsharing operators add a significant value to their service especially regarding competition with other operators in a city. Once *carsonalize* is established successfully and hits a specific user number, carsharing operators are forced to join in the system, since they lose crucial advantage in competition otherwise.
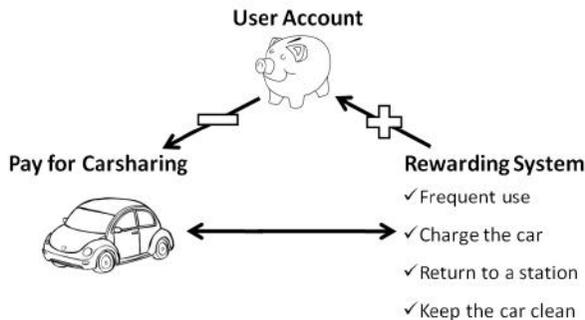
Figure 9.9: Rewarding system of *carsonalize*
Source: own illustration

Besides the personalization of the carsharing experience a rewarding system is

implemented, which enables carsharing operators to offer bonus points to their users for special behavior, e.g. frequent usage of their carsharing fleet. Users who charge the electric vehicle at a public charging station could benefit in form of these bonus points on their carsharing credit (see figure 9.9). When charging they do not have to pay for the actual electricity since this is already included in their carsharing fees, but they are rewarded for saving the carsharing operator labor to do the charging and making the carsharing network work. Users could also get these bonus points when returning the used car to a carsharing station belonging to the carsharing operator. The former fees that were charged when users parked the carsharing cars somewhere else than in a station hereby drop. This allows for a less fragmented carsharing network and again lower effort to collect the cars by the operator himself. Moreover, carsharing users can be rewarded for keeping the cars clean. A user is asked for the cleanliness of the car when entering it and needs to decide between *clean* and *messy*. He hereby judges the driver that used this car before. In order to prevent any swindle, users only get the bonus points after five people evaluated them as clean users.
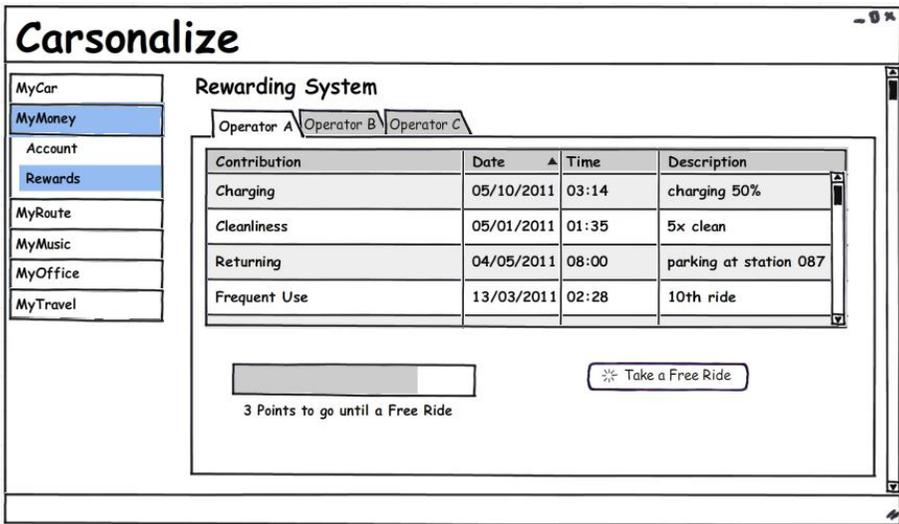
Figure 9.10: User Interface of the platform
Source: Own illustration

The rewarding system is an add-on service which carsharing operators can use to distinguish from their competitors. Since carsharing users collect the rewards in different baskets - one for each carsharing operator - and since the operators decide on the type of reward they want to offer to their customers the best offer will prevail and keep the most end users (see figure 9.10).

The user system is working nationally, meaning that people from one country e.g. Germany can log in to their account in every carsharing car that offers this service nationwide. An inhabitant of Munich rather decides for the tourist feature when going to Berlin and will be suggested sights and places to eat, drink and visit. However, all personalized features will still be available for him, except for the personalized routing, which will automatically adapt and navigate the user through the foreign city. The case of crossing a border is for now excluded since the carsharing business is based upon urban mobility. However, the business idea could be expanded internationally in the long run.

A further possible addition would be the cooperation with location-based marketing businesses. These services automatically save data about user preferences and offer, for instance, special discounts or coupons for cafes or movie theaters according to the current position. This new function could easily be integrated in the existing personalized routing. Furthermore the carsonalize system already collects and stores a lot of information on usage and operators could consider using it for marketing purposes or government cooperation. If they, for instance, started rewarding people for avoiding rush hours, driving safely or for carpooling to make rides more efficient, they could apply for governmental subsidies like free parking space in the city, as the municipality benefits from decreasing congestion and fewer accidents.

9.4.1.1 Customer Segments

The *carsonalize* business model provides a service for carsharing operators to help them attract more end users and improve the functionality of their network. Since the service is tailored to personalize carsharing and operators are the only customers, the market is considered a niche market.

While the main focus of a successful business normally lies on the paying customers, the *carsonalize* service also has to be adapted to the needs and interests of the non-paying end users. Their opinion and taste influence how the web portal and the user accounts have to be designed. Obviously, the *carsonalize* service is only interesting and profitable for the carsharing operators if their end users enjoy and use it.

9.4.1.2 Value Propositions

Carsonalize provides multiple value propositions for its customers, the carsharing operators. The core value proposition is a growing user basis for their carsharing business and thus increasing revenues. This is a result of the indirect value propositions *carsonalize* offers the end users of carsharing.

Carsharing Operator   The concept of traditional carsharing does not offer much room for individuality. Since the cars are not owned by the end user, they are no status symbol and merely function as a neutral device. With the

implementation of the service accounts, there are new possibilities to customize shared cars. They become a more individual and private way of transport and thus are more comfortable to use. Entering the car, with seats and mirrors already adjusted and driving through the city while listening to a personalized radio station is a new luxury for the users. A carsharing operator implementing the *carsonalize* service is able to attract a lot more end users. On the one hand people switch from competitors who do not offer the *carsonalize* service. On the other hand, people who were until now not willing to use carsharing at all can be attracted. Thus the membership grows and customer loyalty is enforced.

Moreover, the implementation of the *carsonalize* account system saves the operator expenses. Due to the rewarding system end users are motivated to charge the cars, take care of them and bring them back to one of the collection stations. Thus, less personnel is needed and organizational processes are automated by the system. Moreover the operator saves money on maintenance due to the better conditions of the shared cars. The rewarding system also offers the possiblity to differentiate from competitors by including special offerings.

Another feature to customize the system and hereby provide the operator with an additional competitive advantage, special add-ons can be developed according to customer wishes and the standard of his carsharing fleet. For instance, an operator specializing on family cars equipped with video screens for children in the back seats could order a feature *MyMovies* to access favorite movies during a family trip.

Carsharing End User   As already indicated, the personalization of carsharing provides the end user with more comfort and luxury. He or she can actually transform every type of shared car into their private vehicle. For instance they can drive a fancy sports car one day and switch to a big family van the other day. Still the inside of the car will always adapt to them and stay their personalized driving experience. In addition, as soon as many people contribute to the rewarding system, the conditions of the cars improve and people are more satisfied while driving them.

Moreover, by making use of the rewarding system, end users can save money and actively contribute to the improvement of the carsharing system. The centralization of all basic processes in one account simplifies the use of carsharing and the payment. The web portal could eventually provide a standard for the different carsharing operators and make it easy to switch between them.

To sum it up, the business model offers appealing value propositions for the customers and the end users. As already indicated in section 9.4.1.1 the *carsonalize* system needs to be accepted by the end users but still the most important value propositions are obviously those for the paying customer.

9.4.1.3 Distribution Channels

As seen before the target market of *carsonalize* is a niche market exclusively consisting of carsharing operators. The first stage of distribution is to raise awareness among these operators. This will be achieved by direct marketing, meaning that the carsharing operators are approached by *carsonalize* personnel coming to their company and talking to them, by e-mails, phone calls and also on special mobility events like trade fairs. For operators, there are two ways to evaluate the value proposition of the service, firstly via conversations with *carsonalize* personnel and secondly via a special segment of *carsonalize*'s website explaining the business model and its advantages for the carsharing operator. When purchasing the business offer for his fleet the carsharing operator signs a contract with the company *carsonalize* and their sales force. The actual delivery includes the software services tailored to the individual car models, which the carsharing operator owns. For instance, the software facilitating the automatic adaption of a seat depends on the seat's features, whether it is a special seat with lots of different adjustment possibilities or an ordinary seat offering only one or two adjustabilities. The car's internet access, which is already installed in the cars, is needed to connect to the system and access the account information. From this point on, having the service implemented for the carsharing operator, he is further accompanied by *carsonalize* and does not have to do anything concerning this service or maintenance since all updates are guaranteed by the providing company *carsonalize*.

9.4.1.4 Customer Relationships

The direct customer relationship of *carsonalize* is based on retention. After having acquired the carsharing operators in the first stage, a stable and well-balanced relationship retention is of utmost importance to maintain the rather small customer basis of *carsonalize* as strong as possible. This relationship will be established by dedicated personal assistance, meaning that each carsharing operator has a contact person in the company, supporting him with after sales services, new features and maintenance of the system. Moreover, the additional services tailored to each customer's wishes (compare section 9.4.1.2) result in a strong consulting relationship from *carsonalize*'s point of view towards its customer. This includes individually developed and implemented add-ons for the carsharing operators that want to distinguish further from their competitors. An example would be an access to the intranet of a company using carsharing for their employees. In this case, the company functions as the end consumer and demands a special service from the carsharing operator.

As already indicated (compare section 9.4.1.1) the end user is not a direct customer but still of crucial importance when trying to sustain the business for the carsharing operator. The focus in between acquisition and retention of the end user is not as clear as before. Obviously the number of end users

will need to grow much further than the number of carsharing operators. It is crucial to gain a broad end user basis. Afterwards, the carsharing users will be handled via automated services, namely their personal online profiles, and have the possibility to make use of the broad community of people also using personalized carsharing.

9.4.1.5 Revenue Streams

The revenue streams of *carsonalize* offer a high profit potential especially in the presented scenario *Sharing* and will be outlined in the following. It is important to explain each revenue stream depending on the different accounting methods and cash flows.

Product License and Maintenance   The company of *carsonalize* develops, improves and sells software to allow an optimized and personalized use of the hardware in the different car models. The manufacture of the hardware inside the car, required to use the *carsonalize* service, is managed by the automotive manufacturers. Furthermore the business provides and charges accompanying customer relationship.

Each carsharing operator needs to obtain a license to participate in the system of *carsonalize*. After that the end users can use the personalized features in the fleet of the carsharing operator. Thus revenue is created due to selling of licenses. This can be subdivided into two, a major and a minor business division. The major business division consists of selling the licenses of the *carsonalize* system itself with its personalization features. In addition operators can decide whether they want to activate the rewarding system. As a result competitive differentiation is possible. Therefore the license fee is higher. Besides the license for the basic features, the licenses for the adjusted software to the different car models is charged.

Apart from the purchase of the *carsonalize* system in the beginning, the operators also pay for maintenance and, in case new features are developed, when they want to include further updates. The maintenance fee includes the personal service provided for each costumer. In addition, the amount of data for each carsharing operator needs to be stored and influences how much the operator has to pay for data storage. The more data there is the higher the server and storage costs for the *carsonalize* company (compare section 9.4.1.9).

Customization and Add-ons   An additional sub business division provides the service of customized add-ons. These are developed on customer request by considering the individual needs of their end users. Another customized software package is needed with every new car model in the fleet, as this needs adjustment of the interaction with the hardware. In both cases the price depends on complexity of development and software. As this service is adjusted

to specific customer requirements, the price and thus revenue is much higher than of the basic *carsonalize* service.

The pricing model for both business divisions is based on the same principles. On the one hand revenue results from the license fee in the beginning of the customer payment transactions. On the other hand systems trigger recurring revenues due to subscription fees for continuous access to additional service usage like data storage. Then the customer can choose between monthly variable usage fees for these services, depending on the used volume or a fixed price, which is calculated based on statistic variables.

9.4.1.6 Key Resources

The business of *carsonalize* is mainly based on software technology. In the beginning a platform has to be developed. Furthermore compatible software for the individual car models of the carsharing operators has to be implemented. This requires human resources as well as time to develop a basis. Afterwards maintenance, constant updates and developments of the system requires personnel. Furthermore the concept of a business to business model needs human resources for sales and management of the customer relationship. As a conclusion, the key resource of the business model is human resources.

As no physical products are produced, physical resources are not required for the product itself. Only general physical resources like offices and servers, which hold the system and the data of the network, are required. This server space could also be leased from a third party or used via cloud. Thus expenses for renting space and maintenance of the server could be reduced.

Apart from human and physical resources, intellectual resources play an important role in the business model. Although the business idea does not base on concrete proprietary knowledge like a new technology, good customer relations have to be established to be successful. The concept of personalized carsharing accounts strongly depends on the developed software and the related intellectual property. The most important part is the network of carsharing operators and end users to run a successful system. Therefore the platform is a further key resource of the business and has to be built up and constantly improved and expanded. This means that good marketing is essential to acquire enough customers and in addition end users. For that, more human and intellectual resources are needed. Although there is no competition in the provided service area yet, it is important to establish and strengthen the brand in the beginning, in order to maintain the monopoly position. Thus high financial resources are necessary to start the business and implement the system in a first version. Later on, running the business does not require further high investments.

9.4.1.7 Key Activities

The software of the platform has to be developed and tailored to the different requirements of each car model or rather each carsharing operator. This requires research work to gain knowledge about customer needs as well as knowledge about the technology of the cars. This can be summarized in the key activity of developing software.

Sales and customer relationship management is a key activity of the business idea as it is a business to business concept. Service has to be provided and promotion needs to be done. This means that marketing is an important tool to establish the network of participating carsharing operators and end users. The platform is the central product and has to be constantly managed and expanded which means that platform and network related activities are further key activities. As the platform highly depends on the network of its users another key activity is establishing the brand by marketing.

9.4.1.8 Key Partners

A network of partners is essential to run the *carsonalize* enterprise. The most important relationships for the business are strategic alliances with the customers, the car sharing operators. The business idea is based on the fact that the system personalizes the driving experience of different shared cars. A good marketing strategy is crucial to defend the position of the business against competitors.

The motivation to create partnerships is less the acquisition of particular resources and activities, but the provision of an optimized product. This leads to a reduction of risk and thus to more success in the market. Especially the partnership with car manufacturers, to adjust the technologies and the system is crucial to gain an advantage in the market. As the car and the onboard technology are not produced by *carsonalize*, no optimization and partnerships for an economy of scale are needed. Though collaboration with car manufacturers could be useful to reduce costs when developing software adjusted to the different technologies of the car models. There even a strategic alliance can be an option to gain a unique selling position and would allow for the development of an optimal carsharing vehicle.

9.4.1.9 Cost Structure

To set up the *carsonalize* business high initial investments, but comparatively low operating costs are required. Especially in the beginning a high financial risk emerges. While creating the business basement, high investment in software development and marketing are necessary. In the early stage a major cost factor is caused by engineering work, as the operating system has to be developed. Furthermore, getting in touch with various carsharing companies and building

up a business network is a mandatory success factor, which goes along high expenses for marketing.

Once the system is developed and in use, costs are generated due to customer relationship and software improvement work. While the software has to be adjusted to customer needs, at the same time customer acquisition and customer care should not be disregarded. These processes result in a constant variable expenditure stream as they vary proportionally depending on the wished level of activity. Another key process is the provision of data storage facilities for saving account data of the end users. As physical storage facilities have to be provided, the costs for the maintenance or renting of servers can be seen as fixed.

9.4.2 Scenario Robustness

The last section made clear that the presented business model is ideal for the scenario *Sharing*. It focuses on the carsharing market and provides a new solution for existing problems and deficiencies in this area. In the following the robustness of the business idea in the other scenarios *Car Free Zone* and *Road Runner* will be examined. As the success of the service idea is dependent on an existing carsharing market as well as a minimum amount of carsharing users, it is of utmost importance to analyze the basic chances for carsharing in the said scenarios.

Car Free Zone In the scenario *Car Free Zone* people are actually forced to obtain from using cars within the city center. Therefore they could start wondering how necessary an own car is. Obviously, two groups of people will emerge.

On the one hand, there are people who are willing and able to get by without a car. Inhabitants who live close to the border of the car free zone can cover the short distance e.g. by bike and do not need a car anymore. The availability of mass transport is also a very important factor. People who live close to a mass transit station do not need a car on a daily basis. Another aspect is the available budget. For some people a car might not be profitable anymore if they have to pay the public transport anyway. For this group of people without private cars, carsharing services could become a flexible solution. If they need a car spontaneously for special trips, need to transport goods or just to get home from the public transport changing points.

On the other hand, there are people who define a private car as a status symbol. They will most likely not be willing to obtain from their cars because of their mind set and because they feel utterly restricted by the *Car Free Zone* already. This applies especially for wealthy people. Moreover people living far away from the city center without a good connection to public transport are dependent on an individual transport solution. At least for the commuters, who

need to drive a long way from the changing points to their homes, a solution could be to offer special carsharing stations in the suburbs as well as directly at the changing points. In this case, they would be able to cover the long distance very comfortably without owning of a private car.

Regarding both groups of people, carsharing businesses will only be able to succeed in the market, if they offer a well spread network and a unique selling proposition, for instance the *carsonalize* service. Otherwise people, especially those of the second group, will not willingly give up their private cars as one of their last remaining personal and private means of transport. Carsharing services could meet the needs of a lot of people without a private car, because of the *Car Free Zone*. But they have to function, in addition to public transport, outside the city center to provide a flexible, individual and occasional transport solution. The problem might be that the business is not profitable enough due to the low number of possible customers.

Road Runner   The Road Runner technology has crowded out most motorized vehicles in the city, especially for short distance traveling. Moreover the ones, who are not able to use the Road Runner technology, namely children, the elderly and disabled people, are mostly not able to drive a car either. Therefore the circumstances for establishing a carsharing market are not very promising. However, as more and more citizens obtain from private cars, they need new ways of transporting goods or traveling as a group. This could be one possible motivation to use carsharing services. However, regulations that favor non-motorized means of transportation raise opportunity costs for companies offering conventional carsharing means. Carsharing providers suffer from special guidelines and competitive disadvantages going along, such as simplified approval procedures for the building of infrastructure elements for non-motorized mobility solutions like the Road Runner.

Apart from that, the carsharing industry would have to focus mainly on long distance traveling to stand a chance in the *Road Runner* scenario. The biggest difficulty here is to keep together a dense network of carsharing cars, when they are mainly used for long distances. As people take them to drive outside the city, the operators need personnel to recollect the cars. Considering the use of the *carsonalize* system, it would be possible to motivate the end user to drive the cars back into the city by offering bonus points for that. Another idea to tackle this problem and to further adapt the existing concept of *carsonalize* to the *Road Runner* scenario could be to add a reservation function. Commuters could take a shared car to drive home from their working place in the city and reserve the car for the next day. Then they could just park the car in their own driveway and use it to get to work again in the morning. Moreover, the individual entertainment and routing information is especially interesting for such long distance traveling.

Another significant advantage for carsharing operators in the said scenario is

the deflationary price structure within the automotive market. The low prices could even allow for small start-ups to enter the carsharing market without making huge investments to build up a fleet. Still they will need to buy the *carsonalize* service in order to be able to compete with bigger market players.

To sum it up, the scenarios *Road Runner* and *Car Free Zone* do not offer perfect circumstances for carsharing in general and for the business model of *carsonalize*. Nevertheless, in both cases the carsharing industry would probably not stand a chance without the personalization *carsonalize* offers. Thus, the presented business idea actually improves the chances of carsharing services to succeed. This is an important argument in favor of *carsonalize* as it might even be successful under adverse conditions.

9.5 Conclusion

In this report a first step was to find and analyze important key drivers for peronals mobility in urban areas. By variing the dimensions of the three key drivers *Mass Adoption*, *Disruptive Technology* and *Political Framework* three scenarios for the year 2025 formed. Focusing on the main scenario *Sharing* the business idea of *carsonalize* was introduced.

An analysis of most important components of the business model, e.g. revenue streams, costs, value propositions or customer segment showed that the model offers a lot of advantages for entrepreneurs and customers and could enhance important values in the scenario. Considering the narrow focus on the niche market of carsharing operators, especially in the *Sharing* scenario, where there are only a few big players, it is quite likely that the business model is expanded to generate new revenues and gain new partnerships.

All things considered the business model of *carsonalize* needs an existing and somehow prosperous carsharing market to work in the first place. Nevertheless it could even enforce the growth of such a market in a rather adverse setting.

Regarding personal mobility the different scenarios revealed that the future could hold some severe changes in behavior of citizens. Whether those changes are voluntarily or dictated by the government, they are always the foundation of personal mobility. Thus, if they change drastically personal mobility will not be recognizable.

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10

Chapter 10

Smart Devices

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The following report discusses the future of smart devices as means to improve mobility within the urban environment of 2025. Therefore three different scenarios are identified as possible futures of urban mobility. The findings are based on the analysis of ten major driving forces. Out of those factors the three key drivers are derived: control over data streams, technological development and technology acceptance. They are seen as highly uncertain in their development and therefore determine the differences between the regarded scenarios which are called Lost Trust, Gadget Wonderland and Big Brother is Watching You. The last-mentioned represents the main scenario which is driven by a massive fear of terrorism and other hazards. These events are the reasons why governments seal their nations off, centralize power and take over control of traffic data streams. This makes a holistic traffic optimization system, the CCS, possible, which facilitates mobility in large-scale cities. Based on this main scenario the Smart Traffic Routing Device (STRD) solution for the urban infrastructure is presented as a product idea that supplements and stabilizes the functionality of a future centralized traffic cloud system and Car2Car networks. It consists of decentralized units, which locally monitor and optimize the traffic, communicating via electronic traffic signs and traffic lights as well as Car2X networks. The final scenario robustness check concludes that long-term success for the STRDs is expected as it meets the municipalities' and citizens' demand for safety, reliability and stability in city traffic.

10.1 Introduction

Smart devices are increasingly used in urban mobility. People are using navigation devices to drive from A to B and use their smart phones to help to orient themselves in an unknown city. The trend of omnipresent computing will continue in the future and therefore a lot of other parts in urban mobility will include smart devices. But its adaption speed is yet depending on societal and technological developments and decisions.

Today's traffic is mostly limited to one-way communication. Recent technological innovations such as vehicle2x communication, cloud computing and augmented reality could lead to a mutual dialogue between individuals, transportation means and infrastructure as well as to improve the interaction between users and devices.

This communication between smart devices can be useful in several situations. It can help to improve traffic flow and congestion management, develop a automatic system of calling an ambulance when accidents occur but also inform traffic participants about possible obstacles. Thus implementing smart devices in transportation can help to make urban traffic more intelligent, more efficient and safer.

In the following section relevant drivers will be explained. These drivers build up the basis of the scenarios, which are described thereafter. With the background of the last scenario a product and business idea evolves which is illustrated in the succeeding chapter. The chapter closes with a robustness check of the product for different futures and a general conclusion.

10.2 Driver Analysis

A driver analysis is not only important to imagine how the future of smart devices could look like but also to understand how the world is changing within the next years. Figure 10.1 shows the classification of all drivers according to their degree of impact and level of uncertainty.
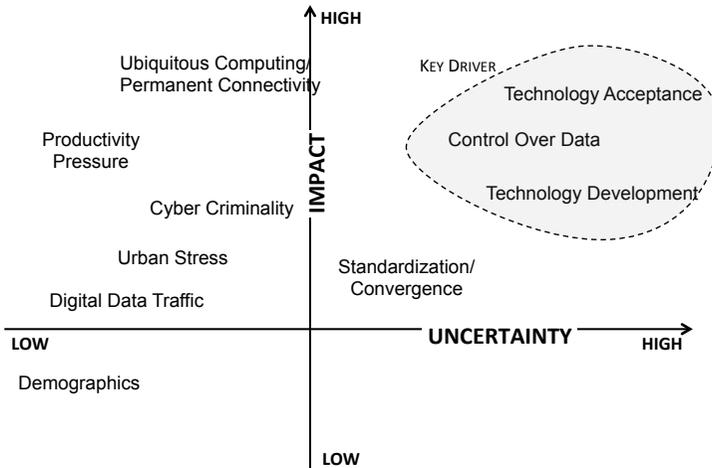
Figure 10.1: Impact-Uncertainty Matrix of Smart Devices
source: Own illustration

The drivers are distinguished into three key drivers and seven additional drivers. The additional drivers are rather sure and of less impact but create the basis for the future outcome. The key drivers however are highly uncertain and have an immense impact on smart mobility devices to therefore shape the scenarios' characteristics immensely. In the following chapters key drivers and additional drivers are presented in more detail.

10.2.1 Key Drivers

The implementation and practice of smart devices in urban mobility are driven especially by the interdependence of technology and society. This is powered by three key drivers that have a high impact, but incorporate high uncertainty. Customer behavior and societal changes are very complex and unsure, global political and environmental events are unpredictable and sudden innovations cannot be foreseen. In the following the variance of the key drivers is illustrated in different possible outcomes. The future of urban mobility differs particularly depending on various feasible developments.

10.2.1.1 Technology Acceptance in Everyday Life

Technologies have a major influence on our everyday life. They can increase productivity, efficiency, fun and even creativity. The beginning of the twenty-first century is often referred to as the information and network era, characterized by free information transferring of individuals and instant access to knowledge.

Technologies as instruments to assure these principals are influencing society but society also shapes them.

As information becomes more important for humankind, especially ICT systems are increasingly embedded in many different parts of our daily live. ICTs are technologies used for transfer, manipulation and storage of data by electronic means. In the last few years, high expectations, technological developments, and effective and efficient services have been shown a lot of improvements in the mobility sector. A major part of them were enabled in virtue of smart devices such as navigation systems, car entertainment systems and mobile payment solutions. Due to the decrease of cost and the improved awareness of benefits, the spread of smart devices expanded. Even though the future of smart devices in urban mobility and its usability is very promising its adoption is still in its infancy. The adoption and its success is strongly determined by the acceptance of new technology.

To narrow down definition the driver denotes the technology acceptance for smart devices in urban mobility. It can be segmented in the trust in a new technology, the value for the user and the amount of utilization. Acceptance is a highly important driver since it determines whether a new technology succeeds or not. There is an interdependence between the development of new technology and its acceptance. Sales numbers are the crucial incentive for companies to develop and improve systems. Some technologies additionally need a critical mass in order to fulfill their function, like car-to-car communication systems. It is highly uncertain whether the acceptance of technologies in everyday life of people will still expand in the next years, since it relies on many variables such as price, alternatives, human/technological failures, human-computer-interaction, privacy and societal and demographic change. The complex and critical nature of humans makes this key driver unpredictable.

The benefits of technology have to exceed the costs. Are there any alternatives that satisfy the same needs? The affinity to adapt can also be limited due to societal attitude such as the controversy of health concerns on mobile phones because of electromagnetic radiation. There might be also privacy issues due to a massive collection and processing of data – e.g. personal data privacy is a major issue especially in Germany. Another essential aspect is the complexity of new technologies. Whereas for a young generation this might not be an issue, the elderly could have various difficulties in using new technologies. Especially in an ageing society these challenges become more important. Besides the fear of technological failure could lead to mistrust and reluctance of smart devices.

The following technologies in the smart devices sector will be massively affected by acceptance: cloud computing, location and context based services, digital payment solutions, the omnipresence of networks and permanent connectivity in daily life. The key driver technology acceptance in everyday life determines the diffusion of those technologies in society. Due to a certain technology dependence of mankind there is a natural acceptance or limited

rejection of technology.

Possible Developments   The driver includes in this analysis two dimensions:
Low and *High*.

Low: Despite all benefits of new technologies its implementation is hindered
due to people's strong concerns and mistrust leading to a low or non existing
willingness to use it.

High: New technology is much appreciated as people see a high value and
the overall benefit. Trust in technology, its application and consumption are
very high.

10.2.1.2 Technological Development

Technological development is one of the most important drivers of smart devices.
With the use of new communication mediums und ultra-fast semiconductors,
data sending, processing and receiving will be faster escorted by higher band-
width. New functionalities and simplified usability triggered by new possibilities
of interaction between humans and computers will be implemented. In wireless
telecommunications technologies like ultra-wideband could solve problems of
wireless data traffic limitations.

At the moment smart devices are often driven by innovations in the field of
touchscreens, displays, cloud computing, context based services or navigation
systems. Additionally, in the upcoming years research areas like augmented re-
ality, audio and video recognition, individual robotics, micro electro-mechanical
systems and human-machine-interfaces might get mature and could constitute
new extensive and innovative products. Such components could merge into
smart devices and might enter mass consumer market with reasonable prices.

Due to the scarcity of resources the traditional electronic industry might face
a serious lack of base materials in the upcoming years. Nations already establish
long-term contracts to secure their future access to raw materials. The field
of material science offers a new, massive innovation potential regarding smart
devices. They could substitute materials or improve physical characteristics,
raise quality or lower prices. Innovations in material science could allow devel-
oping completely new smart devices, thinking of nano structures, carbon or
meta materials. Achieving a better understanding of the brain and the possi-
bility to effectively connect nerves to devices, neuroscience could unexpectedly
play a major role in the human-machine-interaction sector. But there might
also be breakthroughs in areas that currently do not seem to be connected to
smart devices. Biotechnology is a new field that holds yet a couple of unknown
possibilities. The commercial usage of fusion power could lead to almost clean
and endless energy.

Technological development effects smart devices in several dimensions im-
mensely. Smart devices can be revolutionized in the means of how they feel,

how they look and weigh, how they interact with one another, how and whether humans interact with those. The driver is uncertain because, as history states, the technological progress is unpredictable. There can be innovations that improve products or services in ways that are unexpected or even generate ways for completely new ones. These are called Disruptive Technologies (DT), so a leap in technology development. This can change massively the distribution of market shares within an industry - e.g. the impact of the MP3 concerning the course of music business. DT can also lower prices, if the new technology has a price advantage against the old technology. It can attract a completely new set of consumers, like Apple's iPad attracting elderly and children with tablet technology. Through DT emerging countries might be enabled to bridge technology gaps and change traditional industries .

Possible Developments   According to the following scenarios the driver can develop in two different dimensions: *Disruptive Innovations* and *Incremental Innovations.*

Disruptive Innovations: There is a sudden switch in existing technologies that change the currently well-know smart devices tremendously. The market for smart mobility devices has been widely reshaped.

Incremental Innovations: This means the development is a further linear development of existing technologies. It is almost predictable and easy to imagine. No unexpected technology developments concerning smart devices in urban mobility are occuring.

10.2.1.3 Control over Data

Smart devices foster, produce and share a high amount of data and information about the user, his habits, the user's and the device's condition. Amongst these are information about location, travel speed, health, communication and mobility patterns. Many services of smart devices are dependent on information from networks, the access to cloud storage, computing power of remote servers, the data from other users or devices. Hence, sending and receiving data is an essential part of the functionality of smart devices.

In various fields regarding urban mobility there is a necessity for a central data hub, where data is exchanged, often being analyzed, processed and set in a larger context. These include traffic optimization, tolling, mobility statistics, energy consumption and crime in traffic and public transportation as well as evacuation scenarios.

The control over such a hub can take many forms, which depend on the interests that are linked to it. Companies like Google run central data exchange and storage services regarding communication, navigation and location based

services. The more data they get from devices and the more devices they get data from, the better their services work. It could be possible that such companies even expand their area of action as they already collect much more data than their services nowadays utilize. However, especially governments could increase their control of data streams. Due to many synergies to fields they operate in, the exchange, collecting and processing of such data lies in their interest.

Having information about the quantity, the location or even the destination of vehicles, a holistic traffic optimization tools could be implemented. Thereby statistics could be improved by beeing more accurate and by collecting this data over a longer period . These statistics could be used to improve the infrastructure in the future more effectively, to discover travel safety risks, to gain knowledge about the citizens' mobility or preferences of usage. Given scenarios like a tsunami or a terrorist attack, the evacuation of a city could be led more effectively if centrally optimized instructions would be sent to the citizen's devices. Cars could be monitored and fined if they exceed speed limits, hit-and-run would be much more difficult and smart devices could automatically report attacks in public transportation, when connected to governmental hubs. Hence, the fight against crime in traffic and public transportation could be improved a lot. Furthermore a control over data streams could be used as a factor for political stability or national security. Not only in autocratic countries a central control of data streams from smart devices could be exploited for the estimation of and dealing with uprisings. Additionally the prevention of terrorist attacks could be enhanced by collecting personal data from smart devices.

Therefore, on the one hand the central control of data streams brings a lot of benefits for governments and their citizens or companies and their customers. On the other hand the centralization causes a lot of problems and hazards. Such a central control of data could mean for example a major intervention in privacy, concerning personal data. Lastly this control could be abused to spy on, manipulate or even suppress citizens in order to follow aims like political stability, retention of power or individual interests of officials. In conclusion, central control of data streams for the user implies a trade-off between the improvement of a traffic system, stability, security and the limitation of individual freedom as well as the possibility of abuse.

Due to the trade-off mentioned above, the diversity of interests between governments, companies and citizens, the future focus of political action and the change of societal attitude, the development of this driver is highly uncertain. Especially the institutions' and citizens' attitude towards that control can change rapidly with the impact of major events, like terrorist attacks or data leak scandals.

It is on the one hand possible that companies or governments increase their fostering of data and enhance their control much more than today. It is possible

that terrorist attacks, the fear of instability, the need for centralised and wired information convince people to vote for central control. Then laws are made or being changed to allow this development and more and more services are developed that rely on that centralisation.

On the other hand it is possible that there will be a decentralisation of control. E.g. due to privacy leak scandals people refuse companies or governments to take control. Laws are used or being made to hinder central control. Then, there is no development of services that rely on central control. Furthermore it is possible, that services that protect individual data boom.

Possible Developments   The driver includes in this analysis two dimensions: *Centralized* and *Decentralized.*

Centralized: Data ist stored and controlled at a central institution e.g. governments or companies.

Decentralized: Decentralized systems of storage and data control.

10.2.2 Additional Drivers

The additional drivers are influencing factors of less uncertainty or lower impact concerning smart devices in urban mobilty. The increase in digital data traffic and the change in demographic for example are rather predictable events, whose impact on smart devices is nevertheless high. The standardization and convergence of smart devices is hard to forecast because they are strongly dependent on the business, governmental and legal environment. The topic of ubiquious computing and the permanent connectivity of devices is highly linked to smart devices. However these topics bear additional challenges in the area of urban mobility.

10.2.2.1 Digital Data Traffic

The overall Internet traffic is expected to grow by the factor of 100 from 2010 until the year 2020 [485, pp. 422-423]. At the end of the year 2010 28.7% of the worldwide population was using the Internet [490]. Already in the year 2020 it is assumed that more than 60% of all humans on earth access the Internet [491]. That is why the current all-electronic packet switching paradigm will face serious scalability, cost and energy problems in the next years.

Even more drastic is the development in wireless communication. Although cellular mobile systems changed from circuit switched services (GSM, UMTS) to packet switched services (HSDPA, LTE) they can barely manage the upcoming growth of digital data. Figure 10.2 shows the development of the global data traffic in mobile cellular systems with an annual average growth rate of 92% within the next 5 years. Interestingly the growth emerges primarily from data services of smartphones, which produce 78% of the total traffic, but only represents 13% of the mobile phones in 2010 [484].
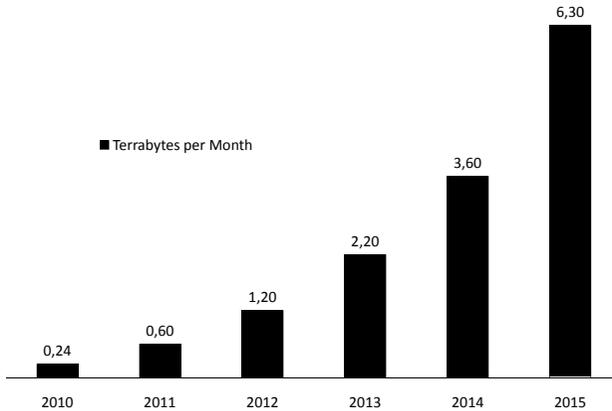
Figure 10.2: Forecasts of the global mobile data traffic by 2015
Source: Cisco VNI Mobile, 2011[484]

Due to physical limitations mobile providers need to invest in a close-meshed net of base stations. Besides the mobile phones and also the sensors of smart devices are generating wireless data traffic. Technologies like Zigbee and Bluethooth are based on public, narrow-band frequencies and therefore can suffer severe interference and crosstalk due to a lot of wireless subscribers.

In conclusion the world will face serious capacity problems in 2025. New intelligent network technologies are necessary and will help to provide stable and high-speed data networks. For emerging countries a high-speed digital infrastructure is a vital requirement to participate in economical growth.

10.2.2.2 Demographics

The long-term prediction of the future age structure is mainly based on statistical data like birth, mortality rate and life expectancy. Although life expectancy all over the world is increasing, especially in Western countries the population is aging. In Germany the share of people over 65 years will increase ten percent points within the next 15 years [483]. The population shrinking process in Germany is accelerated because of the low birth rates within the last decades and is hardly compensated by immigration. Figure 10.3 shows a comparison of the German population age structure in 2010 and 2025. Further information about the global demographics developments are also mentioned in chapter 3.2.2.3.
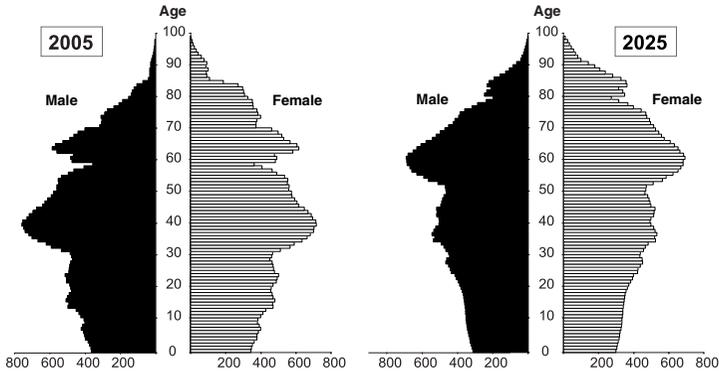
Figure 10.3: Age structure of the German population in 2010 and 2025
Source: J.W. Vaupel [488]

The human ageing process is often affiliated with physical and mental constrains. Decreasing sensorial and motoric abilities influence the mobility behavior. Smart devices will play an important role to help and assist elderly people. Thereby, safety, usability and comfort of transportation means could be increased so that these people could stay mobile and independent. For medical support smart devices can provide a reliable possibility for the telemetric monitoring of biometric data and the treatment of diseases.

10.2.2.3 Standardization and Convergence of Smart Devices

Norms are often set by global, non-governmental institutions like the International Organization for Standardization (ISO) or the Comité Européen de Normalisation (CEN). Often they have more influence on the legislation process than national standardization bodies. Technical standards provide framework conditions and therefore can help to improve compatibility, interoperability, safety or quality. However it also relieves dependences on monopolists and offers security investments. A "de facto standard" occurs if a product or system achieves a dominant market position.

Technological convergence describes the development of different technological systems towards similar tasks. Through similar formats and digital networks all kinds of media (e.g. voice, video, data) have converged and led to great synergy effects. Different hardware, with various software can communicate which each other over common network protocols.

As smart devices become only intelligent with the use of software, general platforms are a big issue. While for smartphones there is a highly fragmented market share of operation systems, the market for personal computers is dominated by Microsoft's Windows, set as the de facto standard. In the field of

embedded systems very different platforms are widely spread, depending on the diverse technical needs. Common communication protocols assure the inter-compatibility but it is highly uncertain weather a platforms convergence emerge.

10.2.2.4 Ubiquitous Computing and Permanent Connectivity

Ubiquitous Computing describes "machines that fit the human environment instead of forcing humans to enter theirs" [486, pp. 771-797]. In the context of smart devices this means that many systems can be used simultaneously and without interaction of the user. Another aspect of Ubiquitous Computing is that almost every machine, item or device of everday life are equipped with robust and small sensors and low-cost computer units to ease the handling or observe, control or automate the process or application. For example, in an electric car Ubiquitous Computing environment vehicles' navigation- and electronic control system might interconnect so that the driver can reach the destination without worrying about the range of the battery.

Additionally smart devices are equipped with networked processing interfaces to establish a steady connection to superior applications and control/remote systems. The widely spread of the Internet has fostered the linking of dispersed networks and helped to establish heterogeneous network structures towards "all IP". Norms like IPv6 and IPSec serve the rapid increase of network devices because of smart devices and addresses the need of universal, reliable and uninterrupted connections.

Challenges of Ubiquitous Computing arise from the design of systems. Hard- and software architechtures have to adapt to special requirements in usabilty, as there is for example no typical user interface. In systems with permant and global connectivity data security becomes a crucial factor. Despite of suitable cryptological procedures available to address the challenges, security tools are often inconvenient, complex, expensive and of impalpable value for the customer. Ubiquitous computing in combination with human-machine-interaction (HMI), artificial intelligence and distributed computing will influence smart devices greatly in the future.

10.2.2.5 Cyber-Criminality

Information technology is a critical factor for businesses of organizations worldwide. Sensitive data that is stored in organizations' networks represent significant monetary values. Due to an increasing complexity and integration Intranet and Internet infrastructure becomes more vulnerable. That is why cyber-criminality has turned into well-organized, illegal business with an estimated value of $100 billion annually [489].

With the emerging of smart devices in everyday appliance the potential vulnerabilities increase dramatically. For individuals hacking assaults will

become bigger threats than burglary. But as malware like Stuxnet [487] has shown also the dimension of attacks will change. Besides the already existing cyber crime of individuals and small groups, rival companies will also fight with illegal means for competitivness. Although it is not officially proven, there are signals that indicate an emerging digital warfare. Especially companies of the western world accuse China to attack their IT-infrastructure systematically to steal Intellectual Property.

Despite digital systems lack of complete security, the establishing and observing of a suitable IT-security policy reduces the risk of a successful attack dramatically. Cryptographic methods are well engineered, but often unhandy, misapplied and expensive.

10.2.2.6 Productivity Pressure

In modern societies people define a large part of their lives over their success in work life. Due to increasing requirements and competition for that success, there is an enormous pressure to be productive. This is a development that not only concerns working people, but also begins in school life. People are under the permanent tension to learn, read, write, research, calculate and communicate to succeed. However, people are spending a large amount of their time commuting and travelling through cities. During this time people normally are quite unproductive being busy with driving and lacking for workplace. The demand for mobile productivity tools is huge.

This implies a large impact on smart devices that are used in urban mobility. More and more devices will be developed and used that deliver a mobile workplace. Essential functions like sending messages while being on the road, cell phone functions, up- and downloading of customer information, access to the Internet already are quite common but will spread even more in the future. Literally moving with the workplace devices that can establish Virtual Private Networks (VPN) will flourish. Data needs to be synchronized and retrievable from everywhere. New human-machine-interaction concepts need to be realized in order to enable working while walking, cycling or driving. People need to be more isolated from the public, hence devices like noise-cancelling earphones might be demanded.

Other fields in which devices will alleviate the pressure are services that make the travel more enjoyable and relaxing. These could include the possibility to buy food and drinks. Also in the field of entertainment, devices could help people to relax effectively to be more productive afterwards.

10.2.2.7 Urban Stress

Urban stress is one of the major factors that endangers health, productivity and the quality of living in cities. Citizens are exposed to a lot of different elements of urban stress like congestion, urban complexity, road accidents, noise and

the pace of life. As urbanization increases, the problems are also intensifying. Through urbanization, increased vehicle ownership, longer commuting distances more people mobile will be using private vehicles. By consistent space and road infrastructure and increasing vehicles the problem of congestions expands massively. As cities grow, their complexity increases and orientation problems occur through permanant change and development. Crowded streets, Cars and construction work create a high level of noise pollution. In megacities citizens are exposed to noise all day long and even at night. The bigger and denser the city, the more accelerates the pace of life - e.g. the walking speed.

Urban stress has a major impact on smart devices, as there is a huge demand for devices that help dealing with different aspects of urban stress. To reduce stress that origins in noise, entertainment and communication devices offer passive noise reduction through overlying acoustic distraction or even active noise reduction. Facing traffic congestion, devices support to navigate around traffic jams, calculate alternative routes. Entertainment, communication and productivity systems make the time being stuck in congestion more pleasant, thus alleviates stress. Assisting in orientation tasks, navigation and map system devices reduce the stress to find the right way. Even when it comes to road accidents smart devices support users. The danger of accidents can be lessened through systems that lead around hazardous spots, systems that enhance human senses in traffic or warn and intervene in critical situations. Such systems could be augmented reality systems, wired navigation systems or sensorial systems that are embedded in transportation means. It is even imaginable that in the future, smart devices led vehicles drive autonomously through the city diminishing risk of congestion, accidents, orientation and the linked stress to a minimum.

10.3 Scenarios

The introduced key drivers are the general framework for the following scenarios. Depending on their various future outcomes they shape the characteristics for the usage of smart devices in urban mobility. In addition, the seven additional drivers that are more certain and build the basis of the scenarios behave differently depending on the combination of the key driver.

10.3.1 Scenario 1: Lost Trust

The scenario of Lost Trust marks consumers' rising fear concerning data insecurity which causes a stagnating technical progress. Several data leakage scandals of firms' databases being hacked nurture the population's mistrust. As a consequence new innovative business ideas depending on individuals' data fail as citizens refuse to put their personal data at stake. Governmental impact on

this situation is weak as it does not manage to find an appropriate solution to influence companies in their data policy.

The following sections explain this scenario describing its main components, depicting the concrete case of New York 2025 and point out the signposts leading to this future.
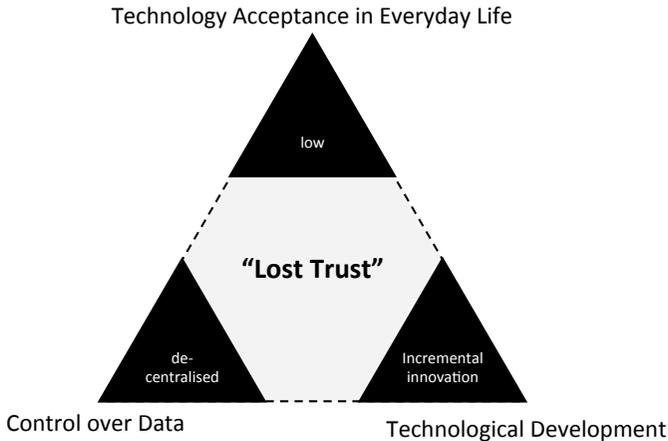

Figure 10.4: Driver constellation for Lost Trust
source: Own illustration

10.3.1.1 Scenario Description

2025 is marking the date of change in western societies. There is an international spirit of realization. The awareness that the race of technology and growth is not sustainable enters the minds of people all over Europe and the United States. Officials debate publicly about alternative ways to calculate the GDP, trying to preserve high living standards without focusing on pure economic growth. After the burst of the technology bubble in 2022 citizens break away from running after consumer trends. This bubble had built up due to the strong belief that ubiquitous technology could solve major problems like energy, traffic, social injustice and a lack in quality of life. Instead of new technologies people now demand more social security, healthcare and infrastructure programs. Explicitly the US, as the center of capitalism, drifts towards higher involvement of the government. This "Europeanization" of the United States with focus on more regulation and social market economy picks up the societal changes to conservative and old values. Due to the demographic development the aging society of western countries mistrusting new technologies and having difficulties of understanding its complexities dictate the course of change.

Cyber crime is a major problem in the society of 2025. Technology empowered squads and networked criminal enterprises abuse both the unconsciousness of governments and companies. Effortless, these "cyber guerillas" attack individuals, companies and governments. The desperation to protect intellectual property, private data and governmental secrets leads to a boom of cryptology and complex defensive measures. Governments all over the world are not only facing the problems of finding a new economic system, they are highly under pressure, after various companies had problems with data security. Climaxed in the data leakage scandal "Googlegate" in 2020, citizens demand for more information security especially concerning sensitive data. As a reaction governments tightened laws limiting many internet services like social networks. But their inability to secure citizens' and its own data result in international protests. The manifestation of the omnipresent hackability becomes obvious leading to resignation and broad denial of digital services. Digital payment and location based services flop. There has been a cutback in cloud computing and a renaissance of local hard disc storage. New internet network services fail due to a lack of participating users. Corporations observe anxiously this progress, as innovations have few chances to be successful. Rethinking their products, they concentrate on expanding security instead of additional features.

New York

New York is a city that still has a uniquely low level of car ownership and use. During the last years there has been an exceptional stagnation in urban mobility. The accident of the new high speed subway line at Columbus Circle in 2021 marked the date of setback. It was the first subway operated without human control. What was thought to be efficient and low cost led to a disaster paid by the life of 150 innocent people. Under the pressure of citizens and politics the Metropolitan Transportation Authority decided to switch back to human operation again. The complete new model range had to be removed from the rail and so the old fashioned trains were reemployed.

Electric Cars are not widely spread in New York, likewise in the rest of the world. The first generation of EVs, although highly subsidized by the state was clearly too expensive. Customers could afford more convenient and luxury combustion cars for the same money. Despite a lot of research battery performance still is quite poor, when having cold weather. Finally the ongoing rumor of EVs emitting dangerous electromagnetic field causing leukemia, caused EVs to flop on the market. Without EVs and due to citizens' reluctance the attempts to build a smart grid in New York failed. That thwarted a broader application of renewable energies. And as globally nuclear energy begins to phase out the main energy sources remain charcoal and oil. The boom of riding bikes in Manhattan is not only an environmental trend it is also more the spirit „if you want to make it right, do it yourself – do not trust technology". Therefore

bike infrastructure improved particularly. It seems like the pace of New York slowed down over the last years.

10.3.1.2 Signposts

This scenario is mostly driven by a huge mistrust of the population towards their governments, companies and technology. So primarily events, where governments and companies loose people's trust, could lead to a scenario like this.

Governments and States

If portals like Wikileaks or Openleaks reveal more inconvenient information about governments, this could lead to a further loss of people's trust in their leaders. To these inconvenient information the unconsciousness to secure sensitive data or to defend against cyber crime could be counted. As a consequence people demand for more transparency and less storage of privacy data but rather become reluctant to their governments' statements and claims.

Governments that try to tackle energy, traffic and environmental problems by subsidizing and hyping the usage of electric vehicles are on a tightrope walk. If EVs in the future still are highly expensive and people are reluctant to buy those cars, those subsidies are necessary. Nevertheless if governments executes this they face the danger of supporting poorly conceived or unwanted technologies, wasting money and time on developments that people do not buy.

Companies

A clear sign for a scenario like this are the increase of cyber crime and data scandals amongst the largest data collecting companies. Especially social networks or digital payment companies hold this hazard, as there is a huge amount of personal data stored or have access to sensitive areas. If more and even more severe events like the leakage scandal from Sony Playstation in 2011 happen, it is likely that people loose their trust in such companies and are more prudent in giving away their data.

Individuals

There could be worldwide protests against nuclear power. But if green parties and companies fail to implement alternatives people will doubt their companies' and governments' ability to tackle such problems. As a consequence people will turn away from politics and turnouts are low.

Finally, the failure of technologies like in autonomously driving subways or car2car safety systems leading to severe accidents could trigger a reluctance to rely on technology in critical situations. This will become obvious when the market of progressive technologies stagnates or even shrinks.

10.3.2 Scenario 2: Gadget Wonderland

A vastly rapid development of technology creates a "Gadget Wonderland" shown in this future scenario. These disruptive technological innovations in urban mobility are mainly driven by private companies which own and control data of smart devices while governmental intervention decreases to a minimum. Ubiquitous Computing becomes a commodity which on the one hand fosters semantic technologies. But on the other hand incorporates the increasing threat of cyber criminality.

The scenario description depicts this situation in greater detail which is further elaborated by the example of Shanghai in 2025. The following signposts highlight events that may lead to this scenario.

Technology Acceptance in Everyday Life
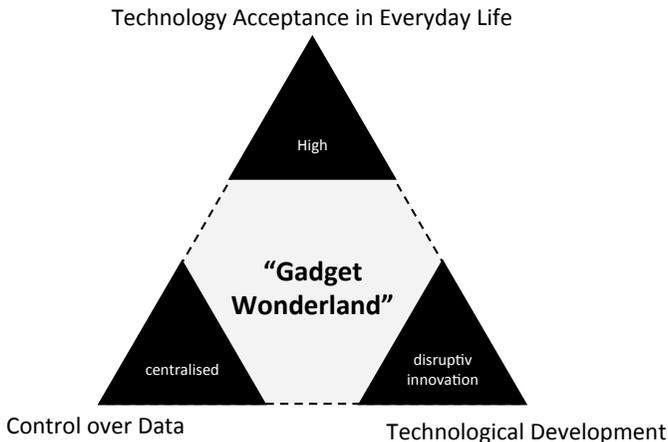
Figure 10.5: Driver constellation for Gadget Wonderland
source: Own illustration

10.3.2.1 Scenario Description

What had often been considered to be science fiction has become reality in 2025. Due to the global achievements of research and rapid technology development the shape of urban mobility has drastically changed. The pace of digital change struck governments all over the world unexpectedly. Laws and regulation concerning new technologies still cannot keep up. The influence of politics on information systems decreases. The Internet is still a grey area not knowing national boundaries and exploiting the arbitrage of differing laws of various nations. Cyber criminality is a main threat to the modern society but limited due to reasonable and widely spread security measurements.

Multinational corporations collect and hold an incredible amount of private

data. Ubiquitous Computing transformed from a word to practice and lifestyle. Currently the boundaries between the digital and the real world are blending, especially caused by augmented reality and semantic technologies. The extension of minds through digital technology is one of the most important topics for psychologists and philosophers. In almost every situation people utilize digital devices. People make use of the vast technological possibilities to save time and energy for unnecessary tasks. Life is much easier for the aging society as companies understood to focus this customer segment. For example exoskeletons help elderly and disabled to stay more mobile. The pace of accepting and applying technology accelerated. To stay tuned with society and the mass of opportunities people need to adapt quickly. It seems that especially the pressure to be productive grew proportional to the possibilities of productivity devices. Critics often refer to this century as the golden cage of technological slavery.

Against all odds Third World countries profit from this technology race. Companies compete for investing in these nations to develop new markets. Furthermore over the last years the price for many technologies sunk drastically. Especially due to vast developments in transportation and ICT many developing countries leapfrogged various developments almost reaching the standards of western societies.

The populations' hunger for technology paired with the new markets in developing countries has led to an explosion of R&D budgets. One disruptive development after another reaches the market. The only limitation that appears at the horizon seems to be the scarcity of resources. Therefore recycling becomes a major issue for the contemporary society. The gradual progress to the Internet of Things meaning the possible identification and interaction of any kind of object allows recycling more accurately.

Strong efforts and high commitments in renewable energy have been undertaken to solve the lack of energy within the last decades, substituting the gradual loss of nuclear power plants. Now, in 2025, it seems like the energy gap is about to be closed. The ITER project (International Thermonuclear Experimental Reactor) was built in 2018. Its scientific findings and success were demonstrated to the public in 2023. The participating nations pledged to quickly build commercial fusion power plants. In the beginning of this year China as one of the first adopters started to build one of them right at the gates to the city of Shanghai. The assumption itself that the electricity prices would decline over the next years already shows its great impact. Electric cars got commonly affordable. The perspective of solved energy issues triggered an average growth rate of 25% over the last years. The OPEC recently reduced the oil production to keep the barrel price of crude oil over $ 100 and looks out desperately for alternative revenues like investing in fusion power plants too.

Shanghai

In Shanghai the change is visible. As a city that constantly transformed since the 1920s, Shanghai tries to be at the cutting edge. With roughly 30 million people living in the administrative area public transportation seemed to be a major issue. As underground transportation reached its limits, the municipality started to build above ground rail transportation racing between the skyscrapers of the flourishing megacity. Subways and above ground express transport citizens autonomously and safe through the jungle of buildings. Under the pressure of the Communist Party of China domestic consumption is held very high. As a result, new consumer electronics, smartphones and other personal devices find a rapid way to the homes of Chinese. Other technologies like smart textiles or brain computer interfaces are widely applied because of the population's love to experiment.

Due to the enormous efforts of the last years Shanghai now is nominated for the UN "Green Megacity Award". Whereas smog has always been a major problem for Shanghai the quality of air improved a lot over the last years as the Chinese leadership restricted combustion cars and massively subsidized EVs. This measure also massively reduced noise. Furthermore as the Shanghai municipality recognized noise as a major problem newly developed noise cancelling devices were installed all over the city. Finally it has recently been announced that the number of traffic deaths fell below the average of the OECD countries due to car2car swarm logic systems and artificial intelligence driving aid in the last generation of EVs.

10.3.2.2 Signposts

This scenario is mainly driven by an international race for technology. The interaction between a massive customer demand for ICT as well as consumer electronics and companies' huge investments in R&D multiplies technological progress.

Governments and States

The scenario becomes more probable if governments and states take part in and fuel an international race for technological leadership 4.3.2.2. Through several events and actions it would become clear that officials are willingly hyping the fast implementation of new technologies. International projects like ITER in France would be supported with higher investments and more often highest ranked officials would battle for taking the credit. Furthermore, cities would broadly change their infrastructure to prepare for the usage of modern technologies. Amongst these changes are a broad network of EV charging stations and the implementation of smart grids. All these changes

would flourish in competing forms, as the accelerated pressure would not leave time to standardize.

Companies

A clear sign for a technology race would be a leap in spending for R&D, patents and licenses. This could be induced by the hype around new disruptive technologies like Brain-Computer-Interfaces and the prediction of large-scale markets for those.

A lack of standardization is another sign for a scenario like this. Competing against each other in large and prosperous markets for new technologies, companies would increasingly try to bring forward and protect their own standards. This would be done in a vast speed. This would be for instance perceivable by a great variety of proprietary interfaces like the "Mini-Display-Port" today.

Furthermore, due to an enormous pressure to be up-to-date companies focus a lot more on progressive fields of science like biotechnology, neuroscience or fusion power physics. Therefore companies compete for the experts in those progressive areas.

When markets in developed countries seem to be competed too much, companies begin to increase their investments in developing countries, trying to establish monopolistic markets. For example telecommunication companies could implement broadcasting infrastructure to enlarge network capacity.

Individuals

Amongst the population the change towards a scenario like this is noticeable when the proportion of people who are early technology adopters grows, which can be measured by a large variety of new technology products that sell. Furthermore events where millions of people line up to get the latest technological product of certain companies increase in number. Spending a growing share of their income on technology people broadly make technology a major part of their life style.

10.3.3 Scenario 3: Big Brother Is Watching You

In this scenario the government has control over most of the data produced by smart devices. On the basis of this information a newly created Ministry of Digital Affairs is enabled to buil up a central traffic control system having the overview over all the individuals traffic data. However citizens see the benefit of this regulation and are open to support the system by giving up part of their privacy rights. Thanks to this attitude technological innovation can take place and is able to progress.

The scenario is unfolded by describing the overall situation which is then specified by the characterization of the urban traffic situation and the represen-

tative example of a commuter living in this environment. Thereafter the value map explains users' expectation towards the traffic system and the timeline shows previous and upcoming events leading to the depicted scenario.
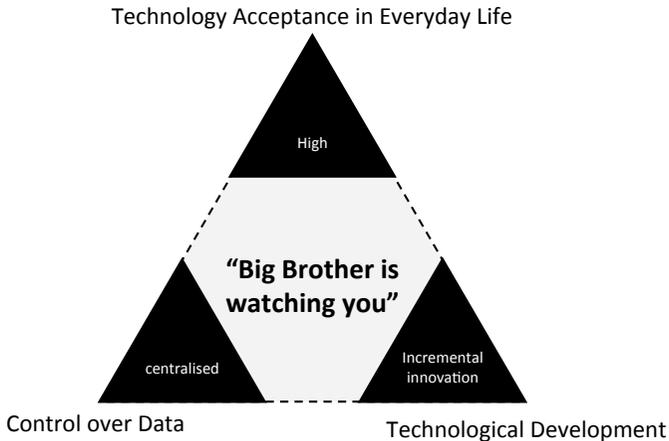

Figure 10.6: Driver constellation in Big Brother is Watching You
source: Own illustration

10.3.3.1 Scenario Description

It is 2025. All across Europe cities are facing the full impact of urbanization. Especially London has faced a serious growth of population during the past 15 years, as over one million additional people moved to the city. Despite exploding housing prices and living costs there is still an enormous urbanization pressure. For the whole metropolitan area this has been even more drastic and some suburbs are about to become cities themselves. It's been quite a hard struggle for the government to deal with problems caused by this increase of residents. The enormous density and the applied load of infrastructure challenged the officials in topics of safety, health and mobility.

Due to the worldwide wave of terrorist attacks in the years 2015 and 2016 and the persisting fear governments were forced to take actions. After the cruel rush-hour attack at Bond Street tube station in London January 2016 a new homeland security policy was introduced that incorporated the EU INDECT project. Under the pressure of this policy (Intelligent information system supporting observation, searching and detection for security of citizens in urban environment) - internet and telecom companies, even social networks were forced to reveal user data to the governments in case of terror suspicion. Today data about citizens like locations and movements can be recorded centrally as the

new established British Ministry of Digital Affairs is in charge of monitoring and processing digital data streams, implementing and developing services around data security and surveillance. This is quite similar to what is implemented in many other European states and the US.

These measurements triggered by terrorism are comparable to those initiated by fear of instability in autocratic Asian countries after the uprisings of the Chinese middle class in 2014. Citizens all over the world willingly gave up some of their sovereignty and privacy to more authoritarian leadership in exchange for safety and stability They tolerate and even demand top-down decisions and oversight leading to a "renaissance of strong governments". Thus, the establishment and enforcement of national programs solving major issues were facilitated releasing a series of acts. Electronic IDs for example, saving biometric data became internationally common in almost every nation. Countries and unions like Europe drive national norms to protect their Intellectual Property, regulating key industries that serve national interests.

As governments in the developed world focus a lot more on issues in their own countries and as borders became more impermeable, third world countries struggle to participate in economic growth or technological progress. There is not much interest in pushing technologies and investing in developing countries because homeland topics seem to be more urgent. Therefore many regional alliances in Africa or South America were expanded. The trade volume between Kenya and South Africa nearly doubled over the last five years.

In 2025 for the Chinese government economic growth still seems to be one of the most important factors in order to preserve stability. Its thirst for metals, oil and nourishments is enormous. Thus, against the trend of withdrawing investments in Africa, China's trade agenda – key raw materials and food for infrastructure – was enhanced. Due to China's massive demand for oil and further the cooled off relations between Western and Arabic countries, energy prices are quite high. After the years 2015 and 2016 the oil price jumped to its historic maximum, which forced governments to find national solutions to energy problems. In many countries there has been a great effort to apply electric mobility, supporting the acquisition of electric vehicles and the development of a smart grid infrastructure. Nevertheless, due to isolation and strict national borders the world is far away from international solutions to energy coverage.

Many innovations are controlled, influenced or even driven by governments, especially services and technologies that reveal and link location and context data of citizens. Many governments are empowered to have insight in companies' und users' data due to their need for security. Almost every country gave up on net neutrality and some nations even charge bandwidth taxes. Inspired by China's firewalls, countries initiate their own mostly independent IT networks. On the one hand this restrains information technology development but on the other hand it allows to build up a holistic systems. In London the collecting and processing of citizens' data has allowed further political improvements. Thus

the Ministry of Digital Affairs not only contains a department of homeland security, but also runs departments for national health and traffic. Over the last years the health department worked on a system that could make use of the citizens' data to suppress the spread of pandemics and the department of traffic implemented the first holistic traffic optimization system.

Traffic

European cities as London are facing the dilemma of an existing infrastructure that cannot be adapted dynamically to population change. Due to the conservation of historic structures, buildings and streets, there had to be other ways to solve traffic problems. The enormous density of people living and even more working in the city caused serious traffic congestion, an overload of the public transportation system and despite a city tolling air pollution was a major problem. So London started the CCS (City Cloud System) as a pilot project in 2020, that made use of the citizens' data previously collected for national security reasons.

The political intervention in the key business forced big internet companies to explore new markets. In 2018 a joint venture between IBM and Google was formed, developing the CCS for large scale cities to optimize traffic and enable context based services. Today in London almost all cars are connected to the CCS. Satellites of the Ministry of Digital Affairs monitor and optimize traffic in their cities. This highly relieves the citys' infrastructure, as traffic can be routed dynamically, reducing the danger of congestion.

Citizens have even more possibilities to benefit from the CCS, as almost every smart phone in London is able to connect to the system. There are services, where people can report damages in infrastructure for example non-functioning traffic lights or elevators. The "London Mobility Application" recommends the fastest, safest and most convenient way of moving from A to B. For this service travel time, costs, weather conditions and personal requirements like the accessibility for elderly or handicapped are considered. In case of lacks in public transportation people are able to call instantly for additional busses or trains, a service that reduces the accumulation of masses especially after big events. As the CCS is connected to the citizen authentication system, digital payment and access to the public transportation via smart phone is possible. Furthermore, this makes the city tolling system a lot more effective and fines for traffic offences can be booked digitally. Due to the high oil prices, electric mobility has been highly incentivized. Therefore, the electric infrastructure has been expanded hugely during the last years and is now suited for the city's use of electric vehicles. An ongoing environmental program encourages people to buy electric vehicles.

Although the CCS already works quite well, there are still some challenges to overcome. Especially in case of accidents and other unpredictable events the

system does not work that efficiently. A few times the cloud has been rather unstable and information were interpreted wrongly, which led to accidents and a break down of the traffic steering. Unfortunately cyber crime has become a major issue over the past years. Almost every citizen is plurally interconnected using smart technologies. From digital payment possibilities to car2car communication systems – cyber attacks undermine citizens' lives in many situations. Even the CCS has been hacked once in 2023. Wrong traffic information was inserted, which led to a two-day break down of the infrastructure. As a reaction the Ministry of Digital Affairs applied a completely new encryption system in 2024. Being the most advanced system currently available, there have not been intrusions reported anymore. "Secure as the data stored by the Ministry" has become one of the most used dictums.

Life

Jason belongs to a group of modern commuters with middle class income who are part of the former Facebook generation and not hesitating to use technology in everyday life. Being a senior analyst for mass data, he works for the London satellite of the new traffic department within the Ministry of Digital Affairs. He lives with his wife and his two children in a house in Harlow 30 miles at the North-East of the London commuter belt. This is where housing still is affordable and the surrounding environment seems to be ideal to raise children.

It is seven o'clock in the morning. Jason leaves the house and jumps into his car. He is a proud owner of one of these new electric Land Rovers. Still, not everyone is able or willing to afford an EV, but as the government started to subsidize new traffic technologies – electric cars became quite affordable. Since fuel prices are still near their peak from 2016 Jason's electric car is much cheaper in consumption. As five years ago the municipality started to implement the CCS, people were at first incentivized to buy 2-way communicating navigation devices. Then, two years ago it became mandatory to have one for each car.

The engine button lights up and shows that Jason's ID card has been recognized. As he starts the car by pushing the button his navigation system starts up with a nice "Good morning Jason – your estimated travel time to work is 46 minutes, if you take the M11 and then the A406 – costing zero credits. The fast track taking the M11 and then the A104 would take you 37 minutes – costing 5 credits. Your total credit amount is 32." The credit system had recently been implemented to replace the outdated congestion charge.

"Today I'll take the A406. Thanks Nora".

As he passes the King Edward Memorial Park Jason is fascinated by the fact that London has preserved its historic shape. Although the streets have not been expanded, the traffic is still flowing quite fluently. Only sometimes it seems that the CCS is working a bit inefficiently. Two or three times he was completely stuck in a traffic jam because of accidents right in front of him. For

hours there has not been any instruction coming from his personal navigation device. Knowing the complexity of the CCS he accepts the teething troubles of the system. One of the major problems his department has to deal with is the handling of bugged connections to the cloud. "I'm detecting a problem on the A1203. Congestion warning ahead. Please turn right at the next crossing. Your remaining travel time is 25 minutes." "News channel please", Jason says. " It's 7:43 and here are your personalized news. An accident on the A1203 currently causes a traffic jam. A driver apparently lost control over his car and crashed into another. As there were apparently some CCS unrecognized cars in the lane the system took some time to adapt to the situation. After fifteen minutes the CCS then managed to handle the situation and now redirects all cars effectively. Within the next 30 minutes the A1203 is expected to be free again. World-News: Tomorrow, the 5th anniversary of the London CCS is celebrated. By tomorrow then the pilot phase of the IBM-Google project is officially over and this will be the starting shot for several cities in the world to run their own CCS. Shanghai, Paris and Sydney will be the next cities to implement the system. However, the planned start of a CCS in Berlin delays by at least one year. Current protests peak in a march of 200.000 citizens on the streets of Berlin demanding state transparency and data privacy. The movement has recently been heated up by a news head line of the German tabloid Bild. Bild reported that an yet unrevealed official abused his access to citizens' data to spy on his ex-wife. The government spokesman still does not want to comment on that. After some leaks in the German state data system in 2024 the mood in Germany towards national authorities tilted. Demonstrations started in the end of 2024. In Hessen one of the biggest German states the Pirate Party focusing on civil rights and information privacy received 16,3% of votes in the regional election. The cloud system debate divides the German society and most recent surveys state that approximately 58% are against the current model of the CCS. German Chancellor Schmitz announced that the CCS program will be suspended as long as stress tests and some rechecks on security issues are done." Angrily Jason turns off the radio: "These foolish Germans! Why do they always complain? Data privacy? There is no reliable place for my data except for the Ministry. They just don't see the various benefits of such a system. It is so much more convenient and efficent."

Jasons' mind wanders from all the further advantages enabled by the system to his daughter. Since the "London Mobility Application" had been released he feels that she travels much more secure. Using this mobile application she is not only getting the recommendation of the fastest and favored way of traveling, but as local crime statistics are also considered the app leads her home safely when going out late. And as parental monitoring is possible, Jason can figure out exactly where Mia checks in. Thanks to this system he recently found out that his son participated in the ongoing student protest for a loosening of national borders and for further support of the Third World. Fearing troubles

for his job, Jason strictly forbid his son to continue. Barely imaginable what his colleagues would think.

Jason parks and hands over his car to the parking management system of the Ministry. Standing in front of the large building he pauses for a minute and observes the large information screen. It shows the city map of London with moving and whirling green objects. Those patterns of tiny little spots are London's cars driving through the streets. Suddenly the warning sign at the A1203 disappears. Now everything is running again, the whole city is in flow. " What a brave new world!", Jason smiles and gets inside.

10.3.3.2 Signposts

This scenario is primarily driven by the anxiety of people and governments and their massive need for security. There is a trade-off between individual freedom and advantages that are connected with welfare and central control.

Governments and States

The most important signpost for such a scenario are events that trigger fears amongst the population and put security issues on top of the political agenda. For example a wave of terrorism could be such an event for the Western World or uprisings that bring instability for autocratic countries. As a consequence governments would enforce homeland security acts, sharpen laws and eventually limit individual freedom. For instance findings of the EU INDECT project could be implemented.

Referring to the evidence that the analysis and control over digital data is one of the most effective measures to guarantee security and stability, governments collect and have increasing insight in citizens' and companies' data. Amongst this are communication and location data as well as information about payment streams. Thus, national departments, like the Ministry of Digital Affairs in the scenario, which foster and process such data would be enlarged or established.

When states increase their control over the Internet, bandwidth taxes and a decreasing net neutrality become beacons for states sealing themselves off. Thus, the Internet becomes more fragmented having clear national borders.

Companies

When governments abolish net neutrality and levy bandwidth taxes it becomes hard for small Internet companies to survive. So many small businesses will disappear. Furthermore, if the Internet is not the free room anymore that it used to be, also large-scale companies that relied on this freedom have to remodel their businesses. Regarding a company like Google it is possible that cloud computing and content know-how then is taken to develop solutions for governments, cities and states.

This is when companies let governments interfere in their businesses, which becomes clear when they give out sensitive information or even collaborate in product development. As a tradeoff companies which are important for a nation then are rewarded and protected. This be for example by lowering taxes for those companies, highly taxing the others. Protectionism then is a usual practice.

Individuals

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Political, Economic, Social, and Technological Analysis

Figure 10.3.3.2 depicts the several events which lead to the scenario described above. The vertical axis is divided into different areas which categorize previous as well as future occasions causing the respective changes. The future headline regarding environment represents the increasing importance of raw materials which support the development towards electric vehicles. Technical progress also takes place in governmental matters: after the electronic ID has been introduced and spread. In several countries the government also abolished network neutrality. As the demand of ubiquitous computing increases bandwidth taxes are imposed. In the succession of technological inventions of the mobile phone, GPS and new vehicles like Segway the city of London launches its City Cloud System (CCS) in 2020. The CCS is a proof of governmental impact gained importance in providing a central solution and increasing care for citizens. This need for governmental control also rises from former terrorist attacks like in New York, Madrid as well as in London 2016. In contrast to that uprisings of the middle-class in China provoke governemental intervention in order to suppress those movements. Furthermore private companies have a crucial share in shaping the development towards the scenario. After the development of vehicles specific for use in the urban environment like the SMART, another step is the facilitation of payment systems. Thanks to the further development of mobile payment systems the purchase of tickets for mass transit and car

sharing services becomes much easier. The state has his central role in this situation. It determines in which way citizen benefit from those technologies as the Chinese regulation of Internet access showed. Furthermore China limited other countries growth potential when stopping its export of rare earths in 2010. As the state has its central role in managing traffic data positive as well as negative cases can be observed. While the reputation of the municipality of London is enhanced thanks to the launch of CCS, a leak in the German state database causes a scandal which weakens the government's position as central player in the traffic system.
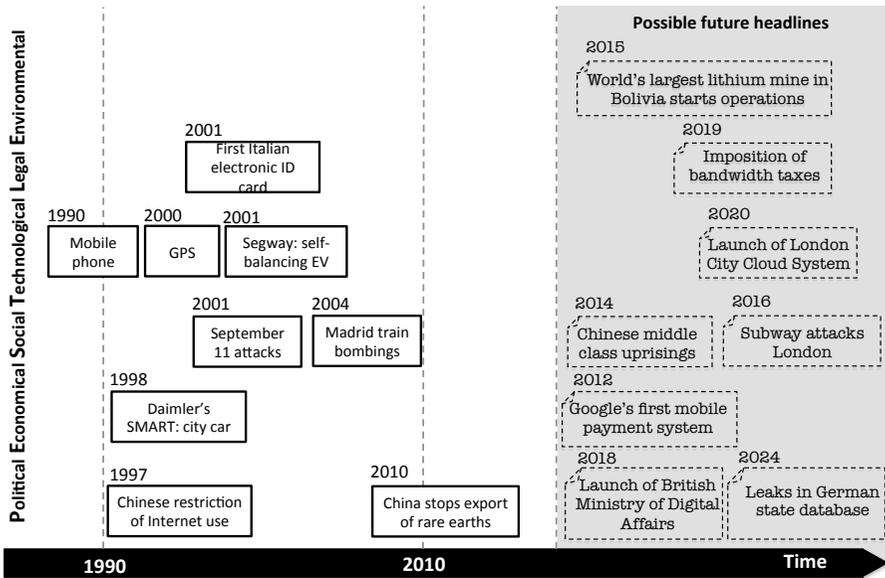

Figure 10.7: PESTLE figure for Big Brother is Watching You
source: own illustration

10.3.3.3 Value Map

Figure 10.8 illustrates the most important values of smart devices in urban mobility derived from the scenario Big Brother is Watching You. Those values originate from the characteristic that smart devices show an intelligent self-deciding functionality which is often paired with the ability to connect to networks. As smart devices build up the basis of Ubiquitous Computing they support people in almost every situation in life. Therefore the features that are developed relate to a large extend to the needs of the end customers.

In a world that suffers from traffic explosion, congestion and accidents are

major challenges. The broad application of smart devices tackles those challenges by enabling better traffic instructions. On the one hand this will lead to a decrease of accidents which creates safety for traffic participants, eventually having a positive impact on the quality of life. On the other hand, smart devices can be used to find the fastest way possible. Especially in a world where people live in the persistent fear of hazards like terrorist attacks, the acceleration of evacuation procedures lets people feel more secure.

Traveling through large cities can cause a lot of stress due to noise and less space for privacy. Additionally people spend more time on being mobile. Therefore a huge demand for entertainment while traveling, hence the isolation from the surrounding world, needs to be satisfied. Thus people are more likely to relax while traveling which is an important prerequisite for their long term success in life.

Smart devices are hubs for ubiquitous connectivity. They support people in communication and information sharing. This enables people to react much faster to events from everywhere, making them more flexible and enhancing their possibilities for professional success. As the society defines itself more and more by communication from anywhere at anytime, a person's availability is essential to take part in society.

The ubiquitous presence of intelligent decision devices makes traffic much more reliable. People can calculate the time they need for traveling and are able to organize their life more efficiently which addresses the important value of satisfaction through productivity.

As the pressure to be productive rises, smart devices that serve as productivity tools will flourish. There will be more possibilities to work and learn while traveling, leading to a more efficient time usage. This eventually has a positive impact on people's decision to travel, making them more flexible, as they do not need to waste time.

Smart devices become more powerful and smaller. The more functions can be combined in fewer devices, the better the overview, simplicity and usability of devices become. This will increase the general usage of smart devices. Supported in more situations, people will be more mobile.
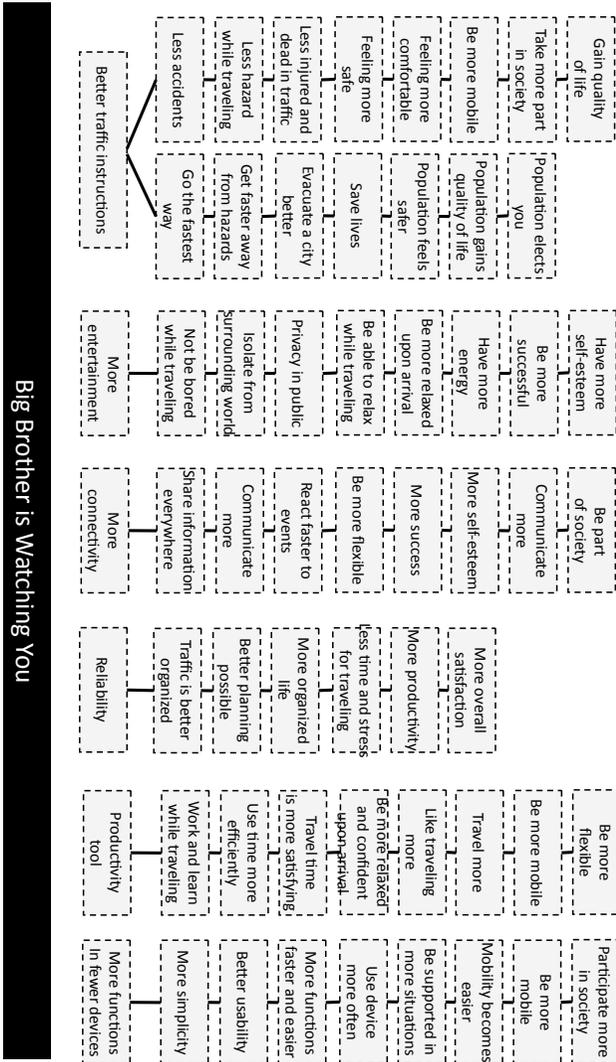
Figure 10.8: Value map for Big Brother Is Watching You
source: Own illustration

10.4 Product Idea: Smart Traffic Routing Device

In the scenario "Big Brother Is Watching You" the London city administration has successfully implemented the City Cloud System (CCS) as a pilot project. Using the CCS the cities' planning authorities can track all registered vehicles and apply traffic optimization. Newer cars are already equipped with Car2X communication by default, hence are able to communicate with the CCS. Older vehicles had to be equipped with an additional device providing this functionality. By that a centralized, holistic and strategic traffic optimization is possible. Precise real time traffic information for navigation devices enables drivers to be guided flexibly to minimize congestion. Furthermore throughout the CCS various devices are fed with location and context based information. However, the CCS is a highly complex system. Independent from a central system there is a need for decentralized local processing to provide stability and better reaction times. Short time decisions, detailed information, danger alarm and traffic signaling security about local events on single intersections cannot be steered and controlled centrally.

Via Peer-2-Peer networks amongst cars, also known as Car2Car communication systems, information between cars is exchanged. These include information that helps to avoid collisions, the information about their destination or road conditions. Through Car2Car systems a swarm logic based traffic optimization is possible. However, Car2Car systems hardly regard more cars than within the immediate neighborhood. And as not every car has a functioning Car2Car system, a supplementing system is needed to recognize and instruct unconnected cars. Furthermore, it has to mentioned that STRDs also work during down-times of the CCS and therefore provide additional value.

Product Description

Smart Traffic Routing Device (STRD) systems are developed to further improve the city traffic in efficiency and safety. They are the missing link between Car2Car communication systems and the CCS, between swarm logic based optimization and centralistic optimization. STRDs not only connect both approaches to provide each system with the other's information they also introduce a new logic, that supplements and stabilizes the other systems. The cloud spreads global traffic decisions to the STRDs. STRDs are decentralized units that connects the global, strategic decision of the CCS with the individual represented through Car2X. Connected to sensors and cameras the STRD solutions monitor and process traffic at specific points, e.g. intersections. Through traffic lights, electronic traffic signs and large displays, Car2X interfaces as well as the CCS optimized instructions and information is provided. As STRD systems work autonomously, Car2X systems or CCS-like centralized networks are not mandatory.

Functionalities and Applications

Enabling Flexible Traffic Signs. In many countries the roads are desperately overcrowded with traffic signs. Too many signs even make streets more dangerous for motorists and pedestrians. Despite the safety risk, traffic signs are expensive, inflexible, often misleading and fallaciously placed. Furthermore, traffic signs are regularly disobeyed, if they seem not appropriate to the situation. Speed, right of way, no overtaking, one-way streets, the driving direction of lanes, low-traffic residential zones, and many more can be regulated flexibly depending on accidents, congestion, commuter traffic and evacuation scenarios. Giving the driver feedback on his behavior related to the current traffic rules, the rule obedience is improved. And in case of traffic violation, recognized cars can be fined immediately.

Figure 10.9: Illustration of an implemented STRD system
source: Own illustration

Improving Intersection Traffic. As described in figure 10.9 the traffic at intersections is monitored, whether via the CCS, the Car2X network, sensors or

cameras. The information provided by these devices or systems then is processed locally by the decentralized Smart Traffic Routing Arithmetic Unit (STRAU) and the density and destination of vehicles is analyzed. At first the STRD gives a redundancy function – checking for coherence between the other systems and the real traffic situation. Recognizing traffic patterns, traffic lights can be controlled dynamically and instructions are sent to the cars navigation devices. In case of low traffic volume, cars do not have to stop at intersections anymore. Instead automobiles are informed to adjust their speed so that everyone can pass the intersection point smoothly. The STRDs can even control the Start-Stop-Automatic of modern cars, saving fuel and lowering noise. A priority system can expedite public transportation means or officials. The traffic flow can be dynamically and automatically optimized to accelerate the passing of emergency vehicles.

Alleviating and Avoiding Dangerous Situations. As patterns of dangerous situations are recognized accidents can be reduced. If for example a pedestrian enters the street unauthorized the system is able to react immediately. Warning signals are sent out and concerning automatic collision prevention systems inside cars – their functionality is accelerated and enhanced. If accidents are detected, the local traffic is immediately informed and guided. The CCS is fed with information. An emergency alarm informs action forces like the police, ambulance or fire department. Before arriving at the scene action forces are provided with detailed information about the accident. Although kindergartens, schools, retirement homes and facilities of handicapped people are considered as danger zones in traffic, the situation varies over different daytimes, vacation periods or special events. Flexible traffic signals could help here to give appropriate instructions. For drivers entering the street traffic, especially when they come out of exits, a better image of the traffic situation can be provided. Drivers are warned about cyclists, pedestrians and other cars. In case of construction works traffic can be regulated locally, particularly in case of large construction machines entering the traffic. Information about the lane condition (e.g. loose chippings) is sent to the CCS and Car2X systems.

Optimizing Parking Traffic. A major part of the inner city traffic is parking traffic. To reduce congestions or accidents caused by this form of traffic STRDs support drivers and the CCS with information and instructions. In public parking areas free parking spots can be detected. Their location is passed on to cars or the CCS. In case of having the right sensors in place or two cars equipped with Car2X systems around a parking space, even the size of that space can be calculated. For recognized cars digital ticketing and payment is enabled. The connection of electric vehicles to a smart grid could be monitored – the STRDs act as a gateway to the smart grid. In cooperation with the CCS even parking space reservations would be possible.
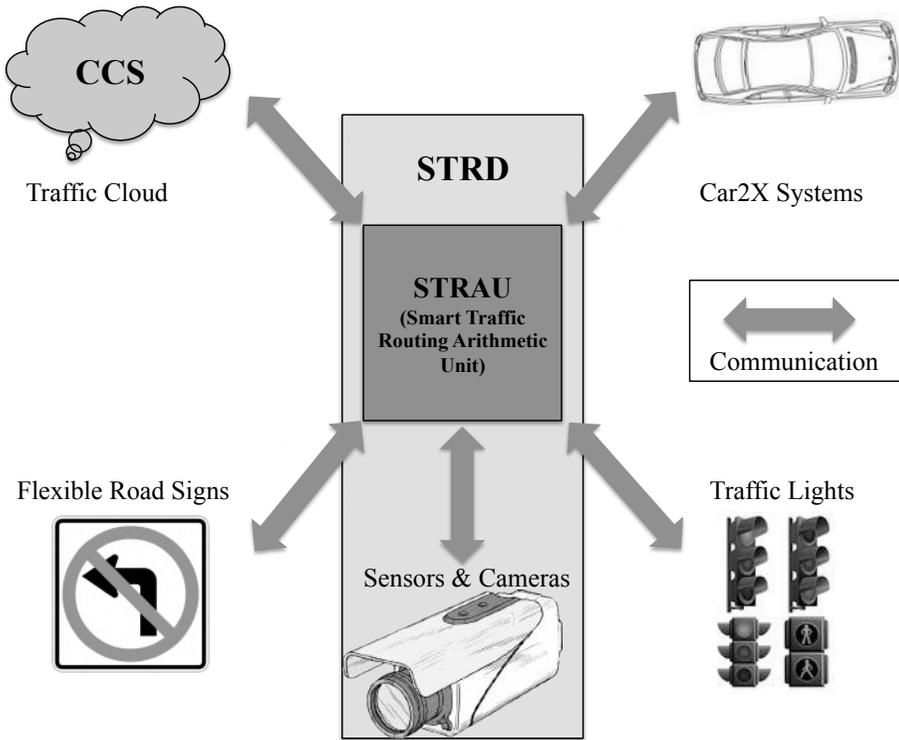
Hardware and Localization

Figure 10.10: Product illustration
source: Own illustration

The hardware of STRD at a distinct location (e.g. an intersection, parking area) consists of an arithmetic unit (STRAU) and peripheral devices as can been seen on figure 10.10. Those peripheral devices are on the one hand sensors and cameras that provide raw traffic data. Amongst others there are motion detectors, 2D and 3D imaging cameras, near field communicating sensors and magnetic pavement sensors. On the other hand there are signal devices like traffic lights or electronic traffic signs that are controlled by the STRAU. It is not mandatory to fully replace existing infrastructure since most of the current sensor and signal devices can be connected and integrated to the core unit, e.g. public surveillance cameras and traffic lights. Common application areas for STRDs, STRAU and peripheral devices, are spots where functional grouping of traffic surveillance and optimization is sensible. These include intersections, parking areas, danger zones (e.g. construction areas) tunnels or other settings

where flexible or multiple traffic signs are needed.

Network Connection

STRDs, respectively the STRAUs (Smart Traffic Routing Arithmetic Units) are wired or wireless connected, depending on the surrounding network infrastructure and needs. There are on the one hand side cabled network connections to sensors or a central network like the CCS possible. On the other hand a wireless network adapter connects to Car2X systems, other STRAUs or wireless sensors. All network connections work with common network standards like the 802.1x or UMTS. A powerful firewall protects against illegal encroachment.

Software

The software is the core of STRD. It utilizes intelligent algorithms that filter, process and merge the information provided by the peripheral units, the Car2X systems and the CCS. There are applications of STRDs that need local 2D maps where cars are discrete points with attributes. There are also applications that process full 3D scenes – as the crash detection logic. The software also uses advanced optimization algorithms that react and optimize situations in real-time, giving defined patterns of situations. An innovative, adaptive and semantic learning system based on neuronal networks incrementally improves the functionalities of the STRDs – e.g. pattern recognition and optimization procedure. The STRDs themselves are communicating in a form of swarm logic as data between neighbor STRAUs is exchanged via wireless or cabled network.

10.4.1 Business Model

After introducing the product idea in detail, the business model explains how a corporation could generate, distribute and capture value out of Smart Tracking Routing Devices (STRD) [482]. Customers are separated in different segments and their relationships are further investigated. The Value Proposition deals with the additional customer benefits generated by STRD. Afterwards the chapter Revenue Streams points out how to earn money out of the created value. By explaining the Cost Structure, Key Resources and Activities internal business structures are outlined. Furthermore, Distribution Channels and the collaborations with Key Partners are mentioned.

10.4.1.1 Customer Segments

Potential customers for STRD solutions can be segmented into one main target group and several secondary target groups.

The major customer is the municipality as it is the most crucial provider for traffic lights, road signs and parking meters in the city. Traffic management authorities as a part of the public administration are in charge of optimizing city traffic. The officials conduct public tenders to allocate the execution of infrastructure projects and monitor their implementation. With STRDs and optional city cloud systems they are trying to steer and route urban traffic. In order to customize the STRD solution and to further improve it this means a very close partnership with the authorities during all stages of the project.

Furthermore, private companies are a additional target group. Their demand for STRDs is normally lower, because they own sites of smaller scale. However, car park operators, airports and enterprises, which have big company sites, are potential clients. They cannot only use the system in order to manage their parking space but also to restrict access to sites that are only open to employees or control traffic on the runway of the airport.

10.4.1.2 Value Propositions

As the major task of the municipality includes the provision of an efficient city traffic system, the value proposition addresses not only advantages for the administration, but also for the citizens themselves.

The advanced traffic information gives the city the possibility to improve their traffic flow and to make the allocation of urban parking space more efficient. As a result car emissions are reduced and roads become saver. Considering the fact that a significant part of all serious accidents within cities occur in unclear traffic situations, STRDs on intersections can provide upfront symmetric information to avoid these conditions. As drivers receive real time traffic information on accidents, construction sites and other traffic obstacles they can avoid the respective area or drive more cautiously. Due to some redundancy with the CCS, STRDs provide a significantly higher uptime of the traffic management system. Breakdowns and maintenance of the CCS are easily overcome and congestions happen less frequently.

Users also need less travel time as they know which route is the fastest and furthermore the traffic flow can be adapted flexibly. With STRDs it is possible for the municipality to change traffic signals smoothly to the needs of the traffic participants. Advanced traffic information data generated by STRD systems lead to smart interaction of the device with the traffic situation. The collected information is spread over vehicle2X protocols and the CCS to provide for optimal traffic routing measures. As a result of the support mentioned above traveling becomes much more convenient.

10.4.1.3 Distribution Channels

Since the municipality is the main target group distribution channels are restricted to some extent. One way to sell STRD solutions to cities is the

participation in tendering procedures. As STRD systems are very innovative products municipalities might not request for them as they simply do not know about it. Therefore a proactive sales strategy is crucial in order to inform them about the advantages and to achieve a public private partnership with the city.

Networking and lobbying are important to spread the message of STRD possibilities. Also the participation on fairs and exhibitions draws attention to the products. Apart from that the sales team approaches private customers by using direct and indirect strategies. On the one hand airports and companies can be addressed directly to offer them the company's service. Nevertheless the number of airports and companies being potential customers is huge. Therefore it makes sense to strive for partnerships with building contractors and planning offices specialized in building such sites. With the help of these actors a bigger amount of companies can be reached in an indirect way.

10.4.1.4 Customer Relationships

The relationship with the customer comprises four different levels: the lobbying, the consulting of cities, the maintenance of the actual devices, and the service of analyzing data and improving the software.

In order to acquire future clients networking and lobbying are crucial tasks to customer relationship. The attendance of sales teams on fairs and social and political events are mandatory. Officials in the municipality have a good understanding of the city's traffic structure but are in general no experts in new technologies. Helping them to find a way through this vast amount of information and technology systems is important. Providing recommendations on the integration and implementation of STRDs is essential in order to use them efficiently. A key account manager assures that each client has at least one customer representative to communicate with and who helps him during and even after the project. The customer relation goes beyond traditional customer vendor relationships. The implementation of STRD solutions is a co-creative process.

Maintenance builds up a strong bond to the customer, the promise of warranty leads to a higher quality perception and since the municipalities have generally little knowledge on ICT and electrical maintenance, an arranged automatic repairing is very valuable to the them.

Service consists of the analysis of data and the supply of software updates for the incremental product improvement. It contains the involvement of the customer, which provides some of the collected data in order to find patterns to improve reactions, resolve malfunctions and adapt the system to further customer needs which come up during usage.

Although the customer consists mainly of the municipality and their officials it can be extended to the end-customer and other stakeholders as seen in Figure 10.11 . Within the outer circle there are insurances and automotive clubs

which benefit from the improved safety. Also there are service and content provider which could use the data to improve their services e.g. navigation systems. The extended circle consists of suppliers of the automotive and the telecommunication industry who are major strategic partners for the running of STRD systems The inner circle consists of directly influenced stakeholders like road operators, traffic participants and car manufacturers.
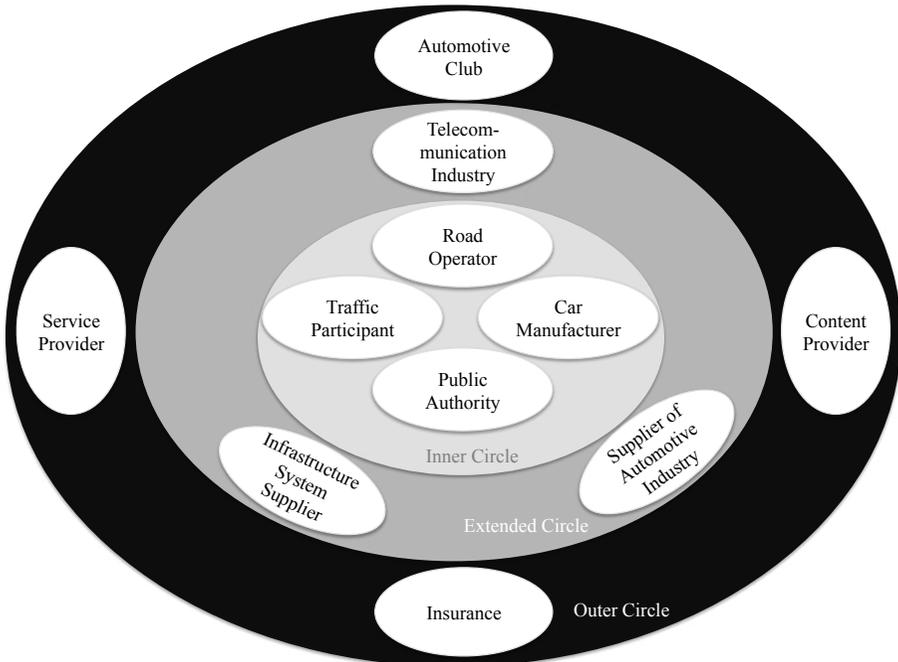

Figure 10.11: Overview of stakeholders
source: Own illustration

10.4.1.5 Revenue Streams

The revenue streams for STRDs are based on the typical structure of a solutions business. Prices are variable and negotiated depending on project volume and bargaining power of the parties. The following revenue posts are sorted by their volume which also reflects their relevance for the company.

Sales Solution and Implementation. The major source of revenue for the company is the sale of planning, customization and implementation of STRDs. A price for the whole project is negotiated with the customer and concluded in a contract. There is a fix price for the hardware included. Other components of the

price are calculated variably depending on the estimated planning, customization, construction and integration efforts. Usually a certain percentage of the price is paid in advance while the rest is financed.

Integration of the System by Competitor. STRDs are ready to be sold and implemented together with a traffic cloud system like the CCS mentioned in the scenario. Thus, it is possible that another company acts as integration partner and project manager. In this case the project managing company is the contract partner. Parts of the solution are now overtaken by the other company. For the remaining solution services, the hardware, planning, customization and construction the company will be paid by the integrating company.

Financing. Large scale projects need high investments that cannot be supplied at once by both parties, the customer and the company. Therefore loans are needed to finance the progress of the project. Financing institutes internal or external of the project managing company provide those. The payment of the loan represents one of the major revenue streams. Due to the customer structure, consisting of municipalities or large scale companies, loan defaults are unlikely.

Service and Maintenance. As usual in solutions business service contracts are signed. Over a longer period after the implementation – e.g. 5 or 10 years – regular service efforts have to be paid. These service efforts contain trainings, system updates and technical maintenance. The volume of the service and maintenance is highly depending on the solutions volume.

Upgrade & Extension of Technical Equipment. The STRD solution can easily be extended by additional sensors, cameras, network access points to improve performance and further services can be added. Thereby additional revenues can be generated. Implementation of additional peripheral devices, extra planning, customization, construction and integration effort can be calculated.

Operator's Model. More unusual for a product like the STRD system and especially a scenario like Big Brother is Watching You would be an Operator's Revenue Model. In this Model some functionalities of STRDs would be sold as a service. It is imaginable that like Toll-Collect the company additionally acts as an operator and fulfills tasks like processing the data for a city tolling system. In this case a certain share of the paid fees is kept by the operator.

10.4.1.6 Key Resources

To produce, operate and further develop STRDs several of important resources are required in order to make the business model work.

The most important physical resources are hardware components such as displays, LED lights, network hardware, CPUs, sensors, cameras and computers and manufacturing facilities.

For the business of STRDs a huge amount of intellectual resources is needed, including IP e.g. individual software, data and partnerships. An individual

software has to be coded to interact between the peripheral equipment, interpret objects captured by the sensors and react based on programmed patterns. To write this software human resource is crucial. Software developers who analyze and interpret traffic patterns are the heart of the system and are responsible for the overall quality of the product. Data is also essential to STRDs, especially the information of cars and motorbikes. Cars for example can interact with the STRD system at an urban intersection via vehicle2x-communication over the common 802.1x protocol. Another partner of providing data could be an existing city traffic cloud that aggregates the data of a whole city and instructs strategic decisions to the decentralized STRD systems.

Human resources are very crucial on the one hand for the knowledge intensive development and improvement of software and on the other hand for the large, skilled sales forces.

Financial resources have to be plenty in order to provide a good basis for huge advance provision and immense loans of big projects.
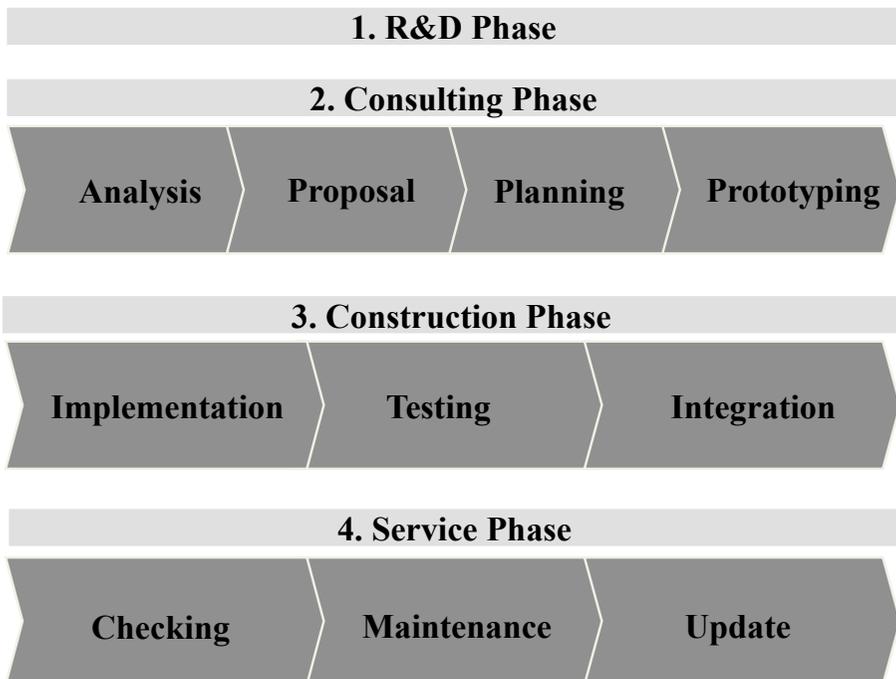
10.4.1.7 Key Activities

Figure 10.12: Key activities of the STRD solution business
source: Own illustration

As described in figure 10.12 the key activities of the STRD solution business can be separated into four phases: R&D, consulting, construction and service phases.

Research and development are essential activities in order to achieve innovation and improvements of traffic infrastructure. How can traffic lights or signs interact with their surrounding, how can they react on certain events in traffic? How can moral hazard through more safety be limited? These are key questions in order to develop systems to make urban traffic safer.

The consulting phase is the stage of supporting city authorities. The current city infrastructure is analyzed, then possible implementations are presented and eligible STRD systems are recommended to the officials. After that planning begins and the first round of prototyping can be run. In addition to that flexible financing can be granted to the customers to realize the best solution possible independent from financial issues.

In the construction phase the system is firstly implemented parallel to the current infrastructure in order not to interrupt traffic flow. Then it is tested and if it is fully working the system is integrated into the existing structure.

Maintenance and service are the keys to customer relationship and therefore updating and improving the software through the analysis of the aggregated data of various intersections of different cities is important. A crucial point is also the maintenance of the actual device and its peripheral equipment.

10.4.1.8 Key Partners

In order to realize the development and the functioning of STRDs there are some strategic partnerships with non-competitors, joint ventures and buyer-supplier relationships that have a high impact on the business success.

Strategic partnerships with non-competitors. Every city is unique and so is the actual STRD solution. The municipalities are not only clients they are partners co-creating in the development and implementation process. Car and motorbike manufacturers are key partners due to the mandatory vehicle2x communication. The protocol has to be defined exactly in order to make communication and interaction between vehicles and STRD possible.

Joint ventures. City traffic cloud providers are also important to embed the STRDs into the existing traffic system and to be partnered in potential bundle sales.

Buyer-supplier relationships. There are a lot of suppliers necessary for the different components that cannot be provided by the company. Especially some of the hardware parts like CPUs and computers have to be bought.

10.4.1.9 Cost Structure

The costs, which accrue when building up the business for STRDs, can be categorized according to different project phases: research and development,

marketing and sales, consulting and planning, implementation and integration and maintenance and service. In the following they are mentioned in order of their emphasis for the business.

As STRDs are very complex systems they need to be further developed technically, so R&D is a main cost factor. It contains developing the respective solution as well as legal costs for patents.

Consulting and planning create other substantial expenditures. The STRD solution has to be adapted to each city individually, which makes in-depth analyses of the current traffic situation indispensible. Thus the effort for this is way higher than for generic solutions. In this field human capital is the most crucial factor which is why salaries are the most important type of costs. In addition to that the expenses of implementation and integration have a high impact on the company's costs.

When realizing STRDs in the city the delivery of necessary devices creates a logistical effort. Furthermore the municipality has to be trained for the system in order to be able to use it.

Nevertheless the company still is in charge of ensuring the functioning of the system after the handover. This includes maintenance, guarantee service and further improvements. Thus an involvement of the company's staff and thereby caused labor costs still come up.

Further costs are caused by marketing and sales expenses. It is mainly composed of the extensive preparation and participation in tendering processes which is extended by travel and labor costs for attending fairs and conferences to promote STRDs.

10.4.2 Scenario Robustness

STRDs are products that can be considered very robust in all scenarios, as they help to tackle the major challenge of traffic management in cities. Especially because of the very certain development of urbanization and the increasing need for mobility in cities, solutions for optimization and rationalization of urban traffic will be demanded in almost any case. In the following it is explained why STRDs in particular are a promising business case.

Both scenarios "Gadget Wonderland" and "Lost Trust" have a decentralized control of data in common that differences from "Big Brother is Watching You". In case of "Gadget Wonderland" there is a huge competition between companies. Hence, data is not controlled by one central company, control is spread. In "Lost Trust" citizens generally mistrust governments as well as companies and data privacy laws prevent both parties from controlling data streams. That means, that in both scenarios a centralized traffic management system like the CCS is not possible. However, the STRDs are not dependent on a network where data is kept and processed centrally. Data collected from STRDs can either be provided or pushed to decentralized swarms like Car2X systems in

case of "Gadget Wonderland" or kept locked safely within the STRD system.

Robustness for "Gadget Wonderland". The STRDs fulfill their functionality mostly utilizing conservative technologies. But even if there is a disruptive new technology, it is unlikely that a concept like the STRD system would be endangered. The STRDs operate in the area of infrastructure where new technologies take long time before being implemented. Disruptive technologies are quite unlikely regarding urban infrastructure. Hence, it is unlikely that there would be a disruptive technology for urban infrastructure that substitutes STRD solutions. It is more likely that disruptive technologies find their way to the end consumer first, as in Car2X systems or autonomous driving systems. Those technologies would even be supported, supplemented and connected by STRDs. However, a major challenge regarding this scenario would be the ongoing competition for technological market leadership which possibly weakens standardization. That would make it different for STRDs to communicate with the various traffic technologies that are utilized there.

Robustness for "Lost Trust". Even in the "Lost Trust" scenario an implementation of STRDs is conceivable as most functionalities are discrete and not directly visible to the end consumer. In this scenario people show a low technology acceptance. People are reluctant to use technology even mistrusting it, hence, several services provided by STRD systems would not work. At first only few people would drive cars with Car2X communication systems and a centralistic traffic cloud would also be unlikely to be implemented. Therefore all services that depend on exchanging information with a CCS or Car2X would not exist. But as mentioned above, STRD solutions do not need those systems to work, as they utilize their own sensors and cameras and are wirelessly interconnected in order to exchange information. Having low technology acceptance some people might be irritated by electronic road signs. But as those road signs almost look the same as conventional road signs and provide the same basic functionality, people would accept it. Most of the services which the STRDs provide not really visible to or influenced by the traffic participant. Additionally, most functionalities of the STRDs provide basic values like safety. Therefore an implementation of a STRD solution is only partly dependent on the technology acceptance. The question here is not whether yes or no, but more to what extent an STRD system is implemented. In case of this scenario STRDs would even be the most likely form of traffic optimization systems because compared to concepts like Car2X or CCS it is less dependent on trust towards technology or governments.

As a conclusion STRDs are a really robust business, needing a little customization regarding different scenarios. As governments, municipalities or large-scale companies are customers sales are mostly dependent on the awareness for traffic optimization and the willingness to pay for such a customized infrastructure solution.

10.5 Conclusion

Discussing the future of smart devices in urban mobility the first step was analyzing the major driving forces. They were categorized by their impact on the topic and uncertainty regarding their future development. Through differentiation three key drivers stood out, as they were high in impact and uncertainty: technology acceptance, technological development and ownership and control over data. Since they were highly uncertain they suited best to illustrate possible future scenarios using varying combinations of their outcomes.

The three presented scenarios were Lost Trust, Gadget Wonderland and Big Brother is Watching You. Big Brother is Watching You was described in more detail as a world where technology acceptance were high, innovations were incremental and the government owned and controled the major part of data. Based on this scenario a product and business idea was presented: Smart Traffic Routing Devices. STRD systems are developed to further improve the city traffic in efficiency and safety. Connected to sensors and cameras the STRD solutions monitor and process traffic at specific points, e.g. intersections. For traffic lights, electronic traffic signs, but also Car2X interfaces or the CCS optimized instructions and information are provided enabling flexible traffic signs, improving intersection traffic, alleviating dangerous situations, improving security, increase reliability and optimizing parking traffic.

As a result it can be noted that the significance of smart devices will increase in urban mobility leading to efficient traffic optimization and more safety. Due to huge challenges in the future of urban mobility this is essential. The diffusion, their success and the pace of their implementation however are highly uncertain and depend on the development of the societal and technological conditions.

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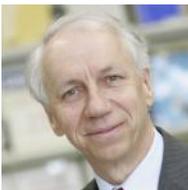Ludwigstr. 28, 80539 München, GERMANY
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