Professional MBA
Automotive Industry

Urban mobility 2030 – fleet management and operation of urban shared demand responsive transport with purpose-built vehicles – a business model perspective in a MaaS environment

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“Master of Business Administration”

supervised by
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Vienna, 28.10.2019

Affidavit

I, **NORMAN LAUER, B.A.**, hereby declare

1. that I am the sole author of the present Master's Thesis, "URBAN MOBILITY 2030 – FLEET MANAGEMENT AND OPERATION OF URBAN SHARED DEMAND RESPONSIVE TRANSPORT WITH PURPOSE-BUILT VEHICLES – A BUSINESS MODEL PERSPECTIVE IN A MAAS ENVIRONMENT", 79 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted the topic of this Master's Thesis or parts of it in any form for assessment as an examination paper, either in Austria or abroad.

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Abstract

Urban mobility in the year 2030 and beyond will look differently than today. The constant rising number of city inhabitants and the changing behavior of consuming mobility requires new ways of thinking and new transportation business models of public and private actors.

In a mobility as a service-oriented world, the importance of the ownership of a conventional passenger car and the inefficient areas of public bus transportation will decrease but the demand for comfortable transportation will increase. This supply gap of demand-responsive transportation could be covered by a fleet of decentralized operated and managed purpose-built vehicles.

But this new kind of dynamically and decentralized transport services cannot be managed and operated within the existing rigid and centralized public transportation networks. Therefore, the way we think about shared transportation services in an asset-heavy industry needs to change.

The thesis aims to analyze the current urban transportation system structure and describes their business models. With this fundament accompanied by the assumptions with regards to urban shared demand-responsive transportation with purpose-built vehicles, a new fleet operation based asset-light ecosystem which creates multiple new platform-based business models, is described.

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I List of abbreviations

AG	Public limited company
App	Application
B2C	Business to Customer
B2B	Business to Business
CAGR	Compound Annual Growth Rate
ICT	Information and Communication Technologies
Km	Kilometer
MaaS	Mobility as a Service
MENA	Middle East & North Africa
MIT	Motorized Individual Transport
OECD	Organization for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
PBefG	Passenger Transportation Act
PPTO	Private Public Transport Operator
PT	Public Transportation
PTA	Public Transportation Authority
SAE	Society of Automotive Engineers
TFL	Transport for London
VW	Volkswagen AG
DB	Deutsche Bahn AG
BMW	Bayerische Motorwerke AG
WL	Wiener Linien
FMC	Fleet management company
RoE	Return on Equity
M1	vehicles for passenger transport, minimum 4 wheels, less or equal 3.5 t total
M2	vehicles for passenger transport, more than 8 passenger seats
RATP	Régie autonome des transports Parisiens
HQ	Headquarter
AB	Public limited company

GDP	Gross domestic product
IT	Information technology
UITP	Union Internationale des Transports Publics – International Association of Public Transport
HV	High Voltage
TCO	Total cost of ownership

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1. Introduction

Today urban areas around the globe are facing various challenges with regards to urban transportation of people and goods. Based on the existing infrastructure, established mobility behavior and logistics landscape, cities have different initial situations but similar difficulties.

By 2050, almost 70% of the world's population will live, commute and work in cities. Between now and then, cities and urban areas will undergo significant transformations to create sustainable living conditions for their residents. Cities will require transportation solutions that are sustainable, affordable and integrated with customer-centric infrastructure and services.[1]
Public transport systems are facing rising costs, funding issues, increases in ridership and an ageing infrastructure, among others.[2]

Private ownership and operation of automobiles has dramatically changed the paradigm of urban transportation by offering fast and anytime point-to-point transportation within cities during the past century. This paradigm is currently challenged because of a combination of factors such as dependency on oil, tailpipe production of greenhouse gases, reduced throughput caused by congestion, and increasing demands on urban land for parking.[3]

Over the past decades the steady increase in transport volumes, a rising middle class, and limited access to public transport has caused growing numbers of residents to acquire motor vehicles, which causes traffic congestion, air pollution, and land use to get worse.[4]

[1] Marina Lombardi (2018); Kristen Panerali (2018), page 4-5
[2] Canales, D., Bouton, S., Trimble, E., Thayne, J., Da Silva, L., Shastry, S., Knupfer, S., Powell, M. (2017), page 1
[3] Markus Maurer / J. Christian Gerdes / Barbara Lenz / Hermann Winner (2016), page 387-388
[4] Canales, D., Bouton, S., Trimble, E., Thayne, J., Da Silva, L., Shastry, S., Knupfer, S., Powell, M. (2017), page 1

Sustainable, affordable, and efficient urban transportation of people and goods helps to improve the lives of all urban inhabitants. Mass transit in particular, remains indispensable for moving people around quickly, preventing traffic congestion, limiting pollution, and freeing land for more valuable uses than parking space.

Private transportation companies already complement public transit systems within pilot projects by serving city areas that cannot be easily accessed by public transit. Public transport authorities, private transport companies and new actors are attempting to integrate and operate new private mobility services independently or by partnering with existing actors.

The considerations that surround this opportunity are complex: encompassing access, convenience, cost, employment, finance, and regulation require a holistic perception and approach. Partnerships between these stakeholders can allow cities to apply the operating models and technologies of new mobility services to make transportation more affordable and convenient for all city residents, while improving environmental outcomes.[5]

Technological progress is a necessary but not sufficient requirement for coping with these challenges. For example, the targets of many European countries to reduce greenhouse gas emission can hardly be reached without a successful implementation of technological and also organizational innovations.[6]

New or adapted business models play a crucial role for the integration and diffusion of new mobility services. They connect customer benefits, profitability for the companies involved, and could have a positive effect on the development of a sustainable urban transport system.[7]

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[5] Canales, D., Bouton, S., Trimble, E., Thayne, J., Da Silva, L., Shastry, S., Knupfer, S., Powell, M. (2017), page 1

[6] Puhe, M., Schippl, J. (2012), page 1-5

[7] Arwed Schmidt (2016), page vii

1.1 MaaS and its impact on public transportation business models

Financially strong and fast-paced, asset-light software-based MaaS firms with direct access to mobility customers could potentially replace complete conventional bus and taxi transportation networks. Hence, cities, transport authorities, and asset-heavy public transport operators need to face the customer/user-centric new MaaS environment and need to adapt to the changing mobility landscape by implementing transportation strategies which are beneficial for the individual and the society.

Today, the mobility landscape and the approach of new privately operated shared mobility services in urban areas are diverse in their business models and openness to cooperate with local city authorities. Depending on varying local legal requirements and transportation laws, different transportation service models are tested or already deployed in cities.

Software and transportation start-ups use mobility data and software intelligence to provide a customer-centric transportation service throughout cities. The media and industry call these different modes of transport and new mobility business models in general Mobility as a Service (MaaS).

The first profound definition of MaaS was given by Sampo Hietanen in 2014. He describes MaaS as a mobility distribution model that deliver transport needs through an interface of a service provider. It bundles different transport modes to offer a tailored mobility package, like a monthly mobile phone contract. This interpretation contains some of the core characteristics of MaaS: customer’s need based, service bundling, cooperative, and interconnected in urban transport modes and service providers.[8]

[8] Jittrapirom, P., Caiati, V., Feneri, A. M., Ebrahimigharehbaghi, S., Alonso-González, M. J., & Narayan, J. (2017), page 14

Based on transport user needs, the user can have the choice of ‘pay-as-you-go’ or pre/post pay, considering user registration. At a second stage, a subscription could result in personalization, framing mobility services around the user´s preferences, which is an important advantage that is currently absent in traditional public transport and thus, does not cover user needs which could lead to inconvenience.[9]

MaaS is an opportunity to provide transport which facilitates the users to get from A to B by combining existing mobility options and presenting them in a completely integrated manner. Thus, it is possible to consider MaaS as a mobility service that is flexible, personalized, and on-demand.

ICTs also play a vital role in the MaaS environment. The information integration and convergence between users, providers, and services is crucial for the transport operation system. Data collection, transmission, processing and presentation is key for identifying the best transport solution for user needs.

Seamless door-to-door mobility is the main goal of MaaS systems. The combination of the cooperation of different operators, technological advances, and the bundling of several transport modes makes this feasible.
With strong cooperation’s between public and private transport providers and the consideration of efficient vehicle fleet management and operation, MaaS can result in a better allocation of resources and services with the citizen as an end-user.[10]

In contrast to the asset-light[11] business model of MaaS and the focus on software solutions to create new service models, public transportation authority’s (PTAs) offer and operate the real transportation (to transport a person from A to B) with the dedicated vehicle types to city inhabitants, which

[9] Atasoy, B., Ikeda, T., Song, X., & Ben-Akiva, M. E. (2015), page 36-37
[10] Jittrapirom, P., Caiati, V., Feneri, A. M., Ebrahimigharehbaghi, S., Alonso-González, M. J., Narayan, J. (2017), page 14
[11] See Figure 2

is highly cost intensive and therefore heavily subsidized by the public sector which is represented in Figure 1.

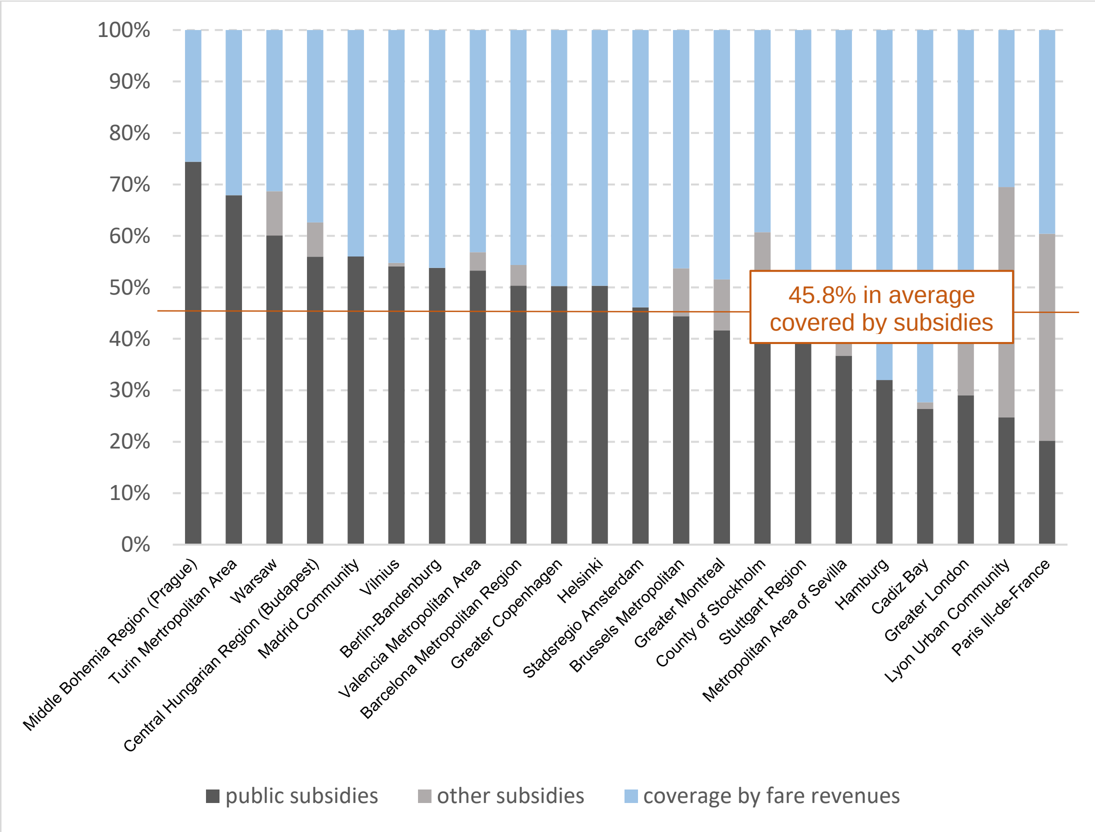

Figure 1 – Costs of public transportation[12]

The coverage of operational costs by public transportation fare revenues vary, some cities cover more than 50% of operational costs with fare revenues. In average, 45.9% of the operational costs are covered by fare revenues and 45.8% by subsidies.[13]

In Figure 2 the differentiation between asset-heavy and asset-light enterprise models is shown. Due to the asset-heavy business model and because of the not sufficient fare revenues the conventional public transportation is underfunded[14], which requires significant subsidies by the public sector. PTAs are typically incumbent transportation companies operating with significant

[12] EMTA Barometer of Public Transport in the European Metropolitan Areas (2011), page 5, Randelhoff, M. (2013)
[13] CEMTA Barometer of Public Transport in the European Metropolitan Areas (2011), page 5
[14] See Figure 1

physical assets (land, building, equipment, stock, infrastructure, vehicle fleets) and a large number of direct employees.[15]

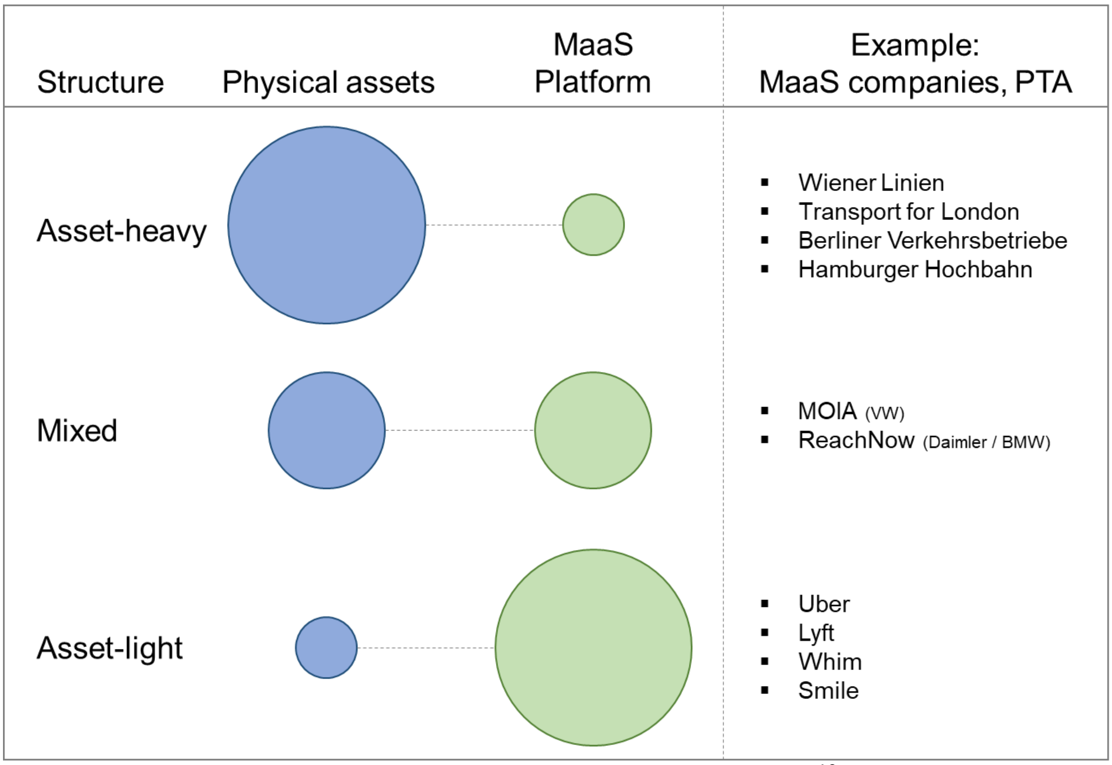

Figure 2 – Asset-heavy vs asset-light transportation business models[16]

Variations of scenarios between platforms and organizational structure of the enterprise open up a variety of important management questions. The ability and willingness of traditional asset-heavy transportation organizations to successfully integrate mobility platforms with new user centric mobility products and services (MaaS) into their existing environment is a challenge.

The asset-light enterprises face a different set of challenges. The asset-light companies face the challenge of building organizational capital across the wider ecosystem that they do not fully control. The risk 1) is too much focus on software systems, 2) is underinvestment in tangible assets that are needed to offer and operate transportation networks.[17]

[15] Evans, P., Gawer, A. (2015), page 19
[16] Own illustration, Evans, P., Gawer, A. (2015), page 20, Jittrapirom, P., Caiati, V., Feneri, A. M., Ebrahimigharehbaghi, S., Alonso-González, M. J., Narayan, J. (2017), page 17-18
[17] Evans, P., Gawer, A. (2015), page 20

The future urban mobility environment is influenced by the ability of PTAs to adapt and or develop own MaaS products and services. Furthermore, there is the question whether MaaS software service-focused can offer and/or operate highly complex transportation systems in an urban environment.

An efficient, reliable, and in particular profitable fleet management and operation for an urban shared demand-responsive transportation integrated in the city environment and operated by PTAs, MaaS providers or public-private-partnership will be key for future sustainable urban transportation.

1.2 Thesis approach

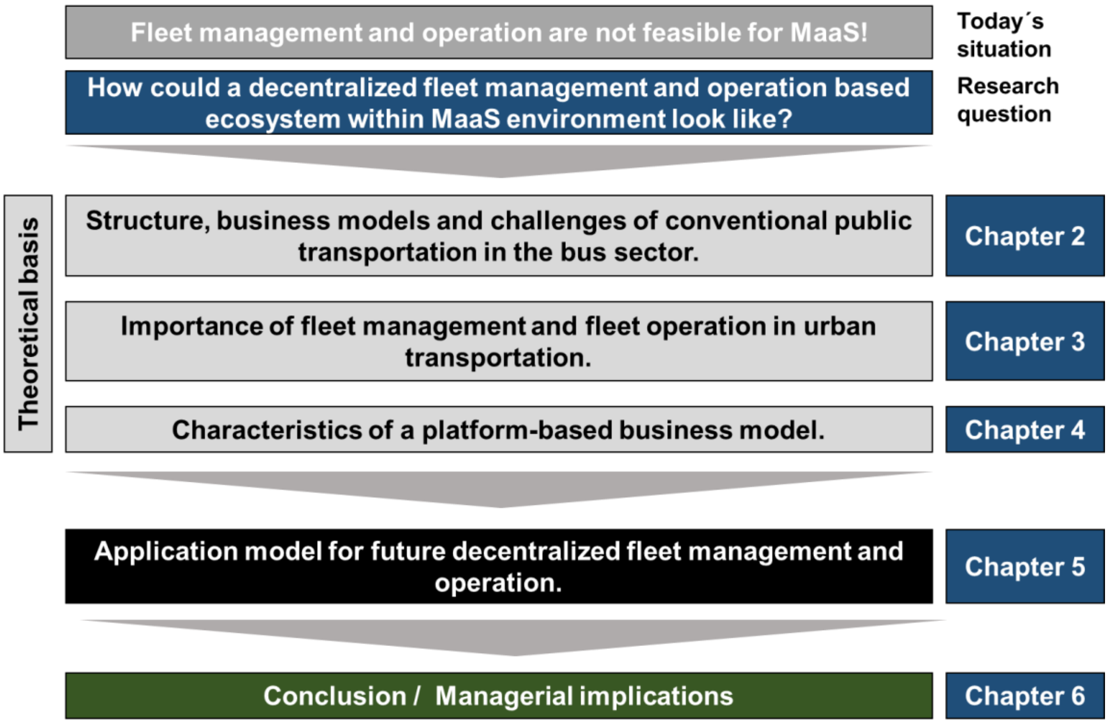

Figure 3 – Thesis approach

A generic view on today´s situation with regards to fleet management and operation within urban transportation in the environment of the growing sector of Mobility as a Service, represents the introduction of my thesis and leads to the research question of the thesis.

The question how a decentralized fleet management and operation based ecosystem in a future urban MaaS environment could look like, will be answered in the following steps.

Chapter 2, chapter 3, and chapter 4 analyze the current urban transportation ecosystem on a theoretical basis and lay the foundation for my assumptions which are the basis to build the application model in chapter 5.
Chapter 6 is dedicated to formulate managerial implications based on the findings of the application model and is followed by the thesis conclusion.

2. Conventional public transportation

Urban transportation and the different regional characteristics around the globe are described by the Modal Split. The mode of transport refers to the way in which passengers and/or goods can be transported.

Transport modes for both passengers and goods include:

- rail;
- maritime (sea);
- road;
- inland waterways
- air.

Transport modes for passengers include:

- passenger car
- powered two-wheelers;
- bus
- tram (light-rail / commuter train)
- metro

The modal split of transport describes the relative share of each mode of transport. It is based on passenger-kilometer for passenger transport and tone-kilometer for freight or goods transport. The modal split is usually defined for a specific geographic area like countries as shown in Figure 4.
In practice, an analysis of the modal split may exclude or include certain modes of transport. For example, the analysis may be limited to inland or city transport and therefore exclude sea transport. Furthermore, walking and cycling is included from a city perspective.[18]

[18] Eurostat statistics explained, Glossary explained: Transport mode

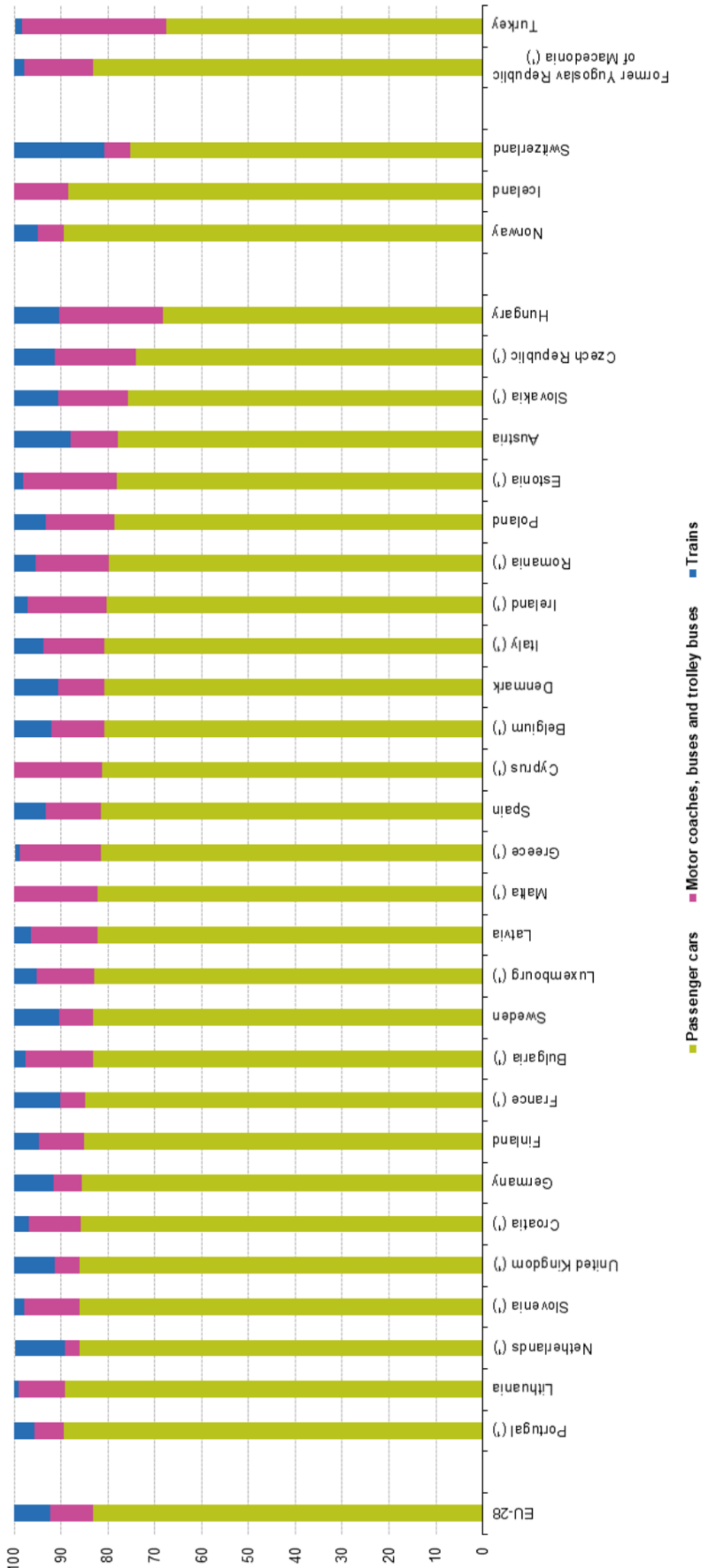

Figure 4 – EU 28 modal split
(% of total inland passenger-kilometers)[19]

[19] Eurostat (2015)

Figure 4 describes the modal split of inland transport for the EU 28 member states plus Norway, Iceland, former Yugoslavia, and Turkey. Due to included long distance journeys, the majority of passenger-kilometer traveled in a member state is covered by private passenger cars. The rest is shared between motor coaches, buses, trolley buses, and trains.[20]

On city level, a more detailed differentiation between transport opportunities is needed to cluster the different transport modes and to understand transport and infrastructure characteristics. In Germany, cities with a population greater than 500,000 inhabitants, approx. 11% (Duisburg) to 27% (Berlin) of transport demand are covered by PT (see Figure 5).

Public transportation includes following transport modes: bus, commuter-train (S-Bahn), and metro. Motorized individual transportation shows the percentage of individual use of passenger cars. In Austria (Figure 6), Vienna with a population of approx. 1,840,226 inhabitants in comparison to Hamburg with 1,735,663 inhabitants shows a significant higher share of PT.[21]

[20] Eurostat (2015), Finger, M., Bert, N. (2017), page 61
[21] European Platform on Mobility Management (EPOMM)

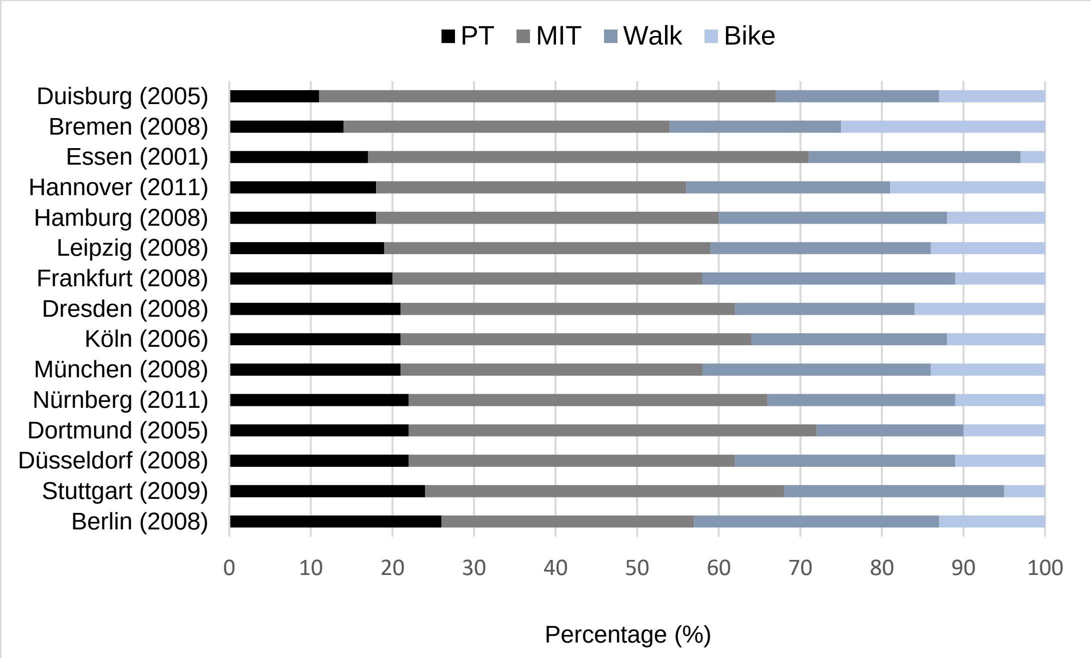

Figure 5 – Modal split of German cities[22]

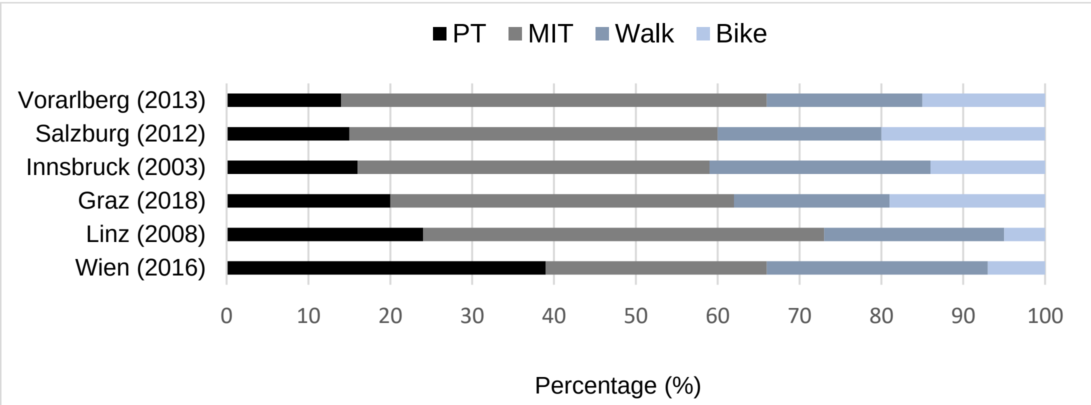

Figure 6 – Modal split of Austrian cities[23]

Out of the German and Austrian cities, Vienna is the only city with a higher PT share than MIT.

[22] Own illustration, European Platform on Mobility Management (EPOMM)
[23] Own illustration, European Platform on Mobility Management (EPOMM)

2.1 Business models of bus-based public transportation

UITP, the International Association of Public Transport, outlines three different types of business models as shown in Figure 7.

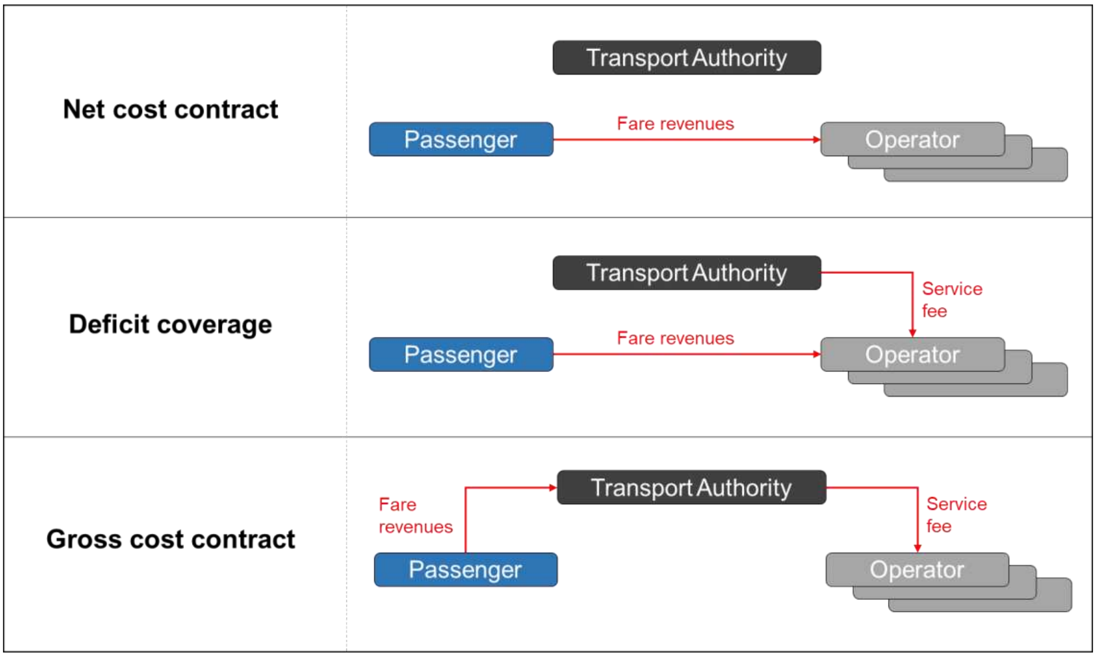

Figure 7 – Types of business models in public transportation [24]

Within the **net cost contract business model** the private or public operator collects and keeps the fare revenues. This model is applied in non-regulated open urban transportation markets. But public or private operators need to be in the possession of corresponding licenses or concessions provided by city authorities to operate in the prescribed routes or corridors. Operators do not usually receive public subsidies to cover potential fare revenues or cost risks of transport service provided to the passenger. Typically, this contracting method is applied in French and Dutch cities.[25]

[24] Own illustration, Trel, E. (2014)
[25] Trel, E. (2014)

The **deficit coverage business model** is common in Eastern European and the former Soviet countries. The operator collects and keeps the fare revenues and on top, the operator receives public subsidies to cover potential operational deficits. In this environment the Transport Authority bears the fare revenue and the cost risk.

Gross cost contracting is the most applied urban transportation business model. In the UK, the public transport authority in London (TFL) and in Austria, the WL organize the city transport operation based on this business model. The PTA collects and keeps the fare revenue via the public ticketing system. The operator organizes and operates the transportation service to the passenger in the dedicated areas or on concession based routes. For this transportation service the PTA pays a service fee. Urban environments, especially large European cities like Hamburg or Vienna, have contracted more than one private operator to cover their transportation demand. Within the gross cost contracting many business model variants can be applied, even PTAs like WL can be both contractor and operator at the same time.[26]

[26] Trel, E. (2014), Moser, J. (2016): Beschaffung von Autobussen und Internes Kontrollsystem, page 383

2.2 Public-operated bus transportation – case study of WL

As indicated in chapter 2.1., Vienna´s public bus transportation system is organized and operated within the gross cost contracting business model, specifically in the environment of bus line transportation.
Hereinafter, in general, WL will be used for Wiener Linien GmbH and for the operational active Wiener Linien GmbH & Co KG.

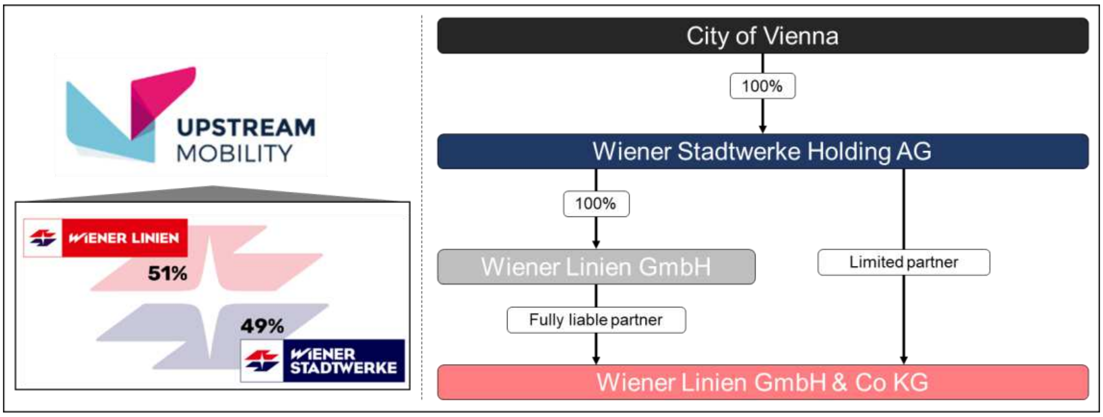

Figure 8 – Wiener Linien company structure + Upstream Mobility[27]

WL is a fully owned subsidiary of the Wiener Stadtwerke Holding AG and is indirectly owned by the city of Vienna. The company is a limited partnership (see Figure 8) and provides public transport services for the city of Vienna. In addition to the operation of metro, trams, and bus lines, WL also owns and operates the necessary infrastructure for the operation and the vehicles.[28]
Upstream – next level mobility GmbH, hereafter called Upstream Mobility, is predominantly owned by WL and provides the software for intermodal MaaS platforms, e.g. for Vienna the intermodal mobility app WienMobil.[29]

[27] Own illustration, based on Moser, J. (2016): Beschaffung von Autobussen und Internes Kontrollsystem, page 375, Website Upstream Mobility
[28] Moser, J. (2016): Beschaffung von Autobussen und Internes Kontrollsystem, page 375
[29] Website Upstream Mobility

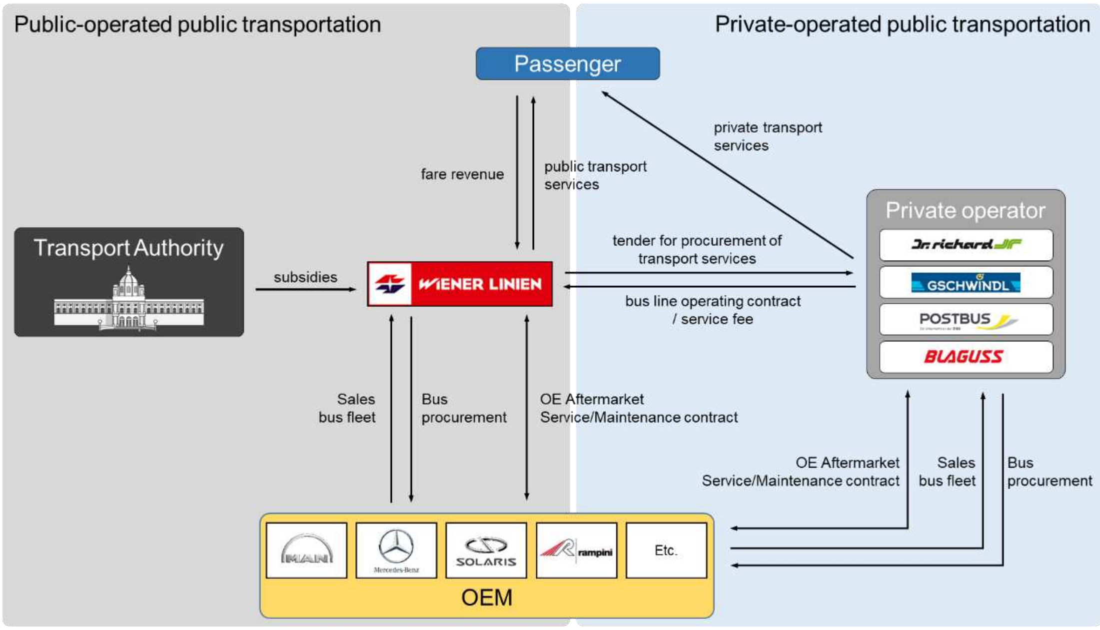

Figure 9 – Vienna public bus operation system[30]

In Figure 9, the main stakeholders within the public bus transportation system in Vienna are shown and separated in public-operated public transportation and private-operated public transportation. The business model and the operational structure of the metro and tram is in the responsibility of WL as well but will not be evaluated in this thesis.

In Figure 8, the left side highlighted in grey describes the public-operated public transportation. In this case, WL is the PTA and the operator at the same time. WL collects the fare revenues and provides the transportation service with their own purchased bus fleet and operational background. On the right blue side the private-operated public bus transportation is highlighted. This case represents a gross cost contract relationship, whereas WL as Transport Authority, line concession owner and fare revenue interface outsources the operation for certain bus lines for a certain time (3 to 5 years) while paying an operational service fee to the PPTA.[31]

The intermodal[32] software and mobility service application, WienMobilApp[33] developed by Upstream Mobility, and their scope of function is not considered, yet. Since October 13, 2015 all concessions which allow private or public

[30] Own illustration, Dr. Pollak., P. (2017)
[31] Own illustration, Dr. Pollak., P. (2017)
[32] Transport of passengers by more than one mode of transportation in a single journey
[33] Wiener Linien Website

operator companies to operate dedicated bus lines have been under control of WL.[34] Hence, WL decided which bus line under certain conditions will be outsourced via a tendering and which bus line will be operated by WL.

As shown in Figure 10, the share of WL outsourced transportation rose from approx. 30% in 2007 to 40% in 2015 with regards to seat-km. The private-operated service was economically more favorable compared to WL conducting the operations themselves. In contrast to economic reasons for decision, in case of market failure it needs to be ensured that the urban transportation demand can be fulfilled. Hence, WL considered a theoretical limitation of 49.9% of outsourced transport service even though it is not economically justifiable.[35]

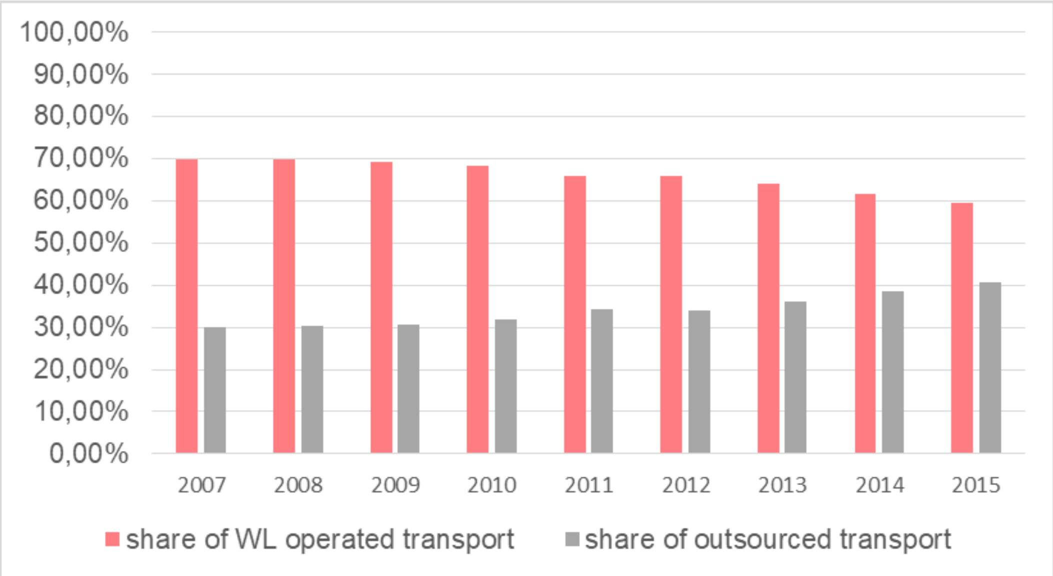

Figure 10 – Wiener Linien – share of transportation service[36]

[34] Dr. Pollak., P. (2017), page 12-13
[35] Moser, J. (2016), page 381
[36] Own illustration based on Dr. Pollak., P. (2017), page 11, Moser, J. (2016), page 380

2.3 Private public transportation operator – a future key partner

In contrast to cities with an existing, efficient, and well established public transportation like Vienna, Hamburg or London, many cities or regions do not have the capabilities or do not know how to implement and operate public labor-intensive[37] transportation services for their inhabitants on a large scale. Furthermore, globally heterogeneous legal frameworks in the public transportation sector facilitate the business model of private transportation operators like shown in Figure 11. The eight largest multinational operating PPTOs with huge global bus fleets are listed.

		Company	HQ	Fleetsize (bus)	Total revenue in €	Total employees	# of served countries (#9 city)
PPTO	1	Transdev Group	France	24.600	6.6 bn	83.000	19 countries
	2	Keolis S.A.	France	21.500	5.4 bn	63.500	16 countries
	3	RATP Group	France	4.700 (only Paris)	5.5 bn	63.000	14 countries
	4	DB Arriva	UK	16.953	5.3 bn	54.650	14 countries
	5	Go-Ahead Group	UK	5.400	3.8 bn	28.150	4 countries
	6	Stagecoach Group	UK	8.300	3.5 bn	26.300	2 countries
	7	ComfortDelGro Corporation Limited	Singapore	18.805	2.5 bn	18.823	7 counties
	8	Nobina AB	Sweden	3.600	1 bn	11.600	4 countries
PTA	9	Wiener Linien	Vienna	462	1 bn	8.700	Vienna

Figure 11 – PPTO landscape in comparison to WL[38]

PPTOs can be seen as a full service public transportation provider. They are able to set up and operate a complete public transportation network (metro, rail, bus) in cooperation with the city authorities (except city transportation infrastructure for metro or rail).

In some cases, PPTOs have been PTAs and have grown into multinational, even global PPTOs who provide their public transportation competence to other cities and partly or fully operate their public transportation network in cooperation with city authorities or contracted by PTAs.[39]

[37] Nobina AB Website

[38] Own illustration, Moser, J. (2016): Beschaffung von Autobussen und Internes Kontrollsystem, page 373, RATP Group Website, Transdev Group Website, Nobina Website, Keolis S.A. Website, DB Arriva Website, Go-Ahead Group Website, Stagecoach Group Website, ComfortDelGro Website

[39] RATP Group Website, Transdev Group Website, Nobina Website, Keolis S.A. Website, DB Arriva Website, Go-Ahead Group Website, Stagecoach Group Website, ComfortDelGro Website

PPTOs offer their services and operate within all three business model types mentioned in Figure 6 depending on the city and regional specific PT regulations.[40]
Depending on the executed business model, the PPTO has direct access to the important end-customer/passenger data and could build data-based transportation and non-transportation related platform-based business models and value streams around these data and further optimize the business case. The service portfolio of the above mentioned PPTOs includes the operation of metro, tram, urban and inter-urban buses, regional trains, sightseeing, maritime shuttles, cable transport, taxi, and transport on demand.[41]

Design and adaption to city needs and particularities of a whole transport network, development, and further improvements of existing networks is part of the e.g. RATP Group portfolio as well and potentially makes them to a strategic city partner for a long-term mobility strategy.[42]

The highlighted capabilities and the global footprint of the companies mentioned in Figure 10 could make them to the ideal business partner for asset-light software-based mobility providers and vehicle manufacturers of new purpose-built vehicles which need to be integrated in existing city transport operating systems.

[40] DB Arriva Website
[41] RATP Group Website, Stagecoach Group Website, ComfortDelGro Website
[42] RATP Group Website

2.4 Demand-responsive shared transportation – legal barriers

The transportation service and its conditions[43] are defined by the PTA. The legal framework for public transportation in Germany and Austria is manifested in the passenger transportation law.[44]
According to the German and Austrian passenger transportation law, currently demand-responsive dynamic shared transportation services have legal fundaments for transportation services[45].

The German passenger transportation law allows certain shared transportation services within the experimental clause regulated in the passenger transportation law in §2 (7) PBefG: For practical testing of new types of traffic or means of transport, the approval authority may, upon request, authorize deviations from the provisions of this act or from provisions adopted pursuant to this act for a maximum period of four years, as far as public transport interests are not concerned.[46] MOIA, a Volkswagen company who has offered demand-responsive shared transportation services in Hamburg since 2019, operates based on this exception.[47]

The Austrian law does not support demand-responsive shared transportation within private or public businesses.
Hence, for the application model in chapter 4. IT will be assumed that shared demand-responsive transportation has a legal basis in an urban environment of platform-based private and/or public transportation business models.

[43] Bus transportation: e.g. route, number of bus stops, timetable
[44] The German Federal Ministry of Justice
[45] Vehicle operations
[46] The German Federal Ministry of Justice
[47] Handelsblatt

3. Fleet management and fleet operation in urban transportation

Looking at a city from a vehicle perspective and how and in which business model these vehicle types are used shows a wide range of variations. Figure 12 explains the relationship of vehicle type and business models and describes the need of fleet management and operations as a key building block in the environment on publicly and privately operated transportation.

In line number 0 to 3 the use characteristics of conventional cars are outlined. Lines 5 to 7 describe the characteristics in which conventional vehicles are used for public transportation.

#	Vehicle type	Type of operations	Operated by	Vehicle ownerhsip	Fleet operation	Fleet managment	Type of passenger transportation	Business model	Platform-based business model	Customer relationship
7	Metro	Fix / scheduled	PTA / PPTO	PTA / PPTO	yes	yes	Shared	PT	no	B2C / B2B
6	Light rail	Fix / scheduled		PTA / PPTO	yes	yes	Shared	PT	no	B2C / B2B
5	Conventional Bus	Fix / scheduled		PTA / PPTO	yes	yes	Shared	PT	no	B2C / B2B
4	People Mover - new vehicle concepts (M1,M2)	Demand responsive / (fixed & scheduled)	?	?	yes	yes	Shared	Ride sharing / pooling	yes	B2C / B2B
3	Conventional car (M1)	Demand responsive	Driver	Driver	no	no	Single	Taxi	no	B2C
2	Convetional car (M1)	Demand responsive	Tenant	Car sharing provider	no	yes	Single / shared	Car sharing	yes	B2C / B2B
			Driver	Driver	no	no	Single / shared	Ride sharing / pooling	yes	B2C
			Driver	Driver	no	no	Single	Ride hailing	yes	B2C
1	Convetional car (M1)	Demand responsive	Vehicle owner		no	no	Single	Vehicle ownership	no	B2C
0	Convetional car (M1)	Demand responsive	Tenant / driver	Fleet company	no	yes	Single	Fleet Management	no	B2C / B2B

Figure 12 – Characteristics per vehicle[48] type[49]

Furthermore, the connection between the type of passenger transportation and fleet management is important. The application of sharing concepts has a significant impact within urban transportation, looking at conventional car usage. Conventional cars are currently mainly manufactured and sold by

[48] Potential vehicle classification: M1 – vehicles for passenger transport, minimum 4 wheels, less or equal 3.5t total weight / M2 – vehicles for passenger transport, more than 8 seats except driver seat, less or equal 5t total weight

[49] Own illustration

automotive OEMs to private persons, which is a B2C relationship (#1), where a fleet management is not required and fleet operation is done by the vehicle owner. In addition, OEMs and fleet management companies providing conventional car fleet focused high profitable business to other companies (#0).

#2 highlights the utilization of conventional cars impacted by mobility service software applications and platform-based new business models like ride sharing/pooling (e.g. Uber, Didi Chuxing, Lyft and Via) and car sharing (e.g. ShareNow).[50]

Lines # 5 to 7 describe the conventional public transport with non-automotive vehicles like metro and light rail plus conventional buses, also a kind of shared transport, but the vehicles are operated and managed by public authorities.[51]

The common goal among transportation business models, let it be traditional PT or MaaS providers, is to improve asset utilization. The key competencies for matching people with mobility are technological ones and provided by MaaS software solutions. The key to minimize per-mile costs is to maximize asset utilization. This in turn demands software algorithms that can estimate journey times and ultimately predict the transportation demand to avoid having idled or empty vehicles that do not earn a return. In other words, the goal of the technology is to optimize the utilization of the asset base – the vehicles.[52]

[50] Statista, Janson, M. (2019); Burgstaller, S., Flowers, D., Tamberrino, D., Terry, H., Yang, Y. (2017)
[51] chapter 2.1
[52] Burgstaller, S., Flowers, D., Tamberrino, D., Terry, H., Yang, Y. (2017)

3.1 Purpose-built vehicles – potential bus replacement

Purpose-built vehicles shown in #4 in Figure 12 could be a new mode of transport in the city environment being a key mobility building block solving the current holistic transport challenges in an urban environment.[53]

These vehicles enable the application of demand-responsive transport services with a smaller vehicle size compared to today´s buses by providing a higher level of passenger comfort. Automated or driver-driven people movers fill the gap between privately owned conventional passenger cars and enable new business models and support and strengthen public transportation systems.

In Figure 13, new purpose-built vehicles and adapted existing and conventional vehicles like VW Crafter and FCA Pacifica are shown. Due to different kinds of use cases for which the vehicles are designed, the vehicle landscape today is diverse. The rise of Uber, Didi Chuxing, and further new mobility companies plus the forecasts of IHS Markit, Roland Berger, McKinsey, and the amount of cities who are piloting new vehicle concepts, underlines the relevance of shared mobility future markets in urban transportation systems and the need for purpose-built vehicles.[54]

[53] chapter 1.1
[54] Roland Berger (2018)

Figure 13 – Purpose-built vehicles for demand-responsive transportation[55]

Passenger-centric or user-centric vehicle design, new vehicle architecture engineered for urban operations and the possibility to connect the vehicle with all necessary relevant interfaces and services for the business case is key to success. Furthermore, it is the key differentiator to exiting vehicle architecture.

Besides vehicle design and connectivity the operational strategy with regards to energy management of an electrified drivetrain, a charging strategy as well as heating and cooling of the cabin is crucial. Furthermore, the implementation of automated driving functions in the long run will potentially supersede the driver and significantly optimize the business case once SEA[56] Level 5 technology is ready and affordable.[57]

[55] Own illustration, 1) Bosch website, 2) Hamburger Hochbahn website, 3) e.go moove website, 4) Karsan website 5) Auto Motor Sport website, 6) Mobilgeeks website

[56] Full self-driving under all conditions: the vehicle can operate without a human driver or occupants

[57] Bösch, P., Becker, F., Becker, H., Axhausen, K, (2017), page i

3.2 Fleet size assessment

To further discuss fleet management and fleet operation in urban environments it is crucial to understand the future fleet size of electrified and automated purpose-built vehicles. In 2015, the OECD study, Urban Mobility System Upgrade – How shared self-driving cars could change city traffic, examined the potential outcomes of a significant change in urban transportation systems that would result from the implementation of a shared and fully autonomous vehicle fleet.

This analysis was based on a real urban context. The city of Lisbon described the changes that potentially result from a large-scale implementation of autonomous[58] shared vehicles (6 seats) replacing private cars and all bus operations in a mid-sized European city. It was found that almost the same transportation demand could be covered with 10% of the vehicles. A shared automated fleet combined with high-capacity public transport could remove nine out of every tenth private and single-used car in a mid-sized European city. Even in the scenario that least reduces the number of cars nearly eight out of ten cars could be removed.[59]

The MEGAFON report in 2016 conducted a similar approach for the Stuttgart region and simulated nine different scenarios. The scenarios were described by a different mix of transport modes. All private single used cars as well as PT buses were replaced and an automated shared vehicle with a passenger capacity of six seats was integrated.
In Scenario 8 (75% automated vehicle not shared, 25% automated vehicle shared plus light rail and metro covering 100% of transport demand) the study predicted **24,900** automated shared vehicles.[60]

[58] SAE Level 5
[59] OECD (2015), page 5
[60] Prof. Dr.-Ing. Friedrich, M., Hartl, M. (2016)

The OECD and MEGAFON studies are grounded on assumptions which cannot be realized in the near future in urban environments. Nevertheless, they give an impression what could theoretically be possible under certain circumstances in European mid-sized cities. Obviously, every state has its own legal requirements and every city is different with regards to public transportation and infrastructure, and therefore, a potential fleet size will be city specific as well as the implementation of running transportation systems.

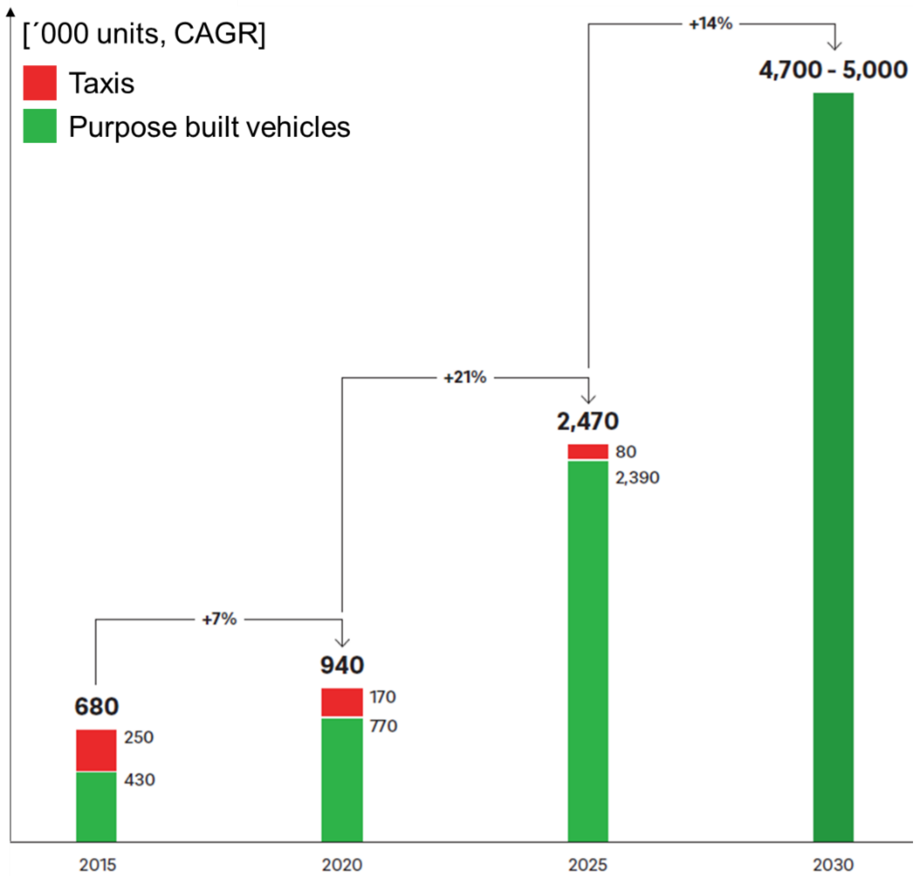

Figure 14 – Purpose-built vehicles – sales forecast[61]

Including taxis, Figure 14 shows the total annual addressable market for new vehicle concepts in Europe, the United States and China will grow steadily from 680,000 vehicles in 2015 up to 940,000 in 2020. With the introduction of purpose-built vehicles, the five years that follow (2020 to 2025) could see a CAGR as high as 21%, taking the total number of vehicles to almost 2.5

[61] Roland Berger (2018), A new breed of cars – Purpose-built electric vehicles for mobility on demand

million. Another five years (2025 to 2030) and the advent of self-driving robocabs could see the number of purpose-built vehicles double to five million.[62]

For further discussion of fleet management and operation for urban shared demand-responsive transport from a business model perspective it is important to think about a potential volume ramp-up scenario for certain areas. The potential fleet size per city and a technical and economic feasibility needs to be estimated to evaluate the involvement of different stakeholders and their potential relevance from a business model perspective.

To build up a ramp up scenario the following will be assumed to derive a potential fleet size for 15 European cities based above 1 million inhabitants. The studies of Lisbon and Stuttgart addressed the replacement of privately owned conventional cars by vehicles applying shared ridership. Therefore, an estimated fleet size of conventional cars per city will be used and a certain share will be replaced by purpose-built vehicles like shown in Figure 15.

[62] Roland Berger (2018)

			400 vehicles per 1000 inhabitans	20% of conventional private cars = replaced cars / PBV = 10% of replaced cars	
			0,400	20%	10%
#	City	Inhabitants	Conventional private cars	Replaced cars	Purpose built vehicle (PBV)
1	Paris	8.730.803	3.492.321	698.464	69.846
2	London	6.754.282	2.701.713	540.343	54.034
3	Madrid	4.878.277	1.951.311	390.262	39.026
4	Barcelona	3.624.554	1.449.822	289.964	28.996
5	Berlin	3.469.849	1.387.940	277.588	27.759
Stuttgart region		2.700.000	Data: Megafon study (not included in calcuation)		24.800
6	Athens	2.641.511	1.056.604	211.321	21.132
7	Lisbon	1.835.894	734.358	146.872	14.687
8	Manchester	2.769.152	1.107.661	221.532	22.153
9	Brussels	1.196.831	478.732	95.746	9.575
10	Hamburg	1.762.791	705.116	141.023	14.102
11	Vienna	1.766.746	706.698	141.340	14.134
12	Lyon	1.351.078	540.431	108.086	10.809
13	Stockholm	1.579.896	631.958	126.392	12.639
14	Munich	1.429.584	571.834	114.367	11.437
15	Helsinki	1.122.101	448.840	89.768	8.977
				Total	**359.307**

Figure 15 – Fleet size evaluation of purpose-built vehicles[63]

A total potential fleet of 359,307 purpose-built vehicles for 15 European cities is the result. When we compare this result to the Lisbon and Stuttgart studies it seems comparable, with the Stuttgart region showing a potential of 24,900 vehicles.

But bearing in mind that in Vienna approx. 790[64] conventional buses operate the whole city of Vienna, 14,134 people movers appear to be high but considering that 14,134 purpose-built vehicles could suppress 141,340 conventional private cars of the urban road by replacing a similar demand of transportation of city inhabitants it seems to be promising.

A significant fleet size for a certain area is crucial to establish the needed network effects at the potential mobility platform and to reach a certain

[63] Own illustration, 15 EU cities above 1 mil inhabitants, Inhabitants: Eurostat Regional Yearbook (2018); 400 vehicles per 1000 inhabitants: own estimation, Eurostat (2016); 3% people mover replacement factor: own estimation based on Lisbon an OECD study

[64] Own research, WL: 462 buses in 2014, Dr. Pollak., P. (2017), Difference to 790: bus fleet of private operators contracted by WL

passenger booking and transportation service level. The profitability and the efficiency of the business case highly depend on the pooling-factor[65].

3.3 Distinction between fleet management and operation

Fleet management in general can be described as the entirety of processes and administrative tasks which are directly or indirectly in relation to the vehicle procurement, vehicle usage, and managing the transition to 2nd life use cases. The distinction between fleet management and fleet operations depends on the respective transportation environment and usages characteristics of the vehicle as highlighted in Figure 12.

The type of passenger transportation and the vehicle ownership in Figure 11 are key characteristics, which implies the need of a fleet management and fleet operation. Furthermore, the scope and the interfaces of fleet management are determined by the business model environment.
Fleet management is part of the business model and processes in case the vehicle is not owned by the vehicle user or driver (0, 2-car sharing, 4, 5, 6, 7). Fleet Management and fleet operation is part of the business model and processes in case the vehicle is not owned by the vehicle user or driver and solely used within shared transportation (4, 5, 6, 7).

Fleet Management in context of public transportation can be clustered in six mayor field of duties:

- Technology Management
- Procurement Management
- Registration Management
- Operation Management
- Maintenance Management
- After Use Management.[66]

[65] Pooling factor: average number of passenger on board at the same time during operation
[66] Lars Schnieder (2018), page 35

Fleet management within public organized and operated bus transportation systems has a different background than fleet management within the conventional sales focused car industry. The circumstances, the vehicles, and usage characteristics are different.

Captive[67] FMCs support the OEM parent companies to market their vehicles and their services. Captive OEM do not provide the actual vehicle operation in Europe to their B2C/B2B customer. Fleet management in the conventional car industry could be understood as a significant part of the sales pipe line to secure and support the sales numbers of the OEM. In contrast, the fleet management in public transportation serves the operations to ensure the vehicle availability.

#	WL	Transport Authority	Public Transport Operator (in-house)	PPTO	Vehicle supplier (bus)	Bank
1		Owner				
		Fincancing				
			Operation			
			Maintenance			
2			Owner	Operation		
			Fincancing	Maintenance		
3				Owner		Fincancing
				Operation		
				Maintenance		
4				Operation	Owner	Fincancing
				Maintenance		
5				Operation	Owner	Fincancing
					Maintenance	
Servcies **not** covered by captive FMC					Servcies covered by captive FMC	

Figure 16 – Vehicle ownership and operation scenarios[68]

In chapter 2.1 the variants of business models with regards to contracting the operations to PPTO focusing on fare revenues and contact to the passenger when it comes to ticket sales have been described. Operation and vehicle ownership is not mutually depended.

Figure 16 delivers a more detailed overview in terms of vehicle operation responsibility, vehicles ownership and financing them. Scenario 1, public ownership, is the most common model in France, Germany, Austria, and Switzerland. Scenario 2, typically applied in France, is called public lease – the

[67] Further explanation in chapter 2.5.4.
[68] Own illustration, Trel, E. (2017), slide 27, Deloitte (11/2018), Moser, J. (2016), page 398, Lars Schnieder (2018), page 135-145

transport authority owns the fleet and the PPTO does the operation. Scenario 3, private ownership, is the most common model if a PPTO is involved. The PPTO owns, operates, and maintains the fleet. In Scenario 4, private lease, the vehicle supplier leases the vehicles to the PPTO. In Scenario 5, full operational lease, the vehicle supplier leases the fleet to the operator. Wiener Linien as transport authority and “in-house operator” in one entity manages their operations like described in scenario 1 and 3 (see also Figure 8).[69]

The vehicle operations and ownership models shown in Figure 16 could be applied for the implementation and operation of large purpose-built vehicle fleets in the environment of shared transport. Depending on the stakeholder involved and the legal framework which need to be considered, PPTO, PTA and FMC could apply their current business models or adapt them with view to new requirements form the market or new actors.

3.4 Fleet management companies – enabler for large fleets

Historically, the European fleet management has been dominated by banks, which is the case today as well. Financial institutions identified vehicle leasing as a highly profitable asset-based business model with potential additional recurring service revenues and manageable risks, e.g. Société Générale generates approximately double the RoE than with its investment bank division. The other half is dominated by automobile OEM-related auto finance companies also known as captives. The top 5 FMC in Europe and two global examples with Volkswagen Financial Services AG and Daimler Financial Services AG are shown in Figure 17.

In this context, captive or parent FMC means it is a wholly owned subsidiary of an automotive OEM (e.g. VW, Daimler) that finances wholesale or retail purchases from the parent OEM. Their indirect business model which leverages the OEM dealer network to sell OEM products and services to a

[69] Trel, E. (2017), slide 28-23, Lars Schnieder (2018), page 135-145

variety of customers made them successful. Stand-alone FMC or non-captive FMC are not fully owned by a parent company like an automotive OEM.[70] The customer base of both types of FMC can be clustered by segments, e.g. LeasePlan separates between corporate customer (76.9%), SMEs (18.4%) and private individuals (4.7%).[71]

FMC				Vehicle fleet	Shareholder
non-captive	Top 5 Europe	1	LeasePlan	>1.8 mil	LP Group B.V., consortium of institutional investors
		2	ALD Automotive	>1.4 mil	100% subsidiary of Société Générale Group
		3	Arval	>1.0 mil	100% subsidiary of BNP Paribas Group
captive		4	Alphabet	>650k	100% subsidiary of BMW Group
		5	Athlon	>350k	100% subsidiary of Daimler Financial Services AG
	global view	Volkswagen Financial Services AG		>2.9 mil	100% subsidiary of Volkswagen Group
		Daimler Financial Services AG		>2.8 mil	100% subsidiary of Daimler AG

Figure 17 – Captive and non-captive fleet management companies[72]

Fleet management predominately contains vehicle sales related tasks and covers the following:

- Vehicle purchase
- Finance and leasing services
- Insurance services
- Sales process and vehicles usage services:
    - Licensing and registration – management of the registration process
    - Fuel management
    - Tire management
    - Maintenance management
    - Accident management

[70] Deloitte (11/2018), page 5, 20, 37, Leaseplan (2018), Leaseurope (2017), page 3
[71] Leaseplan (2018), page 11-12,
[72] Own illustration, Deloitte (11/2018), page 21, VW Financial Services AG (2019), page 7,13, Daimler AG (2019), Leaseplan (2018), page 2-3

  - Telematics
  - Interim Car Management
- Vehicle remarketing services.[73]

Approximate 50% of total FMC profits account for sales process and usage related services, whereas typically FMCs outsource some of these services to 3rd parties. Funding and leasing, meaning financing the assets (vehicles) is the main profit driver of FMC, the profit contribution is roughly 35%.[74]

Daimler with its captive FMC Daimler Financial Services AG has recognized the importance of the changing mobility landscape with the omnipresent trends, which Daimler AG summarizes as CASE (C-connected, A-autonomous, S-shared and Services and E-electric).
Daimler AG is developing the Daimler Financial Services AG from an original vehicles finance based business with the vehicle as a product to a mobility provider with vehicles as transportation tool. New customer channels through its strategic investments in the mobility sector and strategic joint venture, e.g. with BMW Group, could address the CASE trends with regards to shared and electrified transportation.[75]

Volkswagen Financial Services AG is setting visions and targets within its strategy "Route 2025" as well and is adding a new range of services to its core competences banking, leasing, and insurance & services. Changing customer demands and mobility business models require solutions for parking, charging, ride sharing, among others as well.[76]
The highlighted capabilities and the global footprint of the companies mentioned in Figure 17 could be to ideal business partner for asset-light software-based mobility provider and manufacturer as well as operator of new huge a diverse purpose-built vehicle fleets.

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[73] Deloitte (11/2018), page 33, VW Financial Services AG (2019), page 6, Daimler AG (2019), LeasePlan (2018), page 11
[74] Deloitte (11/2018), page 32
[75] Daimler (2019), page 45, 90-99
[76] VW Financial Services AG (2019), page 6

4. Platform-based business models

4.1 Characteristics

Online platforms are technologies, products, or services which serve as foundation for external stakeholders to interact, perform transactions, and create and commercialize complementary innovations. Through the facilitation of interactions and transactions, online platforms create markets that are subject to network effects.

If strong network effects can be realized, businesses can rapidly scale and lead to fast growth and could even lead to "winner takes it all" situations. Their popularity is evident from the large number of the world's most valuable enterprises betting on this technology. Google, Amazon, Apple, and Facebook have aggregated power at unprecedented speed and scale: their combined market capitalization grew from $430 billion in 2010 to more than $2300 billion in 2017 (roughly the GDP of India).[77]

The interaction of external participants allows platform companies to shift their limitations by establishing an ecosystem. Innovation capabilities are no longer restricted to traditional business processes. Infected by their success, a growing number of companies are taking advantage of platform strategies. An impressive number of start-ups are using platforms, disrupting whole industries within a short time. The likes of AirBnB, Uber, and Spotify are said to only have uncovered the tip of the iceberg of this entrepreneurial movement. This makes platform-based business models one of the most successful business strategies ever.[78]

Platforms have existed for years, e.g. malls link consumers and merchants, and newspapers connect subscribers and advertisers. What has changed is that information technology has profoundly reduced the need to own physical infrastructure and assets.[79]

[77] Daniel Julian Moser (2018), page 1, Konietzko, J., Bocken, N., Hultink, E., (2019)
[78] Daniel Julian Moser (2018), page 1, 15
[79] Van Alstyne, M., Parker, G., Choudary, S., (2016)

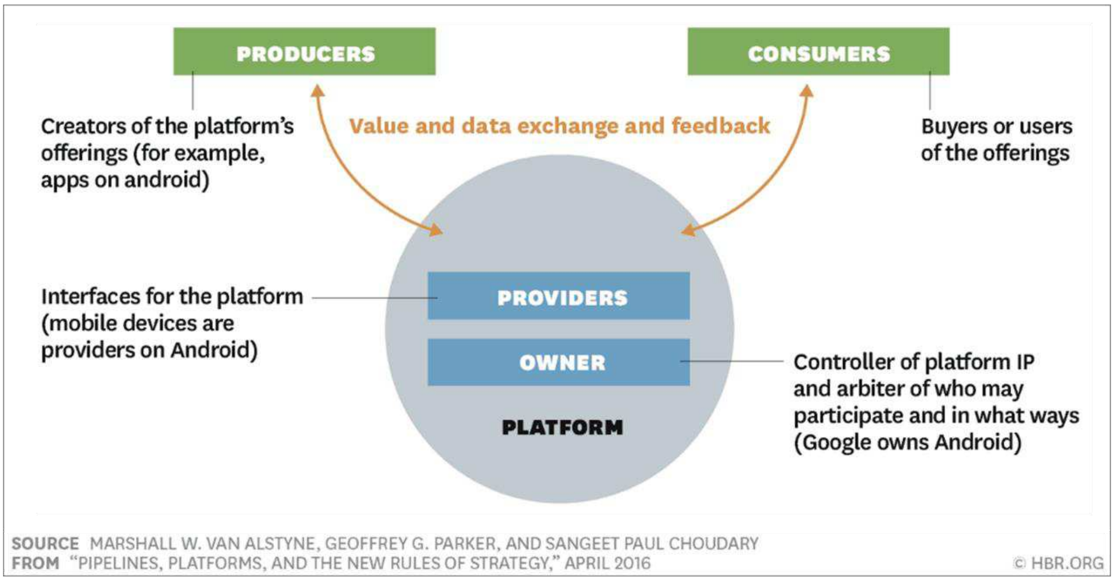


Figure 18 – Basic software platform structure and interfaces[80]

Online platforms have a similar ecosystem with a similar basic structure, comprising four types of players (Figure 18). The platform owner controls their intellectual property and governance. Providers serve as the platforms interface with producers and consumers, producers create their offerings, and consumers use these offerings.[81]

Compared to classic product or service driven pipeline business models, platform-based business models with multiple stakeholders add another layer of business model complexity, which have to be addressed. The platform leader as connecting element builds the ecosystem, that each stakeholder group gets addressed with a specific value creation, value delivery, and value capturing mechanisms.

A platform-based business model creates and delivers a specific value to users and complementors based on standardized contracts and to partners based on individualized contracts. They capture value by covering associated costs of the platform leader and the subsidy of one or multiple stakeholder groups by charging access fees. A constant exchange of value and data

[80] Van Alstyne, M., Parker, G., Choudary, S., (2016)
[81] Van Alstyne, M., Parker, G., Choudary, S., (2016)

between each stakeholder group and the platform leader enables value co-creation and the development of network effects as shown in Figure 19.[82]

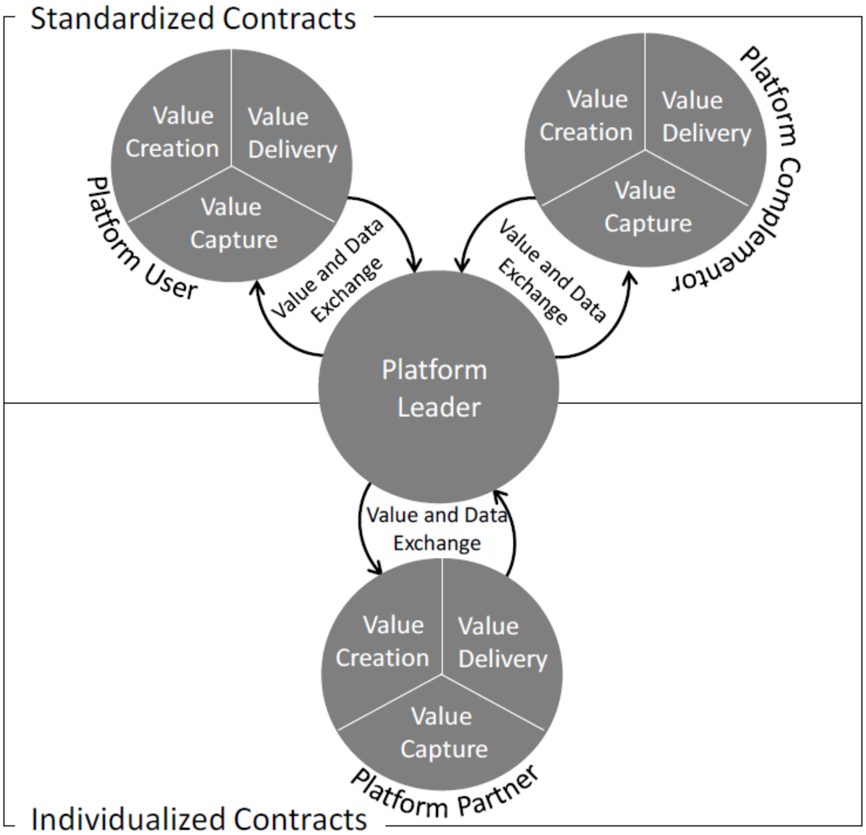


Figure 19 – Generic software platform business model[83]

[82] Moser (2018), page 71-73
[83] Moser (2018), page 73

4.2 Customer-centric mobility platform

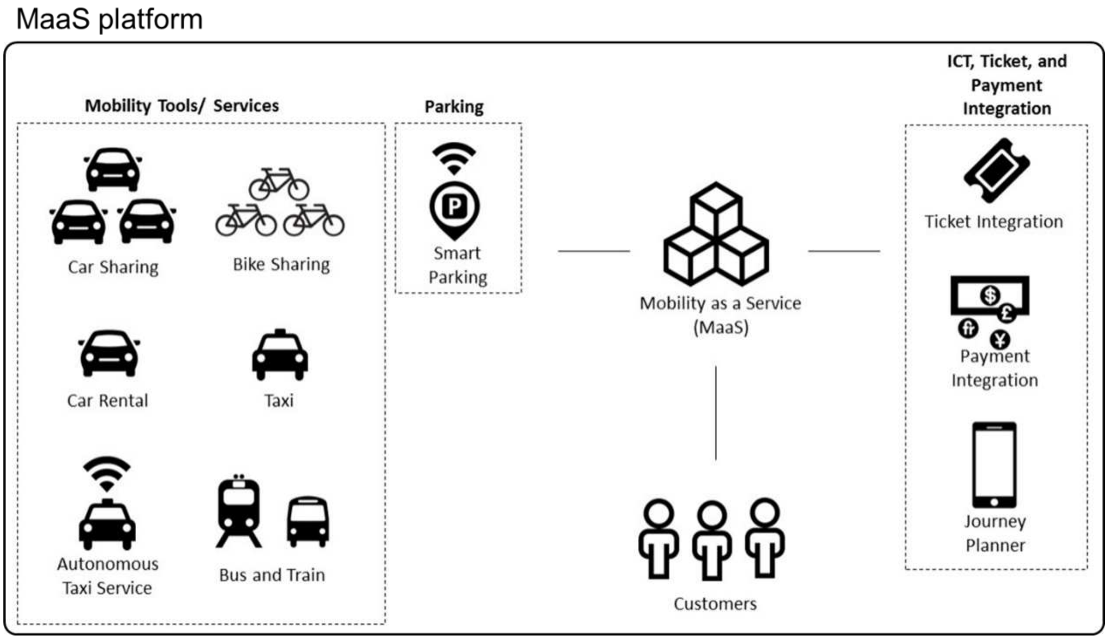


Figure 20 – Customer-centric – MaaS platform[84]

The intermodal asset-light MaaS platforms already implemented have created customer-centric mobility market places for mobility users and the private and public mobility service providers of different vehicle classes. Network effects are realized and the platforms are growing with its users and the services provided.[85]

[84] ETH Zurich
[85] ETH Zurich

5. Application model for future fleet management and operation

In chapter 5, the information and findings of publicly and privately operated public transportation from the previous chapters will be merged with a future urban mobility scenario to develop an application model which describes the potential future fleet management and operation based ecosystem of purpose-built vehicles in cities. Based on existing infrastructure and urban transportation networks (WienMobilApp), and conventional vehicles plus outsourcing of the asset (Uber), new asset-light mobility solutions can be scaled very quickly. Hence, a platform-based ecosystem is built around the passenger – the key business interface.

In contrast to the existing passenger-centric asset-light approach, a vehicle-centric approach, the other future key business interface within the urban transportation sector, as shown in Figure 21 will be conducted.

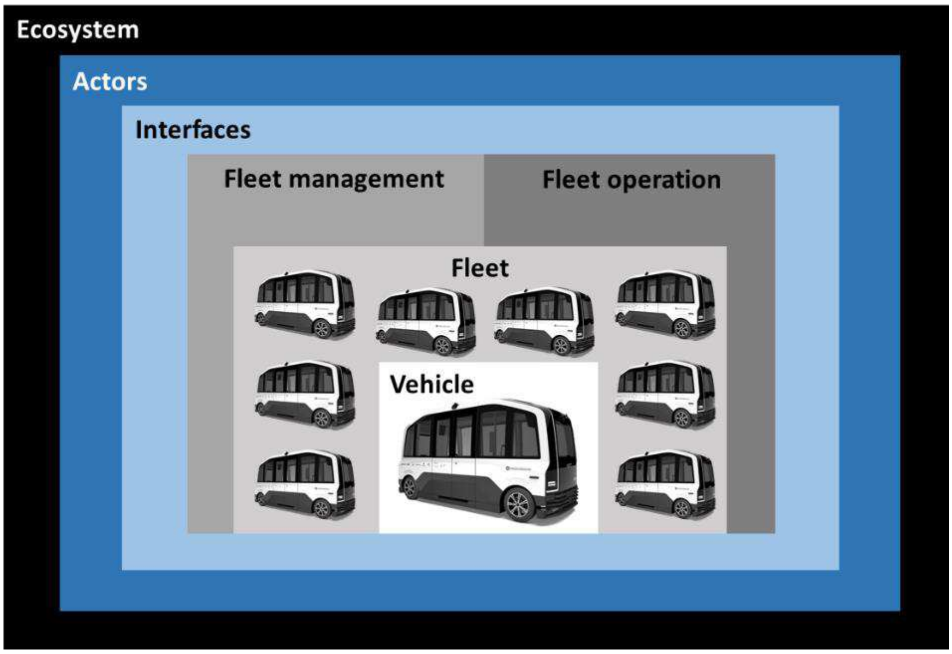


Figure 21 – Vehicle-centric thinking[86]

[86] Own illustration, Vehicle picture: Heat - Hamburger Hochbahn Website

In Figure 21, the purpose-built vehicle is the heart component. The fleet size will be significantly higher than today´s existing bus transportation network in cities. Combined with the switch and implementation of new and more sustainable technologies like automated driving and electrification, this will create completely different challenges and solutions with regards to fleet management and operation.

The swarm of demand-responsive shared purpose-built vehicles cannot be managed and operated within today´s existing centralized business models and infrastructure designed for fixed routes.

The fleet size and their operations with multiple interfaces and potentially decentralized solutions will create a very complex operational environment - a new vehicle-centric ecosystem which consists of new business model variants. Looking at the size, the complexity and the multiple interfaces, network effects could be realized and a new asset-heavy based vehicle-centric platform could grow and enable profitable business cases in a usually non-profitable public transportation environment.
To develop and to analyze an application model for an urban shared demand-responsive transportation fleet management and operation ecosystem a systematic vehicle-centric approach is necessary, which will be described in chapter 5.1.

5.1 Method description – vehicle-centric thinking

In the next step the different layers shown in Figure 22 will be analyzed. Based on the findings and information from the previous chapters the basis to create the application model will be formed to derive and to describe a future ecosystem.

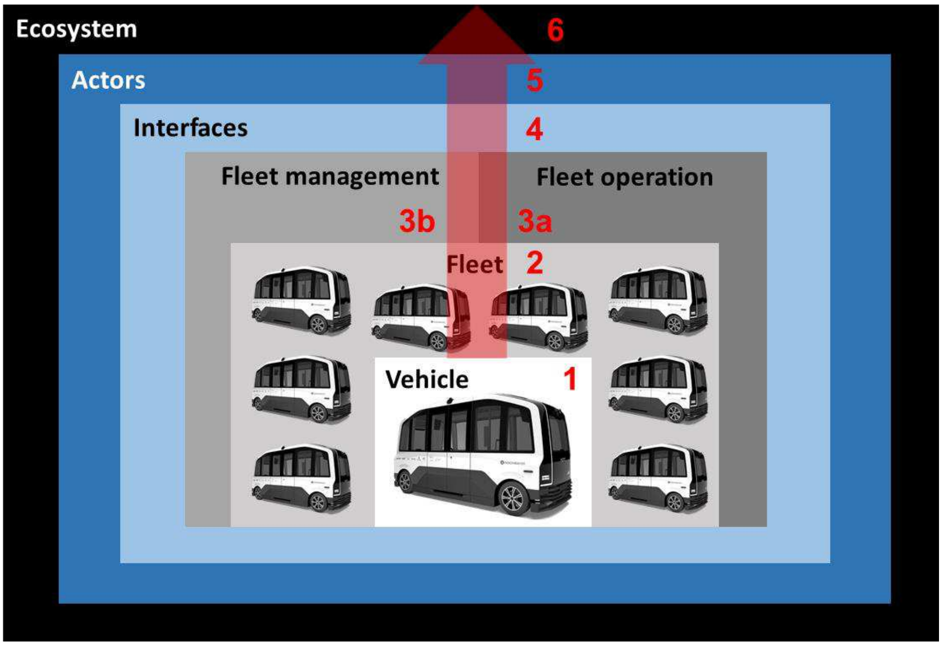


Figure 22 – Method description – vehicle-centric thinking [87]

Based on Figure 22, the starting point will be the purpose-built vehicle (1), which is one of the key elements in the vehicle-centric perspective. Before discussing the layer fleet management and fleet operation, the fleet itself, which is the foundation for analyzing the fleet management and operation, needs to be analyzed and characterized. The layers vehicle (1), fleet (2), fleet operation (3a), and fleet management (3b) create multiple interfaces within the network. These interfaces are determined by the vehicle characteristics and by the vehicle operational usage. Hence, interfaces (4) are process and technology driven connections to transportation related products and services, which are represented by the actors (5). The actors are private or public companies which will create the ecosystem itself. The ecosystem will consist

[87] Own illustration, Vehicle picture: Heat - Hamburger Hochbahn Website

of traditional pipeline business models and potentially new business models can be derived, which could run on scalable online platforms.

5.2 Requirements and expected results of the application model

With the application model an urban transportation environment which is not based on individual ownership and usage of conventional passenger vehicles shall be derived and described.
The future transportation could be partly organized and operated in large fleets of purpose-built vehicles, which enable cities to shape and control the transition to a more sustainable, efficient, and comfortable urban transportation network.

Before developing and conducting the application model, certain requirements and assumptions for input information need to be fixed. To derive and develop a realizable application model for the management and operation of large fleets, the existing transportation network and infrastructure should limit the assumptions regarding the application model and as well highlight existing implementation barriers and challenges.
The specific assumptions and requirements for every layer (see Figure 20) which represent the designated input data are the fundament for the application model respectively the resulting ecosystem.

While building and analyzing the development order and the application model itself, there are certain expectations. Based on the requirements and the specific assumptions on every layer a new fleet management and operation ecosystem should be built. Thereby, the most relevant fleet related processes and actors of the future ecosystem will be identified and relevant business interfaces will be found. Out of this study managerial implications will be formulated.

5.3 Development of the application model

Following the method, vehicle-centric thinking outlined in Figure 22, the development order of the application model will be defined. The development order resulting in the targeted ecosystem is described in Figure 23.

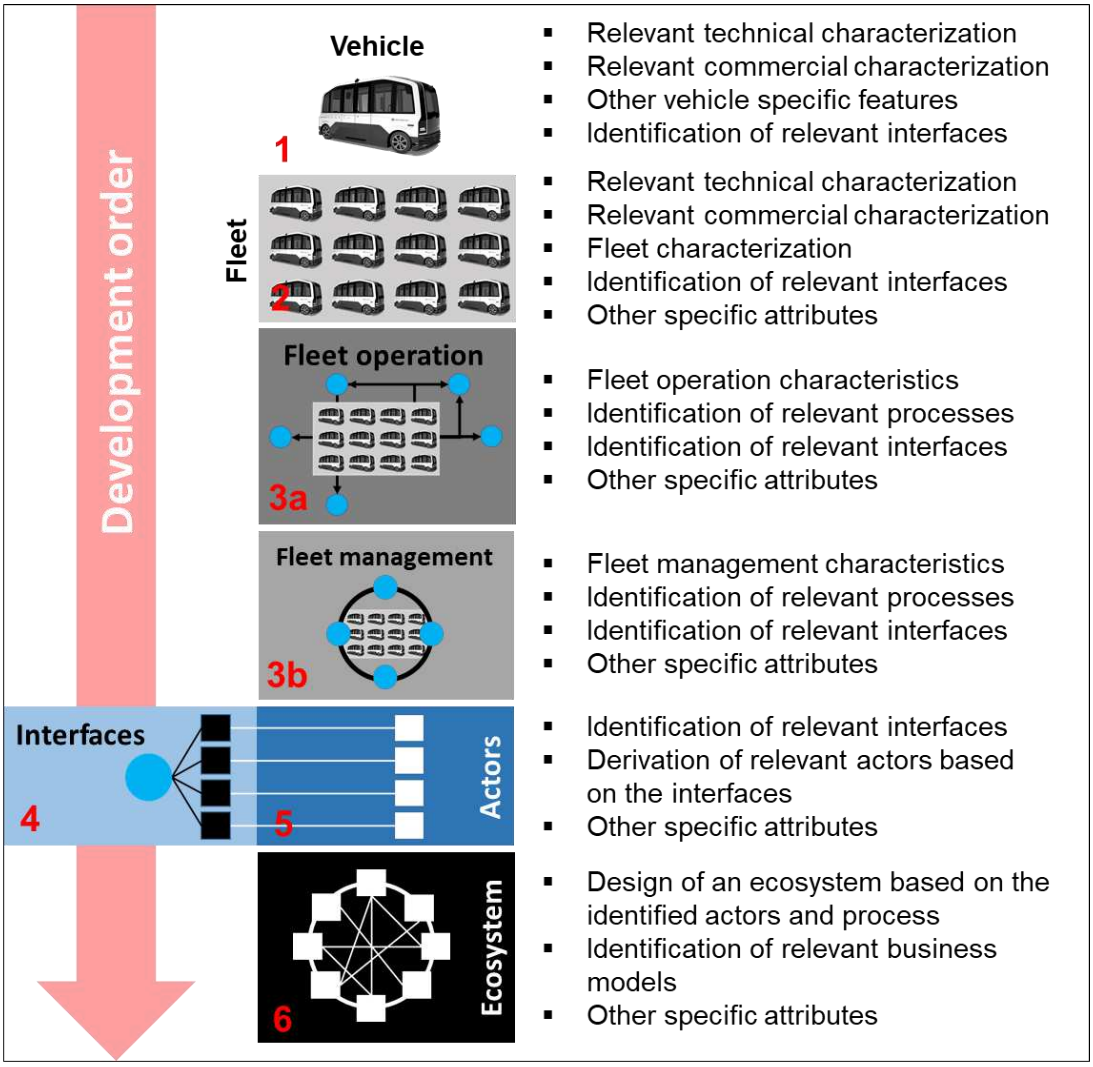


Figure 23 – Development order of application model[88]

According to the method described, the layers will be characterized in the following order: vehicle (1), fleet (2), fleet operation (3a), and fleet management (3b).

After analyzing and defining (1), (2), (3a), and (3b), the main and relevant factors and assumptions will be collected. Out of this and based on the

[88] Own assumptions and illustration, Vehicle picture: Heat - Hamburger Hochbahn Website

processes needed I will generically derive the interfaces (4) associated with the actors (5). Finally, the actors and their recurring operational processes defined interfaces will create an ecosystem (6).

The characterization accompanied with certain assumptions of each layer will carve out the main relevant vehicle and operational interfaces.

The differentiation factors which define which process and interface of each layer is relevant or not are driven by the fleet operations. The main question is which attributes or processes are indispensable for the fleet implementation and operation of a very large fleet of purpose-built vehicles in a city.

5.3.1 Layer 1 – Vehicle characterization

Relevant technical characterization:

- 6-9 seats (+1 driver/operator)
- Vehicle dimensions, max. 2.20m high, max. 2m width, max. 5m length
- Interior designed for refurbishment
- Interior designed for different comfort levels
- Vehicle designed for convenient maintenance
- Vehicle designed for convenient cleaning
- Enables flexible vehicle branding
- Vehicle designed for recycling

Relevant interfaces:

Before operation:
- Vehicle manufacturing

See 5.3.4 Layer 3b – Fleet management

In operation:
See 5.3.3 Layer 3a – Fleet operation

Not in operation:
- After market – maintenance / repair

See 5.3.3 Layer 3a – Fleet operation

After operation
- After market – refurbish / reuse

See 5.3.4 Layer 3b – Fleet management

Figure 24 – Vehicle assumptions for the application model[89]

The technical characterization of the vehicle enables the crucial dynamic and decentralized operations. The vehicle feature defined in Figure 24 offers a new product for flexible use in urban environments. The vehicle is designed to use existing passenger vehicle infrastructure like parking, driving, and charging.
Furthermore, the vehicle and the fleet operation conditions mutually depend on each other and will create new pipeline and platform business models within the ecosystem. The features mentioned and their impact will be explained in more detail when outlining the relevant interfaces.
Since the life cycle, the fleet size, and the use case is different to conventional large city busses, a crucial factor will be the second use scenario. Therefore, it is considered that the vehicle is designed to enable sustainable and efficient after-operation solutions like refurbishment and recycling, which will be covered by the vehicle OEM, the contract manufacturer or a new 3rd actor.

[89] Own assumptions and illustration, Vehicle picture: Heat - Hamburger Hochbahn Website; no differentiation between autonomous and non-autonomous vehicle characterization within the application model

5.3.2 Layer 2 – Fleet characterization

Fleet

Relevant characterization:

- Total fleet size of **14.000** vehicles
(see Figure 15, Vienna)
- Temporal and quantitative scenario fleet ramp-up and step-by-step city integration not to be considered
- Dynamic decentralized fleet operation
- Multiple fleet management companies possible
- Multiple fleet operations companies possible
- Multiple fleet owner possible

Relevant technical characterization:

- No distinction between autonomous and non-autonomous vehicles and operation will be considered

Relevant interfaces:

Before operation:
See 5.3.1. Layer 1 – Vehicle
See 5.3.4. Layer 3b – Fleet management

In operation:
See 5.3.3 Layer 3a – Fleet operation

Not in operation:
See 5.3.3 Layer 3a – Fleet operation

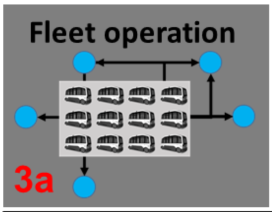
After operation
See 5.3.4 Layer 3b – Fleet management

Figure 25 – Fleet assumptions for the application model[90]

The characterization of the fleet is a crucial step in the application model. Figure 25 describes the key assumptions for the application model which put the fleet operation in the center of future urban transportation by facilitating new business models. A dynamic and decentralized fleet operation is the cornerstone of the application model. This means that the vehicles are used and operated demand-responsive and not on fixed routes and that they do not return to a conventional centralized bus hub. The consequences of this assumption and the assumptions within the relevant interfaces will be explained in the next chapters.[91]

[90] Own assumptions and illustration
[91] The Verge Website

5.3.3 Layer 3a – Fleet operation characterization



Relevant characterization:

- Demand responsive transport service
- Fleet utilization as shown in Figure 25
- Due to fleet size and vehicle characteristics dynamic free floating decentralized fleet operation to be considered → No main vehicle depots considered like in conventional bus sector
- Infrastructural requirements for fleet operation exists
- No fleet operational legal barriers considered

Relevant interfaces:

Before operation
See 5.3.4. Layer 3b – Fleet management

In operation
Decentralized processes →
- Driver management
- Vehicle management
- Charging
- Parking
- Insurance

Not in operation
Decentralized processes →
- Driver management
- Vehicle management
- Charging
- Cleaning
- Parking
- Repair
- Maintenance
- Vehicle surveillance

After operation
See 5.3.4 Layer 3b – Fleet management

Figure 26 – Fleet operation assumptions for the application model[92]

A demand-responsive transport service in combination with a relevant fleet size and the decentralized approach during the operation and not operation mode opens new business fields which are conventionally covered by the PPTO, PTA or private car owners. The fleet of 14,000 vehicles is steered by the demand of the passenger during the day like shown in Figure 27.

92 Own assumptions and illustration

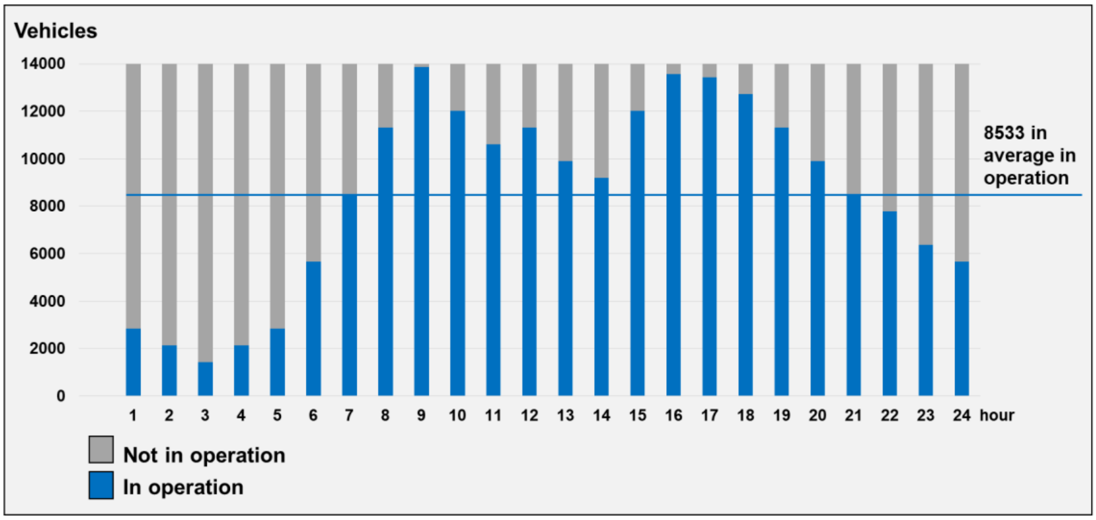


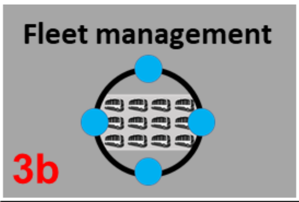
Figure 27 – Fleet utilization – vehicle operation mode distribution[93]

Based on different trip purposes (work, education, leisure, shopping) and the defined fleet size a theoretical fleet utilization for one workday has been derived.[94] As a result, 8,533 vehicles in average are in operation mode hence transporting people through the city. The relevant fleet operation interfaces shown in Figure 26 (blue box) will occur predominantly during the day time as described in Figure 27.

When comparing the information of Figure 11, especially with regards to fleet size, the purpose-built vehicle fleet size in a city like Vienna would have approx. the same size as today`s largest globally operating PPTO. Furthermore, Wiener Linien with its large conventional bus network only operates 462 busses in a centralized operating system.
The fleet size or purely purpose-built accompanied by the decentralized in operation and not in operation interfaces requires new approaches and business models and potentially creates a platform-based ecosystem of fleet operation.

[93] Own illustration, Mobilität in Deutschland (2008), page 142
[94] Mobilität in Deutschland (2008), page 142

5.3.4 **Layer 3b – Fleet management characterization**



Relevant characterization:

- The defined assumptions of Layer 1 – 3a are the basis for the fleet management assumptions and interfaces
- Multiple fleet management companies possible
- Vehicle refurbishment will be done within fleet operation – not in operation

Relevant interfaces:

Before operation:
- Vehicle fleet financing

In operation:
See 5.3.3 Layer 3a – Fleet operation

Not in operation:
See 5.3.3 Layer 3a – Fleet operation

After operation
- Refurbishment
- Reuse
- Recycle

Figure 28 – Fleet management assumptions for the application model[95]

The fleet management characterization and assumptions are defined by the fleet operation conditions. In this application model the fleet operation has the higher priority. Fleet financing, refurbishment, remarketing and vehicle recycling is with regards to the fleet size, financing volume, and not existing used car market a challenge which needs to be addressed as well.

In this environment existing business models are still applicable and the decentralized operation structure of the fleet operation might not change the business processes of the fleet management business significantly.

[95] Own assumptions and illustration

5.3.5 **Ecosystem actors**

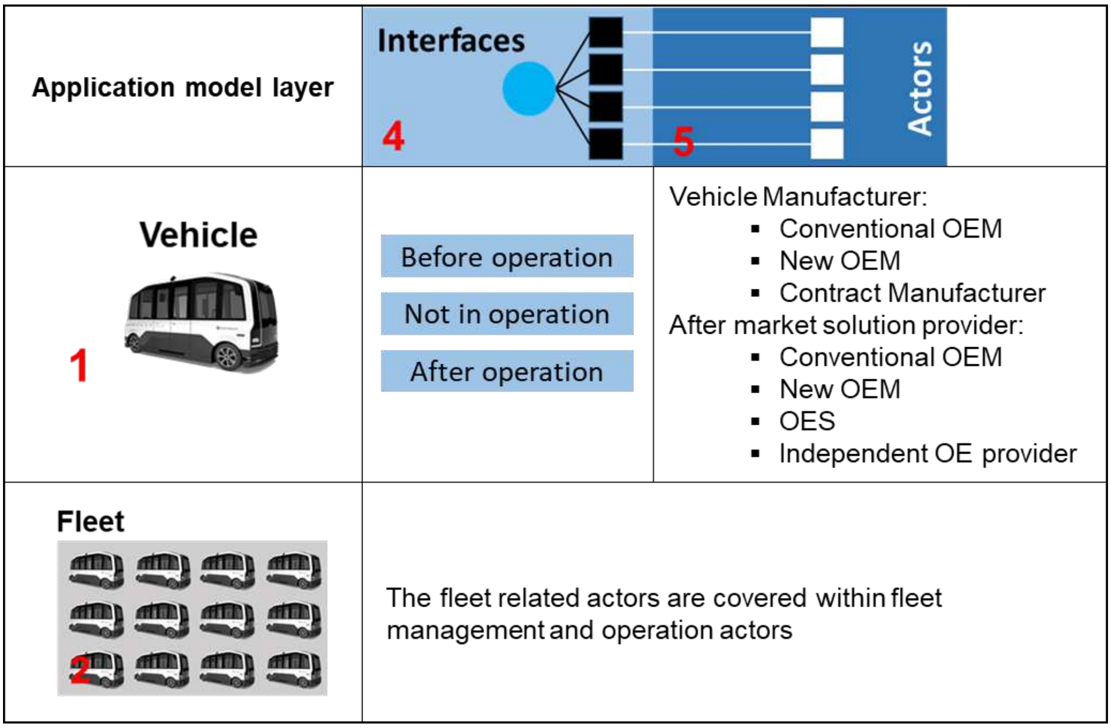


Figure 29 – Actors Layer 1 and 2[96]

The actors in an ecosystem, when looking at the vehicle layer, are conventional OEMs, new OEMs plus contract manufactures when it comes to vehicle engineering and vehicle manufacturing. With regards to hardware component after sales and software updates, independent OE providers might have a significant impact as well.

The same actors will play an important role with regards to after-operation interfaces. Considering new usage requirements and platform-based ecosystem of the fleet operation with the focus on refurbishment, reuse and recycling, the requirements of the automotive aftermarket will change. Hence, the vehicle manufacturer and the aftermarket solution providers need to provide solutions and adapted business models within the new ecosystem.[97]

96 Own assumptions and illustration
97 Renault Website

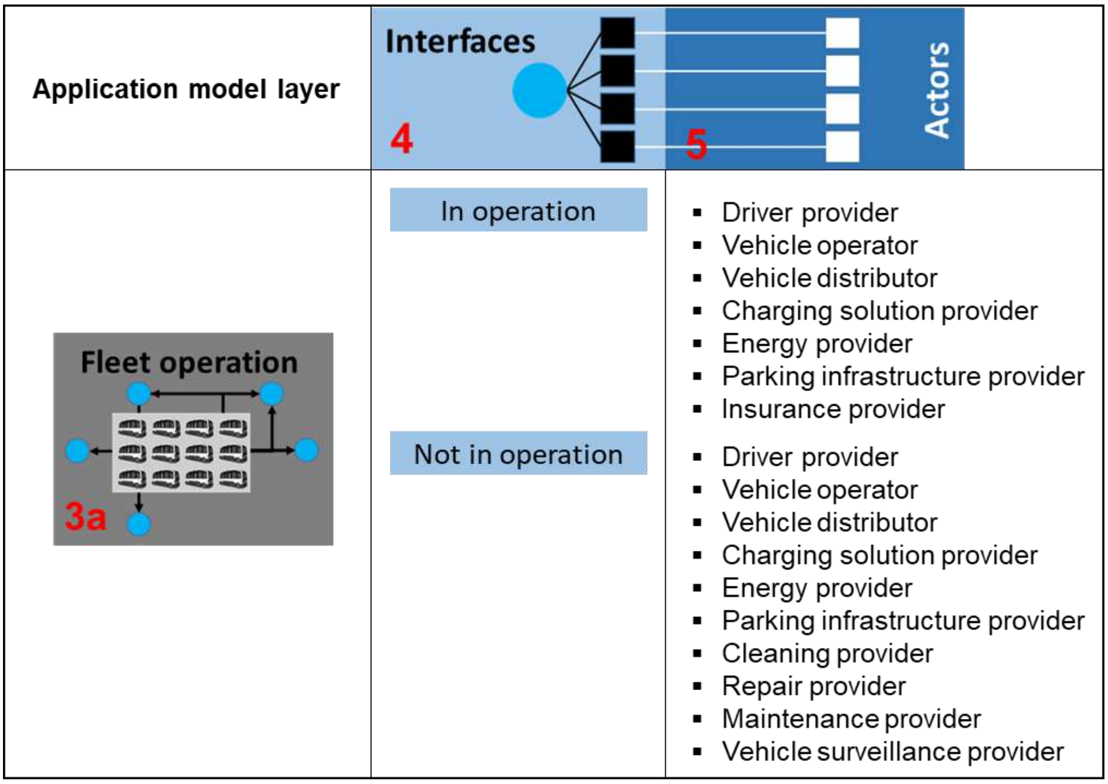


Figure 30 – Actors layer 3a[98]

Looking at layer 3a, fleet operation in Figure 30, the decentralization of the operation processes is the trigger for multiple new business fields. The operational processes and tasks mentioned, conventionally would be covered by the PPTO or PTA but considering the significant larger fleet size and the decentralized approach it requires more flexibility of the process owners and business partners.

Therefore, the operational processes and tasks could be distributed and organized independently within specialized new companies. Additionally, existing business owners with existing infrastructures like car park providers or repair shops could cover future not in operation tasks.

[98] Own assumptions and illustration

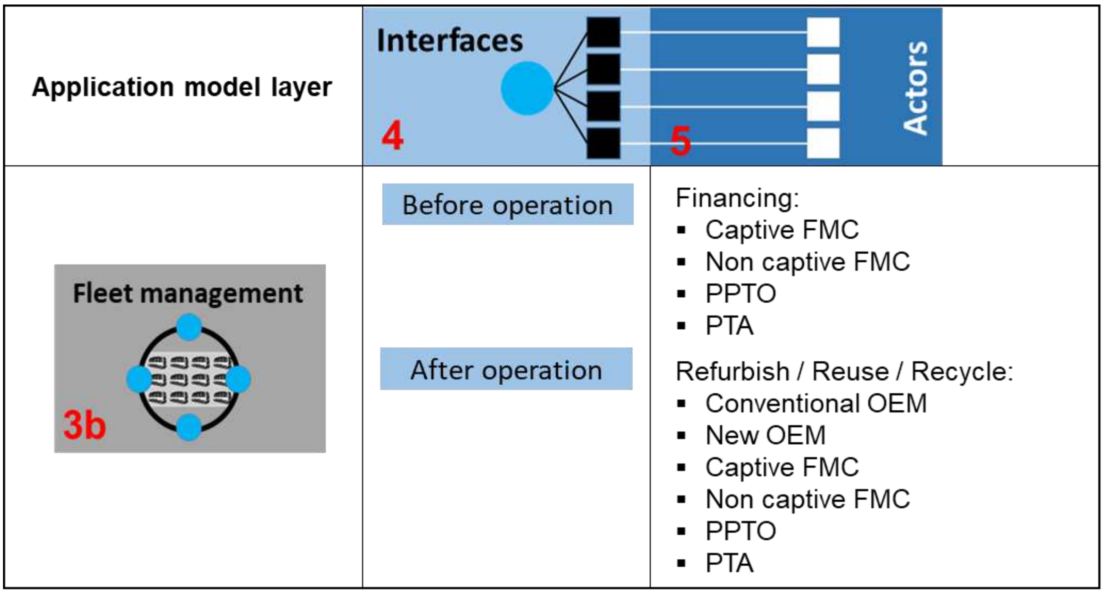


Figure 31 – Actors layer 3b[99]

The fleet management actors described in layer 3b and shown in Figure 31 are predominantly involved and responsible for the interfaces before and after operation. The financing before the operation and the after operation interfaces with regards to refurbishment, reuse and recycle need to be addressed and covered by new solutions provided by the actors mentioned in Figure 31.[100] Additionally, vehicle development and manufacturing actors like conventional and new OEMs need to provide sustainable new vehicle solutions and concepts to address the specific usage and lifecycles.[101]

[99] Own assumptions and illustration
[100] Figure 16 – Fleet management companies and Figure 10 – PPTO footprint within bus transportation in comparison to WL
[101] Figure 12– Purpose-built vehicles and adapted serial vehicles

5.3.6 **Ecosystem creation**

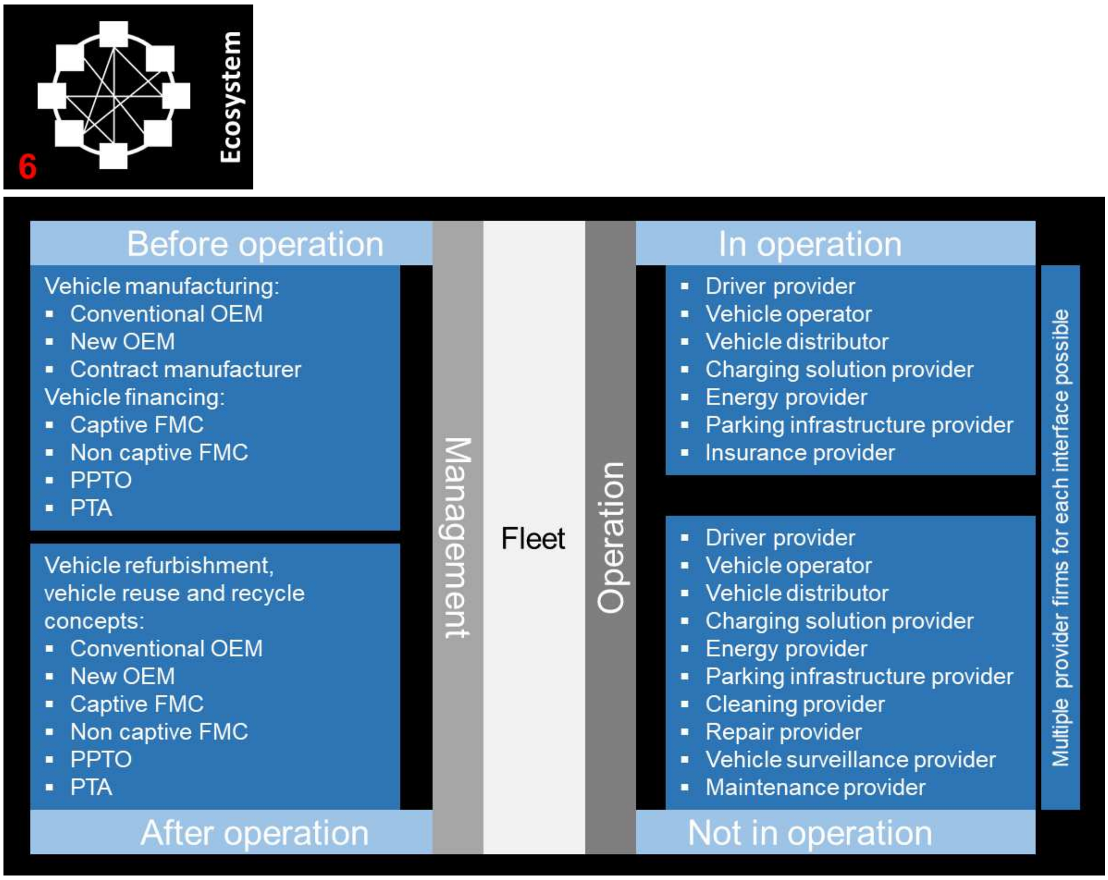


Figure 32 – Fleet-based ecosystem[102]

Based on the previously determined steps of the application model the fleet-based asset-heavy based ecosystem is derived and shown in Figure 32. The fleet, the sum of the purpose-built vehicles is the trigger for all related operation and management processes and interfaces.

A clear separation and segmentation of responsibilities between fleet management and operation is visible. Before and after operation processes and interfaces are covered by the fleet management actors mentioned on the left side of Figure 32. The decentralized fleet operation approach leads to a new perspective of the future fleet operation. The right side of the created ecosystem consists of new products and services which arise because of the scale of the fleet, the demand-responsive operation mode and the purpose-built vehicles. The combination of it enables multiple recurring new business

[102] Own assumptions and illustration

models based on the existing city infrastructure and new collaboration opportunities between transport and non-transport related companies.

The vehicle and fleet based-ecosystem is still an asset-heavy business environment. The difference to a conventional urban transportation bus-network is the demand-responsive operation mode and the scale of fleet.
This leads to a new transportation environment where fleet sizes need to be managed, usually only known from the FMC of the passenger car automotive sector[103], where the vehicle operation is covered by the vehicle owner.
Furthermore, this applies for PPTOs and PTAs as well. The decentralized approach fleet operation and the scale of the fleet accompanied with the complex set of new requirements and circumstances are huge challenges for the existing fleet operating companies.

In contrast, fleet management with the characterization described in the application model unlikely creates network effects. As shown on the left side in Figure 32, fleet management most likely is not suitable for platform-based business models which strongly requires network effects. On the contrary, fleet operation with the characterization described in the application model most likely enables and supports platform-based business models even in an asset-heavy environment.[104]

[103] Figure 16 – fleet management companies
[104] Van Alstyne, M., Parker, G., Choudary, S., (2016), Figure 2 - asset-heavy vs. asset-light company structure

5.4 Decentralized operations enabling platform-based business models

Considering the assumptions and findings from the previous chapter a distinction between fleet operation and fleet management is necessary.

With adding the passenger-centric MaaS perspective, a generic business model landscape and their interactions are described (Figure 33).

The decentralized future fleet operation previously characterized creates a business environment which establishes and supports multiple business relations among multiple fleet operation actors. Hence, network effects can be realized and platform-based business models are possible even in an asset-heavy business environment.

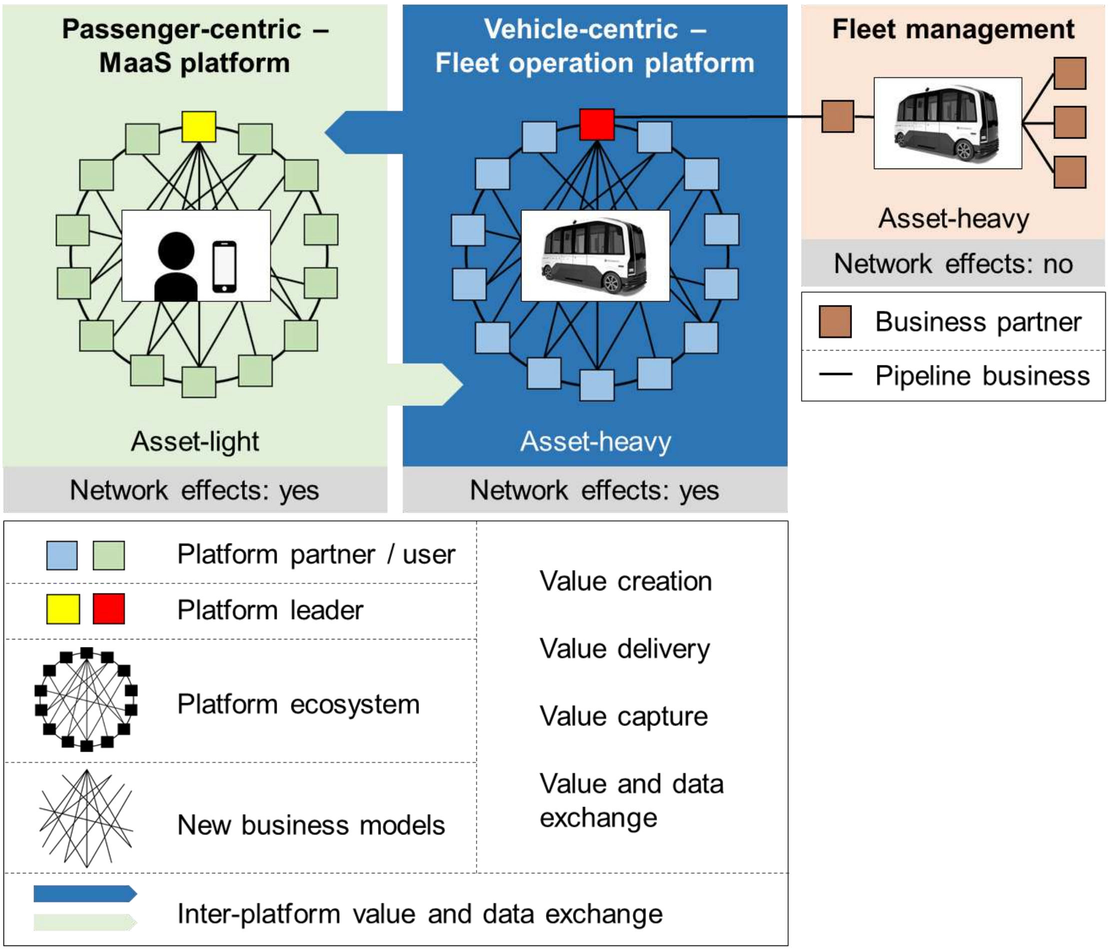


Figure 33 – Vehicle-centric fleet operation platform in a MaaS environment[105]

[105] Own illustration, Moser (2018), page 73, Van Alstyne, M., Parker, G., Choudary, S., (2016), Dr. Wecht, C., (2018), SoftBank Website

Fleet management with its limited actors and the conventional business processes does not create a network between multiple actors. Hence, network effects will not be realized. Therefore, the business environment of managing the asset currently does not show sufficient potential to be managed on a platform basis.

In contrary, a vehicle-centric fleet operation based on the daily operational processes of the vehicle, the vehicle interfaces, and every platform actor creates, delivers, exchanges and captures value and data within the ecosystem. Multiple business models and scenarios are possible among the platform partners and users. The vehicle operator who is responsible for the efficient and profitable operation most likely will be the platform leader with the interface to the fleet management. Having exclusively access to the passenger within the passenger-centric MaaS platform defines the platform leader within the MaaS ecosystem. Owning and operating the vehicle enables the operator to control and steer the access to the platform and the ecosystem. Multiple platform leaders cannot be ruled out.

6. Managerial implications

Pilot programs of demand-responsive transportation in a variety of different cities around the globe are implemented and running. In most cases these pilot programs are triggered by mobility software companies like VIA and ViaVan in Europe. VIA and ViaVan provide PTAs or PPTOs with the necessary software tools and know how (rider aggregation algorithm, dynamic routing prediction, service monitoring, seamless integration) to match multiple passengers going in the same direction with vehicles following optimized routes. The vehicle provision and operations are partly covered by the pilot program partner.[106]
In comparison to the future potential fleet size derived per city (see Figure 15 – Evaluation of potential fleet size for 15 EU cities above 1 million habitants, e.g. Berlin: 27.759), these pilot programs are conducted with a very small fleet of conventional vehicles (100 to 300, 50% fully electric).[107]

According to BVG, it is the largest public sector pilot program regarding demand-responsive transport in the world, yet, they are operating within the existing centralized operational infrastructure.[108] Hence, it seems unrealistic to proof the concept of a vehicle-centric fleet operation platform within a hardware based small scale pilot program.

Therefore, managers in this business environment should consider to simulate a vehicle-centric decentralized fleet operation ecosystem based on the existing findings (with regards to passenger behavior) and know-how of companies like Via, city traffic and infrastructure data, technical vehicle assumptions, and fleet operation scenarios especially including the actors derived in the application model (see Figure 33 – Vehicle-centric fleet operation platform in MaaS environment).

106 VIA website, ViaVan website
107 ViaVan, Berlkönig website
108 Berlkönig website

The outcome would show reliable parameters for:

- optimal technical purpose-built vehicle configuration
- optimal vehicle fleet size for a certain area
- optimal vehicle distribution strategy (in operation / not in operation)
- optimal fleet charging strategy
- optimal fleet operation strategy
- indications for optimal maintenance strategy
- indications for optimal cleaning strategy
- indications for driver distribution / management
- indications for parking strategy
- indications for infrastructure adaption and investments

Furthermore, a model with different scenarios, a strong software tool could be built to convince potential investors, vehicle customers, platform partners, politicians, and city inhabitants of the new sustainable and efficient demand-responsive transport service. A depiction of the optimum could be created and costs and time for pilots could be saved.[109]

Business model scenarios where the battery is seen as a stand-alone asset in a holistic transport system need to be developed. Batteries are one of the key technologies enabling the decarbonisation of transport. The requirements for grid support batteries are lower than those for electric vehicles, which points to grid support being a key second life application for EV batteries.

The potential for batteries to work synergistically with the power system, providing a range of services that can increase a renewable energy uptake and reduce constraints on networks is emerging. The physical separation of the vehicle and the battery already during first life fleet operation and, of course, second life battery scenarios are enablers and could be the result of a decentralized demand-responsive transport system.[110]

[109] ViaVan website, Ioki website
[110] Baltac, S., Slater, S., (2019), page 2

Considering the battery as an asset and looking at Figure 32 as well as at Figure 33 on the left side, fleet management, in the long run, the crucial factor for efficient fleet operation is the purpose-built vehicle and the interface battery.

The vehicle manufactures need to find a solution to finance, develop and industrialize purpose-built vehicles for uncertain vehicle life cycles and markets with unsure annual production and sales volumes. The collaboration of vehicle manufactures, FMC, and fleet operators is important to develop and deliver TCO optimized and fleet based vehicle concepts.[111]

The approach of sector overarching thinking and collaboration in the transportation sector is currently represented by ZF quite well. ZF, usually known as the five biggest automotive component supplier in the world, specializes in powertrain and chassis systems, has been very active with regards to mergers and acquisition and building strong partnerships within the transportation sector (see Figure 34):

1) ZF + e.GO = e.GO moove joint venture, scope: serial production of purpose-built vehicles[112]
2) ZF acquires 2getthere, scope: development of autonomous transport systems[113]
3) ZF and e.GO move partnership with Transdev, scope: development of shared mobility solutions[114]

[111] Roland Berger (2018), page 3-4, Baltac, S., Slater, S., (2019), page 3-6
[112] ZF website, Autonom und elektrisch: People Mover geht 2019 in Serienproduktion
[113] ZF website, ZF übernimmt Mehrheit beim Mobilitätsanbieter 2getthere
[114] ZF website, Transdev, ZF und e.GO verkünden Partnerschaft zu Shared-Autonomous-Mobility-Lösung,

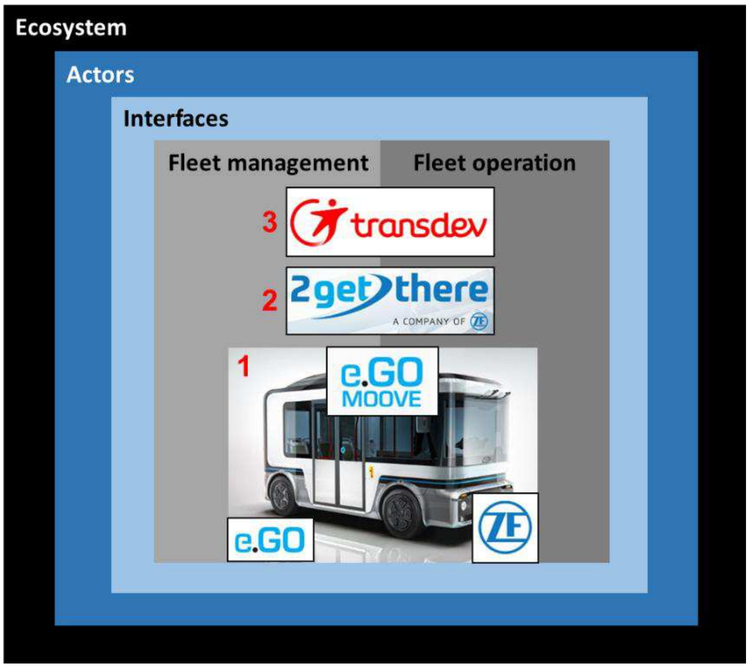


Figure 34 – ZF purpose-built vehicle – fleet operation ecosystem[115]

Sector overarching collaborations and partnerships could lead to fleet operation platforms like shown in Figure 33.

The fleet of purpose-built vehicles accompanied with the decentralized dynamic demand-responsive transportation mode will create multiple new transportation and transportation related business models through the interfaces and actors.

115 Own illustration, Figure 19 – vehicle-centric thinking, ZF website, ZF übernimmt Mehrheit beim Mobilitätsanbieter 2getthere, ZF website, Autonom und elektrisch: People Mover geht 2019 in Serienproduktion, ZF website, Transdev, ZF und e.GO verkünden Partnerschaft zu Shared-Autonomous-Mobility-Lösung

6.1 Summary

Managerial implications		
Main actors	Cities / PTA	▪ Create a policy framework which enables large scale pilots and long-term industrialization of demand responsive and decentralized operated transport services ▪ Involve all relevant city authorities (e.g. energy, infrastructure, city development) to design efficient decentralized fleet operation systems ▪ Support new transportation business models and consider them as trigger for transportation data-based additional revenue streams ▪ Develop and execute a city overarching mobility strategy ▪ Promote transportation system interoperability and co-develop technology standards ▪ Foster joint vehicle and vehicle services procurement ▪ Establish mobility software know-how as a key pillar
	Vehicle manufacturer	▪ Develop use case-centric and TCO optimized purpose-built vehicles for efficient and sustainable urban fleet operation ▪ Design a vehicle architecture which is focused on fleet operation, vehicle refurbishment, vehicle recycling and urban infrastructure ▪ Consider the HV-battery as a service product with several use cases and lives ▪ Enable technological advancement of the vehicle architecture (hardware and software) ▪ Design a vehicle operating system which enables interoperability between different fleet operators ▪ Establish business relations with fleet management and fleet operation providers

Figure 35 – Summary managerial implications[116]

[116] Own illustration

7. Conclusion and outlook

The aim of this research is to understand and predict future urban transport processes in the environment of a vehicle and fleet-based approach. Today, most companies only focus on the passenger and build their business model around the mobility customer. Of course, this is not wrong, it is crucial to success to build the ecosystem around the mobility customer to offer best possible products and services.

But, within a holistic urban transportation system, where the vehicle is moving the passenger from A to B, fleet management and fleet operation related costs and business models cannot be neglected. A wide range of new urban mobility solutions are in development and in operation. Ride sharing, ride hailing, and ride pooling operated by private companies are expanding globally very fast. These are customer-centric and asset-light platform solutions while outsourcing the conventional vehicle operations to the driver. Hence, they can scale rapidly. But most of them are not profitable yet and heavily funded by large investors.[117]

Once autonomous driving technology is affordable and available, the driver with the related costs will disappear and the business case of the ride hailing most likely is profitable. But these companies are still operating large fleets within the public environment without sufficient control of public authorities.[118] On the other hand, there is the public transportation sector analyzed. As described in the previous chapters, this environment is vehicle-centric organized and asset-heavy characterized, with fleet operation as its backbone. Hence, they cannot scale rapidly. Furthermore, the centralized fleet management and fleet operation accompanied with large infrastructure investments is causing huge operational expenses which cannot be covered by fare revenues.[119]

[117] Spiegel website, DiePresse website, CNBC website, Figure 2 – Asset-heavy vs. asset-light company structure
[118] Bösch, P., Becker, F., Becker, H., Axhausen, K, (2017), page 22-26
[119] Figure 1 – Coverage of operational costs of public transportation

Mobility trends like always accessible individual and shared demand-responsive affordable transportation as an alternative to an ownership of cars alongside city challenges like congestion and pollution are the key drivers for new transportation business models and solutions. Furthermore, passenger and customer-centric transportation business models enable cross industry business models and therefore open new revenue pools even for transportation focused companies. Therefore, currently centralized public transportation systems need to change their way of doing business and create future urban transportation solutions according to the future passenger needs and mobility habits under the control of public authorities.

Currently existing asset-light MaaS platforms, with the focus of monetizing passenger data, have not found a solution yet to provide efficient, sustainable, and profitable vehicle operations. Existing asset-heavy public fleet operators with the focus on cost optimization and the operation itself, have not developed a solution to offer a platform-based demand-responsive transportation service. Considering legal boundaries with regards to public operation modes will adapt to customer and passenger needs of shared and affordable mobility, purpose-built vehicles accompanied with a decentralized demand-responsive fleet operation network as derived and explained within the application model in chapter 5 could be the solution.[120]

Figure 33 indicates that the future mobility environment of vehicle-based shared transportation will consist of two key mobility interfaces. The first key mobility interface is the passenger and the second is the vehicle. Both key interfaces are surrounded by services and products which are necessary to execute the transportation service.[121] The collaboration of the MaaS platform and the fleet operation platform as described in Figure 33 could eventually lead to a profitable transportation business environment and support cities to create a sustainable and efficient urban transportation future.[122]

[120] Figure 12 – Purpose built vehicles an adapted serial vehicles
[121] SoftBank website
[122] Prof. Dr.-Ing. Friedrich, M., Hartl, M. (2016), page 66-67

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