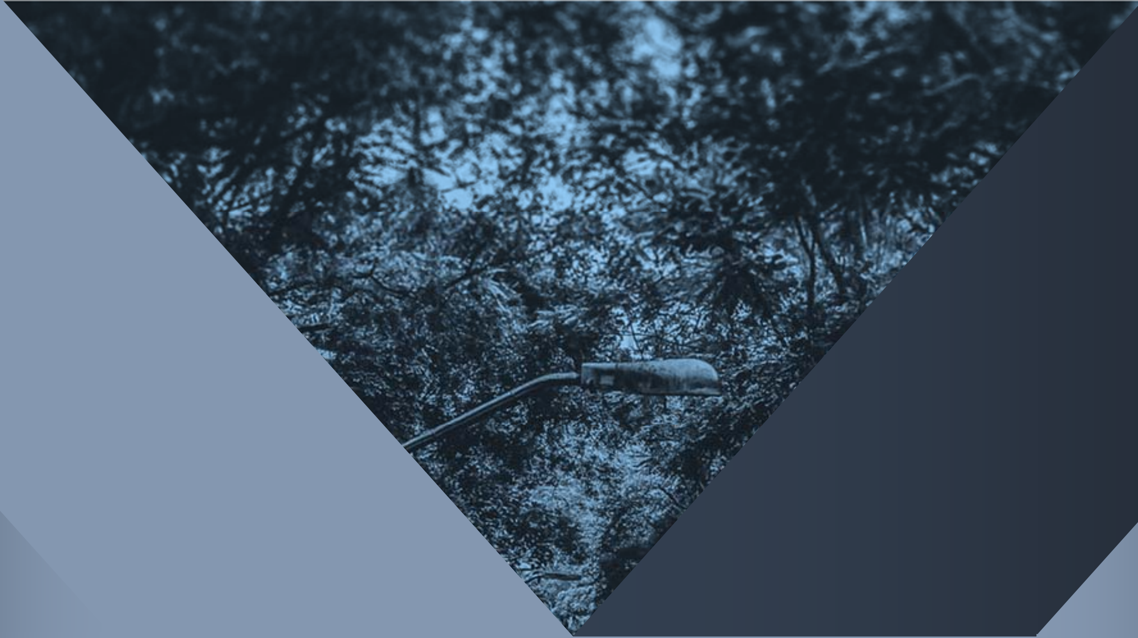

eMaaS Project

Public Summary Report

EMAAS PROJECT
PUBLIC SUMMARY REPORT

eMaaS – electric Mobility as a Service

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EXECUTIVE SUMMARY

THE EMAAS PROJECT

This report highlights results of the eMaaS project, which ran from January 2018 until June 2020. The eMaaS project is part of the ERA-NET Co-Fund Electric Mobility Europe[1]. The programme has the goal to advance adoption of electric mobility in Europe. In the eMaaS project, we do this by combining innovative technology and new business models to create the conditions for large-scale adoption of Electric Vehicles, which are becoming more and more cost competitive. The consortium consists of European mobility SMEs: the Urban Institute (DE & HU), GoodMoovs (NL), Move About (SE) and ZET (AT), supported by the University of Twente (NL). Our aim is to make eco-friendly mobility more accessible. The goals of eMaaS are four-fold:

- Increase user motivation & empowerment
- Improve standardisation in an accessible and open manner
- Realise integration between different systems and services
- Create valuable propositions for data sharing and visualisation

WHAT IS MAAS AND WHAT IS EMAAS?

MaaS (Mobility as a Service) is a relatively new concept in the mobility market but has the attention of many stakeholders. The Maas Alliance defines it as:

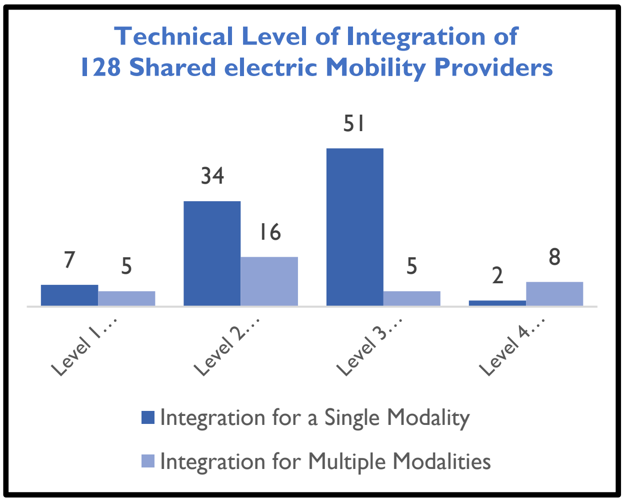
What is MaaS?	*"Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand"* [2]

Our proposition for eMaaS is that MaaS is to be combined with Electric Mobility Systems and Shared Electric Mobility Services to result in eMaaS. Based on this proposition and combined with further insights during the project, we define eMaaS as follows:

What is eMaaS?	*"electric Mobility as a Service (eMaaS) refers to the integration of multiple forms of (electric) transportation modes –including public transport– and shared electric mobility services (e.g. e-car sharing, e-bike sharing, e-scooter sharing, e-bus, e-taxi) into a single mobility service that allows travellers to plan and go from A to B (and/or from B to C and/or vice versa) in an eco-friendly and seamless way. The service is offered through a single customer-centred interface and it also involves the prearrangement of electric mobility technologies and infrastructure (e.g. charging stations, energy contracts)"* [2]

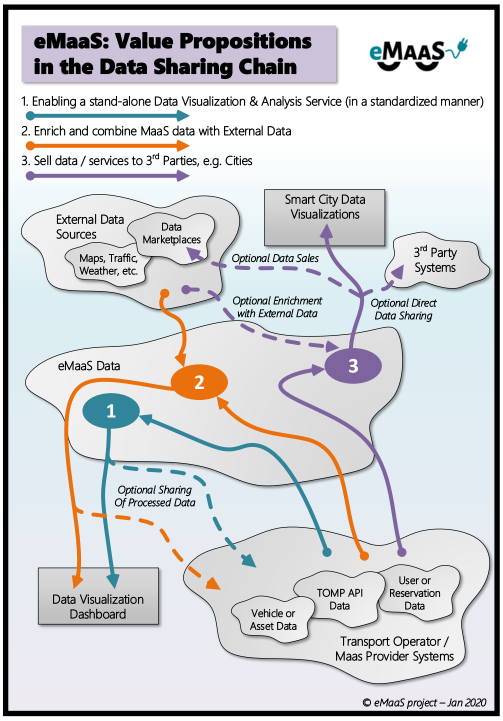
EMAAS MARKET ASSESSMENT

Through an extensive market assessment, we have concluded that current efforts in the market do not emphasize sustainable (and thus electric) mobility enough, nor do they have exclusive integrated offers of these types of mobility. This is somewhat surprising, as the sustainability proposition is one of the key pillars of the integrated mobility offer in MaaS. However, it is also understandable as electric mobility seemingly provides another entry barrier to the MaaS market. Nevertheless, through our experience and observations, the promise of electric and sustainable mobility can also be a very large motivator that actually propels the transition towards less ownership-based mobility.



[1] https://www.electricmobilityeurope.eu/
[2] See section 1.1 for references

EMAAS USE CASES



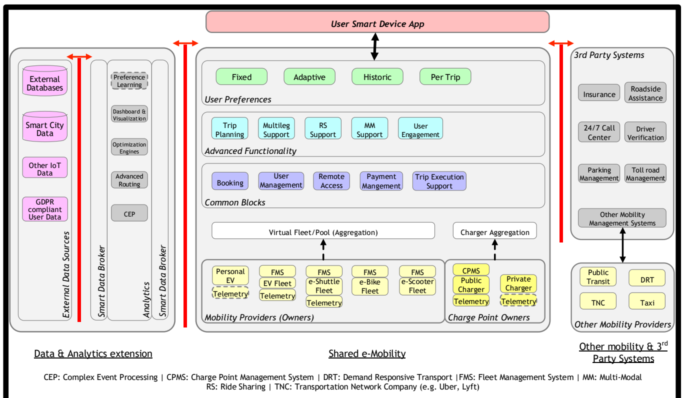
In order to grow in a sustainable manner towards our vision for eMaaS and accelerate the transition towards electric and shared mobility that is happening right now, we aimed to make several first steps that would help us to achieve this future vision. To that end, we analysed several potential business models against the eMaaS project goals.

In this analysis, two things stood out. First, using vehicles of any operator, also known as "roaming", from the app and environment of a single operator. Second, to use the data in the eMaaS ecosystem in a value-adding manner, of course without comprising end-user rights such as GDPR. In the end, we decided to split up both use cases in two sub-categories, resulting in four use cases for the developments in the project.

For roaming, this is addressing the technical challenges that come with national roaming (Use Case 1) and the perhaps more organisational challenges that occur for international roaming (Use Case 2). For data sharing, the focus is divided between supporting the businesses in the eMaaS ecosystem with handling their data (Use Case 3) and utilizing data to monitor and steer towards societal goals (Use Case 4).

EMAAS DESIGNS

In order to establish an appropriate foundation for technical developments, various architecture representations have been created. A key development for an open eMaaS ecosystem that has been and still is supported in this project was the creation of the TOMP-API. This API has as goal to connect Transport Operators with MaaS Providers in a standardised manner. The open nature of the standard supports the notion of an open ecosystem. Further results realised in this project include for example a data connection between partners' systems, resulting in a data dashboard, which shows key eMaaS data.



Functional Architecture for eMaaS

LESSONS LEARNED AND OUTLOOK

A key lesson learned is that the implementation of the TOMP-API showed that standardised communication still holds technical challenges, but even more so organisational ones. Public authorities can play a role in this by setting the use of the TOMP-API as a requirement in tenders or concessions. On the topic of data sharing, we have learned that demonstrating the business value of visualisations is still hard to achieve but coupled with standardised ways of data sharing, this area could receive a huge boost too.

In the future, we will further solidify the development and implementation of the TOMP-API, and further support the TOMP-Working Group in their newly defined activity towards a city data standard (the TOMP-CDS). In the context of eMaaS, fleets of electric vehicles of transport operators can have a very large impact towards local energy systems. In this regard, smart charging and vehicle to grid applications for eMaaS have to be explored.

We also encouraged governments and local municipalities and regions to promote the use of electric mobility services. Municipalities and cities should also help eMaaS-operators with accessible and visible street parking, which we (in terms of usage) have clearly seen is the ideal spot for shared electric cars. Not only would more shared zero-emission vehicles reduce congestion and help reaching the global climate goals, it also provides clean city air and reduces traffic noise levels.

Finally, we have made a first example implementation of journey planning. The potential of journey planning, especially coupled with on demand (commercial) transport, is undeniable and needs to be taken into account for future developments.

CONTENTS

1 INTRODUCTION

The mobility landscape is changing. Electric mobility, shared mobility and autonomous mobility are key developments, fuelled by new technologies in batteries, charging, connectivity, machine learning and many more. Many of these developments are not only on a far horizon, but are here now. This report discusses the results of the eMaaS project that ran from January 2018 to June 2020. This project has explored, designed and implemented innovations in electric and shared mobility.
This chapter will introduce the concept of (electric) Mobility as a Service in general (section 1.1) as well as the eMaaS project (section 1.2). It will also introduce the consortium members of the project (section 1.3) and the outline of the whole report (section 1.4).

1.1 MAAS & EMAAS

MaaS (Mobility as a Service) is a relatively new concept in the mobility market but has the attention of many stakeholders. It centres on the fact that mobility should become more flexible, on-demand and less reliant on personal transportation means. The Maas Alliance defines it as:

What is MaaS?	*"Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand"* [3]

MaaS can address a number of societal challenges such as congestion, use of public space, access to mobility and cost of mobility. The MaaS Alliance expresses this objective of MaaS in the following way:

What is the aim of MaaS?	*"The aim of MaaS is to provide an alternative to the use of the private car that may be as convenient, more sustainable, help to reduce congestion and constraints in transport capacity, and can be even cheaper"* [3]

More concretely, MaaS gives consumers the opportunity to plan, book, execute and pay their trips through an app that offers travel options with various transport operators that offer a plethora of (shared) travel options, such as bicycles, scooters, cars, ride-sharing and public transport as well as simply walking. This service is offered in a seamless manner where registration is made easy, privacy is guaranteed and support is offered where needed. Next to MaaS, all kinds of organizations, businesses, governmental organizations as well as the public are also very attentive to the electrification of mobility, as this is one of the key enablers to make future transport more sustainable. In one of our publications, we describe the synergy between MaaS and electric mobility as follows:

The synergy between MaaS and Electric Mobility	*"With both the growing adoption of electric mobility and the expanding development of MaaS, electric Mobility as a Service (eMaaS) has the perfect opportunity to become one of the foremost solutions for today's mobility challenges. eMaaS expands on the MaaS concept having as a complementary goal to provide users the possibility to go from A to B not only in a multimodal and seamless way but also in an even more eco-friendly way than just reducing car ownership as intended by MaaS"* [4]

Considering this synergy, our proposition for eMaaS is that MaaS should be explicitly combined with Electric Mobility Systems (EMS) and Shared Electric Mobility Services (SEMS) to result in eMaaS. Figure 1 visualises this idea and highlights the components of these three core elements of eMaaS, and thus, the eMaaS ecosystem. Based on this proposition and combined with further insights during the project, we define eMaaS as follows:

What is eMaaS?	*"electric Mobility as a Service (eMaaS) refers to the integration of multiple forms of (electric) transportation modes –including public transport– and shared electric mobility services (e.g. e-car sharing, e-bike sharing, e-scooter sharing, e-bus, e-taxi) into a single mobility service that allows travellers to plan and go from A to B (and/or from B to C and/or vice versa) in an eco-friendly and seamless way. The service is offered through a single customer-centred interface and it also involves the prearrangement of electric mobility technologies and infrastructure (e.g. charging stations, energy contracts)"* [4]

[3] *https://maas-alliance.eu/homepage/what-is-maas/*
[4] *Reyes García, J.R.; Lenz, G.; Haveman, S.P.; Bonnema, G.M. State of the Art of Mobility as a Service (MaaS) Ecosystems and Architectures—An Overview of, and a Definition, Ecosystem and System Architecture for Electric Mobility as a Service (eMaaS). World Electr. Veh. J. 2020, 11, 7.* https://doi.org/10.3390/wevj11010007

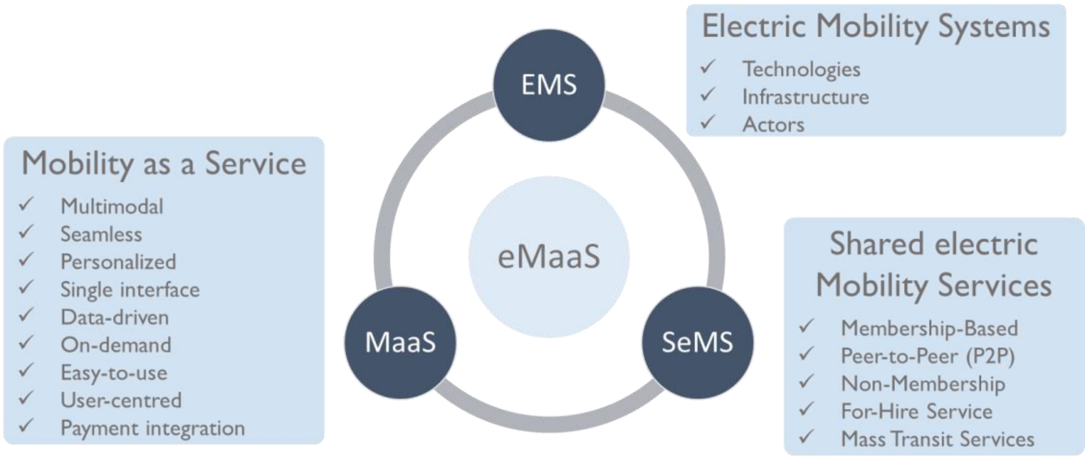


Figure 1 – the eMaaS ecosystem: a combination of Mobility as a Service (MaaS), Electric Mobility Systems (EMS) and Shared Electric Mobility Services (SEMS)[5]

Figure 1 gives a somewhat technical overview of the eMaaS ecosystem. In that sense, the question remains which actors are actually involved, and how they are connected. In Figure 2 we visualise some of these actors, starting with the user. Users can access the services of an eMaaS provider, who offers a cloud solution through a mobile app. The eMaaS provider is connected to transport operators that offer shared electric mobility services. The user can of course book and use these modes of transport. An important actor in electric mobility systems is the charge point operator, as connecting to their system will give information about charging availability, allow payments directly and possibly even give control over smart grid services. Finally, as eMaaS, even more than MaaS, focuses on achieving sustainability and other societal goals, we connect policy makers and other interested parties through Smart City Dashboards in which they can monitor and possibly influence the eMaaS ecosystem.

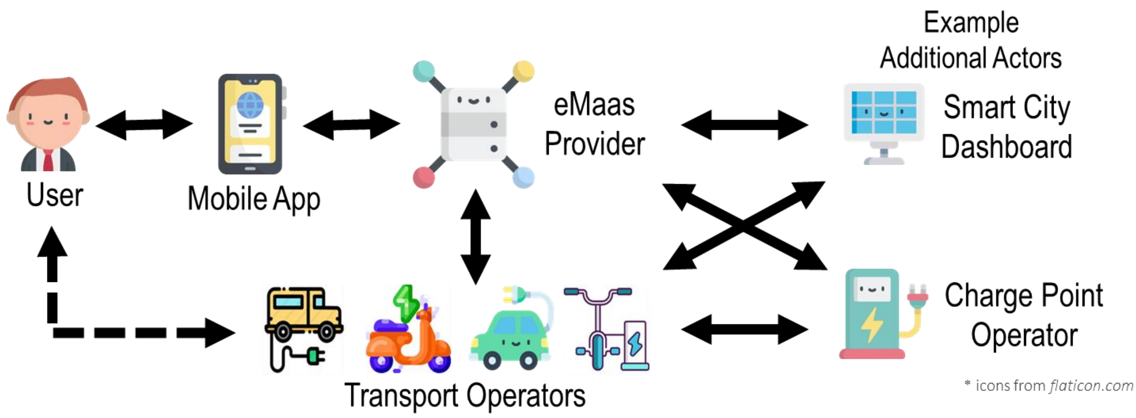


Figure 2 – eMaaS Actors & Connections

1.2 THE EMAAS PROJECT – GOALS & OBJECTIVES

Having introduced MaaS and our vision of eMaaS in the previous section, this section discusses the specific goals of the project. The project is part of an ERA-NET Co-Fund called Electric Mobility Europe[6]. The goal of this programme is to advance the adoption of electric mobility in Europe. In the eMaaS project, we do this by combining highly innovative technology and new business models to create the conditions for large-scale adoption of Electric Vehicles (EV). In the eMaaS project, we have defined the term EV to include not only electric cars, but also electric bikes and electric scooters. This is important as the interest in multimodal solutions is

[5] *Reyes García, J.R.; Lenz, G.; Haveman, S.P.; Bonnema, G.M. State of the Art of Mobility as a Service (MaaS) Ecosystems and Architectures—An Overview of, and a Definition, Ecosystem and System Architecture for Electric Mobility as a Service (eMaaS). World Electr. Veh. J. 2020, 11, 7.* https://doi.org/10.3390/wevj11010007
[6] *https://www.electricmobilityeurope.eu/*

growing among both private and corporate users. We achieve this by enabling sharing of EVs thus optimising their utilisation and reducing cost. To increase user motivation for a low–emission transport future, we connect EV sharing services to other eco-friendly modes of mobility, such as electric public transportation. The objective is not to simply replace ICE (internal combustion engine) vehicles with electric vehicles, but to change the mobility mindset by aiming to reduce the volume of vehicles needed for achieving the customers' mobility needs through optimization of the total mobility chain, and base that on electric transportation options. In that light, it is good to realize that through continuous developments in especially electric vehicle batteries, these vehicles will be cost competitive very soon with their ICE counterparts. Finally, we put our users at the centre and work towards easily accessible solutions. In the following subsections, we highlight some of the project's objectives in more detail.

1.2.1 USER MOTIVATION & EMPOWERMENT

One of our main goals is to motivate and empower users to use shared and sustainable mobility options. Therefore, we develop and implement one mobility offer for:

- Private users throughout cities and regions in Europe
  - For example for residents of new housing developments
- Companies & (Public) Organisations
  - Employees or the public nearby can use company vehicles also for private trips

The mobility offer is also improved by enhancing the e-bike sharing services, adding cargo-bikes, and introducing ride sharing. We also aim to use gamification to stimulate eco-friendly behaviour and uptake of shared mobility.

1.2.2 STANDARDISATION

In order to connect the various actors and systems described in the previous section, many connections are required. In this project, we research and implement standardised interfaces in order to facilitate a truly open ecosystem. A specific result in this regard is the development of open APIs (Application Programming Interfaces) for communication between the different actors and systems.

1.2.3 INTEGRATION

Another objective for the eMaaS project is to achieve integration between services. In particular by connecting to different transport operators, as visualized in Figure 3. This integration is a key accelerator for the EV market and thus aligns closely with the objectives of the Electric Mobility Europe programme. In order to achieve this integration, eMaaS will address both technical and business aspects of how to integrate and optimize different types of electric vehicle providers and ensure a sequential optimization of such trips for the user.

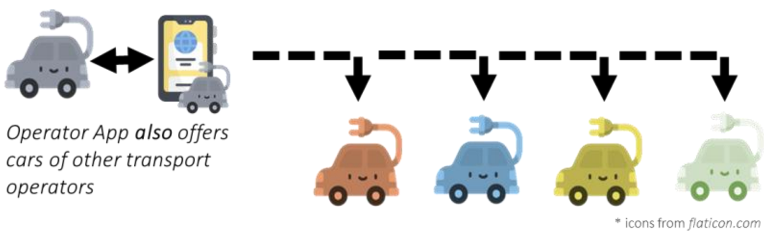


Figure 3 – Connecting multiple EV operators through one single app

1.2.4 VISUALISATION

An important objective of the eMaaS project is to analyse and visualise key data from providers and operators. This is made available for operators and providers themselves, governmental bodies and other relevant stakeholders. This can be analysed data concerning usage of road, parking and charging infrastructure, as well as information on the modal split of eMaaS users, trip frequency, durations and routes taken.

In this project, we thus work towards a future vision for eMaaS where a unique broker service is established for rich real-time data gathered from electric vehicles during the operation of the service to a wide range of actors throughout the e-mobility value chain including for instance insurance, smart grid, and navigation system providers. This data can be both "raw" data and data to which advanced analytics have been applied – "Smart Data".

1.3 THE CONSORTIUM

We are European mobility SMEs from Germany ([ui!] Urban Software Institute GmbH) – lead partner, Austria (ZET GmbH, formerly Move About Austria GmbH), Hungary (the urban institute Hungary Zrt.), the Netherlands (GoodMoovs B.V.) and Sweden (Move About AB) supported by the University of Twente from the Netherlands. We are all working towards making eco-friendly mobility more accessible. Now, we joined forces in this project to increase the adoption of electric vehicles in a broad sense through making zero emission (electric) travel more attractive and convenient.

[ui!] Urban Software Institute GmbH is lead partner and provides the perspective of a data platform provider (primarily for Smart Cities) – [ui!]'s standards-based (DIN SPEC 91357) Open Urban Platform, collects data from a large variety of data sources, applies analytics and produces visualizations for decision makers and other interested stakeholders. At the same time, [ui!] and its wholly owned subsidiary [ui!] Urban Mobility Innovations are involved in a variety of projects that are related to MaaS at up to national scales (German national mobility platform).

Move About is a leader in electric car sharing and vehicle fleet optimization, that offers smooth and cost-effective personal mobility that is truly sustainable and meets all environmental goals, with the least possible use of energy, production resources and public space. In 2008, Move About introduced the world's first commercial car sharing fleet of electric cars in Oslo. In 2009, operations were started in Sweden, and today Move About operates one of the world's largest fleet of electric shared cars with over 400 full electric cars only in Sweden (distributed over more than 25 cities), and fully integrated with a total of 100 shared electric bikes.

ZET, formerly Move About Austria, combines existing mobility opportunities and reconsider the way they can be utilised. Starting at the base with e-car sharing within Bremen (ZET.Bremen) and providing hard- and software possibilities for car sharing solutions (ZET.Share), we expand the idea of mobility by combining all existing mobility solutions for a more flexible and sustainable future (ZET.Link). To further increase the efficiency (of transportation) and to optimise the utilisation of car sharing pools, we use and provide analytical software which can display the user data in an individual and "easy to view" way (ZET.Analytics).

The urban institute Hungary Zrt. (UIH) is a research oriented SME. It has a strong relationship with the leading institution on technological higher education in Hungary, the Budapest University of Technology and Economics. The mission of UIH is to support governments, cities, companies and service providers in developing and realizing various smart city programmes. UIH has several joint programmes with the most important cities in Hungary – Budapest (the capital), Debrecen and Szeged. Moreover, UIH is an active member of the Urban Mobility KIC. In the eMaaS project, UIH's intention is the introduction of new electric mobility services in Hungary. Pilot projects are implemented in Budapest and Szeged, two very important partner cities in Hungary of UIH. In addition, UIH is responsible for the dissemination activities of the consortium – creating and updating the website and monitoring the different dissemination activities like: conferences, fairs, exhibitions, workshops and publications.

GoodMoovs supports governments, employers, project developers and vehicle providers in both developing and executing a mobility strategy, with the aim of structurally changing the mobility behaviour of employees and residents by making more use of electric shared vehicles and other sustainable alternatives, and by making fewer kilometres in fossil fuel cars. The GoodMoovs platform is a sharing platform for EVs and (e)bikes. GoodMoovs currently manages a fleet of more than 250 electric shared vehicles. That is the second largest fleet of electric shared vehicles in the Netherlands. GoodMoovs offers services and systems to facilitate the sharing these electric vehicles. The GoodMoovs platform ensures an increase in the utilization of the shared vehicles. For the operator/supplier of the shared vehicle, this will result in a decrease of the costs per kilometre. GoodMoovs is currently encouraging 9,500 participants to make "good choices" in mobility, encouraged by gamification to make conscious mobility choices.

The University of Twente is a university located in Enschede, in the east of the Netherlands. At the University of Twente, we are pioneers in fusing technology, science and engineering with social sciences to impact the world around us. The group involved in the eMaaS project is the Systems Engineering and Multidisciplinary Design (SEMD) group located in the Department of Design Engineering at the Faculty of Engineering Technology. In general, we research and teach the design of complex systems. We focus on supporting system designers and improving multidisciplinary communications to achieve better system designs. In this project, we aimed to advance the state-of-the-art in Data Driven Architectures and User Centred Design of MaaS Applications. Furthermore, through our experience in architecture and system design, we support the design of a system architecture for eMaaS in this project.

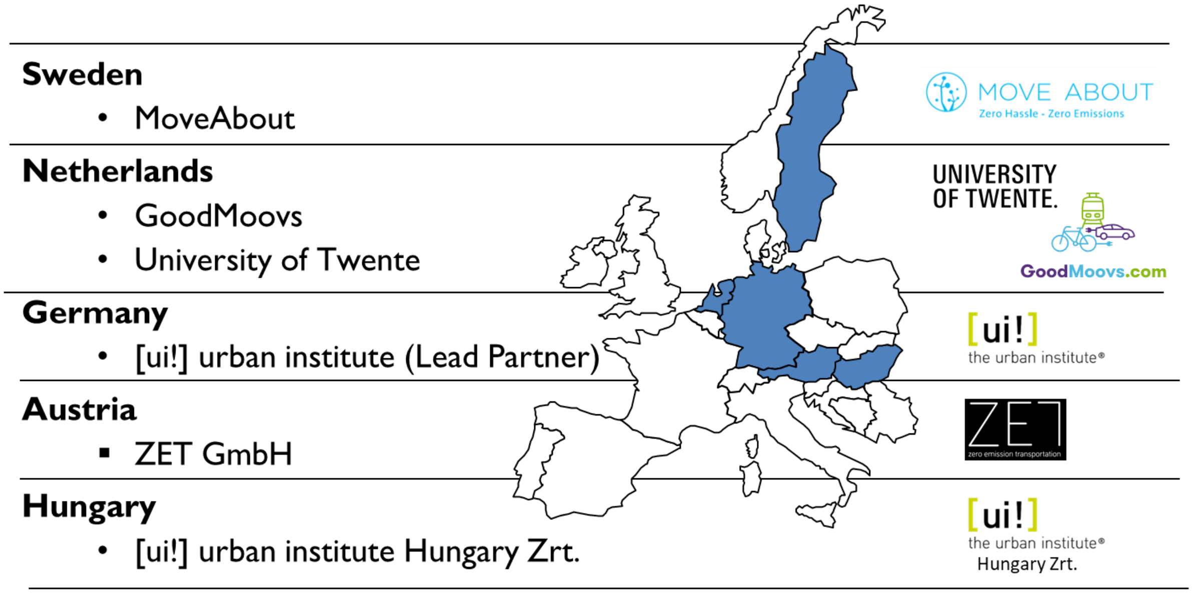


Figure 4 – Consortium Overview

REPORT OUTLINE

In the rest of this report, we have collected and summarised knowledge gained in the eMaas project on the following subjects:

- Chapter 2 presents highlights of a joint market assessment that was executed at the start of the project and provided us a basis to subsequently develop use cases and architecture designs.
- Chapter 3 discusses the design and development of four use cases that took place during the course of this project. The use cases focus both on integration of mobility services as well as on data sharing.
- Chapter 4 discusses the architectural designs and technical developments created in the project. These include a functional architecture, a software architecture, a data sharing value proposition, the development of a standardised API and finally concludes by relating these different architecture views.
- Chapter 5 highlights some of our work on data sharing and visualisations and includes various examples of data visualisations as well as a data sharing value proposition for the eMaaS ecosystem.
- Chapter 6 reflects on the project by providing lessons learned. These lessons learned are categorised per stakeholder for easy access.
- Chapter 7 summarizes the outreach that we have conducted during the project to share our findings, developments and insights.
- Chapter 8 concludes the report by providing an outlook on future activities.

2 MARKET ASSESSMENT

In order to have a solid foundation and understanding for our developments in the project, we have conducted an extensive market assessment in several areas. These are towards car sharing (section 2.1), multi-modal operations (section 2.2), current electric & shared mobility business models (section 2.3) and in what manner market actors are prepared for a transition towards eMaaS (section 2.4). We also offer an example business case from the perspective of a consumer (section 2.5). Finally, we offer several conclusions and observations based on our market assessment (section 2.6).

2.1 CAR SHARING

The car market is currently undergoing various developments. One of these is the increase in both the number of and diversity in car sharing schemes. Traditionally, consumers have relied on car ownership, business leasing and, for shorter periods or distances, car rentals or taxi services.
However, a number of new sharing modes have emerged in recent years:

- Car Sharing (CS), when we refer to car sharing, we mean a transport form, where people rent cars for short periods, often by the hour. This also applies for other forms of transport such as bicycles and scooters.
- Corporate Car Sharing (CCS), where a fleet/pool of corporate vehicles is available for employees for business and personal use.
- Ride Sharing, where multiple people share a single car for a single ride. This, especially under the name Car Pooling, has been around for some time but recent advances in software technologies and social media have put this category in a new light.
- Ride Hailing (or Transport Network Company, TNC), companies like Uber or Lyft which offer taxi-like services from the premises of their operators sharing their own car for these services.

In Figure 5 we give an overview of various car sharing business models and structures. Within the eMaaS consortium, the involved SMEs that currently operate a vehicle fleet focus both on (electric) Car Sharing in Business-to-Business (B2B) applications and Business-to-Consumer (B2C) offerings. B2C is made available directly but also in several cases through usage of company fleets for private use outside of office hours. Peer-to-Peer (P2P) car sharing is not in focus of the eMaaS project.
With respect to whether a car-sharing operator is station-based or free floating, the consortium members mainly focus on station-based car sharing. This is partly due to a large focus on B2B applications and partly because the consortium members purely offer electric vehicles in their car-sharing applications and availability of charging infrastructure can be an issue. However, in the current market there are several examples of free-floating e-car sharing schemes (e.g., Car2Go / ShareNow in Amsterdam[7]), so this is not a limitation per se.
An important distinction to be made in the business models is that there can be both car sharing operators, as well as car sharing technology & platform vendors. This can be within one organisation or distributed over various partners. Finally, in Table 1, we offer the highlights of our analysis on various aspects of Car Sharing.

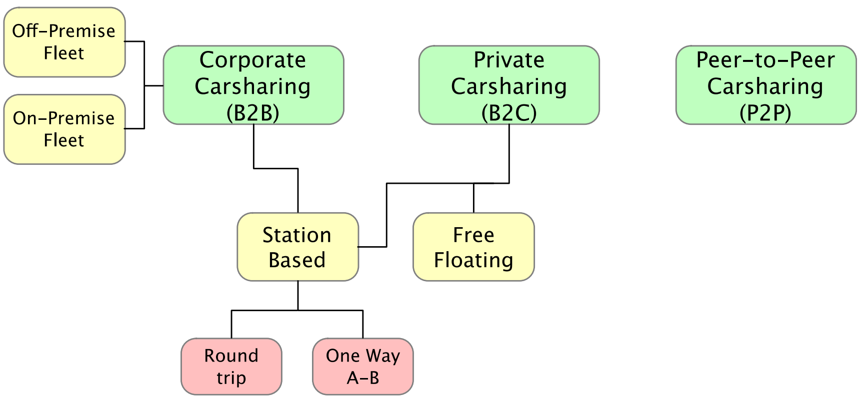


Figure 5 –Car Sharing Business Models

[7] https://www.car2go.com/NL/en/amsterdam/

Table I – Highlights of eMaaS Car Sharing Market Assessment

Car Sharing Provider Attributes	• Geographical coverage (local, regional, national, global)
	• Size of operator, age (incumbent or newcomer), ownership (e.g., OEMs such as BMW or Daimler, public transport operator)
	• Partnerships (other CSs, insurance company, OEM, etc.)
	• Trip Structure
	  • Free floating
	    • May need parking permits
	    • More appropriate for large cities
	    • Complicated for EVs (ideally needs charging infrastructure, which is simpler for station-based)
	  • Station-based
	    • Near public transit hubs (e.g. train station) for last/first mile solution
	    • More appropriate for smaller cities/towns; more difficult to handle intercity travel
	• Fee structure
	  • One-time registration, club annual membership, per km, per time, etc.

B2C (Business-to-Consumer)	• Customer convenience: Round trip (least convenient), A-B (more convenient), free floating (most convenient but needs to have dense coverage) • Insurance, roadside assistance, maintenance and 24/7 customer service expected • Special requests may include • Special needs population, EV, larger vehicles for cargo, etc. • Basic analysis shows gross daily income of about 50 Euro per day per vehicle (assuming only 3-hour daily usage per vehicle)
B2B (Business-to-Business)	• Allows employees to take vehicle for private use • Allows third parties to "rent" company vehicle when available (income for company) • Ideally, there is on demand usage, resulting in no unutilized periods • Automatic per department billing (or payroll deduction for private use) • EVs may be desired (especially, if there are some credits that can be collected) • Smart energy schemes (e.g., smart buildings or Vehicle-to-Grid, V2G) require on premise charging infrastructure
P2P (Peer-to-Peer)	• Brokering platform + insurance + roadside assistance + 24/7 support • Brokering platform takes a percentage • Possible integration with other CS (partnerships)

Technology	• Telematics – distance driven, fuel consumption, additional optional data (location, driving behaviour, etc.)
	  • EVs are more complicated (no standard yet; getting battery data is necessary but not simple to collect; OEM owned CS with EVs have an advantage
	• Smartphone app for reservation/booking, dashboard, cost calculation, routing, emergency service, additional services
	  • Simple interface
	• Seamless automated billing
	• System integration with other CS systems, public transportation (multi-modality), parking management (especially, for free floating), municipal systems (smart city), charging infrastructure (for EVs), ride sharing services
	• Navigation and routing capabilities

Connected Automated (Electric) Vehicle (CA(E)V) readiness	• Autonomous vehicles will lead to some fundamental changes • Many mobility options will consolidate/merge (e.g. the difference between CS and ridesharing will become fuzzy when drivers are no longer needed) • Charging of electric CAVs will potentially happen at a few central depots • Phased approach – mobility operators start with a small fraction of CA(E)Vs; opportunity to test and validate autonomy (operation and tech)

2.2 MULTI-MODAL OPERATIONS

Consumers have increasingly embraced new mobility options and apps over the last decade. According to Deloitte[8], Car Sharing had nearly 5 million members worldwide in 2014, up from around 350,000 in 2006, and is projected to exceed 23 million members globally by 2024. Furthermore, they find that there are more than 1,000 public bike share schemes in more than 50 countries. In 2004, only 11 cities worldwide had such programs. Finally, they also conclude that ride-hailing services have seen similar rapid growth. In six years of operation, Uber's global footprint has expanded to more than 500 cities in more than 70 countries.

It is clear that new modalities and combinations of these different modalities for one journey are becoming increasingly common. On the other hand, journey-planning apps, which help users identify and compare different modal options for getting to their destinations, have become commonplace, with local and global offerings available in every city.

The natural next step would be to bring all of these options together on a common platform. This would enable journey planning across a range of transportation modes, offering flexible payments and personalization based on user preferences regarding time, comfort, cost, and/or convenience. With so many more choices available, customers should have the ability to seamlessly plan and pay for multiple services as they travel.

One of the forerunners in this regard is MaaS Global, the company behind the Whim app[9]. This Finnish company wants to bring all means of travel together. It combines options from different transport providers into a single mobile service, removing the hassle of planning and one-off payments. It works out the best option for every journey – whether that is a taxi, public transport, a car service or a bike share, or a combination of the former. In a recent analysis of the operations of Whim[10], it was deduced that:

Multimodality in (Whims') MaaS	*"The data suggest that public transport is clearly the backbone of MaaS users' travel habits, MaaS users excel in multi-modality, and the MaaS platform is potentially facilitating first/last mile choices that lead to greater access to public transport"* [10]

However, in our experience, the fact that public transport is the backbone of Whim's business model does not necessarily dictate that public transport always governs this role in MaaS. In our eMaaS proposition, we focus more heavily on accelerating the transition towards electric transport starting with transforming car usage and reasoning from the perspective of current car owners. These car owners might not even be inclined to use public transport, but could be open to use other means of transport such as shared cars or shared e-bikes. In that sense, we consider multimodality in eMaaS as follows:

Multimodality in eMaaS	*The underlying goal of the eMaaS proposition, accelerating the transition to electric and sustainable transport, dictates that the backbone of eMaaS is electric mobility. Therefore, offering various forms of electric and sustainable modalities is key. Given this approach, a large focus is on incorporating electric passenger cars clearly in the offering to provide a suitable alternative for fossil fuel car journeys for even the most car-reliant consumers*

The statements above offer a first learning for eMaaS. Others are that advanced communications technologies coordinate the customer's point-to-point mobility experience: Intuitive interfaces enable users to order a vehicle pickup within minutes and travel from point A to point B efficiently, safely, and cost-effectively. Vehicle and traffic network systems operators, in-vehicle content-experience providers (e.g. software and infotainment firms), and data owners (e.g. telecoms) could have further opportunities to monetize the value of passengers' attention in transit as well as additional metadata pertaining to system use.

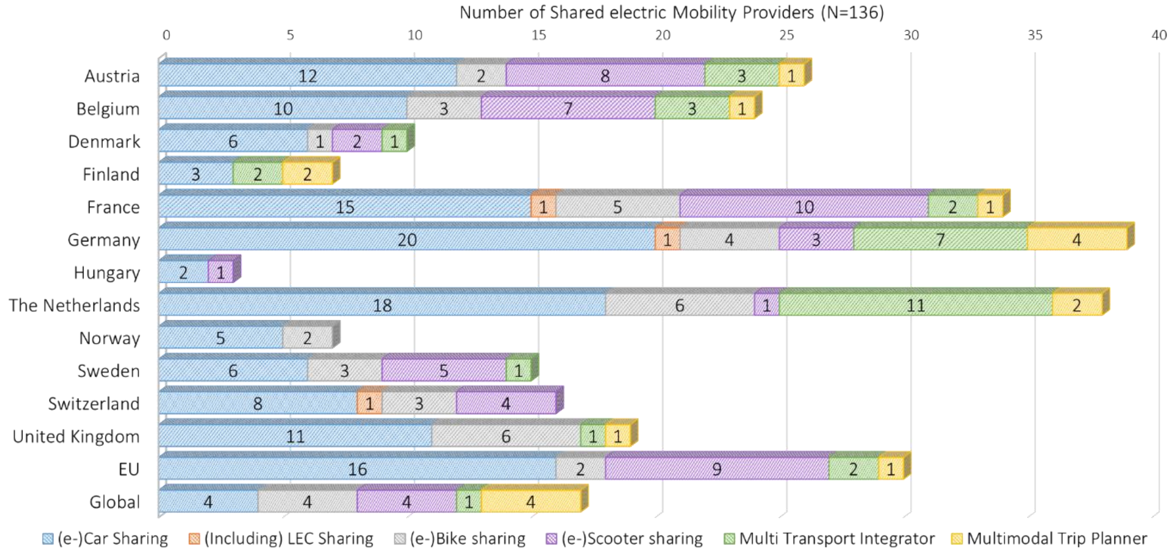
2.3 ELECTRIC & SHARED MOBILITY BUSINESS MODELS

In this section, we highlight electric & shared mobility business models. We conducted a very broad review of actors, mainly active on the European Market (section 2.3.1). Of course, we also investigated this at a local level in the context of the partner's operations. Section 2.3.2 shares some of our experiences in the Austrian market, whereas 2.3.3 discusses an example business case from the perspective of a consumer in the Netherlands.

[8] *Deloitte: The future of mobility 2018.by Scott Corwin, Joe Vitale, Eamonn Kelly, Elizabeth Cathles*
[9] *https://whimapp.com/*
[10] *Whimpact - Insights from the world's first Mobility as a Service solution, Ramboll, 2019*

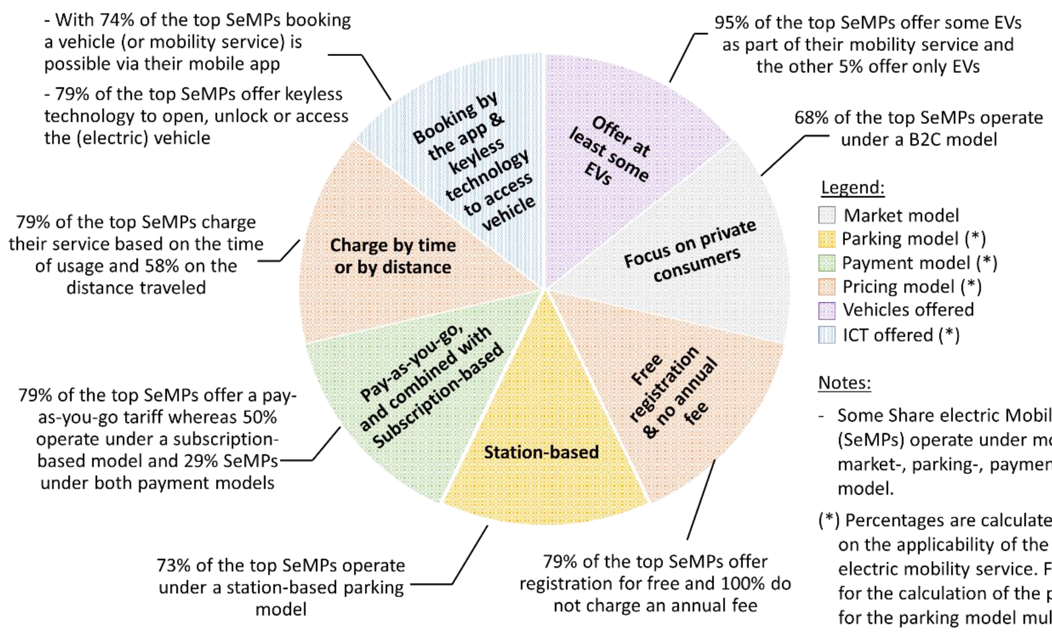
2.3.1 REVIEW OF BUSINESS MODELS IN THE EUROPEAN MARKET

In order to understand the current state of business models that include both electric & shared mobility, we have conducted an extensive review[11] and created a database of 229 existing providers and mobile apps that offer Shared Electric Mobility (SEM). Here, we present some of the highlights of this research.



Notes:
- Some SeMPs are available in more than 1 country. SeMPs are listed for each country where they operate.
- EU: Providers operating in at least 2 countries in Europe.
- GLOBAL: Providers operating in at least 2 continents.
- (e-)Car Sharing: Including corporate (e-)car sharing, P2P (e-)car sharing, and e-car rental providers.
- LEC: Light Electric Car. Only in France and Switzerland there is one provider that offers LEC sharing. In Germany, LEC sharing is provided as part of an e-car sharing provider (e-WALD) service.
- (e-)Scooter sharing: Including e-kick scooters and (e-)mopeds.
- (e-)Bike sharing: Including corporate (e-)bike sharing, (P2P) (e-)bike sharing, and two bike sharing providers (INDIGO weel & VelHop) that offer another kind of shared (e-)mobility service.

Figure 6 – Shared electric Mobility Providers (SeMPs) by type and country of operation[11]



Notes:
- Some Share electric Mobility Providers (SeMPs) operate under more than one market-, parking-, payment- or pricing-model.

(*) Percentages are calculated depending on the applicability of the shared electric mobility service. For example, for the calculation of the percentages for the parking model multimodal trip planners are not taken into account.

Figure 7 – Elements of an effective business model for future electric Mobility as a Service (eMaaS) providers based on the analysis of top Shared electric Mobility Providers (SeMPs)[11]

[11] *Reyes Garcia, J. R., Haveman, S. P., Westerhof, M. W., & Bonnema, G. M. (2020). Business models in the shared electric mobility field: A market overview towards electric Mobility as a Service (eMaaS). In Proceedings of 8th Transport Research Arena TRA 2020, April 27-30, 2020, Helsinki, Finland. (Conference cancelled).*

The focus of our analysis was on the European market, and especially on the eMaaS project partners' origin countries. In this analysis, we studied three groups: Shared electric Mobility Providers (SeMPs), (electric) Mobility Mobile Apps (MMAs) and Mobility-related technology providers.

Figure 6 offers an in-depth overview of identified SeMPs throughout the identified countries. We analysed the business models of all SeMPs in extensive detail. This resulted amongst others in the identification of key business model characteristics of top performers under all SeMPs, which we detailed in Figure 7.

An important observation is that the shared electric mobility market is very dynamic. This firstly means that for example the number and type of SeMPs presented here will have changed significantly in the meantime. On the other hand, this proves the importance of having well-founded business models that ensure Mobility Service Providers, including SeMPs, to remain competitive in the market. Furthermore, since the eMaaS market is expected to be a collaborative market, if SeMPs are willing to enter this market their business model should be flexible enough to deal with its dynamism while at the same time be structured in a way that allows for open collaboration with other mobility and mobility-related service providers.

2.3.2 CONSIDERATIONS FOR AN EMAAS BUSINESS MODEL IN AUSTRIA

Next to exploring business model aspects on a broader scale, we also explored local perspectives. In this report, we share some of the insights from Austria. To understand the willingness of both corporate and business users we held several workshops and dialogue sessions in Austria, which revealed various considerations. These considerations are summarized in Table 2.

Table 2 – Key Observations from an Austrian eMaaS Business Case analysis

Main Observations on Austrian mobility service providers in the Austrian Business Case	• The main interest for corporate users is to replace ICE vehicles with EV vehicles because they can document that the OPEX is clearly lower, even when the CAPEX is higher. • The step to increase the utilization of each car, and thus reaching a faster payback for the higher initial cost are now widely taken into account. • Some corporate users begin to see the total value chain and the opportunity to reduce the total transport cost for employees through the integration of various electric transport options, especially with the arrival of the electric kick-scooter. • The sequential optimization of multiple electric transport providers is still regarded as complex and difficult, even if one can demonstrate the climate benefit, as we did with the ZET-link optimization in Vienna. The key is to have a very intuitive front end. • Some of the existing electric car-sharing providers are more hesitant to sharing data with others as they afraid that they give insight into their internal operational secrets. • Many car-sharing operations are station-based. Also, they are primarily looking for stable business relations and preferably corporate contracts (especially after the present COVID-19 pandemic). Therefore, they are less interested in joining a sequential optimization initiative that requires one-way rental of vehicles.

2.3.3 EMAAS BUSINESS CASE ANALYSIS – EXAMPLE OF A DUTCH CONSUMER

This section highlights one of the analyses done in the context of exploring various business cases. This business case is for a calculation of the Total Mobility Costs (TMC) for a hypothetical traveller in The Netherlands.

This traveller is Maria, a 27-year-old teacher who owns a VW Golf 2006 and lives in Raalte, the Netherlands, a town with roughly 40.000 inhabitants in a rural area. Currently she uses her car to cover all her mobility needs but now she is willing to make a transition towards a more sustainable way of transporting. To do so, she is considering to start traveling by public transport or to buy a car-sharing subscription. Table 3 below summarises the mobility behaviour of Maria.

Table 3 – Summary of the Mobility Behaviour of a Dutch example consumer

From	To	Distance (single trip)	Type of trip	Round trips per week	Weeks per year
Raalte (8101 CT)	University of Twente	53 km	(W) Work	5	44
	Raalte, 8106 AR	5 km	(L) Leisure (Tennis)	2	46
	Raalte, 8102 CC	1.3 km	(G) Groceries	2	46
	Utrecht, 3572 HJ	102 km	(F) Visit family/friends	1	46

Table 4 shows a summary of the resulting TMC of the user by means of different transportation modes. The type of trips (W)ork, (L)eisure, (G)roceries and (F)amily/Friends refer to the trip types identified in Table 3.

Table 4 – Summary of the Total Mobility Costs of a Dutch example consumer

Transportation mode	Trips covered				Time single trip (min)				Mobility cost per week	Mobility cost per month	Mobility cost per year
	W	L	G	F	W	L	G	F			
Own car[a]	x	x	x	x	45	8	6	70	€ 211.15	€ 914.97	€ 9,420
We Drive Solar[b]	x	x	x	x	60[c]	23[c]	21[c]	85[c]	€ 195.63	€ 847.73	€ 8,920
Green Wheels EV[b]	x	x	x	x					€ 570.50	€ 2,472.15	€ 24,676
Green Wheels ICE[b]	x	x	x	x					€ 198.77	€ 861.33	€ 16,043
Public Transport[d]	x	x	x	x	75	33	8	110	€ 165.82	€ 718.55	€ 7,215
Bike		x	x		-	20	4	-	€ 5.22	€ 22.61	€ 240
PT[d] + Bike	x	x	x	x	75	20	4	110	€ 153.88	€ 666.80	€ 6,858

a - TCO based on 32,000 km driven per year, according to the mobility behaviour of the user. Source: ANWB
b - Assuming availability of the (car-sharing) service in the region. For the calculation of costs, an 11-months subscription (per year) is considered.
c - Assuming a car located in a radius of ~7 minutes distance from the user.
d - Prices without discount

Through the analysis of this and other similar scenarios, we made several observations. These range from financial implications for a consumer to the change in lifestyle that would be required. Table 5 presents several key observations.

Table 5 – Key Observations from the eMaaS Business Case analysis

Main Observations on Dutch Consumer Business Case Analysis	• To compare the Total Mobility Costs, understanding the Total Cost of Ownership of vehicles is crucial. • The cheapest option for a user is to use Public Transport in combination with a bike, however the travel time would be longer, especially for the trips with Public Transport and the user would have less flexibility, and therefore this option would have a bigger impact in the lifestyle of the user. • Due to the mobility behaviour of the user, car sharing would not be a suitable option because the car would spent too much time parked (and still paying for the service). Note that also, no parking costs were calculated in the presented scenarios. • Using a subscription as the one offered by the company We Drive Solar, car sharing would be a little bit cheaper than owning a car. However, travel times would be a little bit longer (depending on the location of the car). • Using a bike for leisure activities and groceries in combination with Public Transport for longer trips (i.e., work and visit family and friends) would also be a feasible option for the user. In addition, this implies a change in the lifestyle of the user. • Offering a user's own car for rental/car sharing while is not used could be another option for the user, for example by using a P2P platform such as SnappCar[12] or MyWheels[13].

[12] *https://www.snappcar.nl/*
[13] *https://mywheels.nl/*

2.4 THE TRANSITION TOWARDS EMAAS

In the MaaS market, several frameworks exists that described various levels of MaaS and thus give a sort of roadmap of a transition to MaaS. Examples of this are publications by Kamargianni et al. (2016), Sochor et al. (2018) and Lyons et al. (2019)[14]. These all have slightly different perspectives, but we experienced they do not offer a good framework to assess integration on a more technical level. Therefore, we developed our own assessment scheme. Based on the results of the extensive market analysis described in section 2.3, we conducted an in-depth analysis towards the technical level of integration of Shared electric Mobility Providers to transition towards eMaaS, using this newly developed assessment scheme. In this report, we share some of the highlights of this research[15]. 128 providers have been assessed on integration of key functionalities for eMaaS. These key functionalities are the following five: Asset & Operator Information (A&OI), Planning (Pl), Booking (B), Trip Execution (TE) and Payment (P).

Figure 8 shows an overview of the overall results of our analysis. Actually, all of the SeMPs evaluated in our study have the Asset and Operator Information (A&OI) function integrated on their interfaces, so Level 0 (non-integrated functions) is not shown in the graph. In fact, most SeMPs in our study (approx. 83%) have either a medium or high level of integration with respect to their (e)Maas functionalities. In contrast, only a few of the evaluated SeMPs have fully integrated (approx. 8%) (e)MaaS functionalities or a low level of integration (approx. 9%). Out of the 56 SeMPs that have a high integration, and thus three integrated functions, all of them have exclusively integrated Booking, Planning and Trip execution. As a further observation, only 12% of the SeMPs included planning in their offering.

In conclusion, the results of our study showed that the current state of the European Shared Electric Mobility market already includes Mobility Service Providers (MSPs) with a high- or even a full-level of integration with respect to their technical functionalities. However, most of the MSPs in the European SEM market still lack the integration with respect to multiple modes of transport of multiple MSPs.

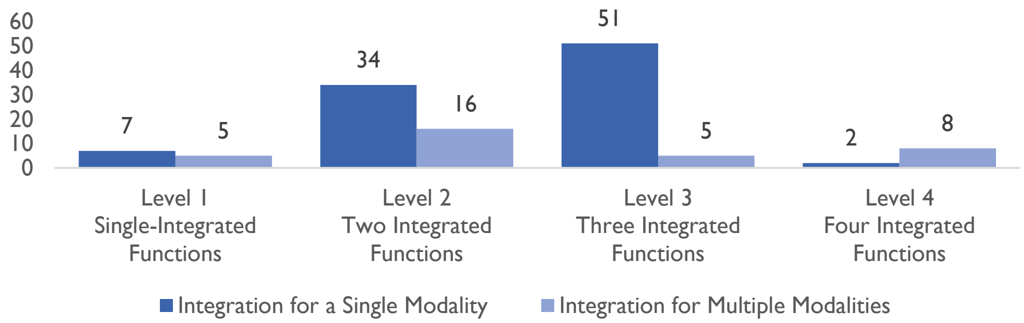


Figure 8 – Technical Level of Integration of 128 Shared electric Mobility Providers[15]

2.5 CONCLUSIONS

This chapter has presented a very broad and in-depth assessment of the eMaaS market, both in its current state and in expected future developments. We have discussed many developments and approaches, and highlighted some key elements of existing business models. Most of them are giving the user a choice of different alternative transport options. Only few try to combine these options into a sequential transportation offer.

[14] *Kamargianni, M., Li, W., Matyas, M., & Schäfer, A. (2016). A Critical Review of New Mobility Services for Urban Transport. Transportation Research Procedia, 14(0), 3294–3303. https://doi.org/10.1016/j.trpro.2016.05.277*
Sochor, J., Arby, H., Karlsson, I. C. M., & Sarasini, S. (2018). A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of societal goals. Research in Transportation Business & Management, 27, 3–14. https://doi.org/10.1016/J.RTBM.2018.12.003
Lyons, G., Hammond, P., & Mackay, K. (2019). The importance of user perspective in the evolution of MaaS. Transportation Research Part A: Policy and Practice, 121, 22–36

[15] *Reyes Garcia, J. R., Westerhof, M. W., Haveman, S. P., & Bonnema, G. M. (2019). From Shared electric Mobility Providers (SeMPs) to electric Mobility as a Service (eMaaS) players: A first approach to assess the Technical Level of Integration of Mobility Service Providers' functionalities applied to the European (e)MaaS market. In Proceedings of the 2nd International Conference on Mobility as a Service (pp. 162). Tampere, Finland.*

The optimization of a multi-modal journey is difficult as it entails a very large number of alternative combinations. Intermodal journey planning is a central topic of research and is quite challenging even if only public transit is considered. However, new machine learning and artificial intelligence approaches driven by advances in computing power (both hardware and software) are enabling significant progress in this area. The end goal is, of course, an intermodal journey planner that can include both public transit fixed stations, schedules, etc., with station-based and free floating based shared mobility, and account for multiple traveller preferences (possibly through integration with techniques such as preference learning.

Through the assessment, we have concluded that current efforts in the market do not emphasize sustainable (and thus electric) mobility enough, nor do they have exclusive integrated offers of these types of mobility. This is somewhat surprising, as the sustainability proposition is one of the key pillars of the integrated mobility offer in MaaS. However, it is also understandable as electric mobility seeming provides another entry barrier to the MaaS market. Nevertheless, through our experience and observations, the promise of electric and sustainable mobility can also be a very large motivator that actually propels the transition towards less ownership-based mobility.

3 EMAAS USE CASES

In order to develop propositions for our developments in the eMaaS projects and direct our efforts towards maximal impact, the consortium has sought to define several use cases. We report on our initial analysis in section 3.1 and discuss the design of our selection of four use cases in section 3.2. Of these four use cases, there are two similar pairs (use case 1 & 2 and 3 & 4). We report more extensively on use case 1 and 3 and in the description of use case 2 and 4 we discuss several additions. Each use case is also linked to the eMaaS project goals mentioned in section 1.2. Finally, we offer several conclusions in section 3.3.

3.1 USE CASE ANALYSIS

The analysis phase of the use case development has been the subject of several workshop sessions between the consortium partners. Stakeholders outside the consortium were also involved through each of the partners in their respective countries.

The approach followed was to identify requested functionalities as well as directly envisaging solutions through the definition of app elements / features for various business opportunities. To more strongly visualise and concretise the envisaged use case, we described detailed user stories. We then gathered and presented all these elements in a canvas for each business model. For each involved country (Austria, Germany, Hungary, The Netherlands and Sweden), several canvasses have been created. This report does not share these canvasses as they contain commercially sensitive information, but Figure 9 presents an anonymised example:

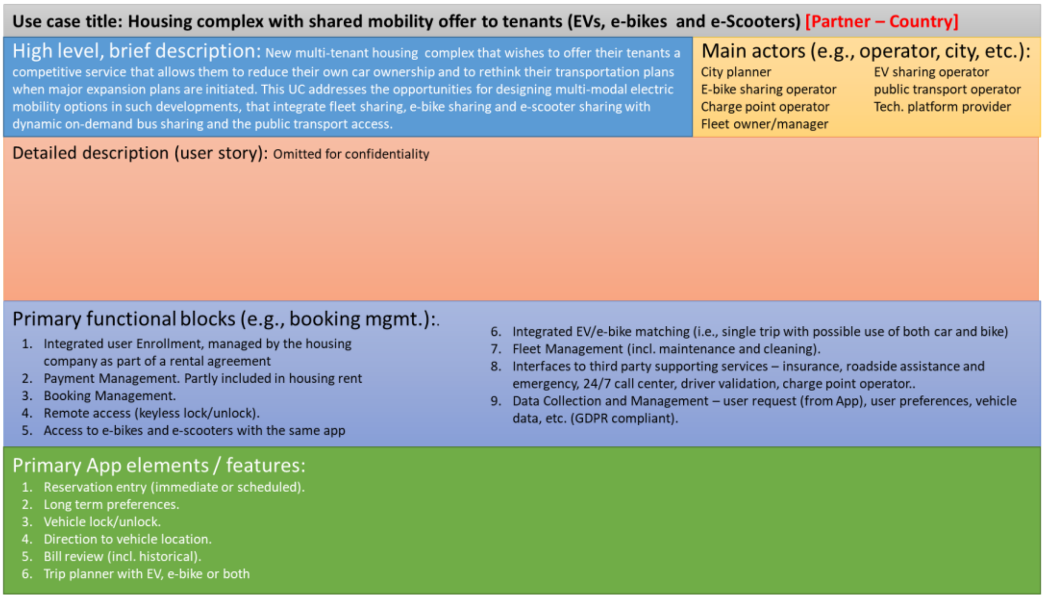


Figure 9 – Example eMaaS Business Model Canvas[16]

3.2 USE CASE DESIGNS

From the above-mentioned canvasses that reflect the consortium partners' activities and goals in various countries, we aimed to extract several generic use cases to focus our development efforts for the eMaaS project. Of course, it is tempting to develop a solution for eMaaS that directly matches the provided future visions. This solution unfortunately will still encounter many barriers, such as a sufficient percentage of the population being open to this form of mobility and a very extensive and integrated coverage of shared vehicles throughout regions. However, in order to grow in a sustainable manner towards this vision and accelerate the transition towards electric and shared mobility that is happening right now, the eMaaS consortium aims to make several first steps to achieve this future vision. To that end, we analysed the developed business model canvasses against the eMaaS project goals as highlighted in section 1.2, which were user motivation & empowerment, standardisation, integration and visualisation.

[16] *The detailed description and partner name are omitted for confidentiality*

In this review, two main use case types stood out. Firstly using vehicles of any operator, also known as "roaming", from the app and environment of a single operator. Second, to use the data in the eMaaS ecosystem in a value-adding manner, of course without comprising end-user rights such as GDPR. In the end, we decided to split up both use cases in two sub-categories, resulting in four use cases for the developments in the project.

3.2.1 USE CASE 1 – NATIONAL ROAMING

The first two use cases centre around roaming between operators. For this first use case, this means that in a specific region, a user from one EV sharing provider can access vehicles from another car-sharing provider via the same app (or platform) of a "local" operator. In this, we thus distinguish the local operator, who governs the customer contact and provides the interface for bookings, and a roaming operator, who provides additional vehicles for a customer to select. Below, an overview of potential goals and capabilities for each of the main actors in this use case is given.

- A customer, through the app of the local operator can:
  - View available EVs of local and roaming operators
  - Book these EVs of local and roaming operators
  - Open and close all of these vehicles
  - Fulfil all payments through the local operators' app or platform
- The "local" operator will have access to:
  - Booking details such as start time, duration, etc. for all bookings made through their app
  - Vehicle status, in very much detail for their own vehicles
  - Customer profiles, for their own customers
  - Historical usage data as well as forecast data
  - Payments to roaming operators
- The "roaming" operator will have access to:
  - Booking details such as start time, duration, etc. for all bookings made through a local operators app
  - Vehicle status, high level data such as availability of faults
  - Customer profiles, exclusively for driver authentication where data is appropriately anonymised from local operators (key information such as possession of a valid driver' license needs to be validated)
  - Receive payments from local operators

Finally, Table 6 gives an overview of the connection between this use case and the overall eMaaS project goals.

Table 6 – Relation between "Use Case 1: National Roaming" and eMaaS project goals

User Motivation & Empowerment	• Customers who are transitioning to shared mobility are able to do so for a limited set of use cases. Currently, as soon as users leave their "local" and regular environment, they are often unable to continue using shared mobility through their known environment. A roaming proposition can thus further motivate users to use shared electric mobility on more occasions. The roaming principle also empowers users, as the type and number of vehicles offered at any location is greatly increased by combining services from different operators. This allows users to find a right-sized vehicle for each journey at hand.
Standardisation	• With the rapid rise of shared mobility and MaaS, a wide variety of approaches and systems has sprung up. In order to enable roaming, standardisation will need to be established to form a base for communications between all modes of travel. The focus of eMaaS is initially to standardise the communication between EV operators, but the standardisation efforts also takes into account other modalities.
Integration	• The establishment of a roaming service for electric vehicles gives ample room to address the topic of integration in various regards. For example, the integration of external offerings in the app design, in the business models of the involved operators as well as technical requirements that need to be fulfilled.

Visualisation	• With regards to visualisation, we aim to explore within this use case in what manner data shared within a roaming environment need to be handled and how it can contribute to data visualisation functionalities.

3.2.2 USE CASE 2 – INTERNATIONAL ROAMING

Use case 2 centres on roaming as well, but on the international aspects of roaming. The information given for use case 1 in section 3.2.1 also applies here and in this section, we only highlight the additional aspects that this use case brings us. As the consortium is fully based in the European Union, we do not intend to directly address complications that arise from offering propositions that fall outside of the regulatory framework that the EU offers. Below, an overview of additional, potential goals and capabilities (next to those already mentioned under use case 1) for each of the main actors in this international roaming use case is given.

- A customer, through the app of the local (home-country) operator can:
  - Use transport services in a transparent manner with regard to pricing, offered support, insurance and other related services, regardless of the country of origin and the country where is travelling
- The "local", home-country operator will have access to:
  - Localised (in home-country language) information regarding booking, vehicle options and vehicle operation
  - Services providing international payments to a roaming operator
- The "roaming" operator will have access to:
  - Services receiving international payments
  - Customer profiles, exclusively for international driver authentication where data is appropriately anonymised from local operators (key information such as possession of a valid driver' license needs to be validated)

Finally, Table 7 gives an overview of the connection between this use case and the overall eMaaS project goals.

Table 7 – Relation between "Use Case 2: International Roaming" and eMaaS project goals

User Motivation & Empowerment	• The international use case expands user empowerment by further increasing the reach of users towards international travel. The focus within the eMaaS project is to enable daily cross-border travel in border regions using shared and electric mobility. International roaming is crucial in this regard to offer users a seamless experience when frequently travelling between countries.
Standardisation	• International standardisation efforts require a further collaboration that will encounter challenges towards adapting to different national standards and different organisational structures in each country.
Integration	• With respect to integration, the international use case further expands work on the integration goal mainly on the topic of localisation, that is supporting different languages and modes of operation that kind greatly differ between countries, requiring tailored user support.
Visualisation	• Visualisation for international roaming brings no significant new developments compared to the national roaming use case, but it does require new types of visualisations that are relevant in an international context. It might also pose requirements on data processing as data from different countries can be structured quite differently due to for example differences in naming conventions.

3.2.3 USE CASE 3 - EMAAS DATA SHARING FOR BUSINESSES

The eMaaS ecosystem generates a multitude of data. These different sources can, if connected in a smart manner, deliver many interesting insights. However, gathering, processing, analysing and presenting data can be a quite intensive process. We therefore foresee that there are value creation opportunities for parties who can master these particular activities. This particular use case focuses on creating value for businesses. The business types

we refer to are transport operators (those who provide and manage the vehicles), and mobility (as a service) providers (those who support the user in planning, booking, executing and paying their journeys). We expect that improving data sharing will allow these parties to direct their efforts in the most applicable manner because they have appropriate insight into their operations.
Below, an overview of potential goals and capabilities for each of the main actors in this use case is given.

- A customer will:
  - Be informed in a transparent manner about how data is processed
  - Be provided with relevant historic overviews (trip history, routes chosen, payments, etc.)
  - Receive suggestions for more optimised trips based on data by other users
  - Receive an enriched user experience (e.g., leader boards in km travelled or CO_2 emissions avoided, special assignments or "quests" or trip suggestions)
  - Gain insights into transport providers via user reviews
- An eMaaS data processing & analysis provider will:
  - Provide a safe and transparent environment for receiving, processing, storing and sending data
  - Access data sources of transport operators and mobility providers
  - Process and combine data sources from both the businesses themselves as well as external data (maps, weather, traffic, etc.)
  - Perform both manual and automated analyses on this data
  - Present the data in a dashboard for businesses (transport operators / mobility providers)
- A transport operator will:
  - Share and possibly receive data streams with an eMaaS data processing & analysis provider
  - Receive processed data in a dashboard that allows the transport operator to:
    - Gain insight into usage of vehicles over time and location
    - Gain insight into behavioural patterns of users, mainly in how they used the vehicles
    - Gain insight into user experience by combining for example user reviews with other data
    - Gain insight into vehicle status (e.g., a maintenance view with faults, service schedules)
- A mobility provider will:
  - Share and possibly receive data streams with an eMaaS data processing & analysis provider
  - Receive processed data in a dashboard that allows the transport operator to:
    - Gain insight into behavioural patterns of users, mainly in how they plan, book, execute and pay for their trips
    - Gain insight into user experience by combining for example user reviews with other data

Finally, Table 8 gives an overview of the connection between this use case and the overall eMaaS project goals.

Table 8 – Relation between "Use Case 3: Data Sharing for Businesses" and eMaaS project goals

User Motivation & Empowerment	• The relation between this use case and the eMaaS project goals has been highlighted under the possible features listed above already in some detail. In essence, it comes down to the fact that by utilising data generated by a user and combining this with other user, or external data, users can be motivated better and make better choices towards their mobility choices. Of course, it needs to be ensured that this happens in a safe and transparent manner.
Standardisation	• In order to share and process data effectively, some measure of standardisation is needed. In this use case we analyse the different data sources that we encounter and aim to find measures of standardisation in providing data and connecting to the various systems within the back-end of businesses.
Integration	• Use case 1 & 2 more directly represent this particular project goal. However, especially for transport operators, data analysis is often a very labour-intensive and demanding side job next to the main objective of providing customers with mobility. In the eMaaS project, we explore how to ensure that daily operations can integrate this data analysis process better.

Visualisation	• The use case data sharing for business has an obvious and very strong connection to visualisation, as the visualisations will provide businesses with the required insights, not the data itself. In this use case, we will explore various types of visualisations and evaluate their effectiveness.

3.2.4 USE CASE 4 – EMAAS DATA SHARING FOR CITIES

Use case 4 is fairly similar to use case 3, except that the shared data will not be fed back to operators, but towards cities and other relevant public authorities. This also means that the type of data that is relevant changes. For example, cities expect that shared data allows them to monitor and steer the mobility in their area towards certain societal goals, such as sustainability and ensuring that less mobility poverty occurs. What is important in this regard is that disaggregated data of a single provider might not be as useful towards monitoring societal goals as aggregated data of all eMaaS providers in a city. This aggregated data can possibly even be enriched with data sources of more traditional forms of mobility. Furthermore, we are seeing a trend in which cities or regions are setting data sharing as a prerequisite for transport operators and mobility providers to operate in that city. This makes sense from the perspective that eMaaS might fulfil the role of public transportation in some manner, and cities very much steer policy decisions based on shared data of the public transportation companies, in order to achieve aforementioned societal goals.
Below, an overview of potential additional goals and capabilities (next to those already mentioned under use case 3) for each of the main actors in this use case is given:

- A customer will:
  - Receive additional feedback on how their behaviour supports societal goals
  - Receive potential benefits for their contribution to societal goals with respect to sustainability or mobility poverty (e.g. mobility funds)
- An eMaaS data processing & analysis provider will:
  - Aggregation or fusion of data from transport operators to determine
    - Total energy consumption per city
    - CO_2 emissions (saved)
    - Local air quality monitoring
    - Mobility patterns (e.g., to determine well or poorly serviced areas or key locations for mobility hubs or charging infrastructure)
  - Present the data in a "smart city dashboard" for cities and other public authorities
- A transport operator or mobility provider will:
  - Gain a mandate to operate in a certain area, or receive similar benefits
- A city or public authority will:
  - Receive processed data in a dashboard that allows the city or public authority to:
    - Gain insight into behavioural patterns of users and of mobility in their city or area
    - Gain insight into key sustainability parameters

Finally, Table 9 gives an overview of the connection between this use case and the overall eMaaS project goals.

Table 9 – Relation between "Use Case 4: Data Sharing for Cities" and eMaaS project goals

User Motivation & Empowerment	• One of the key aspects of the shared mobility is that it can spark a grassroots development of communities centred on this proposition. In this use case, it is relevant to explored how this can be supported. Furthermore, cities can make better choices towards their sustainable mobility planning and therefore motivate their citizens (the users) to utilise this form of mobility while at the same time empower them towards societal goals.
Standardisation	• We will further explore standardisation (such as the recently initiated City Data Standard or CDS working group inside the TOMP-API group) as already mentioned in use case 3, but in particular towards a standardised manner to aggregate data of different transport operators or mobility providers.

Integration	• As mentioned under use case 3, integration is better represented in use case 1 & 2.
Visualisation	• The use case data sharing for cities has an obvious and very strong connection to visualisation, as the visualisations will provide cities with the required insight, not the data itself. In this use case, we will explore various types of visualisations and evaluate their effectiveness.

3.3 CONCLUSIONS

In this chapter, we have discussed our process and rationale for the selected use cases. These use cases address existing and relevant challenges in the eMaaS market and hold value to both society and the members of the consortium.

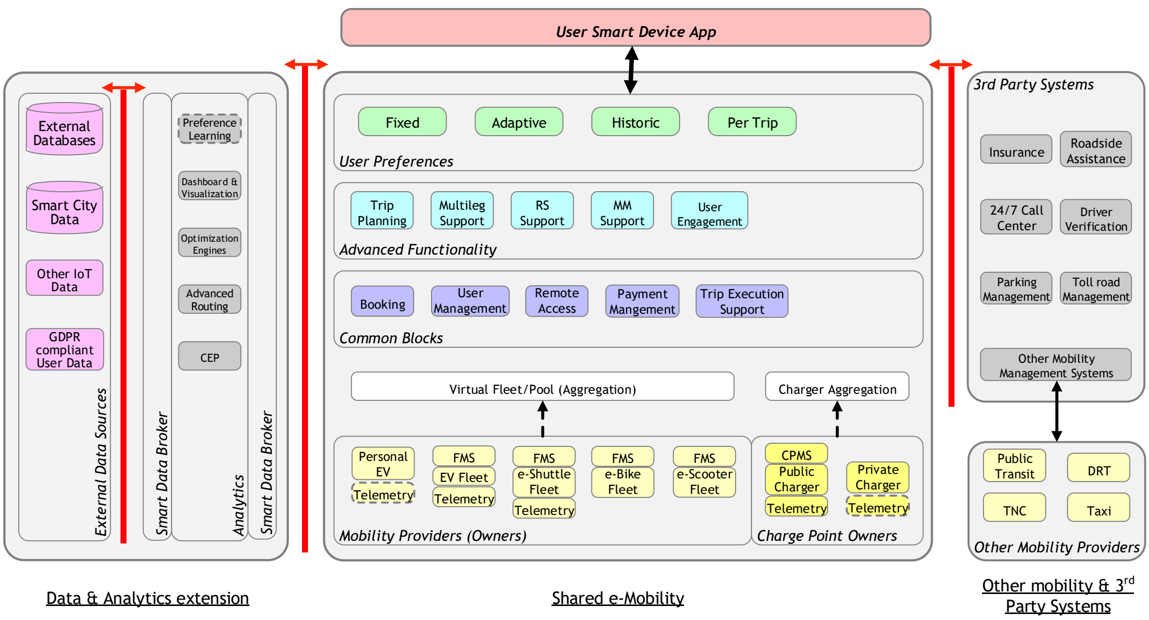
The use cases can be divided into two distinct categories, with each two use cases that support further exploration within the category. For roaming, this is addressing the technical challenges that come with national roaming (Use Case 1) and the perhaps more organisational challenges that occur for international roaming (Use Case 2). For data sharing, the focus is divided between supporting the businesses in the eMaaS ecosystem with handling their data (Use Case 3) and to utilise data to monitor and be able to steer towards societal goals (Use Case 4).

4 ARCHITECTURE DESIGN

In this chapter, we establish the underlying design needed to meet the use case requirements outlined in the previous chapter. Therefore, the eMaaS consortium has created several designs that together constitute an architecture for eMaaS. These designs comprise a functional architecture, a software architecture, a standardised interface – the TOMP-API – between transport operators and MaaS providers. For the eMaaS project, the TOMP-API is a main enabler for Use Case 1 (National Roaming) and Use Case 2 (International Roaming). Note that these architecture descriptions are not only technical in nature. It also helps to clarify the roles and relations between actors in the eMaaS ecosystem and thus outlines possible business models.

4.1 EMAAS - FUNCTIONAL ARCHITECTURE

In our market assessment (Chapter 2), we also identified various existing conceptual architectures[17] that describe some of the elements in the eMaas ecosystem shown in Figure 1 (p2). However, in that assessment we also identified that there is not yet an open architecture that can be used as a base for the further development of eMaaS. This section highlights the functional architecture for eMaaS presented in that publication.
The functional architecture proposed here is composed of functional blocks and elements that cover all elements within the eMaaS ecosystem. As shown in Figure 10, the architecture can be explained by dividing it in three main blocks, namely (1) Shared e-mobility, (2) Data & Analytics extension, and (3) Other mobility & 3rd Party Systems. One of the distinctive characteristics of this architecture is that it is more extensive than the ones intended for MaaS systems. It not only covers electric mobility requirements such as charging points' management and EV fleet management, but also combines elements that not all architectures take into account (e.g., smart data brokers' integration and advanced analytics).
Having a clear overview of the elements in this functional architecture helps in the development of eMaaS by identifying the requirements, functions, stakeholders and interfaces that need to be covered. With the eMaaS architecture proposed here, all the required capabilities of eMaaS are covered. The architecture takes into account the additional elements of Electric Mobility Systems (such as EV fleets and charging points, etc.) and Shared Electric Mobility Services (such as e-car sharing, e-bike sharing or e-scooter sharing, and even extra mobility modes such as e-public transport or demand responsive transport).



CEP: Complex Event Processing | CPMS: Charge Point Management System | DRT: Demand Responsive Transport | FMS: Fleet Management System | MM: Multi-Modal
RS: Ride Sharing | TNC: Transportation Network Company (e.g. Uber, Lyft)

Figure 10 – Functional eMaaS Architecture[17]

[17] For details see: Reyes García, J.R.; Lenz, G.; Haveman, S.P.; Bonnema, G.M. State of the Art of Mobility as a Service (MaaS) Ecosystems and Architectures—An Overview of, and a Definition, Ecosystem and System Architecture for Electric Mobility as a Service (eMaaS). World Electr. Veh. J. 2020, 11, 7. https://doi.org/10.3390/wevj11010007

4.2 IEEMAAS - SOFTWARE ARCHITECTURE

In the project, we also explored a software architecture that focuses more on the system's elements and interconnections. This software architecture has been part of one of the publications done in context of this project[18], the architecture visualised in Figure 11 is an extension of the architecture presented there.

The architecture covers various roles (light gray) and interconnections, or interfaces, (dark gray) between those roles. It includes charging infrastructure with the existing Open Charge Point Interface protocol (OCPI) and Open Charge Point Protocol (OCPP) as interfaces. It further illustrates no less than seven potential locations for (open) APIs within the eMaaS ecosystem. Within the eMaaS project, we have actively worked on the TOMP-API between (e)MaaS Provider and Transport Operator and we discuss this in more detail in the next section.

Of course, the roles presented here could be combined within one actor, for example by combining the block "eMaaS provider SW" with "Transport Operator Back-End". In that case, the interface is still present but somewhere internal in a company's systems. We have observed that the transition to eMaaS sometimes forces organisations to open up their systems, for example if company A acting as both eMaaS provider and as transport operator also wants to connect as eMaaS provider to transport operator B, or, conversely, if another eMaaS provider (company C) needs access to the vehicles managed by the transport operator role of company A.

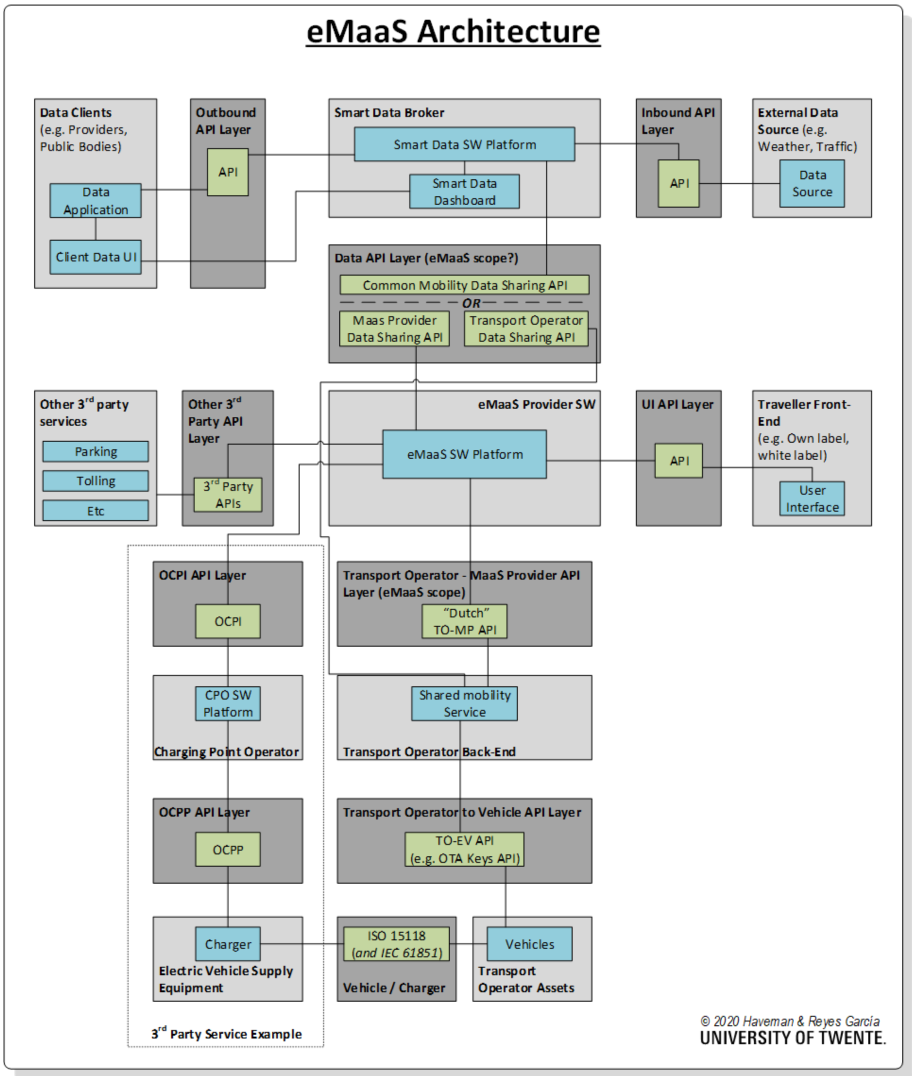


Figure 11 – eMaaS Software Architecture with a focus on roles & interfaces[18] (adapted)

[18] *For details see: Haveman, S. P. , Reyes García, J. R., Felici, E. , & Bonnema, G. M. (2019). Creating effective MaaS systems: Using a systems engineering approach to design an open (e)MaaS architecture. Paper presented at 13th ITS European Congress 2019, Eindhoven, Netherlands.* http://www.emaas.eu/wp-content/uploads/Creating_Effective_MaaS_Systems_ITS19_Eindhoven.pdf

4.3 TOMP API – STANDARDISED INTERFACE

As highlighted in the previous section, the eMaaS consortium has and still is actively participating in the development of the so-called TOMP (Transport Operator & MaaS Provider) API[19]. The University of Twente has been one of the leading parties in the Working Group that governs these developments, GoodMoovs is one of the first parties to develop a working implementation of this API and [ui!] Urban Software Institute is an active participant in the Working Group meetings. Originally, the Working Group was established by the Ministry of Infrastructure and Water Management in the Netherlands and combines earlier efforts of two separate working groups, one between bike-sharing providers and one between car-sharing providers.

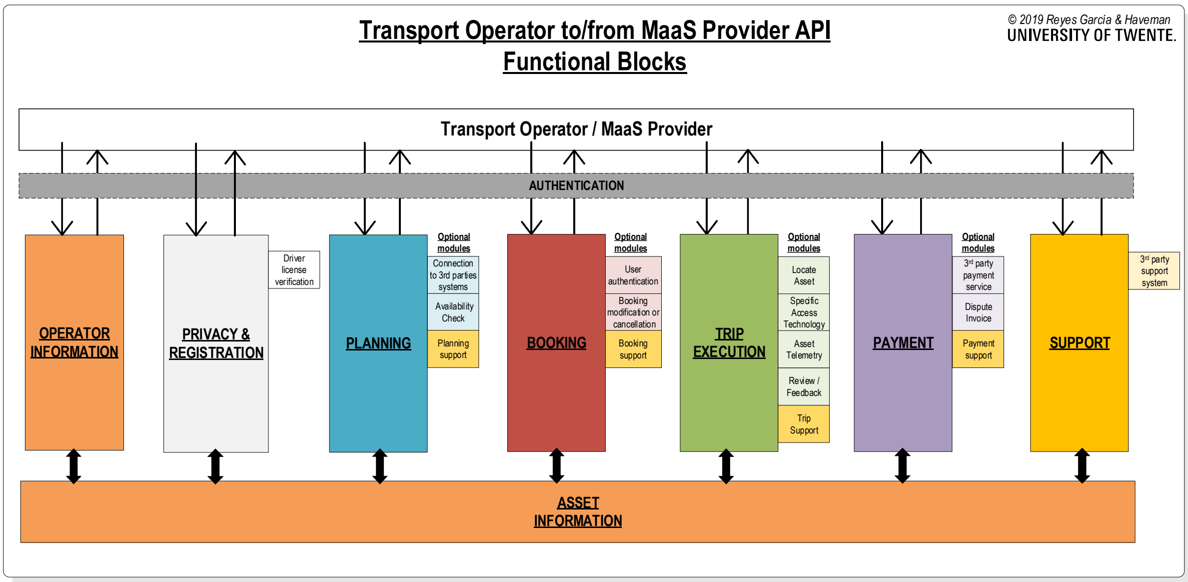


Figure 12 – TOMP API Functional Blocks[19]

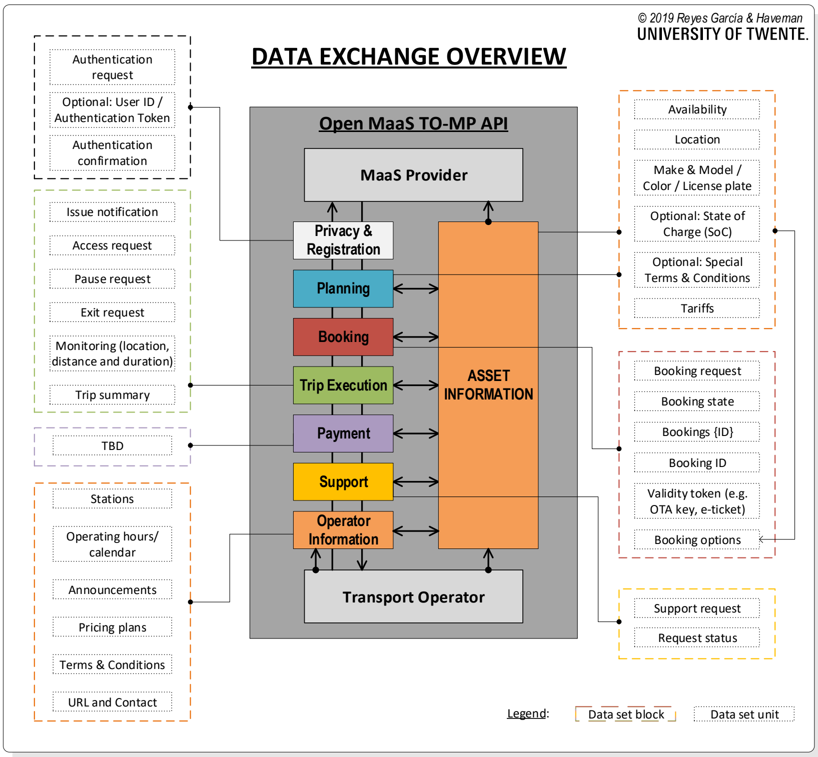


Figure 13 – Data Exchange Overview in the TOMP-API[20]

[19] For details, visit: https://github.com/TOMP-WG/TOMP-API

The goal of this API (and the working group developing it) is to provide a generic and open interface between MaaS Providers and Transport Operators, enabling an open ecosystem. The API facilitates the open ecosystem by lowering entry barriers of new actors on the market as they can connect easily to a wide range of stakeholders. In the Netherlands, public authorities have begun to establish usage of the TOMP-API as an entry requirement for MaaS Providers and Transport Operators in cities.
In Figure 12 the main functional blocks of the API are visualised. These include operator information, privacy & registration, planning, booking, trip execution, payment and finally support. All of these blocks are supported by a separate block that includes asset information. Figure 13 provides an overview of some of the data elements that constitute the messages in these functional blocks. Standardised communication on all of the elements in these functional blocks is required for a fully supported process. However, a limited subset can be chosen for initial implementations as well. The design of the TOMP-API not only governs a specification for communication messages, but also ties this to an operational flow in which the order of messages and thus the manner of operation is standardised also. More details on this operational flow are described in the TOMP-API Blueprint[20].

4.4 CONCLUSIONS

In this chapter, we have presented two architectures for eMaaS developed as part of this project. We feel that together, these two representations provide a solid foundation and reference for any developments in the eMaaS ecosystem. We also highlighted one of these developments, the TOMP-API. In Figure 14 we made a mapping (indicated by the orange circles with numbering) between the two representations, and highlighted the role of the TOMP-API in this mapping.

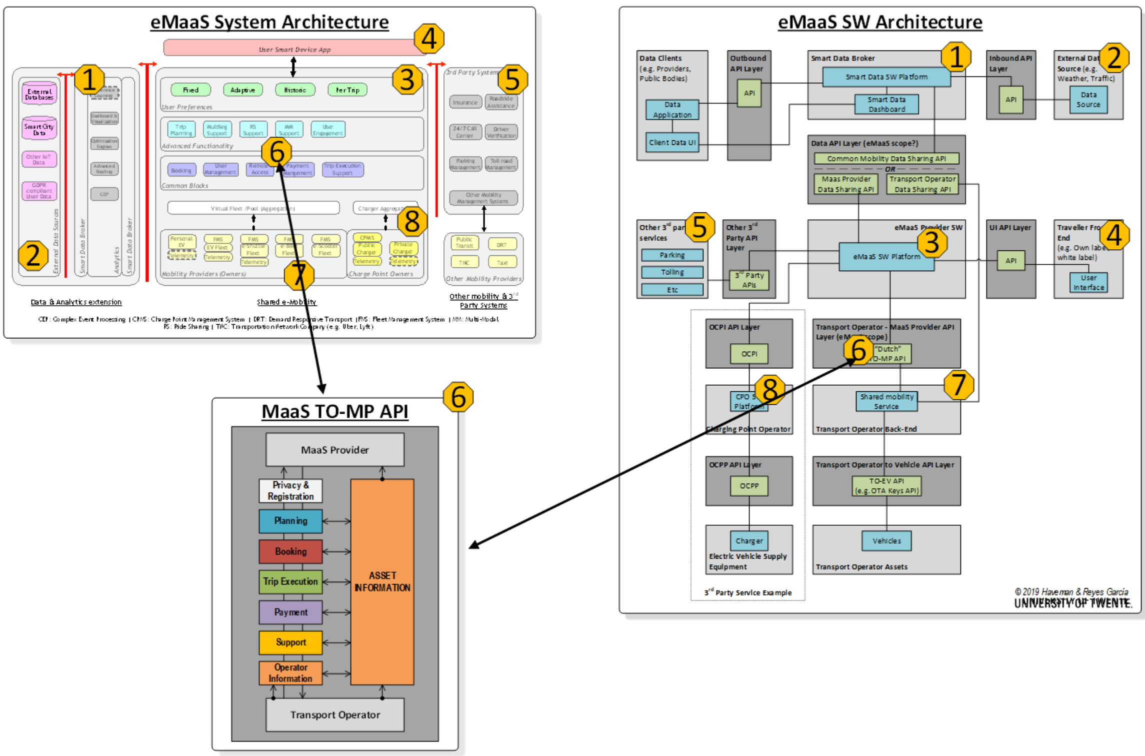


Figure 14 – Mapping between various presented Architecture Views

[20] Felici, E., van den Belt, E., Reyes Garcia, J. R., & Baart, R. (2019). *Blueprint for an Application Programming Interface (API) from Transport Operator to MaaS Provider - Version 1.1: A first technical milestone towards Mobility as a Service (latest version via https://github.com/TOMP-WG/TOMP-API)* .

5 DATA SHARING & VISUALISATION

In this chapter, we highlight some of our work on data sharing & visualisation, that was done mainly in the context of Use Case 3 (eMaaS data sharing for businesses) and Use Case 4 (eMaaS data sharing for cities). First, we discuss our insights on value propositions for data sharing in the eMaaS ecosystem. Second, we share various visualisations that are the results of our efforts and illustrate the value of enabling data sharing, processing and visualisation. Thirdly, we share results of our work on data dashboards and finally we provide several conclusions on our data sharing & visualisation work.

5.1 EMAAS DATA SHARING VALUE PROPOSITIONS

During the project, various workshop sessions as well as further discussions centred around the value that can be created through data sharing in the eMaaS ecosystem. To sum up some of our deliberations, we created the visualisation in Figure 15. This visualisation presents three main value propositions, of which the first and second relate to Use Case 3 (eMaaS data sharing for businesses) and the third one relates to Use Case 4 (eMaaS data sharing for cities). All of these three propositions offer ample grounds for worthwhile business models.
The first proposition, supporting transport operators and MaaS providers in data processing and analysis allows those parties to do what they do best and want to focus on - providing mobility to their customers.
The second proposition is a more advanced version of the first proposition, as the value added comes from the combination of mobility data of a transport operator or MaaS provider with external data sources.
The third and final proposition is that of data sharing to external parties, with the cities and other public authorities as main customer, but also external third party systems or data marketplaces could be customers.

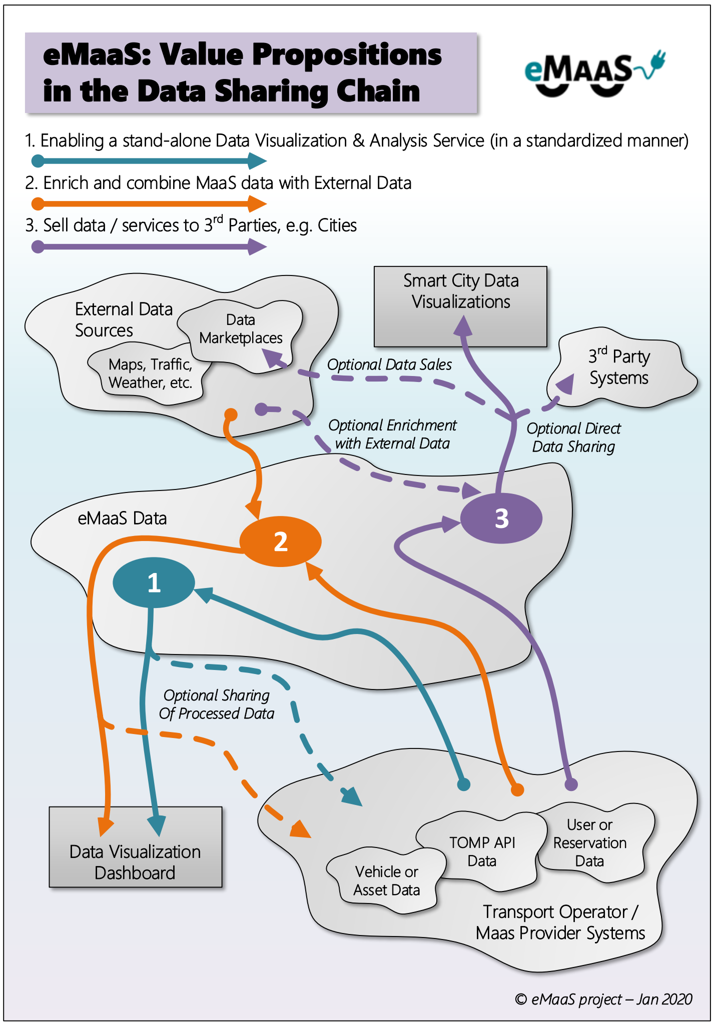


Figure 15 – eMaaS Data Sharing Value Propositions

5.2 DATA VISUALISATIONS

During the project, we have retrieved data from various sources from within the systems of those consortium partners who are mobility providers (GoodMoovs & Move About). These data sources are mainly comprised of booking data and telematics from vehicles. In this section, we share some of the analyses and visualisations that were conducted with these data.

In Figure 16, we give some examples that are based solely on vehicle booking data and associated parameters such as trip type in case of visualisation B, or most used location in case of visualisation D. The figures give insight into behavioural patterns, for example the “over-reservations” occurring visualised in A, as well as the preference of users for certain car models for certain trip types. From a business perspective, it shows that there is a consistent distribution between usage of vehicles per individual user in visualisation C. At the extremes of this plot is visible that about 500 people have made one or two bookings, but about two people have made 500 bookings. In visualisation D it can be seen that there is a strong preference for “location 4” as pick-up location. However, this is a corporate car sharing data set so in that sense the preference for a single pick-up location is not surprising. We also have made these visualisations for non-corporate car sharing were the balance between pick-up locations is spread more evenly.

We also created visualisations based on vehicle telematics. Figure 17 gives one example that is especially relevant for eMaaS, as we can monitor vehicle charge levels and user behaviour regarding these charge levels in high detail. This particular visualisation is to drill down in a single vehicle, but others can be made to indicate where and when users have to interrupt trips for intermediate charging.

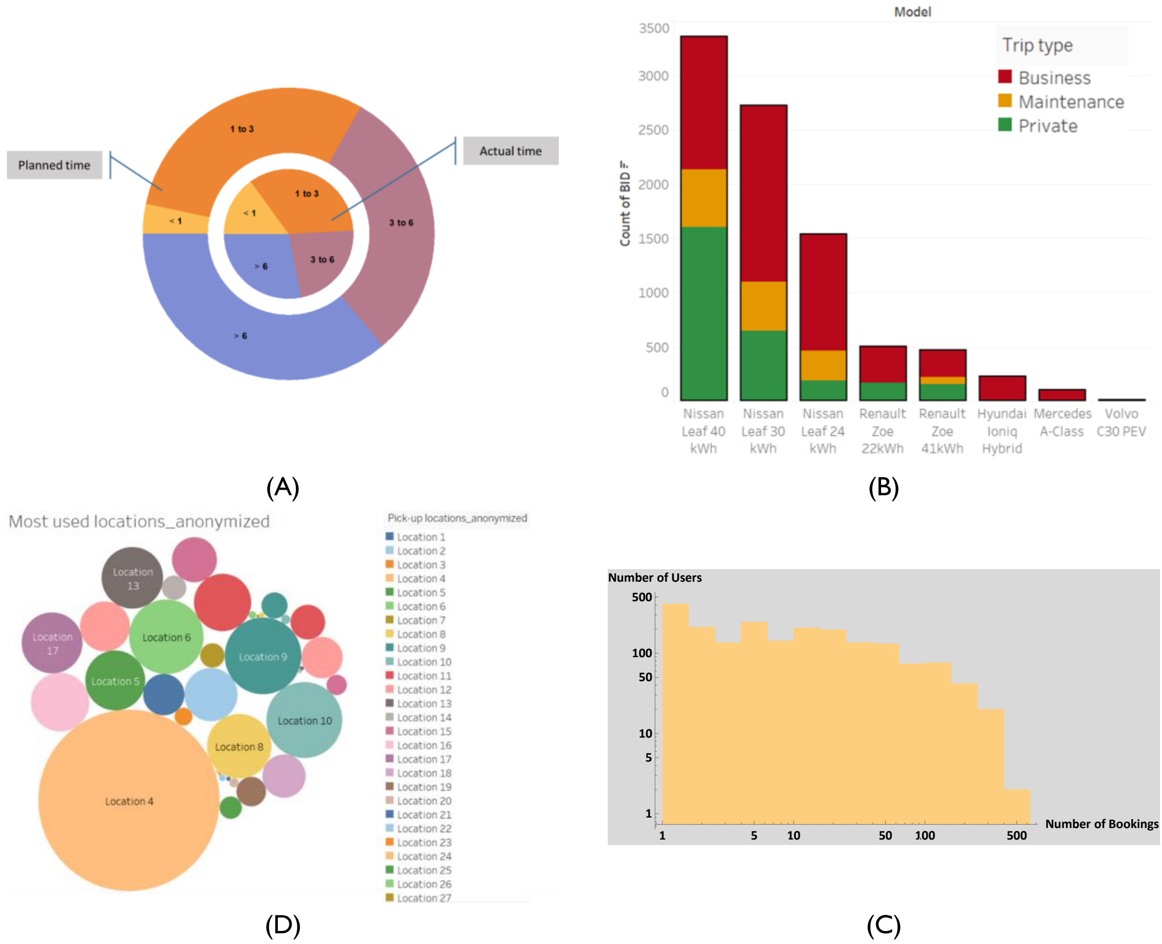


Figure 16 – Examples of Data Visualisations based on booking data. Clockwise from top left:
(A) Visualisation of reserved time of vehicle in booking and actual time used
(B) Number of bookings per vehicle model, split per trip type
(C) Histogram of number of bookings made per individual user (on a log scale)
(D) Overview of most used pick-up locations for a corporate car sharing dataset

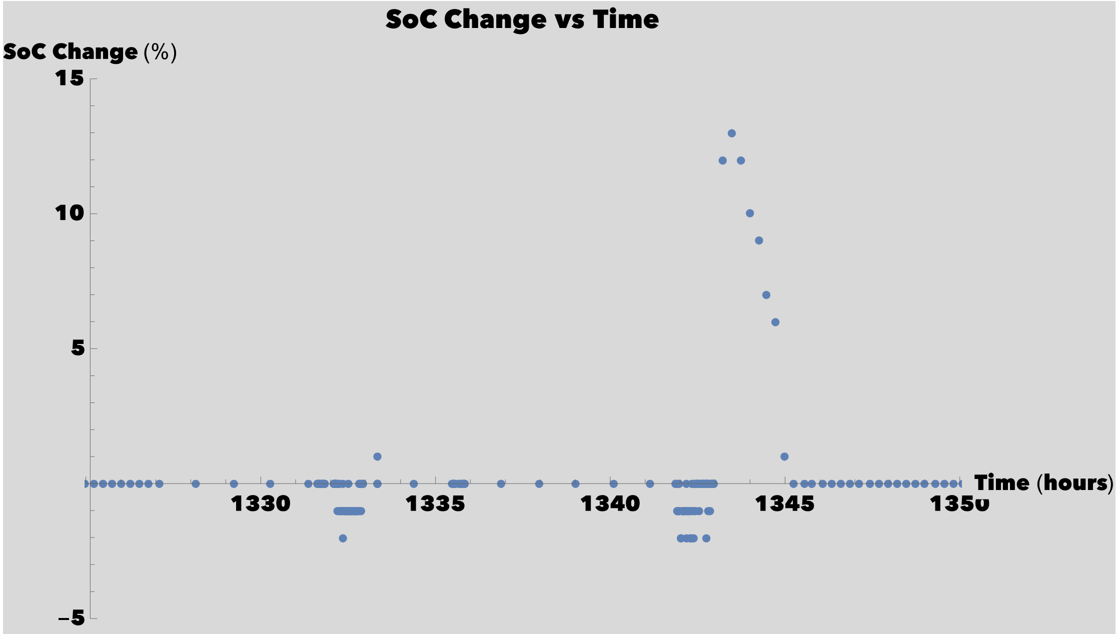


Figure 17 – Example of Data Visualisations based on Telematics – The change in a State of Charge (SoC) for a single EV during a day

Finally, we also created visualisation based on a combination of booking data and telematics, revealing even more usage patterns and other trends. For example, Figure 18 gives an indication of the average distance (in km) driven per hour of a booking, which is clearly relatively low. This can be caused by long standstills of the vehicles as, for example, in a corporate environment people use the vehicles to drive to and from appointments. This is also a result of the fact that the consortium partners mainly operate station-based. In a free-floating scheme, the booking more often ends when a destination is reached and thus there is no idle parking time bringing down the average.

Figure 19 shows a similar trend in which the duration of the booking is mapped against the total distance travelled. As can be seen, most bookings fall in the short duration, short distance category, and it is also clear that there are more long bookings with low distance than short bookings with high distance.

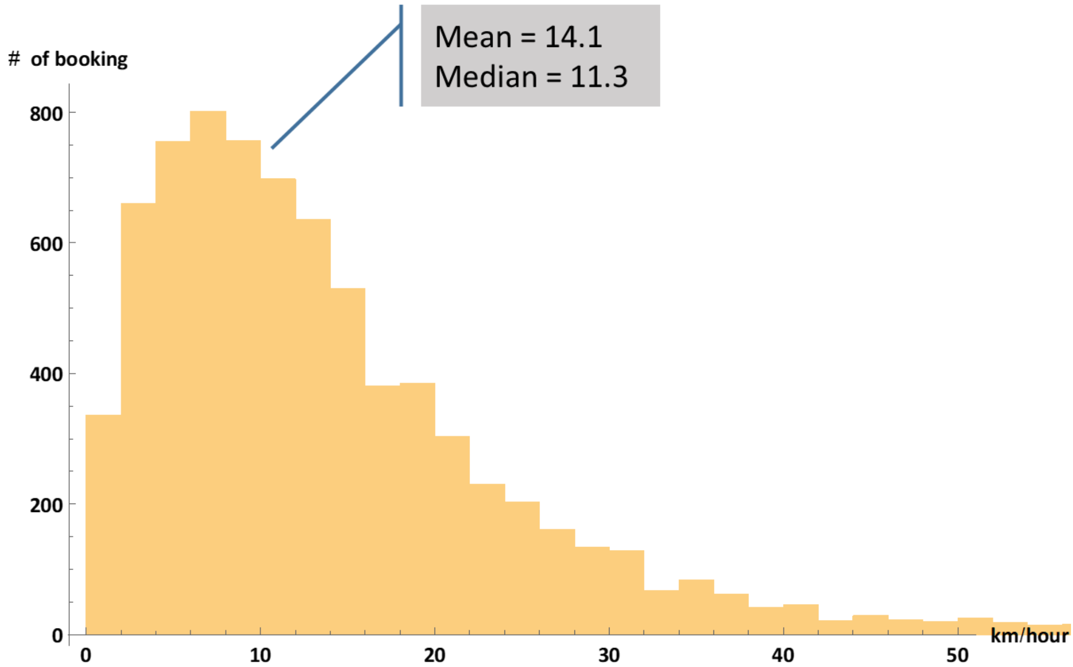


Figure 18 – Example of Data Visualisation based on combined Booking Data and Vehicle Telematics: Visualisation of average number of km driven per hour of actual booking

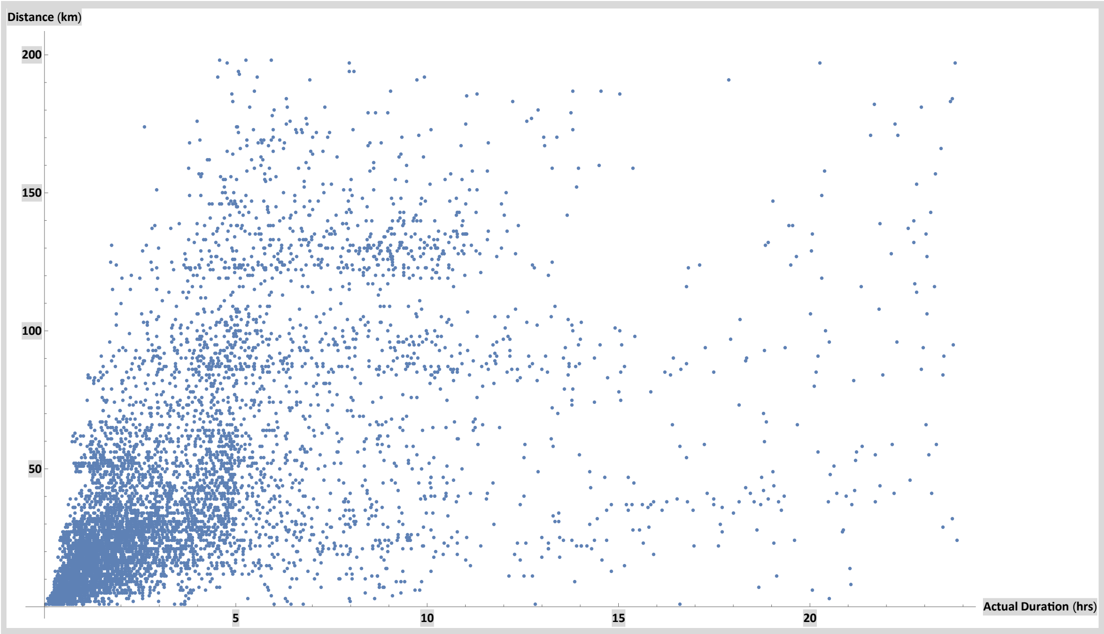


Figure 19 – Example of Data Visualisation based on combined Booking Data and Vehicle Telematics: Plot of booking duration (x-axis) versus total distance travelled (y-axis)

In this section, we have shown various visualisations that we found useful to understand the performance of the mobility providers in the eMaaS ecosystem and that also gave more insight into behavioural patterns.

5.3 DATA DASHBOARDS

During the project, we not only did manual analysis and created various visualisations, but also set up a more permanent data sharing connection between partner systems. A data dashboard, developed especially for this project, was used to show the received data. Figure 20 and Figure 21 show several screenshots of the dashboards and associated visualisations.

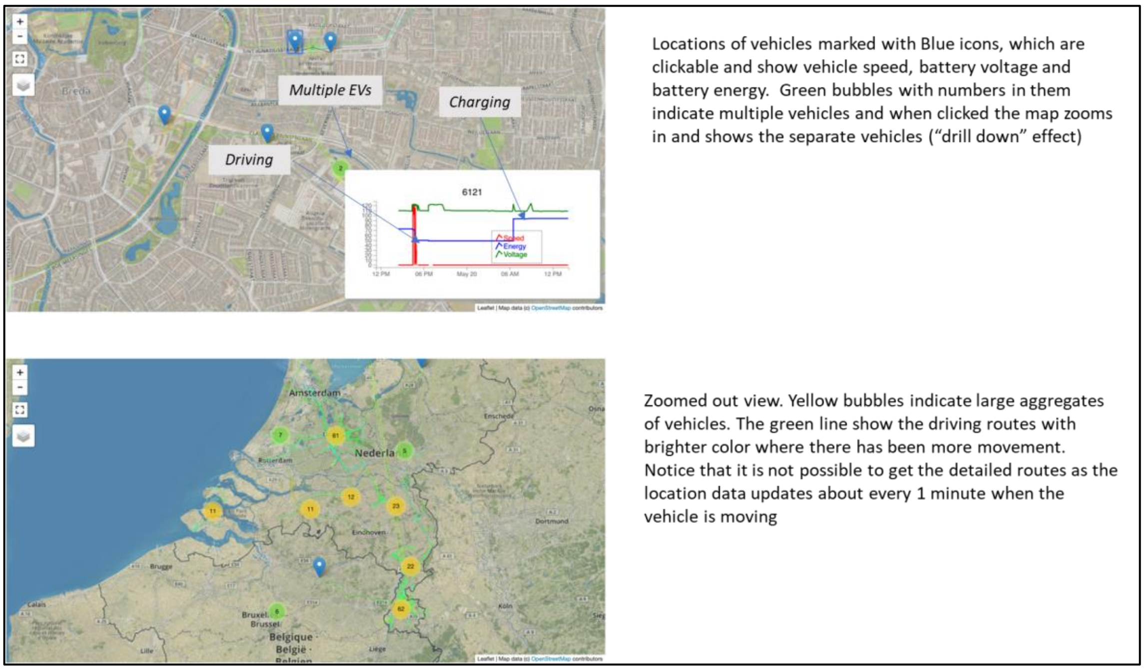


Figure 20 – Example of Data Visualisations for a Car Sharing Operator Dashboard

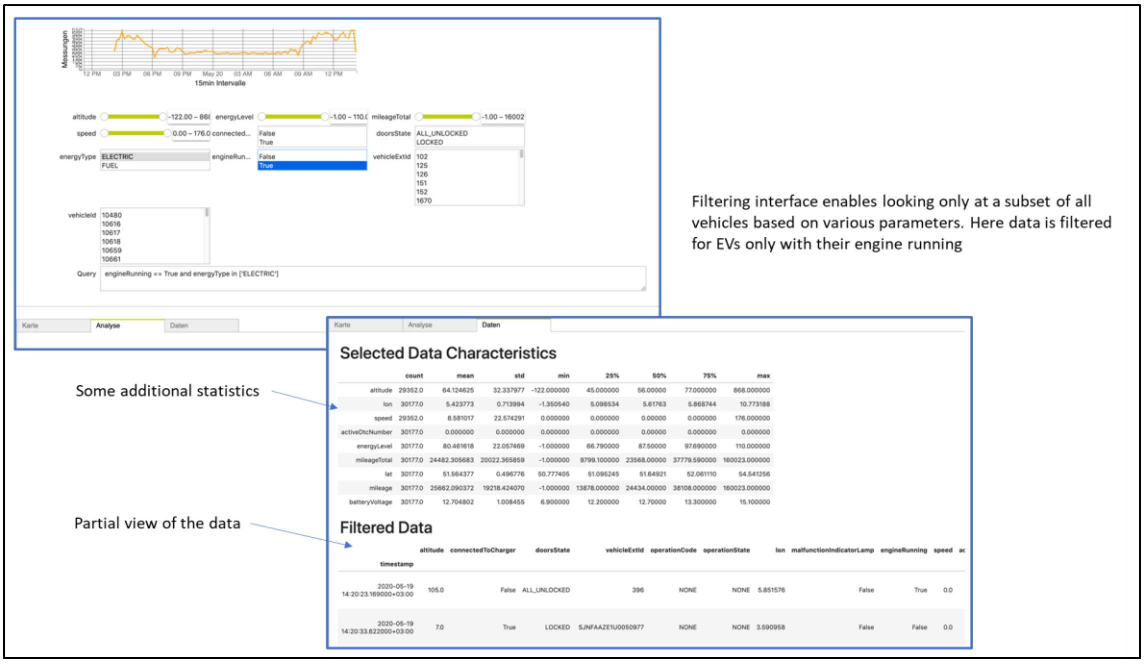


Figure 21 – Example of Data Visualisations for a Car Sharing Operator Dashboard

5.4 CONCLUSIONS

In this chapter, we have highlighted several of our activities in data sharing & visualisation. These activities have taken place in the context of Use Cases 3 & 4 as defined in Chapter 3.

We have identified that there are various value propositions for data sharing & visualisation services in the eMaaS ecosystem and have elaborated on some of those. The visualisations in this report are mainly meant as a source of inspiration to show in what manner data can be analysed and what type of visualisations can be made based on these data.

6 LESSONS LEARNED

In this chapter, we discuss the lessons learned in our project. We already have shared some of those in preceding chapters, but we provide new ones here and summarise what has been stated earlier. First, we shortly highlight some of the activities we conducted in a more practical manner is section 6.1. Section 6.2 then, contains the actual lessons learned, categorized per stakeholder category. Finally, we end the chapter with some conclusions.

6.1 WHAT DID WE DO IN THE PROJECT?

The main goal of the project was initially to launch and evaluate a cloud-based open electric-mobility as a service (eMaaS) back-office solution. This solution would consist of a suite of management functions, which both enables the shared usage of e-mobility, fleet management functions (routing & scheduling, maintenance management, billing, etc.) and integration of existing mobility applications. During the project, we decided to focus on data integration and visualisation, per our defined use cases.
In the end, we conducted a wide range of activities next to those already reported in earlier chapters (e.g., market assessment, technical design) of which several are highlighted here:

- [ui!] Urban Software Institute focused mainly on data visualisation and integration. In this, they analysed various data sources, connected to the back-ends of partner systems and delivered data visualisations and automatically updated dashboard with eMaaS data.
- GoodMoovs focused mainly on integration of different services and has made a first implementation of the TOMP-API to connect to other mobility providers' systems.
- ZET Austria (formerly MoveAbout Austria) focused mainly on new use cases and technology developments. One of the realised implementations was a sustainable journey planner for participants of the Future of Transport Global Conference in Vienna, 2019. Another is a quick-access sharing software built to be compatible on the hardware that the other consortium members are using.
- Move About Sweden expanded the number of accessible vehicles from 100 at the project start to 423 at the end. They also launched enhanced electric bike sharing, cargo e-bike sharing as well as introducing early versions of ridesharing. Parallel to this, they focused on improving and extending key services in the eMaaS ecosystem and working with local stakeholders to further evolve the eMaaS solution.
- The Urban Institute Hungary has built a fleet analysis toolkit in collaboration with the municipality of Szeged. This toolkit focuses on outlining the possibilities to transition to electric and shared mobility. Furthermore, they have developed a simulated environment for a MaaS solution in the city of Budapest.
- The University of Twente has been an active and leading collaborator in the development of the TOMP-API Working Group, focusing on functional design of the API and organisation of the working group.

6.2 WHAT DID WE LEARN?

As we shortly highlighted our more practical activities in the previous section, we share our lessons learned during those activities in this section. We have categorized the lessons learned in six stakeholder groups and mentioned each lesson learned for the most applicable stakeholder only, but sometimes they of course hold true for more than one stakeholder. The six stakeholder categories are consumers, companies (as customers), transport operators & mobility providers, data service providers, public authorities and finally the "open market".

6.2.1 EMAAS FOR CONSUMERS

- For a consumer, (we refer to the user who wants to travel), ease of use is the key priority. A user does not want to get information overload by being presented with all alternatives that are available. A user wants a simple way to be informed that what is suggested is the best transport option aligned with his or her preferences. We want to convey that the best way to travel is electric. Therefore, we have to maximize all the advantages that electric transport provides.
- The integration of all available data in the way eMaaS is proposing, is therefore the necessary basis for creating the synergies between various electric mobility options, but from the user perspective, still further

understanding is needed of what data and information is needed and what is required to make a better product and service in the future.

- As the power of habit is strong, and since many people are still used to own a car, the consumer needs a big "carrot" in terms of attractive benefits for using eMaaS, as well as a painful "stick" with clearly raised costs for owning an private car. Also, smaller benefits like free (and thus also *hassle*-free in terms of escaping the practicalities of paying a parking ticket) parking for shared electric cars could be an important contribution, as it psychologically makes the consumer feel like a winner.
- The adoption of shared e-bike services among consumers has been slow and requires more exploration and incentives. It seems many people prefer to own their own e-bikes, rather than sharing them, as it is viewed as more practical and the cost of owning an e-bike is much less than owning a car, which make e-bikes less prone to sharing. In Sweden, it was seen during the project that consumer usage of shared e-bikes is still very low, with no positive trend in sight. We have learned that the end-result of a multi-modal integration, as we tested on a national level in the ZET.link programme in Austria, was appreciated. As a product it competes with large global players, like Google, which are trying to combine such services with commercial product promotions (advertising for sales of goods and services "along the way") which are regarded by many consumers as a rising nuisance.

6.2.2 EMAAS FOR COMPANIES

- Companies as part of their corporate responsibility strategies are increasingly accepting electric mobility. This means that the inclusion of electric vehicles is not only a superficial expression of environmental understanding, but becomes a part of the urgency to do something about the climate impact of corporate transportation, but also on understanding the bottom line impact.
- This means that the economic impacts and benefits of electric mobility have come more into the focus of corporate attention. The eMaaS approach of optimizing numerous electric transport options also within the company mobility demand, and the transparency the eMaaS project aims to achieve, are now seen as important drivers of such a trend.
- For companies, a proper and seamless integration of the information regarding multi-modal transport options, and how they can be accessed by the responsible persons in large companies, is important.
- We had discussions with several corporations who also asked if the same approach can be sued for optimizing the transport of goods, especially packages. They see that small goods transport is exploding and package delivery is beginning to clog streets, as well as heavily increasing the climate impact from delivery of the goods companies need as resource or want to deliver to their customers. As a result, some preliminary options of a similarly standardized approach for package delivery have been discussed by several member of the consortium.
- The experience in encouraging local companies or public authorities as well as operators to put more focus on electric mobility in the Hungarian case shows that we need "local champions" that can raise the in-house interest and excitement about the electric mobility models we propose in the eMaaS project.

6.2.3 EMAAS FOR TRANSPORT OPERATORS & MOBILITY PROVIDERS

- In order to facilitate integration between systems, especially those of Transport Operators (TO) and Mobility Providers (MP), we have implemented a Minimum Viable Product (MVP) version of the open TOMP-API (short for Transport Operator Mobility Provider) in the GoodMoovs platform. We also convinced a number of external partners to start (or intend to start) with the implementation of the TOMP-API within their systems as well.
    - We have had discussions with various partners about the application of the TOMP-API. From these conversations several possibilities have emerged. The first is a so-called roaming function, in which two Transport Operators open up their fleet to each other's users. This possibility is currently being implemented cross-border in cooperation between GoodMoovs and an external partner, Hub2Go.
    - Another possibility is connecting MPs with TOs. GoodMoovs is in negotiation with three MaaS Providers in which the GoodMoovs fleet is opened to users of different MaaS apps.

- With respect to the integration of charging services, we see possibilities to use the TOMP-API to facilitate smart charging. This application uses the API request on the availability of shared cars to determine when and how fast these cars should be charged, taking into account real-time data from the energy markets.
- Multi-modal journey optimization still poses many challenges. Mainly because of the fact that the possible optimization is difficult as it entails a very large number of alternative combinations, requiring a large amount of computing power. In recent years new machine learning approaches and increase data power makes such sequential optimization possible, which we have tried in the Austrian case.
- We learned that involving the local public transport provider is key. This means that the information flow to the city that controls the public transport is an important element to make eMaaS successful, which again underlines the need for standardization of information to do this efficiently. The TOMP-CDS efforts in this regard are very important.

6.2.4 EMAAS FOR DATA SERVICE PROVIDERS

- We successfully managed to offer a broker service for rich real-time data gathered from e-cars during the operation. To do so, we integrated the Urban Institute data platform and the GoodMoovs sharing platform.
  - The visualisation of vehicle data provides new insights into the use of the shared cars. Displaying trips on a map gives an immediate impression of the vehicle usage, which destinations are there and which routes are chosen, how the utilization develops during the COVID-19 crisis, etc.
- We realised early on that an eMaaS platform is inherently a data platform and has the potential to offer much more than operational services. Data that originates from vehicles (via telematics) and from Transport Operators' booking systems brings value to the Transport Operators (TOs) themselves (after analytics and visualisation are used to produce new insights) and to other stakeholders such as cities
  - The value of such data for cities was realised also in the TOMP-API Working Group where a new subgroup has been established to advance mobility data for cities (TOMP-CDS, City Data Standard)
- Implementing an interface between the data stores for the TOs (including telematics data and booking data) and the UI platform, has also proved to be initially challenging. Here too, business value had to be demonstrated.
  - We had to start with receiving simple spreadsheets from the TOs themselves (receiving telematics data from their telematics provider), producing visualisations based on analytics and showing results that had clear value (as discussed in Lessons Learned from Transport Operators & Mobility Providers)
  - We also realised that real-time data collection and analysis was even more difficult to handle and not necessarily required in these initial phases. It is still an open question if and when real time data in this context is really required and/or brings additional value. In the future, data sharing of this type may become a part of the TOMP-API, or more likely be standardized in a separate Mobility Data API.
  - From our involvement in larger MaaS platforms we also realised that such data will also be required for more sophisticated MaaS services such as advanced intermodal planners/routers that include both shared mobility TOs and public TOs.
  - Once the data interfaces had been developed and tested, regular data transfer was handled automatically, and visualisation tools could be developed and shown.

6.2.5 EMAAS FOR PUBLIC AUTHORITIES

- Several public authorities we talked with expressed an interest in the eMaaS approach. They underlined that in order to encourage a wider roll-out of electric mobility, they need to understand the impacts of various initiatives, and therefore must be able to follow the initiatives they are asked to support. The clear and easy communication as proposed in the eMaaS project is important for them.
- Public authorities do not want to have detailed information about who is using what type of transport, in order not to infringe on GDPR requirements. Nevertheless, they need some anonymous analysis to understand trends and movements. This has become even more relevant after the COVID-19 situation, and will clearly impact the post-crisis situation, where public transport sees strong challenges. The TOMP City Data Standard efforts in this regard are really important.

- It helps when governments require the availability of the TOMP-API in the context of tenders. This is currently already the case in the Netherlands and results in several TOMP-API implementations in the near future (e.g., seven nationwide MaaS pilot projects[21]).
- Municipalities and cities could accelerate the transition to eMaaS in society by helping eMaaS-operators with accessible and visible street parking, which we (in terms of usage) have clearly seen is the ideal spot for shared electric cars. Not only would more shared zero-emission vehicles reduce congestion and contribute to reaching the climate goals, it would also provide cleaner city air and reduce traffic noise levels.
- Governments, cities, municipalities and regions as well as government agencies, universities and institutions can help the transition to eMaaS by "clean procurements" where they lead by example by only purchasing fossil-free eMaaS for their own mobility needs.

6.2.6 EMAAS FOR THE OPEN MARKET

- Any MaaS platform – one that brokers between mobility users and transport operators (TOs) – requires a common API. The TOMP-API is exactly such a MaaS API that enables advanced mobility services such as roaming (explored in this project). As [ui!] Urban Software Institute already has much of the data infrastructure, the UI platform (with suitable enhancements) is considered as a candidate for being a MaaS Platform.
- A MaaS platform will only work if there are multiple (at least two) TOs, all of which are implementing and adhering to the same API (in our case the TOMP-API). The more TOs adopt the common API the better the MaaS platform will be and offer real choices to the end mobility users.
- Practically, TOs have to see the value in investing development resources in the implementation of the API, which leads to a "chicken and egg" problem. We have therefore opted for a specific use case that offers real value to the TOs with relatively little development investment – the demonstration of roaming with two TOs (that are actually located in different countries).
- We have experienced that with the implementation of the TOMP-API the technical challenge is most likely not as big as the communication and coordination challenge. We have had several conversations with all potential partners to inform and convince them of the value of the TOMP-API. This process sometimes takes longer than a year. After that, the technical implementation can be started. This too is often underestimated. Potential partners find it difficult to free up budgets and capacity for the development of the TOMP-API.
- One partner, GoodMoovs, implemented the TOMP-API; a second partner, Move About, uses a previously developed API (that will hopefully be migrated in the future to the TOMP-API; this beyond the current eMaaS Project scope). A small piece of middleware could be developed to map between (the quite similar) APIs. Note that this effort when completed and integrated with the planned UI eMaaS Platform, will serve as a full eMaaS system capable of many more mobility services.

6.3 CONCLUSIONS

In this chapter, we have provided a short overview of our activities and a longer list of lessons learned. In this, we see that there are not only technical lessons learned, but also organisational ones.

On the topic of data sharing, we have learned that demonstrating the business value of visualisations is sometimes still hard to achieve but as more and more capabilities arise in this area, coupled with standardised ways of data sharing, this area could receive a huge boost too.

As highlighted in this chapter, implementing the TOMP-API for standardised communication still holds technical challenges, but even more organisational ones. There is also a chicken and egg problem. To the first parties, implementing the TOMP-API holds relatively little value, but as more and more parties join, the value can grow exponentially. Public authorities can play a role in this by setting use of standardised ways of communication and data exchange (such as provided by the TOMP-API) as a requirement in tenders or concessions.

[21] *For details, visit: https://dutchmobilityinnovations.com/spaces/1105/maas-programma/files/29510/brochure-maas-pilots-a4-en-190523-pdf*

7 OUTREACH

In this chapter, we give a short overview of the outreach conducted by the consortium during the project. The objective of our dissemination activities is to show the advantages of electric mobility combined with shared nobility for the widest possible audience, through various channels. One of the important objectives is to tear down mental barriers that withhold the spread of EV car sharing.

7.1 PROJECT WEBSITE (WWW.EMAAS.EU)

The eMaaS website (www.emaas.eu) has had the task to distribute regular information and news about the progress of the project and upcoming events. The website is up to date and contains all information in connection with conferences, workshops and publications.

7.2 CONFERENCES, ROUND TABLES, FAIRS AND WORKSHOPS

The consortium has taken part in various conferences, round tables and fairs. Near the end of the project in 2020, the COVID-19 outbreak has halted some of the planned participation in events. Nonetheless, the consortium has taken part in events ranging from:

- Events of the overall Electric Mobility Europe Program
- (Scientific) Conferences
  - Presentation at WoCoMoCo in Rotterdam, The Netherlands (2018)
  - Presentation at the 2nd IcoMaaS in Tampere, Finland (2019)
  - Project Pitch and Presentations at Electric Vehicle Symposium (EVS) 32 in Lyon, France (2019)
  - Presentation at the MaaS Congress in Rotterdam, The Netherlands (2019). We also published a summary of the event on our website.
  - Presentation at ITS EU Conference in Eindhoven, The Netherlands (2019)
  - *Participation in TRA 2020 was planned but cancelled due to COVID-19*
- Fairs and Symposia
  - Participation and panel discussions at the "Almedal week" in Gotland, Sweden (2018)
  - Pitch and Roundtable at the Micromobility Expo in Hannover, Germany (2019)
  - Participation in the Scandinavian real-estate fair in Stockholm, Sweden (2019)
  - Participation in the Ekotransport fair in Stockholm, Sweden (2019)
  - Participation in the Power Circle Summit in Gothenburg, Sweden (2019)
  - Presentation at the BOZAR Mobility Conference in Brussels, Belgium (2019)
  - Panel discussion at the EcoMobiel Expo in 's-Hertogenbosch, The Netherlands (2019)
  - Presentation at the Arise Symposium in Enschede, The Netherlands (2019)
  - Stand presentation at the E-Mobility Forum - Workshop and Exhibition in Budapest, Hungary (2019)
  - Presentation at the international MOVE Conference in London, UK (2020)
- Workshops
  - "The Future Council", IVA in Stockholm, Sweden (2018)
  - "Challenges of Urban Mobilty" in Visegrad, Hungary (2019)
  - "Rethinking transport – the modular autonomous bus- and parcel-on-demand solution" & "Affordable mobility software solutions" at the Future of Transport World Conference in Vienna, Austria (2019)
  - "Future Mobility: Care to Share?" for a delegation of Apollo Tyres in Enschede, The Netherlands (2019)
- Other
  - Presentation at the International Environmental Institute in Lund, Sweden (2018)
  - Panel debate with leaders from industry & politics in Gothenburg, Sweden (2019)
  - Presentation of the project at the eMobilitätstag in Bregenz (2019)
  - eMaaS has acted as case owner for the UN Global Goals Jam in Enschede, The Netherlands (2019)

7.3 PUBLICATIONS

The eMaaS consortium has made several (scientific) publications in the course of this project. They are all referenced in earlier chapters of this report. Noteworthy to mention is that one of the publications has won the best scientific paper award at the 32nd EVS conference in Lyon, France (2019). An overview is given below:

- Reyes Garcia, J. R., Lenz, G. , Haveman, S. P. , & Bonnema, G. M. (2019). State of the Art of Mobility as a Service (MaaS) Ecosystems and Architectures: An Overview of, and a Definition, Ecosystem and System Architecture for Electric Mobility as a Service (eMaaS). World Electric Vehicle Journal, 11(1), [7]. https://doi.org/10.3390/wevj11010007
- Reyes Garcia, J. R., Lenz, G., Haveman, S. P., & Bonnema, G. M. (2019). State of the art of electric Mobility as a Service (eMaaS): an overview of ecosystems and system architectures. In 32nd International Electric Vehicle Symposium (EVS32) – (Won best paper award)
- Reyes Garcia, J. R., Westerhof, M. W., Haveman, S. P., & Bonnema, G. M. (2019). From Shared electric Mobility Providers (SeMPs) to electric Mobility as a Service (eMaaS) players: A first approach to assess the Technical Level of Integration of Mobility Service Providers' functionalities applied to the European (e)MaaS market. In Proceedings of the 2nd International Conference on Mobility as a Service (pp. 162). Tampere, Finland.
- Reyes Garcia, J. R., Haveman, S. P., Westerhof, M. W., & Bonnema, G. M. (2020). Business models in the shared electric mobility field: A market overview towards electric Mobility as a Service (eMaaS). In Proceedings of 8th Transport Research Arena TRA 2020, April 27-30, 2020, Helsinki, Finland. (Conference cancelled).
- Haveman, S. P., Reyes Garcia, J. R., Felici, E., & Bonnema, G. M. (2019). Creating effective MaaS systems: Using a systems engineering approach to design an open (e)MaaS architecture. Paper presented at 13th ITS European Congress 2019, Eindhoven, Netherlands.
- Felici, E., van den Belt, E., Reyes Garcia, J. R., & Baart, R. (2019). Blueprint for an Application Programming Interface (API) from Transport Operator to MaaS Provider - Version 1.1: A first technical milestone towards Mobility as a Service.
    - And its consecutive version: Blueprint of the TOMP-API - version 1.2, by van den Belt, E., Reyes Garcia, J. R., & Baart, R. (2020).

7.4 NEWS ARTICLE

During the course of the project, we also reached out to wider audiences several times. Noteworthy publications in this regard are:

- "Weerstand tegen rijden op stroom" (resistance against driving electric) – Interview with Edward Bongers of GoodMoovs in the Limburger (regional Dutch newspaper) – 11-03-2020 (In Dutch)[22]
- "We Drive Solar ziet meerwaarde van nieuwe 'standaardtaal' TOMP-API" (We Drive Solar sees added value of new standard language TOMP-API) – Interview with Robin Berg, director of We Drive Solar (customer of GoodMoovs) on the website Dutch Mobility Innovations – 14-05-2020 (In Dutch)[23]
- "Mobility and the TOMP standard data flows" – An interview with Roberto Reyes Garcia and Steven Haveman of the University of Twente, posted on the HelloEV blog – 04-06-2020[24]
- "Halmstad has got their first electric car pool" – Interview with the city mayor of this Swedish West coast city that inaugurated an eMaaS hub (i.e., an electric car and e-bike pool) by the train station, to encourage multi-modal and emission-free travel (Swedish National Television) – 04-09-2018 (in Swedish)[25]
- "It will be odd to own your own car" – Interview with Mikael Kilter of Move About, regarding the increasingly changing behaviour towards eMaaS (Swedish newspaper ETC) – 13-02-2020 (in Swedish)[26]

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[22] See: *https://www.limburger.nl/cnt/dmf20200310_00151235/weerstand-tegen-rijden-op-stroom*
[23] See: *https://dutchmobilityinnovations.com/spaces/1105/maas-programma/articles/news/32471/we-drive-solar-ziet-meerwaarde-van-nieuwe-standaardtaal-tomp-api*
[24] See: *https://helloev.city/news/f/mobility-and-the-tomp-standard-data-flows*
[25] See: *https://www.svt.se/nyheter/lokalt/halland/halmstad-har-fatt-sin-forsta-elbilspool*
[26] See: *https://www.etc.se/klimat/det-kommer-vara-konstigt-att-ha-sin-egen-bil*

8 OUTLOOK

The eMaaS project does not conclude the efforts of the consortium partners towards eMaaS, but is merely a first stepping-stone towards establishing our full future vision for eMaaS. Through the eMaaS project, many developments have been put in motion that will be followed up in the near future. Additionally, the consortium partners in eMaaS have built up a better understanding of the various challenges in different countries, and an insight how the pan-European effort must be enforced with common standardized interfaces and solutions. Furthermore, various new avenues of development have been identified. To sum up our future ambitions:

- We aim to further solidify the development of the TOMP-API, and to further support the TOMP Working Group in their newly defined activity towards a city data standard (TOMP-CDS). We will do this by continuing our participation in the TOMP Working Group and by continuing to work towards a fully working implementation of the TOMP-API in our daily operations.
- In the context of eMaaS, the integration of Electric Mobility Systems is very important. The fleets of electric vehicles operated by transport operators can have a very large impact towards local energy systems. In this regard, developments in smart charging and even vehicle to grid (V2G) applications have to be explored in further detail. Data from the eMaaS system, possibly via (a derivation of) the TOMP-API can be used to request the availability of shared cars to determine when and how fast these cars should be charged or discharged, taking into account real time data from the energy markets.
- The eMaaS project, as designed in our original proposal, has only limited focus on journey planning and on demand transport in order to increase electric mobility. However, given that these items have become more prominent in the urban mobility scene (e.g. the EIT Urban Mobility task force[27]) we had the opportunity to also explore these options throughout the project and made a first example implementation. The feedback obtained showed that the potential of on-demand transport, also connecting this to commercial transport, is an important element to reach our goals defined in the eMaaS project.
- Our cooperation continued when the COVID-19 crisis limited some of the physical meetings at the last period of the eMaaS project. However, it also led to a direct cooperation between the parties in Hungary, Austria and the Netherlands to build on standardised electric mobility solutions.
  - As a result, ZET and UIH, the Austrian and Hungarian parties, submitted a response to the EIT Urban Mobility call for COVID-19 initiatives for two Hungarian cities, using the analysis tools developed in Hungary under eMaaS.
  - Furthermore, [ui!], the city of Budapest, UIH, and the Technical University of Budapest also submitted a response to the EIT Urban Mobility call for COVID-19 initiatives using the backend solution and the simulator developed under eMaaS.
  - ZET and GoodMoovs also worked to launch a highly integrated solution to the same call. It proposes to integrate various e-mobility providers in eight countries (The Netherlands, Spain, France, Switzerland, Germany, Austria, Denmark and Norway) in order to make more low-emission vehicles available for urgent transport needs during a pandemic crisis. The TOMP-API will have a central standardisation role. This was a direct result out of the eMaaS project, which hopefully can already begin in July 2020, i.e., directly after the completion of the eMaaS project.

While this project focused primarily on e-car, and to some extent micro mobility and public transit, there are additional mobility options that were mentioned only briefly – ridesharing, TNCs, taxis, and others – all of which should also be connected to an eMaaS platform. This also holds true for autonomous modes of transportation (autonomous (e-)shuttles, autonomous (e-)taxis, etc.), which are already being seriously considered and piloted in many locations around the world. Connected, (Shared) Electric AVs will have new ways of operating, e.g., returning to a "Home" location when necessary to charge or provide V2G service, and these attributes will possibly need to be considered in a future eMaaS platform.

For large (possibly national or international) eMaaS platforms, Artificial Intelligence (AI), or advanced analytics, will take a more central part in the platform's operation. Intermodal journey planning covering public transit, shared mobility, inter-regional transport (planes, long distance train, etc.) with multiple constraints and

[27] *https://eit.europa.eu/our-communities/eit-urban-mobility*

preferences is still a very challenging problem. Similarly, integration with city systems that manage real time traffic, recurring and non-recurring events, local weather and environmental data, parking, etc., and using this data to enable better (or new) services will also require sophisticated analytics tools. These will be "modules" adding functionality to eMaaS.

As a final conclusion, we think that the eMaas project and its results demonstrate that future efforts should be made in connecting already existing services through standardised interfaces across Europe.

COLOPHON

This report describes the results of the eMaaS project and is a summary of project activities. It has been compiled as a joint activity between the consortium partners.

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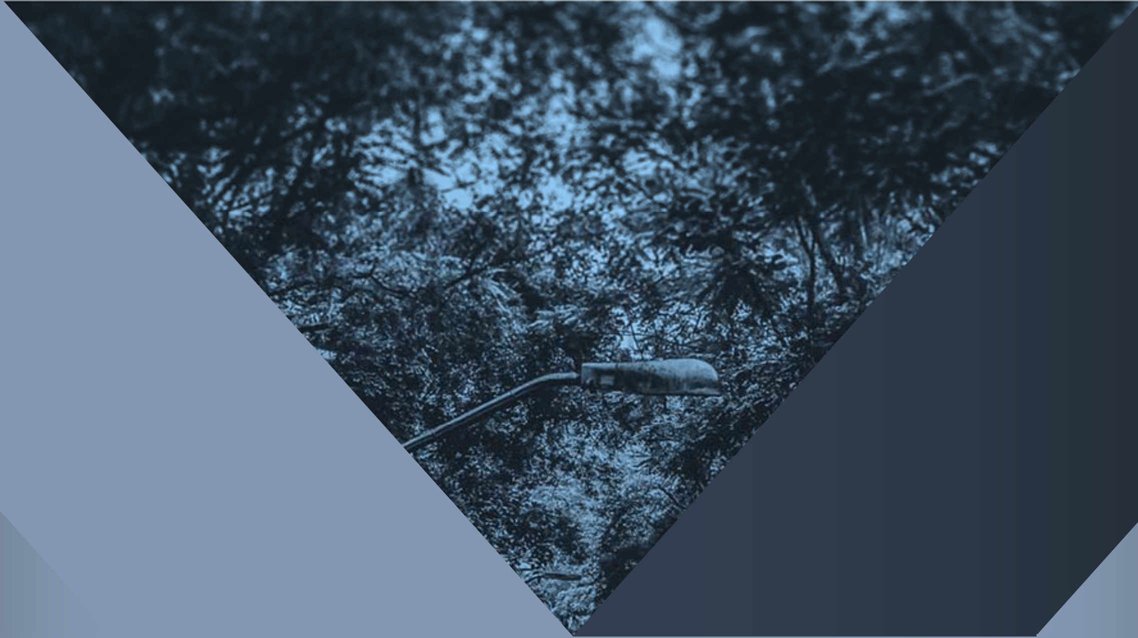

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