VMaRS

Values of MaaS potential impacts based on Representative Scenarios

ITRL – INTEGRATED TRANSPORT RESEARCH LAB
KTH ROYAL INSTITUTE OF TECHNOLOGY

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About the project

Mobility as a Service (MaaS) aims to facilitate seamless, intermodal travel, with the goal of providing a sustainable alternative to private car. Mobility as a Service (MaaS) is considered as one of the potential solutions for the sustainable transport sector.

Public officials and practitioners have for several years sought assessments of the sustainability of MaaS for informed decision making, governance and service design. This project has been conducted with the aim to provide reference values of MaaS potentials by evaluating its impacts on environmental, economic and social aspects through a selection of representative scenarios.

The project has explored how and to what extent MaaS can lead to, for example, reduced emissions, reduced energy consumption, reduced private car usage and ownership, as well as reduced private car VKT (vehicle kilometre travelled). The knowledge generated from this project can support decision-making within both public organisations and among service developers.

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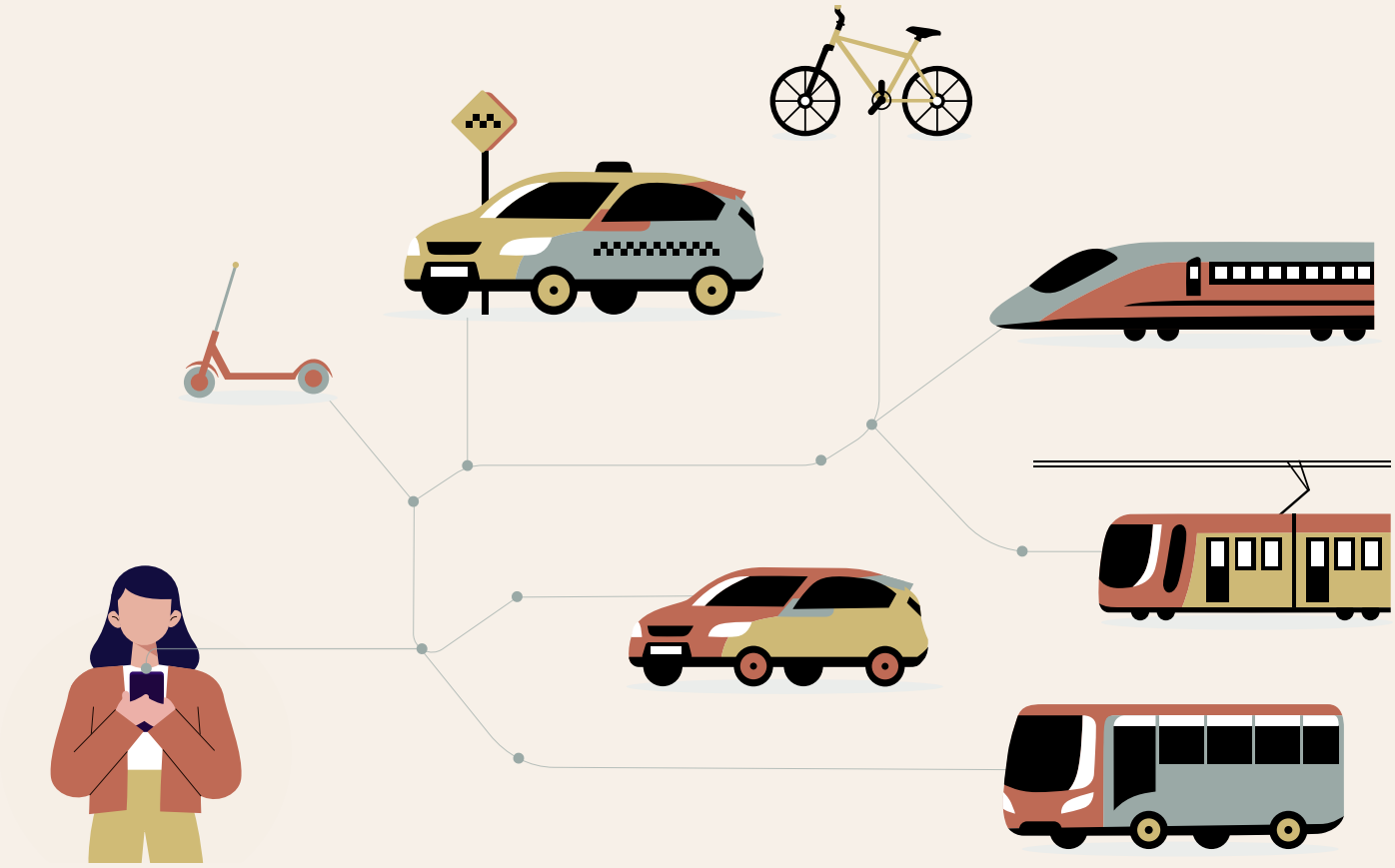
Why MaaS?



> The integration of, and access to, different transport services (such as public transport, ride-sharing, car-sharing, bike-sharing, scooter-sharing, taxi, car rental, ride-hailing and so on) in one single digital mobility offer, with active mobility and an efficient public transport system as its basis.
>
> UITP, 2019

The urban mobility demand is growing fast and solutions for seamless and sustainable travel are being developed all over the world. Mobility as a Service (MaaS) is one of the solutions that may deliver transport services with improved energy efficiency on road transportation systems (Sarasini and Linder, 2017).

Since MaaS is still developing, and its definitions and understandings are dynamically evolving (Jittrapirom et al. 2017; Arias-Molinares and García-Palomares, 2020). The number of continuous and large scale empirical evidence is still very low (Karlsson et al., 2019).

There are some ongoing initiatives and pilots within Sweden (Sochor, 2014; Lund, 2016; LIMA, 2018); these are important to gain knowledge about user acceptance, business models, and public/private stakeholders collaboration.

This knowledge can help public authorities to set incentives, subsidies and fiscal policies for MaaS integration into the transportation system. The service operators can formulate agreements with partners, promote procurement activities and implement MaaS based on the knowledge.

Why evaluate MaaS Impacts?

Although, public and private key stakeholders have started evaluating the potentials of MaaS, studies on MaaS impacts are still limited to a few aspects, such as travel behaviour, influences on public transport, willingness to use MaaS.

The indication of overall potential impacts of MaaS on economic, environmental and societal perspectives have not yet been captured.

The development, implementation, operation and outcomes of MaaS also vary by region and are influenced by socio-economics and demographics, overall trip patterns, the quality/coverage of existing public transit systems, availability and quality of the regional communications infrastructure, such as the availability of real-time data to support transit planning and services.

The empirical knowledge on the potential values of MaaS impacts is a critical factor for policymakers, regulators and planners to make decisions on developing and implementing MaaS.

However, there is uncertainity regarding the extent and significance of these MaaS impacts.

While some MaaS pilot studies in Sweden have shown how people's travel attitudes and behavior can be influenced by MaaS solutions, it is difficult to generalize these findings to a larger scale.

While these pilot studies provide certain new insights regarding the user attitudes towards the public transport sector and MaaS, in reality, the empirical knowledge is lacking.

The pilots' data are often limited in terms of number of users, user groups, number of transport options, and time period and often require time and effort to conduct and follow these experiments.

The aim of this report is to provide potential values of MaaS by evaluating its sustainability impacts through future scenarios.

This report explores how and to what extent, under each plausible future scenario, MaaS contributes to a sustainable transport system.

The potential values of MaaS impacts are evaluated based on key performance indicators such as private car usage, emissions, energy consumption and vehicle kilometer traveled.

The generated knowledge from the impact evaluation provides guidance to understand the environmental, economic and social impacts of ongoing MaaS pilots.

It is also essential to assist the proposed MaaS roadmap and adapt actions within both public organisations and MaaS service developers to reach potentials of MaaS as a sustainable mobility solution.

Scenarios

Defining the dimensions

Key Dimension 1
Policy and Regulation actions to enable MaaS

Strategic uncertainity: Whether policy and decision makers act proactively and quickly on MaaS development and implementation, or they act more conservatively and slowly based on user and market reactions.

Key Dimension 2
Public Transport operator openness to integrate with MaaS

Strategic uncertainity: Whether the public transport sectors are willing to share data, platform, services and so on to form an advanced integrated mobility platform, or they will only share certain information with private mobility service providers on a limited basis.

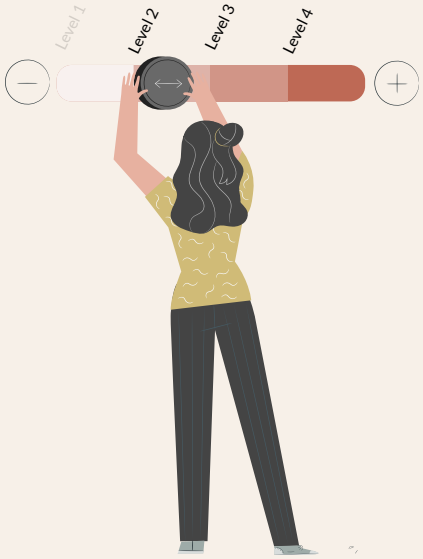
The first essential step for scenario analysis to define four plausible futures of MaaS operation is to identify the key dimensions in building the scenarios.

For the successful implementation of MaaS, Kamargianni and Goulding (2018) and Kristoffersson and Pernestål Brenden (2018) listed the maturity indexes such as transport operators openness and data sharing; policy, regulation and legislation; citizen familiarity and willingness to use MaaS; transport services and infrastructure; ICT infrastructure, public transport operators' openness to integrate with MaaS as well as policy and regulation. The European platform on sustainable urban mobility plans (Eltis, 2019) also emphasized the importance of these two aspects in developing MaaS as a potential sustainable mobility solution.

We consider these indexes to be crucial dimensions in setting up scenarios for future transport systems.

For this project, we specifically chose two dimensions, Policy and regulation actions to enable MaaS, and Public transport operator openness to integrate with MaaS.

Assumptions



We assume that in all four scenarios, a minimum of level 2 MaaS is available to clarify that private mobility service providers are always present regardless of the scenario.

A fixed MaaS level is assigned to each quadrant that is formed by the two dimensions.

Transport services, ICT infrastructures and technologies are required and are assumed in place accordingly.

We assume that users will be satisfied once they adopt MaaS services and will keep using the services under each scenario.

The New MaaS Levels

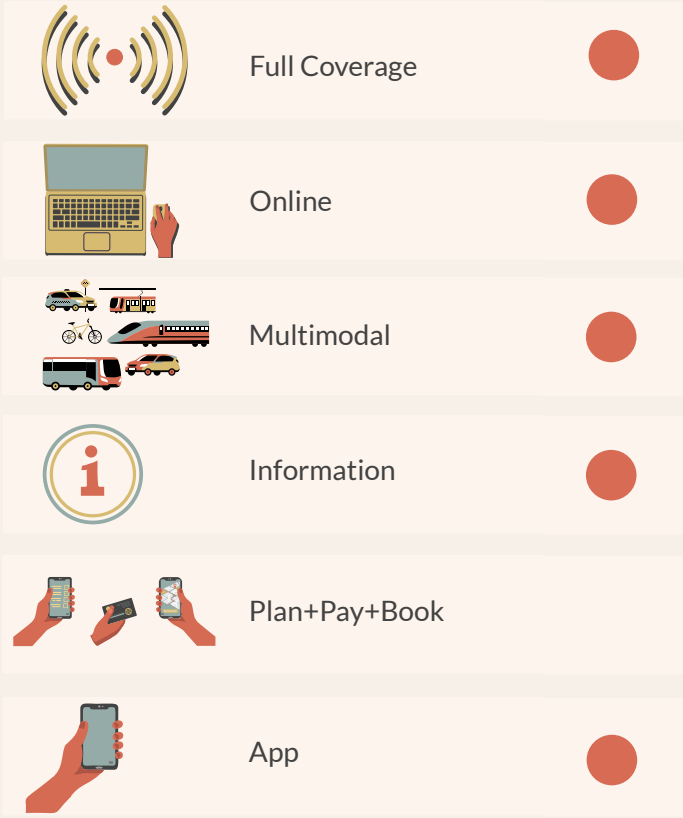
Level 1
The Partial Information

The service at this level only provides information to the users through an app or online service. The information includes transport modes and time tables, while price information is only available for a few transport modes included in the service.

At this level, all transport modes are independent to each other, only one transport mode can be chosen at a time (either public, private or shared).

There is an option to plan your journey, however, plan, book and pay features for a journey combining different modes is not available.

Level 2
The Multimodal Planner



The services aggregate different information regarding multiple transport modes through an app or online service.

Multi-modal plans can be offered including information on transfer time, waiting time and cost. However, the number of transport modes that are integrated in the service is still limited.

Users can choose between different optimization schemes when planning their trips, e.g. fastest or cheapest route. Plan, book and pay at one go is not available.

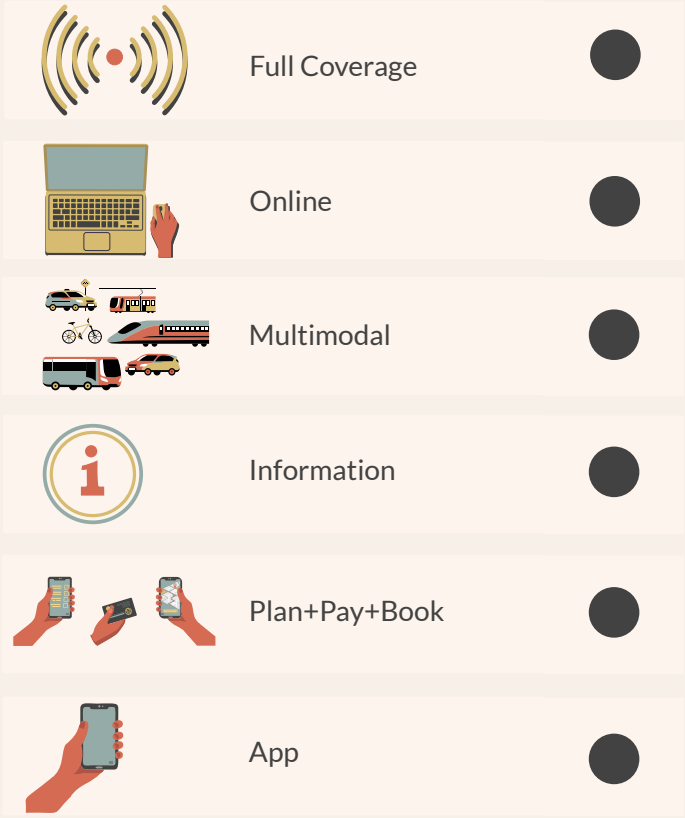
Level 3
Plan, book, pay with partial coverage

The services allow users to plan, book and pay for a whole trip through one app, with multimodal options.

Transport modes are various but limited with partial coverage, e.g. limited to geographical regions such as city centers.

Payment options such as ticketing schemes, subscriptions and travel cards are can be also included in the app.

Level 4
Plan, book, pay with full coverage



Same services as in Level 3 are provided. In this level, the provided services are more adaptable to different scales of on-demand needs, from city center to suburb to certain rural areas.

The coverage of the services fulfills transport needs in urban areas, rural areas and inter cities.

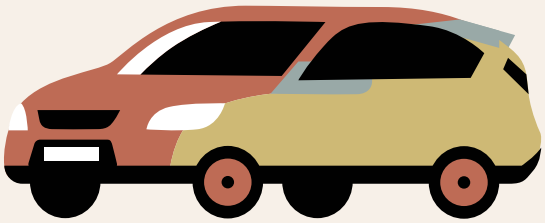
Defining the key performance indicators

KPIs for measuring individual's travel

68.7 x 10^9 km
(Trafa,2018)

Vehicle Kilometers Traveled

Vehicle kilometers traveled (VKT) is an essential indicator for measuring individual's travel. The number of VKT is important an important factor in measuring to congestion and energy consumption.



6.22 x 10^6 km
(Trafa,2018)

Private Car Usage

Private car usage is another crucial indicator for measuring individual's travel. The rate of private car usage will help in measuring to what extent MaaS can lead the shift from private car usage to shared mobility.

KPIs for measuring energy use and emissions

123 gCO_2/km
(Transportstyrelsen,2018)

CO_2 emissions

To understand the impacts of new mobility solutions on the environment, measuring the reduction or increase of CO_2 emissions is an important indicator.

Diesel consumption

0.051 L/km
(Trafikverket,2018)

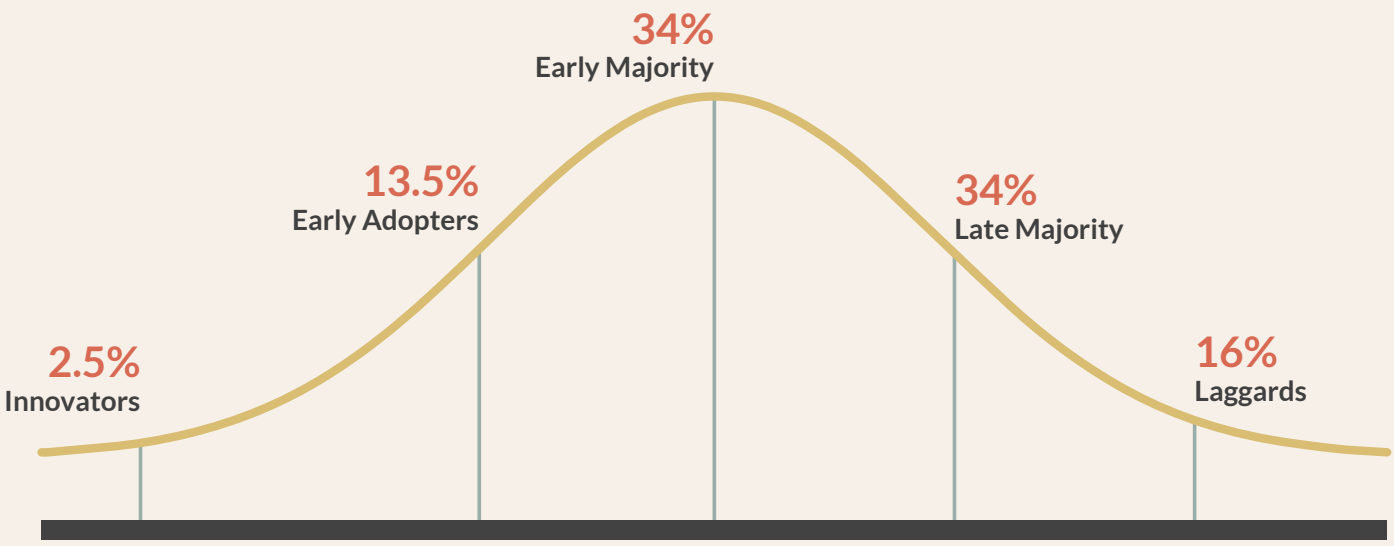
Gasoline consumption

0.058L/km
(Trafikverket,2018)

Fossil fuel consumption

Similarly, the reduction or increase in the consumption of fossil fuels is a key indicator for understanding the impacts of new mobility solutions on the environment.

User Acceptance Rates



In order to understand and assess the impacts of MaaS, one crucial and decisive parameter is that of MaaS usage. Determining the portion of the population that uses the services will help understand the extents of MaaS impacts.

In this project we used the diffusion of innovation theory (DoIT) of Rogers (2003) which has been widely used in transport fields, such as acceptance and diffusion of green fuel vehicles and integrated multimodal mobility.

DoIT is a comprehensive framework that incorporates multiple factors and perspectives, such as users, innovation, incentives and society.

The DoIT has been used in various MaaS studies to date where the terms “innovator”, “early adopter”, “early majority” have been used to describe types of users in a specific sample group. This often has the risk of overestimating the adoption rates as users usually tend to incline towards the innovation.

As diffusion of innovation like MaaS in transport is rather slow and in order to avoid impractical overestimation of the KPIs in measuring MaaS impacts, we first take into account the influence of MaaS services on use of private cars.

This is where the rates in DoIT of Rogers (2003) have been applied based on the MaaS levels and the scenarios.

Using DoIT, we worked with user acceptance rates: we first defined the potential reduction of private car usage, then we represented the willingness of the users to entirely replace private cars with MaaS services.

These user acceptance rate can help understand how many users will shift from private car ownership to MaaS usership and differ in each scenario.

Scenario 1

The private vehicle addiction

The bus stop is around 1 km from his home.
He tried to use a scooter to reach the stop instead of wall
but he has to download four different apps on the phone in
to find the information, book and pay, and it is too time cons

Mr Carson lives in the suburb and
works in the city. The options for him to get around
are taking 3 bus lines, one metro line, a couple
of commercial car pools, shared scooters
and his private car.

When he goes to work, he almost always drives,
because this is most convenient and comfortable.
He believes it is much better than catching
a bus or metro during the crowded rush hour.

MaaS Level 2

This is Mr. Carson

king,
order
suming.

It costs him 300 SEK per week to park in the city, he has to pay congestion tax.

Scenario 1

The private vehicle addiction

Dimensions

Conservative policies and regulations, not supportive of MaaS

Public transport operators not willing to collaborate to build integrated mobility services.

In this scenario, private mobility service providers are unable to get public transport operators onto their platform as the public transport operators do not want to collaborate to build integrated mobility services.

Meanwhile, the policies and regulation actions are conservative and are not specifically supporting MaaS. Private mobility service providers only integrate on a basic information sharing level and are not willing to fully share data and integrate platforms among each other due to market share competition.

The private mobility service providers focus on promoting services that are profitable for their business but are not necessarily the optimal ones for the city or the environment since there are no restrictions in the policies and regulations.

The Level 2 MaaS in this scenario does not respond to most travelers' seamless travel needs and is not able to attract enough users to trigger the shift towards shared mobility services. The lack of simplicity, impartiality and flexibility forces people to attain private vehicle ownership for convenience and comfort.

Impacts

Private Car usage

0-2.5%

Private Car Ownership

0%

Vehicle kilometers traveled

0-1.72 x 10^9 kms

CO_2 Emissions

0-2.11 x 10^6 tons

Gasoline consumption

0-4.35 x 10^6 liters

Diesel consumption

0-4.17 x 10^6 liters

In this scenario, MaaS level 2 might instigate 2.5% the users to replace private car trips with MaaS services.

However, the provided MaaS services are rather limited since the public transport is not on board.

The reductions of private car use is at most 2.5%. There are no strong incentives from the authorities based on the slow and consevative policy and regulations actions.

The users may accept to use the MaaS services to replace some private car travels, however, car ownership does not decrease since users are not ready to give up ownership.

Scenario 2

The rise of private shared services

Mr. Rider lives 15kms away from the city. His office is located there so he travels with his car.

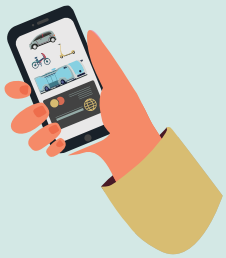
The transport services in his neighbourhood are inadequate. The bus connecting to the city operates in very less frequencies.

P+R

Since the parking prices in the city are quite high, he prefers to park his car at the new park and ride service located just outside the city limits. This facility offers parking spots for 40kr/24 hours.

This is Mr.Rider

MaaS Level 3



Once within the MaaS operation limits in the city,
Mr. Rider has access to various services which costs him 500kr/ month.
He sometimes shares an electric car with his colleagues during lunch or takes an electric bike to run errands. These services enable him to travel easily without worrying about parking spots in the city which usually cost him 60kr/hour

Scenario 2

The rise of private shared services

Dimensions

Proactive policies and regulations, supportive of MaaS

Public transport operators not willing to collaborate to build integrated mobility services.

In this scenario, policies and regulations are reformulated to enable shared mobility services. The policies show active support to provide mobility services that integrate all modes of transport and allow users to plan, book and pay for their travel through the same application.

However, since public transport operators are not willing to share or collaborate with other mobility service providers, the MaaS services in this scenario cannot provide all transport modes.

Level 3 MaaS services operate with limited to partial coverage, primarily in city centers. Thus, within the service boundaries, users can get easy access to private shared mobility services along with public transport as an alternative to personal private vehicles.

However, for those who live outside the MaaS service boundaries, the dependence on private vehicles and their ownership is high, and private vehicles are considered as the most reliable, flexible and convenient alternative for daily travel.

Impacts

Private Car usage

2.5%-16%

Vehicle kilometers traveled

1.72 x 10^9- 1.01 x 10^9 kms

Gasoline consumption

4.35 x 10^6- 2.78 x 10^6 liters

Private Car Ownership

0%- 2.5%

CO_2 Emissions

2.11 x 10^6- 13.5 x 10^6 tons

Diesel consumption

4.17 x 10^6- 2.65 x 10^6 liters

In this scenario, public transport is not willing to integrate with the private mobility services providers.

The incentives and subsidies from the quick and proactive policies have started to promote the private service providers to improve their services, hence the users are also stimulated to try the new shared mobility services.

Due to that, the adoption rate is between 2.5% and 16%. Amongst the users, the innovators start to give up their car ownership, which reduction is in the range [0%, 2.5%].

The reduction of private car usage is between the interval [2.5%, 16%] corresponding to the increased adoption rate: this triggers a further reduction of vehicle kilometers traveled, fossil fuel consumption and CO_2 emission

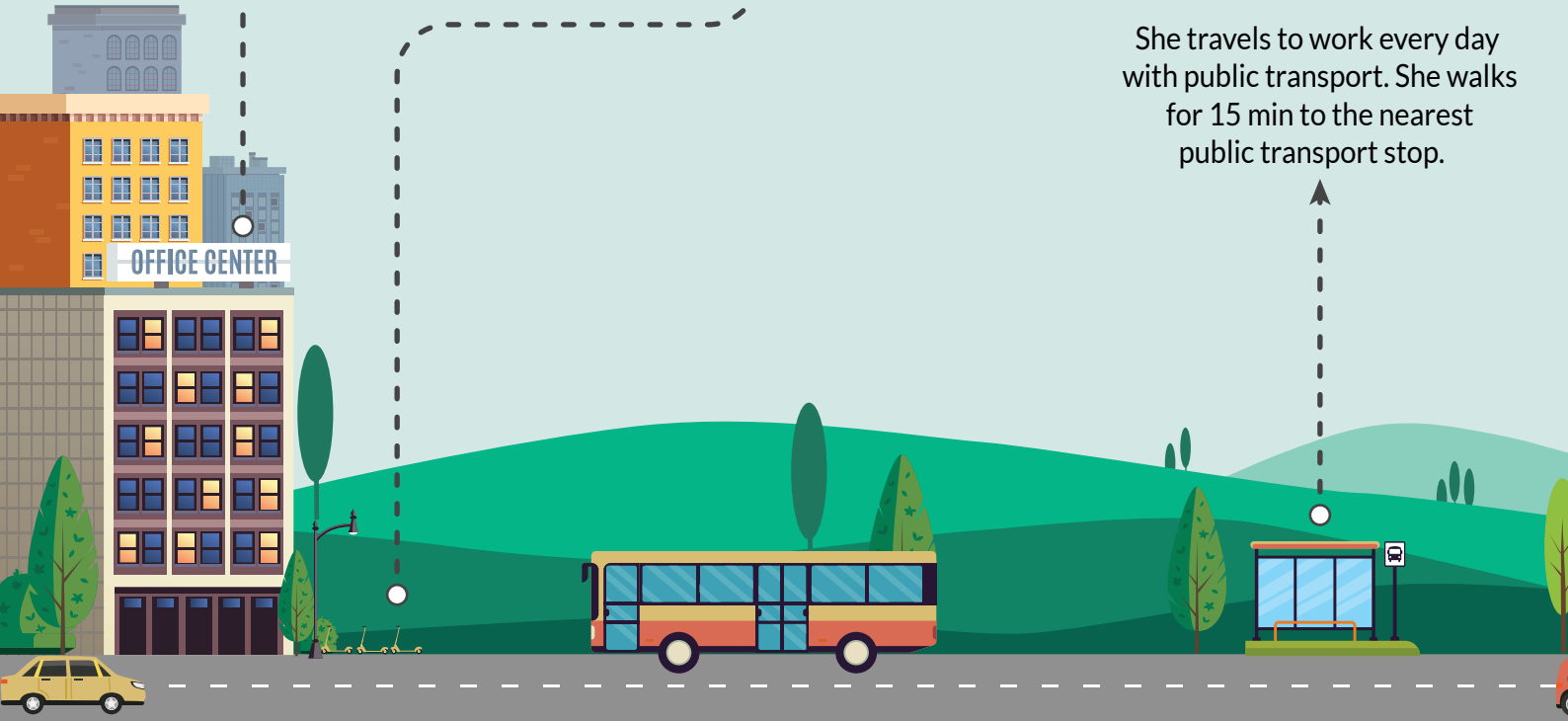
Scenario 3

Trends win over policies

Ms Steppy is a young professional working in the city center.

She sometimes uses the e-scooter sharing service to get around in town, but she doesn't use it all that much around her neighbourhood because there are not so many vehicles available.

She travels to work every day with public transport. She walks for 15 min to the nearest public transport stop.



MaaS Level 3

This is Steppy

She lives in the suburbs of the city, she does not own a car, it would be too expensive for the use she would have for it. She loves her neighbourhood and she is satisfied with her way of commuting.

Her brother's family owns a vehicle, which they consider necessary for a family in their neighbourhood. Her brother has a kid and she wishes to visit them more often but the public transport available to reach his neighbourhood is poor and she rarely finds time to visit them during the week.

Scenario 3

Trends win over policies

Dimensions

Conservative policies and regulations, not supportive of MaaS

Public transport operators willing to collaborate to build integrated mobility services.

In this scenario, the public transport operator is open to collaborate with private mobility service providers. However, the support of policy makers is lacking. The private mobility service providers are willing to partner with the public transport operators to maximize their market share and profits since the policies do not provide incentives.

This is also beneficial for public transport operators since the integration can lower the cost, ease the pressure of travel demands and increase the attractiveness of transport services. The public transport operators take the role of integrating all the mobility services in a single platform that allows users to plan, book and pay for every trip.

In this scenario, the level of MaaS is also on level 3. Although the Level 3 MaaS services are partially available to a certain geographical boundaries, the integration of public transport and other mobility services can fulfill most travel demands, especially in urban areas.

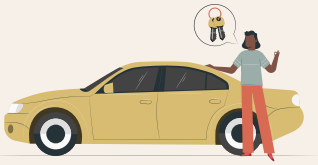
Even with lack of regulations and incentives, the MaaS trends are winning over policies and attracting users to shift towards shared mobility solutions.

Impacts

Private Car usage

16%- 50%

Private Car Ownership



2.5%-16%

Vehicle kilometers traveled

1.01 x 10^9- 3.43 x 10^9 kms

CO_2 Emissions

13.5 x 10^6- 42.2 x 10^6 tons

Gasoline consumption

2.78 x 10^6- 8.71 x 10^6 liters

Diesel consumption

2.67 x 10^6- 8.34 x 10^6 liters

In this scenario, even though the policies are conservative and slow in MaaS development and implementation, the public transport operators are fully open to integrate with the private mobility services providers in building the MaaS platform.

The highly integrated MaaS platform provides features that can attract more users to adopt the platform to fulfill their transport needs, hence the adoption rate is between 16% and 50%.

Amongst the users, the early adopters also start to give up their car ownership, which results in a reduction of [2.5%, 16%].

Although the MaaS coverage is mainly in the central urban area, the reduction of private car usage is in the range [16%, 50%].

The reduction of VKT, fossil fuel consumption and CO_2 emissions are further higher.

Scenario 4

MaaS is the new black

Ms Shary lives in a newly built smart city with advanced technologies and sharing-oriented life styles. Like most people in the city, she doesn't own a car herself, self-ownership is replaced by sharing-ownership.

The old parking lots and bus stops have been re-planned and re-designed to be parks, activity centers to equip more social activity needs

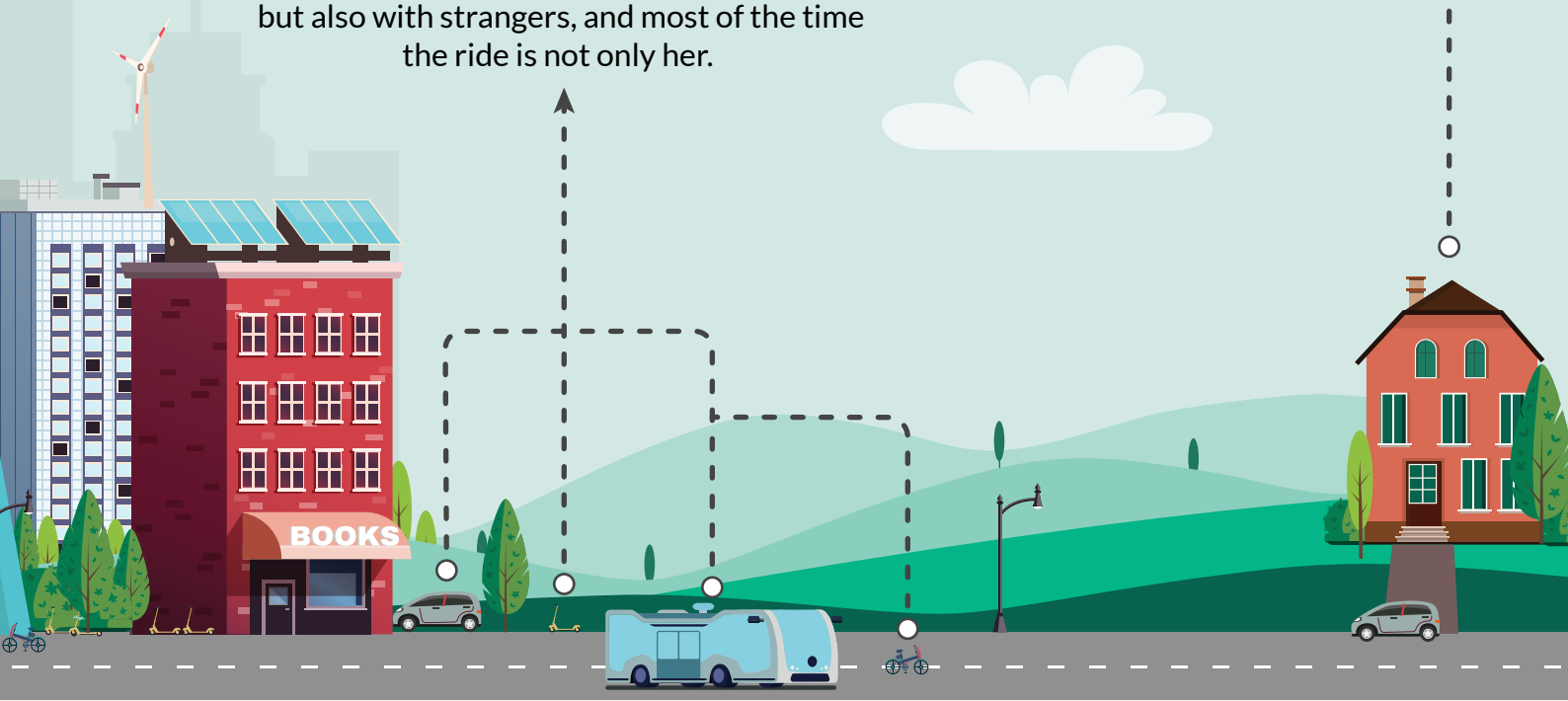
This is Shary

MaaS Level 4

When she has to travel around, she can open her phone and find the suggested modes for a seamless travel. The app is easy to use and can conduct from initial search for information to the final payment. She can choose to have a subscription to use the services, which on average is 500 sek per week.

Her grandparents can easily use the services platform and meet her in the city although they live in the countryside. The on-demand service can be pre booked and they do not need to drive a car.

There are so many on-demand mobility services and she not only shares a ride with friends but also with strangers, and most of the time the ride is not only her.



Scenario 4

MaaS is the new black

Dimensions

Proactive policies and regulations, supportive of MaaS

Public transport operators willing to collaborate to build integrated mobility services.

In this scenario, policies and regulations are quick and proactive in supporting integrated mobility services. The public transport operator and other mobility service providers work together to provide highly integrated MaaS services.

The MaaS services aim to make the customers' journey as seamless and efficient as possible. All strategic decisions from the authorities and actions from the public and private stakeholders are together to provide flexible, integrated transport options with all possible transport modes and broad coverage.

Mobility services in this scenario are distributedin wide geographical boundaries from central cities to rural areas to inter cities. On-demand services are optimally distributed with the best combination of transport modes to address various users' needs. MaaS level 4 is available in this scenario, plan, book and pay is enabled through one app.

The user friendly travel plan and easy to use application enables different groups of people to get access to the services and fulfill their travel needs efficiently and seamlessly.

Impacts

Private Car usage

>=50%

Private Car Ownership

>=16%

Vehicle kilometers traveled

>=3.43 x 10^9 kms

CO_2 Emissions

>=42.2 x 10^6 tons

Gasoline consumption

>=8.71 x 10^6 liters

Diesel consumption

>=8.34 x 10^6 liters

In this scenario, the public transport and other mobility service operators work together to build the MaaS platform, with support of quick and proactive policies and regulations.

The seamless and efficient on-demand travel services and the wide coverage to cater for travel needs of different users in various locations have made the adoption rate come up to at least 50%.

At least 16% of adopters are willing to give up their car ownership. The upper limits of the KPIs reduction in Scenario 3 become the new lower limits in this scenario.

However, it is hard to estimate the new upper limits: perhaps the change will be slower due to the diffusion, but the potential impacts of the KPIs will continue to grow as long as the MaaS services can be improved and meet people's travel needs.

Reflections

This report shows the potential values of MaaS impacts in each of the four future scenarios. The four scenarios all show positive impacts in reducing private care usage and ownership, VKT, fossil fuel consumption and CO_2 emission. The results presented in this report rely on the following assumptions.

Assumption 1

The change in the vehicle kilometers traveled in the MaaS sector was not checked since the usage of multimodal transport is quite complicated to estimate.

It is possible that people will be making more trips than before to fulfill various needs due to MaaS services being more accessible and flexible. With the maturity of autonomous technology and the optimal use of vehicle capacity, the congestion related issues might decrease even with increased vehicle kilometers traveled.

Assumption 2

All vehicles included in the MaaS services are assumed to be environmentally friendly with green fuel and induce zero CO_2 emissions.

It is in line with the inevitable trend that fossil fuel will be gradually replaced with environmentally friendly fuel following the market trend. This assumption may induce an overestimation on the reduction of fossil fuel consumption and CO_2 emissions.

Assumption 3

The rates of the private car usage change due to use of MaaS are based on the numbers proposed by Rogers's (2003) diffusion of innovation theory.

These numbers are further linked to the rates of user acceptance and the reduction of private car ownership. These rates may not fully capture the MaaS adoptions in a specific scenario.

Assumption 4

The fuel consumption numbers used in this report are based on the averages for new vehicles purchased in 2018.

The actual fuel consumption numbers would be higher since not all vehicles are newly purchased in 2018, and older vehicles tend to consume more fuel. Therefore, the fuel consumption that could be reduced due to shift to MaaS services would be higher in each scenario.

Takeaways

In this report we propose a method of conducting evaluation of the potential values of MaaS impacts on a large scale. We define four future scenarios based on two strategic uncertainties.

The four scenarios are assigned with different MaaS levels representing different function integration and application coverage.

Based on diffusion of innovations theory, 2.5%, 16% and 50% are applied to represent the adoption rate of MaaS under each scenario.

KPIs of individual travel and energy use and emissions are chosen to measure the impacts. We provide the following two takeaways as a result of our analysis.

Takeaway 1

The potential reductions of private car usage and CO_2 emissions are dependent on policies and the public transport sector, such as in supporting MaaS implementation and green vehicles, data sharing and services integration.

Takeaway 2

MaaS can lead to sustainable mobility and CO_2 emission reductions from the private car sector in a span of 2.5% to 50% if the vehicle capacity can be optimized and technologies enable greener fuel.

VMaRS

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Summary

As Mobility as a Service (MaaS) is gaining fast popularity as one of the potential solutions for achieving a seamless, efficient and sustainable transport system, understanding its potential impacts is crucial in order to develop and implement the service efficently.

Although there are studies claiming that MaaS can deliver net positive impacts on the transport system whether these impacts are marginal or significant is either unclear or is only limited to a few pilot tests.

This report provides potential values of MaaS by evaluating its impacts through a future scenario analysis. We beleive that these potential values of MaaS impacts will inform both public and private key stakeholders on how to adapt actions in MaaS development and implementation.

The different impacts of MaaS in the different scenarios do not mean one scenario is worse than the other. Instead, it is important to know that the impacts of MaaS depend on how it is implemented and adopted, which in turn depends on the policies implemented and the business ecosystem.

Real data from large scale implementation of MaaS could be valuable emperical evidence to compensate the theoretical estimation and scenario analysis made in this report to better understand MaaS impacts.


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