Analysis of future transport in the City of Helsinki

Helsinki

Foreword

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In autumn 2019, Mayor Jan Vapaavuori established a workgroup to compile a future analysis of transport for the City of Helsinki. The basis for this work is to strive to reinforce the City's ability to be prepared for the changes in its future operational environment, driven by many global phenomena. The purpose is to utilise this future analysis in the strategic development of the City's transport system as well as for sharing the City's good practices and communicating in international contexts.

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Introduction

Background and objectives

The objective of the City of Helsinki's future analysis of transport was, on the one hand, to create understanding on what kinds of changes to the operational environment affecting transport can be expected to occur in Helsinki and, on the other hand, to establish a view on how the City should prepare for these changes in its development work and how matters could be prioritised in accordance with the City of Helsinki's strategy based on the information received.

The purpose of the future analysis of transport is to help prepare for the future changes, review the City's development critically based on the potential change pathways and, if needed, find the best possible methods for guiding the development in accordance with the goals of, for example, Helsinki City Strategy and the UN's sustainable development programme, to which Helsinki has committed. The future analysis of transport can thereby be utilised in the strategic development of the City's transport system and as a support method for sharing Helsinki's good practices and communicating about them in both Finnish and international contexts.

The future analysis was conducted as a multi-disciplinary work process that utilised the expertise of both the City organisation and its stakeholders. The analysis progressed in stages in the workgroup's five separate workshops. In between these workshops, the members completed pre-assignments assigned to them. A scenario method was used to review the future phenomena and trends that are difficult to forecast but have significant impacts. In this method, the workgroup described potential future development pathways within the established boundary conditions. To support the workgroup's own analyses and scenario depictions, a literary study was conducted including review of future studies in other cities and organisations, adoption of new technologies in forerunner cities and analyses of megatrends by several acknowledged experts.

A change readiness analysis was also commissioned in relation to the future study. Its purpose was to create better understanding of the field of operators related to the development of the transport sector in the Helsinki metropolitan area, their interests and the readiness of Helsinki residents to adopt new practices and adapt to future changes. The analysis has been reported as an attachment to the future study.

Forecasting the future is a prerequisite for creating the most functional city in the world, securing sustainable growth and ensuring responsible finances. A better understanding of the future will create capabilities for long-term development of transport.

Image 1. Developing Hernesaari. City of Helsinki Media Bank / Tietoa Oy

A review of the current transport situation

The City has strived to develop the transport system in a way that considers all transport modes, so that the city structure development efforts are supported and a mobility culture that embraces environmental conservation is promoted. The healthiness and safety of environment have been central focal points in traffic planning.

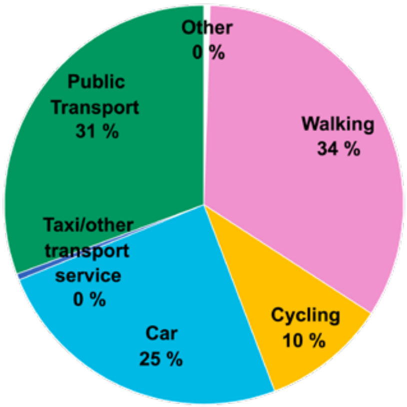


Figure 1. The primary travel mode of citizens of Helsinki autumn 2018. Helsinki Region Transport 2020

In Helsinki, people walk, cycle and make use of public transport clearly more than in other municipalities in the region. Recreational trips are the most common trips, and their number has been rising. The second most common trips are work and study related trips. No significant changes occurred when reviewing the average number of daily trips or the time spent on them. (HLT 1992, 1998–1999, 2016a and 2016b, HSL 2010, City of Helsinki 2002 and 2020a)

The proportion of sustainable modes of transport has increased in the inner city over the course of the past decades while car traffic has decreased around the borders of the inner city and the cape. Factors that have promoted the use of sustainable modes of transport include the proximity of various services, the high service level of the public transport system and the persistently implemented parking policy measures. Inner city residents make most of their trips by foot, but public transport is also used frequently. The investments in the cycling network in recent years can also be seen in the growing popularity of cycling. The development of cyclist numbers at the measurement points is a proof of this. Most trips are taken by foot also in the suburbs, but many trips are also made both by public transport and by car. The proportion of sustainable modes of transport account for is high in suburbs compared to the rest of the region. At the city borders, the motor vehicle traffic numbers have been growing for a long time. (HLT 1992, 1998–1999, 2016a and 2016b, HSL 2010, City of Helsinki, 2002, 2019 and 2020a)

Car ownership numbers in Helsinki have grown relatively slowly. According to Statistics Finland, 45% of Helsinki residents live in households without a car. Car ownership elsewhere in the has clearly grown more quickly. The vehicle fleet, however, is renewing fairly slowly: the average age of cars is 10 years in Uusimaa. The number of electric vehicles and hybrid vehicles is still low in Finland, but the fastest growth is taking place in Helsinki. (HLT 2016a and 2016b, HSL 2016 and 2019, Traficom & Statistics Finland 2020)

Parking policy is one of the key elements by which the city is promoting the use of sustainable travel modes and vehicle fleet renewal towards electric vehicles. The chargeable parking area, time and tariffs have been gradually extended in the city. Owners of electric vehicles can obtain the residential parking permit for half the price and in addition the charging time at on-street parking points is not counted as parking time.

In order to foster the vehicle fleet renewal and address the needs for charging services for electric vehicles, the city's eMobility working group has defined several actions. The main actions are to set out the minimum requirements for charging infrastructure on private properties and principles by which private charging operators may obtain permits on public places (2016).

Transport and traffic cause approximately 20% of Helsinki's greenhouse gas emissions. About half of these emissions are caused by cars. During the past 30 years, the carbon dioxide emissions of traffic have decreased by about 5%. Tram traffic has been free of carbon dioxide emissions since 2012, and the regional bus fleet will entirely run on renewable forms of energy by 2025. (Helsinki Region Environmental Services Authority 2020, City of Helsinki 2020b)

Traffic safety in Helsinki has developed significantly. A key factor in this was the extensive regional speed limit reductions. Traffic safety has also improved thanks to improvements to the street environment, increasing traffic control, the development of vehicle safety measures and technology, and the development of rescue services.

Traffic causes health risks by decreasing the air quality and causing noise. However, the development of engine technology and fuels has reduced and eliminated problems related to the likes of carbon monoxide and sulfur dioxide. Currently, fine particles, street dust, nitrogen dioxide and ozone are decreasing the air quality, especially on busy streets. Traffic noise causes harm to nearly 40% of the City residents. Road and street traffic clearly cause most of the noise pollution, but rail traffic also generates noise. The number of people exposed to the noise pollution

Figure 2. Road traffic casualities. City of Helsinki 2020

The distribution of regional public transport trips on a weekday in autumn 2018:

Metro: 25%
Train: 24%
Tram: 11%
Bus: 40%

The distribution of public transport trips made by Helsinki residents in the Helsinki region on a weekday in autumn 2018:

Metro: 29%
Train: 14%
Tram: 16%
Bus: 40%

(HSL 2019 and 2020)

of road traffic has increased in the 2010s. (Helsinki Region Environmental Services Authority 2019, City of Helsinki 2018 and 2020d)

The City of Helsinki's public transport system has been developed by focusing on rail traffic for decades. Local trains and metro transport are the basis of regional public transport, and significant investments have been made in them over the course of the past decades. A comprehensive bus route system complements the public services in areas without rails. The inner city features an extensive tramline network, which has been developed and expanded into new construction areas of land use. Transverse public transport connections have also been developed intensively in the last decade. It has been decided that the relatively slowly developed tramline network will be expanded significantly in the coming decade.

The City of Helsinki participates in the regional MAL-process (contract for land-use housing and transport), led by Helsinki Regional Transport Authority and covering 14 municipalities, which sets the common regional targets for the development of sustainable urban structure, rail investments and an efficient transport system. In addition to the regional investment programme for transport infrastructure, also public transport services and e.g. city-bike services are regionally administered.

The major investments in road traffic network during the past few decades have been targeted at transverse traffic on the ring roads and in Hakaniementie on the north side of the inner city, for example. Additionally, the street network has been expanded in land use development areas. Otherwise, the City of Helsinki's main network has not changed much in the past decades. Tram and bus lane traffic arrangements are used to ensure the smooth operation of public transport utilising the street network. Public transport signal priority systems have long been used to reduce delays at intersections. The inadequate conditions for cycling have been improved, especially in the inner city. Following international examples, Helsinki moved on from the combined pedestrian and cycling paths to safer and more functional cyclist traffic solutions at the beginning of the millennium. This way, cycling in now considered its own mode of transport by separating it more clearly from pedestrian traffic and taking it closer to other vehicle traffic.

The number of parking spaces along the side of streets has decreased in the city centre, but, on the other hand, the total number of parking spaces available in the centre has increased in the past decades as more parking garages have been built. Traffic and parking needs of property maintenance and delivery transport have been developed in cooperation between the City and private companies. Currently these operations are using the space in the street side. Some larger operators use the maintenance yard spaces or the centre's maintenance tunnel for their deliveries. In suburban areas, maintenance services usually utilise the building plot instead of the street. (The City of Helsinki 2013)

Digital technology has been utilised in the City of Helsinki's traffic arrangements for more than 20 years now. Technology has advanced a great deal and so have the networks. Today, digital technology is utilised in many areas, including traffic management, transport studies and various transport services. The digital infrastructure in use today does not take up much street space, but the new 5G technology will require a much more extensive base station network. Each base station will require both a communications connection (fibre-optic) and electricity supply (electricity cables).

Today, Helsinki offers various service packages of the 'mobility as a service' concept (MaaS), which grant user licences to various transport services, such as public transport, taxi service, car sharing services and city bikes. As transport has become more service-oriented, the digital services and their use, especially among the inner city residents, has also quickly grown more popular in the 21st century. The different route and map services are used more actively both online and through mobile applications. Tickets for public transport services are bought digitally, and ordering goods or foods for home delivery is also fairly common. By comparison, ordering rides online or through a mobile application is less frequent for now, as is the use of services offering cars for shared use. In a survey carried out in 2018, 13% of the region's residents said that they had used a ride service during the past four weeks and 4% had used a car sharing service. The popularity of new city bikes, available for residents' shared use, exceeded all expectations when the service was launched in 2016. The city bike system has been expanded several times since its opening. Many electric scooter companies also provide their services in Helsinki. (HSL 2019).

In addition to the central role of the city in the development of land-use, transport system and services, the city of Helsinki is an active participant in public communications, transport education and surveillance together with its partners, targeting safe and sustainable travel decisions of different resident groups. The city is also investing in high-quality public engagement processes, through which the change readiness of the citizens can be increased and the social acceptance of transport system development improved (Akordi 2020).

Street-side parking is controlled through fees and time limits. The payment zones of street-side parking have been expanded and the fees for lower charge classes have been increased in recent years. The tenant and business parking system has also been expanded in recent years. The prices of tenant parking have been raised gradually in the 2010s to better cover the costs of the system.

Image 2. Separated cycle lanes on driveway facilitate for fluent traffic flows. City of Helsinki Media Bank / Jussi Hellsten

Megatrends of the future

Analysis method of megatrends

There is a huge number of change trends that are essential to the transport operations in Helsinki. These changes can be divided into political, economic, social, financial and environmental change factors. This facilitates the compiling of an extensive and comprehensive range of driving forces, some of which can be considered megatrends and some more uncertain trends or development pathways. The essential driving forces can be summarised under seven themes:

1. Urbanisation
2. Digitalisation
3. Electrification and automation of traffic
4. Limited resources
5. Servicification
6. Climate change
7. Individualisation

The potential impact of each driving force on the transport of the City of Helsinki was assessed. The driving forces that were assessed as being the most probable were chosen as the basis for scenarios, which is why their realisation and impacts are assessed as being quite similar, regardless of the scenario. On the other hand, the uncertain but potentially most influential driving forces were selected as critical driving forces in the scenarios. The critical driving forces' various realisation alternatives and their combined impacts have been assessed in the different scenarios presented in the next chapter.

The development pathways assessed as being the most significant and almost certain, regarding transport in Helsinki, are:

1. Climate change and electrification of traffic
2. Change of work
3. Urbanisation
4. Aging population

The following section focuses on the impacts of these megatrends on traffic in Helsinki based on both literature and specialist assessments. Climate change can be considered the most significant megatrend, as the measures of mitigation and adaptation are present in all the sectors.

Climate change

In general, climate change refers to any significant changes related to the climate, but now-days it is most often used to refer to global warming of the climate. Global warming is an undeniable fact, according to the Intergovernmental Panel on Climate Change (IPCC), and to a large extent it is caused by greenhouse gas emissions generated by humans (IPCC). Climate change as a phenomenon is very different to other environmental issues, such as water or air pollution or waste, as greenhouse gas emissions do not have direct health impacts and they are invisible and odourless. Furthermore, they do not cause any local problems, but rather accelerate a global phenomenon that has impacts that may not emerge in the place they originate from.

In Finland, the physical impacts of climate change will lead to increased average temperatures, especially in the winter, more infrequent low temperatures and more common and prolonged heat waves. Precipitation will also become more common and will usually come as rain instead of snow in the winter. Heavy rain and storms will grow stronger in the summer, whereas the period of snow cover on the ground and the thickness of snow will decrease in the winter. (Climate Guide)

The phenomenon itself will likely not be one of the major factors impacting transport, but the measures striving to prevent and mitigate climate change will be. The measures and the policies behind them were born out of very comprehensive scientific research work focusing on the impacts of climate change, for example. One of the most notable milestones in the work is the establishment of the Intergovernmental Panel on Climate Change IPCC in 1988. This panel is a forum for the science community for promoting understanding of climate change and the impacts it has (Delbeke & Vis).

The European Union has been especially active in promoting emission reductions and has included the following significant measures in its climate policy, among other actions:

1. Implementing emission reductions while continuing economic growth
2. Using market mechanisms to reduce emissions
3. Deploying low-carbon and energy-efficient technologies in various sectors
4. Integrating the climate dimension in the sectors with the highest economic relevance,such as automotive, chemical and steel industries.
5. Implementing a stable regulatory environment rather than short-term policy interventions

The Clean Vehicle Directive (CVD) of the European Union is one the concrete tools to foster the change towards sustainable energy sources within the public vehicle fleets. There are clear requirements for the share of clean vehicles by 2025 and 2030, varying between different vehicle types. The regional transit authority HSL has already set an ambitious target that at least third of the bus fleet procured by HSL will be electrical in 2025. However it is possible that the bus operators will electrify their fleets even faster.

The transport sector is one of the largest emission sources, and the Finnish Ministry of Transport and Communications has identified three ways of cutting the greenhouse gas emissions of transport in Finland:

1. By reducing the performance (kilometres) of emission-generating transport and by improving the energy efficiency of the transport system in other ways
2. By adopting low-emission or emission-free technologies in vehicles (such as electric cars)
3. By introducing fuels with even lower emissions or renewable fuels

In Helsinki and other urban areas, in particular, the intention is to reduce the number of kilometres driven by cars and replace them with public transport, walking, cycling and various transport services. At the same time, there is an attempt to replace vehicles with low- or zero-emission vehicles as quickly as possible. The Ministry of Transport and Communications estimates that the most impactful measure in the short-term is the introduction of road tolls in the Helsinki metropolitan area and, in the long-term investments in a sustainable transport system. The increasing costs of using cars must simultaneously be compensated for through significant improvement of the conditions of sustainable modes of transport.

The Ministry's report strives to achieve significant growth in the number of electric cars. The purpose is to increase the number of electric cars from the current couple of thousand to about 670,000 by 2030 and to two million electric cars by 2045 nationally. The proportion of electric vehicles is very small in heavy traffic, and mostly consists of a few electric buses. However, the goal is to have 7,000 electric vehicles in this sector by 2030 and up to 42,000 by 2045.

Another plan promoting low-emission traffic in the Helsinki region is the Land use, housing and traffic (MAL) plan, which combines all these sectors with the purpose of promoting low emissions, among other issues. The measures in this plan strive to reduce the greenhouse gas emissions of traffic by 50% in comparison to the basic trend. The range of measures in this plan are similar to the actions listed by the Ministry of Transport and Communications, and the measures that are identified as the most significant are the strong growth of low-emission cars, road tolls, emission-neutral bus transport, supporting the technological solutions of heavy traffic and focusing the transport sector's projects and land use in central areas. This plan is one way of promoting comprehensive thinking where, instead of promoting individual projects, the measures will be promoted as a single venture with the same goals.

The City of Helsinki approved the Carbon-Neutral Helsinki 2035 action programme in 2018. This programme presents 143 measures targeted at different sectors, through which the City of Helsinki will attempt to become carbon-neutral by 2035. The City will attempt to cut traffic emissions by 69% by 2035, compared to the level of 2005.

According to this action programme, about half of the potential emission reductions can be achieved through the basic reduction measures (e.g. vehicle technology and renewable forms of energy). The most significant new measures presented in the programme were increasing the proportion of electric cars significantly, investing in heavy traffic technology, the emission reductions of the Port of Helsinki and the pricing of car traffic (parking fees and road tolls). The programme presents a total of thirty measures for transport.

How could climate change impact transport in the City of Helsinki?

Climate change has multifaceted effects, some of which are due to actual changes in Helsinki's climate, but more significantly due to policies and measures used to mitigate or adapt to climate change, such as striving towards low emissions of transport.

Potential impacts in Helsinki:

- *Electrification of transport will become more rapid as the policies aiming to mitigate climate change gain traction. However, extreme weather conditions, such as heat, wind and floods may reduce the attraction of cycling.*
- *The proportion of year-round cycling will grow as winters become more temperate.*
- *Extreme weather phenomena, such as urban flooding, will create substantial problems for the operational reliability of transport, especially the metro. Rail traffic is particularly vulnerable to snowstorms, which are expected to become more common and stronger. However, average operational reliability will improve as winters grow shorter.*
- *The numbers of climate refugees may increase in Helsinki quite rapidly, as the living conditions deteriorate in Africa and Asia, for example. Growing refugee numbers will increase the City's growth but also demand careful planning to prevent segregation.*

Change of work

The Finnish Government has compiled a presentation of the potential development pathways affecting work in Finland. It can be expected that the utilisation of automation and AI will increase in working life, and all work that can be automated will be automated in the name of cost efficiency. Expert and knowledge work, in particular, will become even less dependent on time, place and employer. Work will become more diverse, self-managed and multi-mode. Future work can also be independent of any employers or, at least, the role of an employer will diminish. In the future, work can be based on the platform, sharing or gig economy; self-employment; co-operatives; joint production or a combination of several or all of the above.

As the work field becomes more fragmented, income will also consist of several streams. Irregular work leads to irregular income and, therefore, uncertainty and worry over one's livelihood. This trend diminishes the role of work as the main channel of social attachment, while also decreasing the significance of work as the basis for the transport system. The mixing of working hours and workplaces, the growing number of people outside working life and the automation of transport-related work will have major impacts on the transport system. The amount of traffic will not necessarily change, but the directions, rush hours and the purpose of transport will develop along with the changes in working life.

How could change of work impact transport in the City of Helsinki?

It is still difficult to forecast the rapidity and extent of the change to work. However, it is clear that the nature of work will change, and automation will take over many blue-collar jobs at an accelerating rate.

Potential impacts in Helsinki:

- *Blue-collar jobs will decrease as automation becomes possible. The remaining jobs are mainly knowledge and service work. In knowledge work, the location of a workplace will become less solid, and service jobs will be focused in urban centres and densely-built areas.*
- *The nature of work will become irregular and the proportion of work that is not dependent on location will increase, which will be reflected in the rhythm of commuter traffic and even out the peak hours.*
- *As the proportion of unemployed people and others outside working life increases, the focus on commuter traffic shifts to recreational trips, which means that the capacity will be sufficient with fewer lanes than now, but predictability will suffer.*
- *Planning the schedules, shifts and fleet of public transport will become more difficult and dynamic. Schedule-based connections will shift towards on-demand operations.*

Urbanisation and aging population

According to a population forecast of the City of Helsinki and the Helsinki region, compiled by the City, it is estimated that population in Helsinki will grow from around 648,000 residents in 2019 to about 795,000–884,000 residents by 2050. This range depends on the selected projection, from the options of basic option, fast option and slow option. However, there will be a growth of at least 147,000 residents (+23%) according to the forecast, and, at the most, as many as 236,000 residents (+36%). The population in the whole Helsinki region (14 municipalities) will increase from the current 1.49 million to 1.89–2.0 million residents (+26–32%).

The population will also age notably at the same time. According to the population forecast, the proportion of people aged over 75 will grow by up to 100% in Helsinki by 2050, based on the basic option, which means that of the total population they would account for 11% instead of the current 7%.

The same population forecast also includes a regional forecast up until 2034, which lists the following major growth areas:

- Kalasatama project site (+16,300 residents),
- Kruunuvuorenranta and Laajasalo (+13,700 residents)
- Pasila (+13,000 residents)
- Jätkäsaari (+9,500 residents)
- Vuosaari (+8,500 residents)
- Lauttasaari (+5,300 residents)
- Hernesaari (+5,200 residents)

Several factors affect urbanisation, such as the changes of livelihood and production structures, scale benefits brought by population and business density, and cities' attraction factors, such as institutes of higher education and service selection. Demos Helsinki has identified six driving forces of urbanisation: changing working life, immigration, investments in infrastructure, real estate markets, housing preferences and city attraction factors. The background factors of an aging population include matters such as increase in life expectancy, retirement of large population groups and low birth rate (The Ministry of Social Affairs and Health)

On the other hand, the ongoing coronavirus pandemic has brought up new questions concerning urbanisation. The fact is that dense cities are particularly vulnerable to epidemics, which was proven by many other epidemics even before coronavirus. However, cities have the prerequisites to cope with various crises the best, as they have more economic activity. Diverse services, the wealth of financial and social opportunities available, short distances and a smooth day-to-day life are all factors that have driven the growth of cities for centuries and will also continue to do so.

How will urbanisation affect transport in Helsinki?

The impact of urbanisation on the City of Helsinki's transport system is significant, as the growing population will also increase traffic performance. Urbanisation will lead to the city's growth, which is a very important goal to the City of Helsinki. However, this growth cannot lead to increasing car traffic, not only due to already limited street space but also – and especially – due to the other detrimental effects of cars.

Potential impacts in Helsinki:

- *Larger population facilitates efficient public transport, which makes it easier to achieve the emission reduction goals.*
- *If the amount of car traffic cannot be decreased sufficiently, especially along the key entry roads, the capacity of the street network will not be enough and traffic will become congested. The capacity problem will also quickly be reflected in the reliability of public transport, if space reserved solely for it can no longer be guaranteed.*
- *Street space is highly sought-after in the busiest areas, as space is in demand for services, parked cars, public transport stops and residents alike. Street renovations, building rail connections or improving cycling conditions will cause large, temporary problems for such areas.*
- *If the modal share of car traffic remains the same, the problems caused by local emissions and noise will increase, especially if the vehicle stock's electrification does not occur fast enough.*
- *The larger number of residents will lead to absolute growth of pedestrian and cyclist numbers, and, in the current street network, this increases the risk of potential conflicts between the different modes of transport (especially between cars and cyclists or cyclists and pedestrians).*

- *The growth of the Helsinki region also means the growth of traffic coming from the region. It is important to promote the housing, service network and zoning policies of the entire region, as well as its public transport and park-and-ride solutions, towards more sustainable development in order to prevent traffic coming from elsewhere to Helsinki from causing local problems.*
- *The growth will not be distributed evenly among all residential areas, as some areas are more attractive to residents than others. This may lead to segregation between the areas and, if the matter is not taken into adequate consideration, to unequal transport services.*

How will aging population affect transport in Helsinki?

The aging population will increase the need for more versatile transport needs as the role of commuter traffic grows smaller. Facilitating the individual mobility of the elderly decreases costs and enables them to live at home longer, but also places more demands on the local environment and accessibility of transport.

Potential impacts in Helsinki:

- *The transport needs of seniors differ a great deal from those of commuters in terms of time and place. The availability of local services and usability of residential buildings will be highlighted when choosing a residential district.*
- *In densely built areas, the distances between services and apartments are short, which makes using pedestrian and cycling traffic more attractive. Muscle-powered transportation, for its part, helps mitigate several health hazards and reduces the mortality rate.*
- *The demands for improving accessibility and availability will increase, especially in services popular among the elderly. Such services include social and healthcare services, sports and culture services and the stops and stations of public transport, for example.*
- *Digital accessibility will play an even larger role as services move online and to mobile services.*
- *The risks of traffic accidents increase as the population grows older. The senses and reaction times of seniors deteriorate and the urban environment grows more complex, which both increase the risk of accidents. At the same time, the consequences of accidents become more serious as bodies become more fragile with age.*

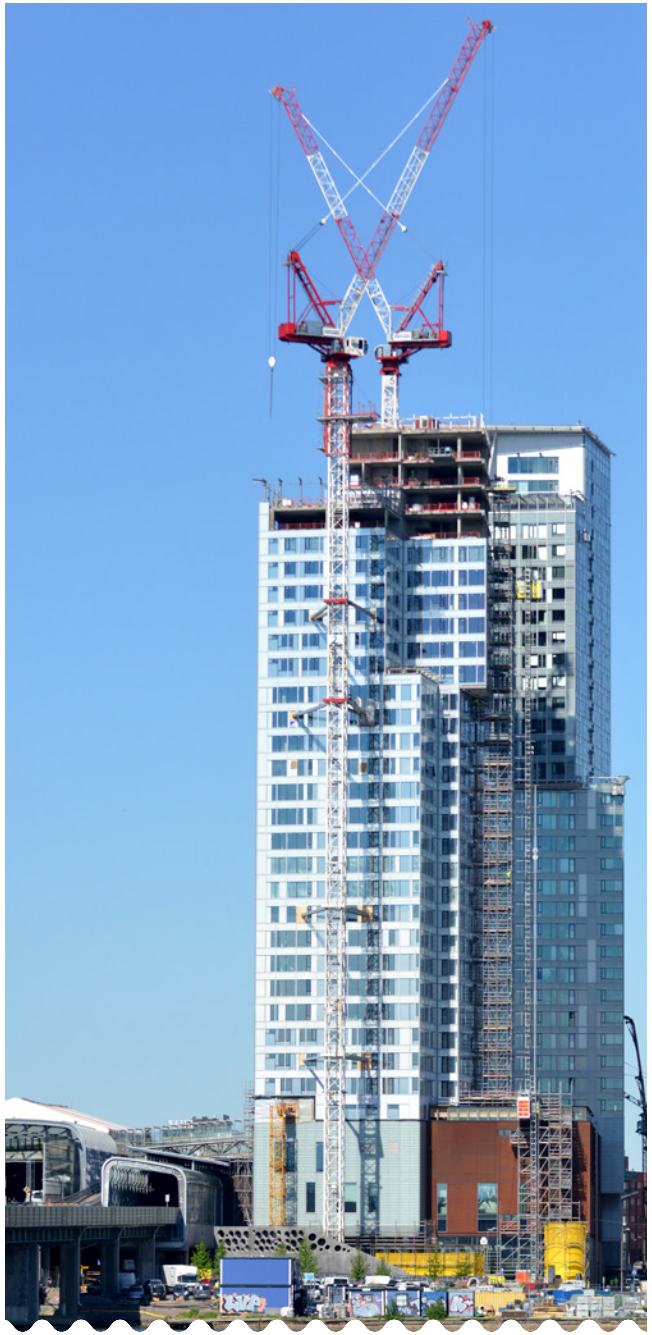


Image 3. Developing REDI high-rise in Kalasatama 2020. City of Helsinki Media Bank / Tero Pajukallio

Future scenarios in other cities

The study also assessed the future reviews and strategies of a few example cities. The most interesting of these was the scenario work for Copenhagen regional organisation, called *'Future mobility in the capital city area'* (Ramboll Denmark 2018), which extensively reviewed the drivers impacting future mobility up until 2040 and compiled three scenarios, in which three variables considered uncertain developed in different directions. These variables were the willingness to invest in public transport, the ownership / servicification of automated vehicles and the development of social structure. Indicators and warning signals that may indicate that the situation is developing in accordance with a certain scenario were identified for each of these scenarios. These indicators and the scenario stories themselves can be used as a way to support decisions concerning the future to ensure that the decisions made and policies drafted are functional for all potential future scenarios.

The key conclusions of the Copenhagen review were that future is not yet written in stone, but that decision-makers have a central role in the utilisation and control of new technologies and other drivers in a way that is optimal to the region's development. Another conclusion was that due to the limited urban space, space-saving public transport is necessary also with regard to a transport system that is largely automated, which is why the gradual expansion of the rail transport system should be continued.

Disruptions to urban transport caused by technology

New technologies spread quickly on the market in the global economy. The following section focuses on the changes regarding a few development trends

Singapore, Mobility as a Service

Singapore has a dense urban structure and 5 million residents, which are a few factors that attract companies to the area. The city has its own application for shared driving, which has transformed public transport information into public data, and the city's innovative approach to transport development is part of Singapore's Smart City plan. MaaS services in Singapore are offered and designed by, the likes of: (Koh, 2017; Maas Global, 2019; MobilityX, 2019)

- MaaS global, route planning for public transport and door-to-door taxi service.
- Beeline, on-demand bus service, which was available until January 2020. Real-time tracking, seat reservation and route suggestions possible.
- The NTU-NXP consortium, a test platform for new mobility services in the university area. Includes the transport network with its services, traffic lights, toll fees, parking control, communications, autonomous cars.
- MVL Foundation, an ecosystem for mobility services, which pays for data with MVL virtual cash that can be used to acquire the platform's services, such as shared rides, taxi and navigation services and data processing in connection to servicing or pur-chasing vehicles, for example.
- mobilityX, produced the Zipster platform, which aims to make as many modes of transport as possible available to the customers through one platform.

Oslo, electric cars

Oslo is a wealthy city measured by the purchasing power of its residents, and Norwegian electricity production is based on renewable forms of energy. This means that the market conditions are quite propitious for electric transport. During the first half of 2019, the proportion electric cars accounted for of all registered new vehicles was 48%. Electric cars are popular, especially in the capital city Oslo, which offers free charging with renewable energy at all type 2 charging points, as well as free-of-charge public parking spaces and priority for parking space applications. The government has also further facilitated electrification through tax benefits and procurement subsidies. (Fridstöm, 2019; Solsvik, 2019)

Berlin, electric scooters

According to the company Lime, during the first 80days it provided electric scooters in Berlin, they were used on more than a million trips. In Berlin, electric scooters are operated by Tier, Circ, Bird, Lime and Voi, among other operators. At the end of September 2019, the largest operators– Lime, Tier and Voi – owned more than 11,000 electric scooters in total in Berlin. The City has allowed the companies to expand their operations in Berlin without an upper limit. (Petz-inger, 2019)

The City of Berlin has prohibited the use of electric scooters in pedestrian lanes for safety reasons. Additionally, any faulty electric scooters need to be removed within 24 hours according to the rules, and separate guidelines have been compiled for parking.

New York City, new kinds of taxi services

Since the beginning of 20th century, New York has been developing and using a taxi permit system that was controlled the city's taxi and limousine commission. However, growing demand inflated the price of an individual permit to $1.3 million in 2014. Ride sharing services have since grown more popular and cut the prices of taxi permits down to around $180,000 while simultaneously reducing the amount and profits of traditional taxi operations. (Slater, 2018)

Today, 1.6% of commuters use a taxi for their daily commute and 4% use various ride sharing services. The largest ride sharing services are Uber, Lyft and 511NY Rideshare. Passenger numbers have increased in particular in the more distant suburbs with lower income levels, where owning a car is fairly rare. The City has established uniform requirements for the quality and capabilities of the taxi fleet, for example by demanding that the cars need to be replaced by hybrid vehicles during the 2010s and that the taxis have equipment that provide passengers with a real-time map, entertainment, air conditioning and a card payment terminal.

The City of New York attempted to limit the number of ride sharing services towards the end of 2010s, but failed as the attempt was faced with a great deal of opposition from the various ride sharing services, such as Uber. (Hawkins, 2019)

Operators and roles of a seamless mobility system

This work entailed a literary review of future studies compiled by international organisations and consultancy agencies. Based on the review, similar trends have been identified not just in Helsinki but elsewhere, too, and scenarios based on similar factors have been compiled.

The World Economic Forum has produced a White Paper: Designing a Seamless Integrated Mobility System (SIMSystem) - A Manifesto for Transforming Passenger and Goods Mobility (2018). In its proposal, the WEF identified three central elements of a transport system.

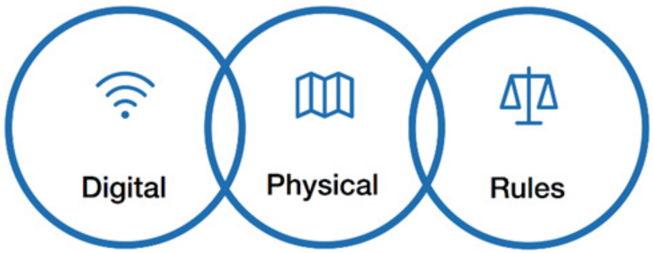


Image 4. Interoperability Layers. World Economic Forum 2018.

Additionally, the WEF states that a seamless integrated mobility system requires active investments from public operators, private sectors and consumers alike, so that the obstacles related to such a system can be overcome and that the operators are able to work together in new ways. Potential roles as users, operators, owners and regulators have been identified for the different parties. The City's potential roles are connected to the last three

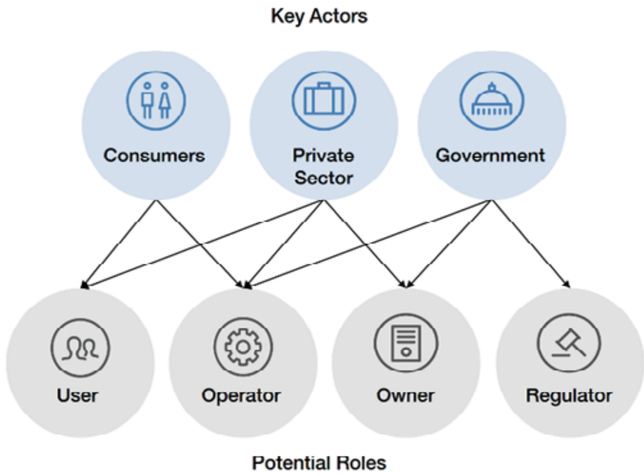


Image 5. Key Actors and Potential Roles. World Economic Forum 2018.

Future scenarios of Helsinki

Method of scenario work

The purpose of futures research is to study existing images of the future. Futures, or futures images, can be divided into (Sirkka Heinonen 2018):

1. Possible (open exploration),
2. Probable (analytical anticipation), and
3. Preferable / unpreferable (normative and critical pro-action) futures.

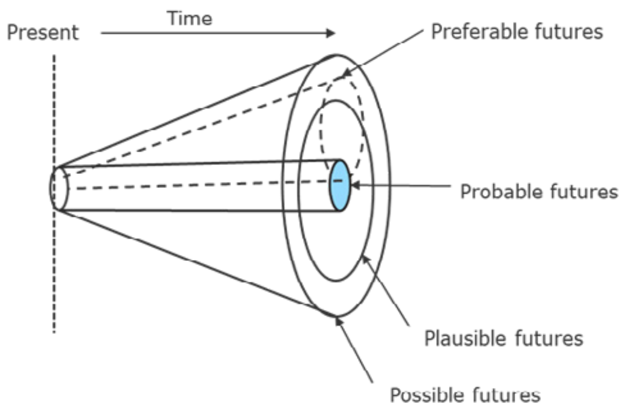


Image 6. The plurality of futures images. Nesta, edited Dufva, redrawn Ramboll

Scenario work is a widely applied method in strategy and vision studies, for example. A future scenario is a free-form, visionary story of a potential future that is still firmly based on the currently available information. Scenarios do not attempt to forecast a future that will become a reality, but instead their objective is to discern several different, potential development pathways of the future. Scenarios may help identify the key variables and actively promote the implementation of positive alternatives to help pre-vent the negative development pathways.

During the first stage of constructing the future scenarios, the uniform, default starting points for these scenarios were identified and agreed. These referred to variables that can be considered fairly certain and that may have a major impact on City of Helsinki's transport, but to which is was not necessary to apply various values in this work. Climate change, electrification of traffic, change of work, urbanisation and the aging of the population were selected as the default variables.

The next stage involved identifying critical variables, the uncertainties of which were then studied in the future scenarios. These refer to variables that may have a major impact on the City of Helsinki's traffic, but the realisation of which includes some significant uncertainties. Additionally, there are uncertainties related to the direction and magnitude of these variables' impacts. A SWOT analysis was used to identify the impacts and probabilities of these variables. The variables identified as critical:

1. Automation of transport, with uncertainties related to its realisation.

2. Use of mobility services and ownership of vehicles, which may be based on individual mobility and private ownership of vehicles or extensive use of mobility services with vehicles in shared use.

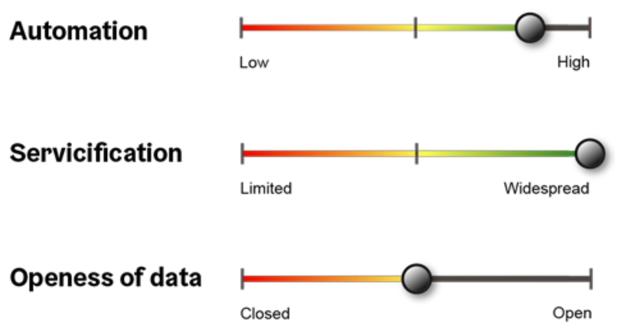
3. Openness of data and ownership of data infrastructure, which may be realised with businesses as the drivers and lead to centralised data ownership, or with the principle of open data, in which case individuals and the public sector have larger roles.

The future scenarios in the study were created by combining the values set for the critical variables, such as how and to what extent automation, servicification and openness of data will develop. The objective of these future scenarios was to discover the combined effects of the critical variables' uncertainties. The scenario stories are presented in full in Appendix 1.

Scenario A ”Integrated market-driven”

City transport driven by global companies, based on automation

There are a few mega corporations in the world that have started to dominate digitalisation and the transport service market. The mega corporations function as MaaS -operators in ecosystems that consist of global transport service operators and a few local companies that for a charge utilise the mobility data and technical platforms provided by the corporations.



More than half of motor vehicles in Helsinki adhere to the high level of driving automation (SAE 4). The level of automation is even higher for vehicles in commercial and public transport use. Motor vehicles are in use most of the time, as the fleet of cars transitions into shared use through servicification (source: Google Waymo). The proportion of households without a car has climbed to 80% in Helsinki due to the aggressive price competition of the MaaS operators and the ease of services based on the exceedingly common automated vehicles.

The transport system is based on rail traffic organised and developed by public operators as well as a versatile selection of transport services, which complements and competes with the rail transport system.

City transport driven by global companies, based on automation

Mobility service providers are able to serve their customers on a door-to-door basis, utilising on-demand and autonomously operated transport. These services are affordable to use and guarantee good availability to many various user groups. On the other hand, the door-to-door services replace trips made on foot or by cycling, and, as a consequence, lack of physical activity threatens to grow as an issue of public health.

Transport safety is at a high level, thanks to automation. The predictability of vehicles improves from the perspective of unprotected road users, which, in part, promotes better conditions for walking and cycling.

Since a part of the transport system is built on services owned by global companies, honouring the service promise given to the consumers requires the physical urban environment to have sufficient space and areas for passengers' embarking and disembarking actions, both in numbers and regionally. These areas dedicated to the companies partly suppress the uniqueness of Helsinki under globally standardised modular solutions.

City transport driven by global companies, based on automation

Mobility services develop into a seamless service selection in the ecosystems compiled by the global MaaS operators, in which the price competition

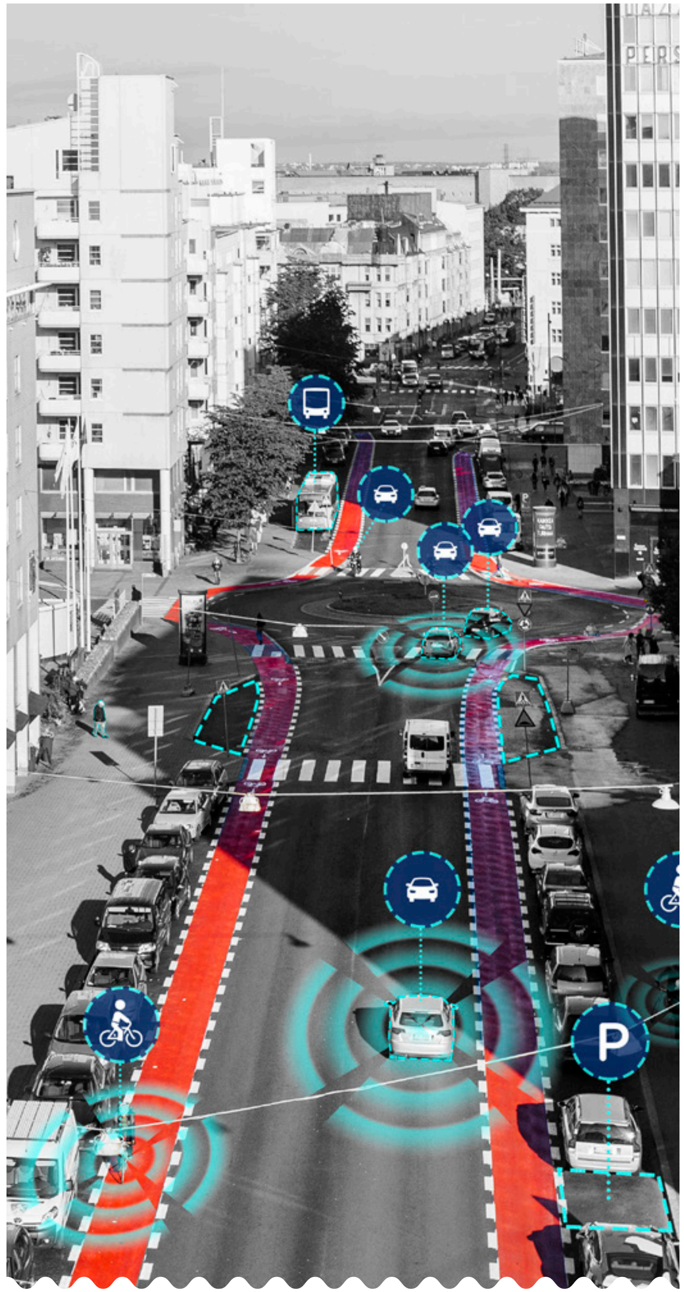


Image 7. Automated vehicles are exchanging information. Ramboll

between mobility service providers ensures affordable prices for the consumers and guides operations towards the economies of scale. Automated vehicles are controlled through automation and remote control, which makes the production of automated taxi services and shared taxi services affordable.

This trend results in combinations of public and commercial services that have adapted to the demands of the different areas in Helsinki. They are offered to the consumers through a couple of commercial platforms dominating the market. The ecosystems of major companies also feature a few local service operators, which are linked to the global platforms and adapt to the rules and business logic of the major companies' ecosystem.

This development is supported by data collected centrally by the companies, which facilitates an even more personalised customer experience. The companies barter with each other using mobility data collected from the consumers, which is widely used in the business optimisation of the service operations. Small, agile companies can discover opportunities for value creation, especially by combining these data sources in unique ways. The city is also collecting and sharing some traffic related data mainly from it's own systems, but this data has lesser significance in the business value chains.

The service level of small-scale logistics is high due to automation and drone transportation services. Problem situations in traffic are mostly resolved with the help of systems based on artificial intelligence.

Impacts on a sustainable city

Public transport is based on rail transport, by which large masses of people travel between regional centres. Tram, metro and local train transport have all grown notably compared to 2020, tramline traffic the most in relation to the others. Multimodal travel is commonplace, as the strong trunk routes are complemented by mostly automated mobility services implemented with various smaller modes of transport. Functional feeder services support a car-free way of life even outside the urban centres, though the commercial service selection still remains underdeveloped in certain suburban areas of the City of Helsinki. There is a risk of regional segregation of transport services' service levels as well as the risk of selective choosing of customers.

After gaining a strong foothold, the automated commercial services developed by mega corporations may attempt to challenge the services organised by public operators by offering aggressively priced alternatives based on shared vehicles on the trunk routes (Source: Deloitte), if the use of space makes this possible.

Servicification leads to a high usage rate of the vehicle fleet. As car ownership becomes rarer and the traffic performance of private driving decreases, street-side parking and the capacity demand on the street network decreases to the extent that it is possible to assign street areas extensively for other purposes. Part of this available street area will serve the needs of commercial mobility services, for example as stop areas. The increasing amount of street area no longer needed for parking has also been a large factor in building a high-quality, extensive cycling network in the entire Helsinki area.

Separating the modes of transport has been implemented through different street classes. At main streets and collector streets, ensuring the smooth operation of automated vehicles requires separation of cycling and other, lighter modes of transport into their own lanes. The busy pedestrian and cycling traffic in the centre areas limits the chances of creating a well-functioning operating environment for automated traffic. The automated drone transports of global logistics operators are a part of the logistic last-mile transportation of time-critical goods, and space has been reserved for them both on the roofs of buildings and in public spaces at street level. A significant driver in this scenario are the business interests, which may conflict with the efficient use of the City's resources and the City's operational needs.

With regard to the physical need for space, the demands of digital infrastructure are not very high.

Scenario B ”Private autonomy”

Transportation based on privately-owned automated vehicles

Car manufacturers have gone through some significant reforms over the decades. The prices of electric automated cars have been decreasing for a long time, and the various mobility services or public transport services have not been competitive enough. About a half of households own a motorised vehicle, and transportation has become easier as automation manages the parking and driving. User data is owned by car manufacturers and it is not extensively used for optimising the transport system. Unexpected congestion occurs at various places as the cars attempt to optimise their routes, but as user data is strictly controlled by the car manufacturers and owners.

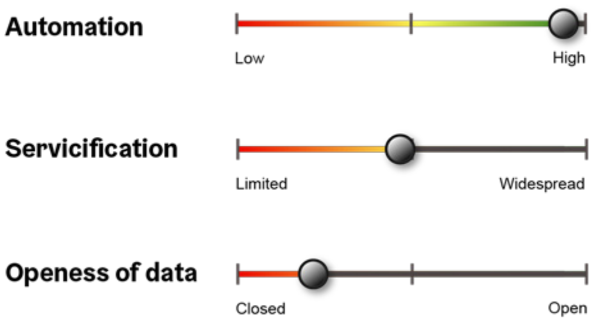


Image 8. Automated private vehicle may enable working and relaxation during travel. Ramboll

The impacts of the scenario on a healthy, safe and attractive environment

Transportation in the City is automated. The automated cars offer such a high service level for households that it is difficult to come up with competitive alternatives for them outside the centre areas. However, residents living in the inner city mostly use cars in shared use, as a part of seamlessly operating mobility services. As the demand for public transport decreased outside the areas with a high service level, some of the trips are made by walking, cycling or driving, depending on the length of the journey.

The increasing automation facilitates traffic safety. Speeding, for example, is clearly less frequent than today, thanks to the vehicles’ advanced automation.

The size of the vehicle fleet grows and its lifecycle emissions emerge as one notable issue that must be resolved. Due to the increasing driving mileage, traffic congestion is a real threat despite automation making the utilisation of existing capacity more efficient. This requires intelligent traffic network control.

An automated vehicle allows for working during a commute. This scenario holds a risk of a dispersing urban structure as the significance of city centres decreases and the commuting area grows.

Impacts on growth and the conditions of business life

Car manufacturers own a large proportion of the data and may use it for their navigation services. Therefore, they can impact the functionality of traffic arrangements and the user's mobility. Despite this centralised collection of data, the companies are aware that practical street traffic requires them to share the data. This gives rise to new forms of data economy. The city is cooperating with the data providers to acquire vast quantities of real-time data to be used in advanced network-level traffic management.

Pick-up point services are a key part of urban delivery services. Customers can send their own vehicle to pick up deliveries, such as groceries or items bought online. The pick-up point network is flexible and not bound to any delivery routes.

Impacts on a sustainable city

Competitiveness of public transport is maintained in the city centre and the service area of rail transport, and there are still enough public transport users in the area. However, public transport service level drops in areas with a less dense population and the services may even be withdrawn. Not all households have the option to get an automated vehicle, which may lead to rather strong areal segregation of service levels.

Among those who can afford it, anyone can own and use a car, regardless of their physical condition or age, which increases the independent mobility of seniors as well as children and young people. The selection of mobility services is limited and traffic is focused on individual, privately owned modes of transport. The space requirements of motorised vehicles grows, which also increases the pressure to grow the street and road network's capacity and management of that space consumption efficiently.

The City has attempted to utilise the advantages of automation to the maximum extent, especially on the main car traffic networks by assigning separate lanes for automated vehicles. The street space can be divided dynamically based on the traffic situation, especially in the lanes assigned to automated vehicles. Lanes with alternating traffic direction have been used on certain selected main streets. Streets that are not part of the main network are divided functionally into two parts: a walking and recreational area and an area for faster modes of transport. The impact of automation on street capacity is not large in centre areas, as large amounts of pedestrians and cyclists set boundary conditions for optimising the throughput of cars.

The demand for parking spaces grows as the number of vehicles increases. Parking garages have been built near the borders of the city, in noisy areas and other areas with a lower utilisation rate. Some cars can be directed there for the night.

Scenario C ”Open and shared”

Local service providers operating based on open data

The automation of transport has progressed slower than in the other scenarios. The high-level automation applications operated in vehicles without a driver have not proven to be safe enough to use in an open, complex urban environment. All data is open and available for utilisation to all, and local service providers have emerged based on this.

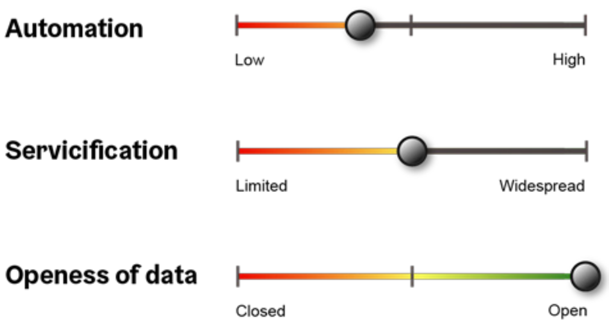


Image 9. Data exchange between APIs is open and flexible. City of Helsinki Media Bank / Antti Pulkkinen edited Ramboll

The impacts of the scenario on a healthy, safe and attractive environment

Longer everyday trips are taken by rail or car, but shorter trips and park-and-ride trips in particular are made by walking, city bikes or various micro-mobility services. A guide based on artificial intelligence familiar with the consumers’ preferences and needs is used to support the choices. The prices of transport services are high, but so is the quality of these services and the attractiveness of urban environment. There are several mobility options available in urban centres with a large number of people. The degree of automation is high in public transport and the use of public transport services is very common. Muscle-powered modes of transport are also popular.

The increasing automation facilitates traffic safety. Speeding, for example, is clearly less frequent than today, thanks to the vehicles’ advanced support systems for drivers. However, safety does not improve as much as in the scenarios with faster automation development.

Most orders from online stores are usually picked up personally from local delivery points. Some deliveries will be delivered to the customer’s front door.

Impacts on growth and the conditions of business life

A public transport authority manages the main service based on rail transport, as well as the interfaces for supplementary services. Open data facilitates high-quality information and guidance services and situational awareness, as well as the optimisation of traffic flows at regional level.

An open mobility ecosystem with its advanced service sales interfaces creates opportunities for companies to provide high-quality, comprehensive and affordable mobility services. This creates a boost for multimodal travel choices. However, public administrative-driven open data does not significantly increase the interest of market operators, as the potential market share is too small and production costs too high without a high level of automation. Market-based competitiveness has not been achieved in the costs of on-demand transport services.

Local companies with business and social interests in developing the transport system in Helsinki develop the information and guidance services based on open data.

Impacts on a sustainable city

The basis for public transport is rail transport, organised by the public sector, which takes large masses of people between the regional centres. The role of areas surrounding the stations is highlighted and the role of rail transport strengthens. Public transport is highly competitive.

The physical urban environment also caters to the competitiveness of public transport and the accompaniment and waiting areas necessary for the publicly available mobility services. The open data policy and the service ecosystem built on it increase the need to equip the street space with various sensors and data collection systems that facilitate accurate situational awareness of traffic. Even though automation has not progressed far, vehicles do transmit situational data to each other and exchange information with the infrastructure through various cooperative services.

The street space operator dynamically controls the space reserved for parking based on the time of day and demand, also assigning some of it to logistic needs, for example. Streetside space and its use are monitored and controlled extensively and automatically in real-time. Managing the streetside space has become more important, and, as the space is limited, various ways have been utilised to make its use more efficient. The use of streetside space is managed and priced dynamically, which allows it to be used for other purposes.

The scenario generates a socially fair transport system, but, on the other hand, the heterogeneous nature of mobility services may create challenges for the services' accessibility.

Summary and recommendations

Summary

The future study of City of Helsinki's transport was mainly carried out as the City's internal expert work. During the course of the work, the workgroup has attempted to identify the probable, potential and even uncertain future trends and phenomena connected to transport in Helsinki. Climate change and preparing for it, urbanisation, change to work and aging of the population were identified as predictable megatrends with significant impacts. The identified change factors that are uncertain but would have major impacts are automation of transport and factors related to it, servicification of transport and traffic data and its openness. The scenario working method applied for the uncertain variables has steered the conversation towards promising future opportunities, but has also forced those involved to think about the various unfavourable development pathways, which the technological trends and the different drivers linked to them may bring along. If one should be interested in continuing the scenario analysis, a perhaps interesting new scenario could be "Open and automated" scenario, a mixture from developments in the current C and A scenarios.

The study has identified some of the best methods with the help of which the City of Helsinki can prepare for the future changes to its transport system by maintaining and further developing its status as an international forerunner of sustainable development and mobility.

The recommendations born as a conclusion of this future analysis of transport are based on the impact assessments of the megatrends reviewed and the phenomena identified in the scenario descriptions. The impacts have been assessed in relation to the compiled set of goals, which is based on the objectives of the UN's sustainable development agenda, the City Strategy, the region's long-term land use and transport system plans, and the goals of both the City's own and national development programmes. The tables compiled for the impact assessments are presented in Appendix 2

Recommended operational models

Helsinki pro market

The transformation of mobility, the transition from car ownership to service use and the progressing automation of traffic constantly produce new transport services and business models on the market. It is important that the City of Helsinki actively monitors the development of these services and recognises the market's business logic to maintain its status as a forerunner. There is also a need to regulate the services and define the common rules, but it is not usually necessary to proceed quickly with such measures. Instead, the City should attempt to guide the more extensive introduction of these new services during the stabilising stage in a way that ensures that

Image 10. Open competition benefits the city. City of Helsinki Media Bank / Niila Varpunen

these services promote the City's general interests. The City must facilitate open competition between companies and attempt to avoid the creation of monopolies. The best way the City can build a functional ecosystem for transport is by presenting clear common rules and acting in a predictable, persistent manner while allowing the market to produce the functional solutions. Regarding this, the development of the City's procurement competence, change abilities and market understanding plays a major role. The creation of the best cooperation model requires both theoretical and practical exercises in the future. An example of such an area is urban goods transport and parcel delivery services. There integrated market-driven solutions are anticipated, but also the city needs to define its role as market enabler in the most feasible way.

In addition, the market development can also be controlled through public acquisitions, which highlight the perspectives of sustainable development even more than now.

Impacts on a sustainable city

A central conclusion of this scenario review is that steering the City's growth towards a network-like multi-centred urban structure supports the sustainable development goals in all the scenarios reviewed. Expansion of the inner city, dense urban structure and mixed land use support the prerequisites of market-based transport services, multimodality and car-independent life. Developing rail transport connections between the different urban centres is also necessary in the different scenarios of transport automation.

Good traffic connections maintain the service level of traffic in all areas in Helsinki, which is important for social equality, availability of labour and the renewal of suburban areas. Various seamlessly operating last-mile services are also essential for the service level of a system based on rail transport, and their availability must be ensured everywhere in Helsinki. Following city's strategy of a network city the land-use development is always planned in conjunction with rail and tram network. Urbanisation proceeds gradually but inevitably and is supported by the city's masterplan for 2050.

Need for financial steering in the future

Financial steering affects the mobility and transport choices of consumers and businesses and help decrease the negative external impacts of traffic. With the electrification of traffic and the transition to carbon-free energy production, the emissions of the vehicle fleet will be reduced significantly compared to the current situation. In the sustainable mobility of the future, the focus will actually shift to the emissions generated during vehicle manufacture and its use of resources, as well as the street space necessary for traffic. In the future, the goals set for financial steering will highlight use of the transport system, vehicle fleet and street space that is as efficient as possible. The methods of financial steering can be used to encourage mobility service companies to develop business models that promote sustainable development goals. One option is to use road pricing scheme that addresses the above mentioned goals and enables the direction of the collected fees back to the development of the transport system to increase the pace of its sustainable renewal.

Subsidy policy is a part of financial steering. The need for public transport subsidies will continue in the future so that a sufficient service level of public transport can be maintained in all areas in Helsinki. The automation development of transport may highlight both automated vehicles used as a service (such as robot taxis) and privately procured automated vehicles, which are mainly used to meet a household's transport needs. Even in the light of international estimates, these development pathways can be present simultaneously, so that services such as the robot taxis will become more common in denser, very urban areas, whereas the number of privately-owned vehicles will increase in the city's border areas. Financial steering will likely be needed to guide this development pathways sustainably so that the regional dispersion of land use can be avoided.

The kinds of subsidies appropriate for the likes of transport services based on muscle-powered modes of transport, which promote the city strategy's goals most effectively, should be reviewed.

Urban space for everyone

In the future, the street and urban space necessary for population growth, the expanding inner city and new mobility services will place growing pressures on urban spaces. City bike and micro-mobility services, the strongly growing local delivery services (possibly including drone deliveries) and automated robot taxis all require delivery and pick-up areas, both on the sides of streets as well as in other public areas. The risk here is that the street space will become structurally too complex. Attention and careful consideration need to be put especially to efficient use of the space between the driveway and the sidewalk, where competitive demands for space can be identified. This further addresses the high requirements of the multidisciplinary planning skills of city's transport and city infra planners as well as the requirements for wide public engagement to address all possible demands and needs.

Well-functioning automated traffic likely requires infrastructure dedicated to cycling and pedestrians on main and collector streets. Street space should become available due to decreasing street-side parking if the servicification of transport progresses a great deal. Good distribution of space in the inner city and central areas requires careful planning. Creating a comfortable and attractive urban environment also requires maximal public space for other purposes than those of transport, such as recreation and socialising. Shared solutions with efficient use of space will be important in the future and should also be encouraged with the tools of financial steering. Street space should not be privatised; the City maintaining control over it to enable flexible use of space is well justified.

Added value from data

The data collected about transport will, in the future, become a key tool for realising a sustainable city, and the openness of data is considered a central enabling factor here. Based on the scenario review, the future scenarios built on closed data and purely commercial data could very likely lead to unfavourable partial optimisation if considered from the City's perspective. Therefore, the City should take an active role in the ecosystem of transport as a collector, refiner and distributor of raw transport data. The initial steps towards this role are already taken as the city is building its' open cloud-based data platform as part of the recently updated ITS action plan.

The open data policy is built on comprehensive shared benefit – an operational model, where the companies providing mobility services (and data) will also benefit from opening their own data. In this operational strategy, the City will carry out analytics based on data fusion with the raw data it has collected, and the refined products generated as the end result will give an accurate and comprehensive overview of mobility and transport needs. This openly shared situational data regarding traffic system status, people flows and service demand can also be used by companies to develop and optimise their own business operations. The essential factor with regard to most critical data is to remain independent of any single data source.

Based on the scenario work, it is seen as necessary for the total optimisation of the transport system that the City retain a central role in traffic control and management of traffic flows, especially as the automation of transport goes forward. Highly developed situational awareness data, implementation of digital infrastructure and cooperation with operators providing transport services will all be key factors in the future.

Open society and participatory operational culture

The City of Helsinki's growth and success in the competition against the other metropolitan areas of Europe require an open society. Immigration of competent labour as well as competence development of immigrants have a central role to play in this. Currently, the transport sector is a significant employer and should keep its status as one in the future, too, despite the progress of automation, as labour will still be needed for various customer service assignments and the maintenance and development of intelligent infrastructure.

Openness and transparency of decisionmaking, as well as high-quality public engagement processes during the planning of major investments increase the satisfaction for transport administration and improved change readiness among citizens. As the city continues to grow and attract new citizens and immigrants, it is important to extend the public engagement processes and analysis of mobility needs not only to existing citizens but to the potential future citizens groups. The COVID-19 pandemic has greatly increased the significance of digital public engagement channels and tools, which should be utilised also after the current pandemic is over.

The City of Helsinki promotes a conversational and participatory culture. Understanding the market logic and developing new mobility services requires constant interaction with the market operators. International cooperation is also needed, for example with building the operational environments of automated transport and developing and introducing data models for standards.

International interaction also supports early identification of new phenomena and a proactive approach. Multidisciplinary cooperation between experts has also proven valuable for discerning and assessing the complex development pathways of a future transport system, which are hard to predict. This cooperation should be continued at the New Transport Policy Club, which is managed by the Urban Environment Division.

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Appendices

Appendix 1. Scenario stories

Scenario A 'Integrated market-driven'

City transport driven by global companies, based on automation

Human in the city

Mobility features a high degree of services and automation. A personalised service based on artificial intelligence guides the users with mobility choices, suggesting customised transport options in real time. Mobility service providers are able to serve their customers on a door-to-door basis, utilising on-demand and autonomously operated transport. These services are affordable to use and guarantee good availability to many various user groups. On the other hand, they compete with walking and cycling with regard to their attractiveness, replacing some muscle-powered trips. A significant share of everyday trips are still made by walking or cycling, especially outside the centre areas, where the selection of mobility services is not as diverse as in denser areas.

Increased automation has, for its part, facilitated the improved conditions for walking and cycling through better traffic safety. The amount of speeding, for example, has decreased noticeably, thanks to which accidents between motorised vehicles and pedestrians or cyclists have also decreased a great deal. Traffic accidents causing damage to property have also become rarer.

Most orders from online stores are usually picked up personally from local delivery points. There is also available a large selection of services that facilitate dynamically controlled delivery to a desired place with a certain, determined service level.

Mobility and transport services

Mobility services develop into a seamless service selection in the ecosystems compiled by the global MaaS operators, in which the price competition between mobility service providers ensures affordable prices for the consumers and guides operations towards the economies of scale. Automated vehicles are controlled through automation and remote control, which makes the production of automated taxi services and shared taxi services affordable. Global service providers also bring various city bike and micro-mobility services to the market.

The strong presence of automation has facilitated the creation of sustainable, market-bound feeder traffic services that support public transport. Functional feeder services support a car-free way of life even outside the urban centres, though the commercial service selection still remains underdeveloped in certain suburban areas of the City of Helsinki. In these areas, the feeder services are organised as a public operator's purchased services, for social reasons. This trend results in combinations of public and commercial services that have adapted to the demands of the different areas in Helsinki. They are offered to the consumers through a couple of commercial platforms dominating the market.

The ecosystems of major companies also feature a few local service operators, which are linked to the global platforms and adapt to the rules and business logic of the major companies' ecosystem.

This described development is supported by data collected centrally by the companies, which facilitates an even more personalised customer experience. The companies barter with each other using mobility data collected from the consumers, which is widely used in the business optimisation of the service operations. Companies control the transport data and attempt to utilise it to grow their role in traffic management services. The corporations control the traffic flows of their services and the use of different modes of transport through route selections and dynamic pricing, striving towards an optimised situation that allows them to maximise their benefits to business.

The sensor data collected from the urban environment has allowed for the creation of reactive, real-time urban models, in which the traffic situation and, in particular, the behaviour of people can be monitored. Problem situations in traffic are mostly resolved with the help of systems based on artificial intelligence. Small, agile companies can discover opportunities for value creation, especially by combining these data sources in unique ways.

In urban logistics, goods are still delivered to local pick-up points and stores with delivery vans, which are now electric and partly automated. Automation has made the operations more efficient and decreased the costs. Local self-service pick-up points have been established all over Helsinki, and people pick up most of the goods they have ordered from these pick-up points. However, delivery services to the customer's front door and dynamic delivery services to the customer's current location are also becoming more common. The technology utilised for these services is various modes of light transport, such as bicycle deliveries, delivery robots using the streets and automated drones, which are used for certain time-critical deliveries.

Shared use can also be seen in the logistic services. Crowd-sourced last-mile services are popular and have been separated from rest of the delivery chain.

Public transport system

Public transport is based on rail transport, by which large masses of people travel between regional centres. Tram, metro and local train transport have all grown notably compared to 2020, tramline traffic the most in relation to the others. The strong trunk routes are complemented by mostly automated mobility services implemented with various smaller modes of transport.

As well-functioning public transport is a major cornerstone of a city's competitiveness, attractiveness and functionality, large investments in it are funded through municipal and state taxes. Automation increases the reliability and cost efficiency of public transport. Buses, trams and the metro operate automatically, without drivers, which allows for the time between runs to be reduced significantly without notable increases in costs.

Commercial automated transport developed by mega corporations emerges as a significant form of feeder traffic. After gaining a strong foot-hold, it may attempt to challenge the services organised by public operators by offering aggressively priced alternatives based on shared vehicles on the trunk routes (Source: Deloitte), if the use of space makes this possible.

Urban space and digital infrastructure

As car ownership becomes rarer and the traffic performance of private driving decreases, street-side parking and the capacity demand on the street network decreases to the extent that it is possible to assign street areas extensively for other purposes. Part of this available street area becomes available for the needs of commercial mobility services, for example as stop areas. The increasing amount of street area no longer needed for parking has also been a large factor in building a high-quality, extensive cycling network in the entire Helsinki area.

The inner city has expanded along the built city boulevards, and adding boulevard-type green areas has also been possible in the current inner city areas, as space has become available due to decreased traffic. Many underground parking facilities have transformed into exchange and maintenance terminals for automatic cars. The terminals have connection to public transport services and the commercial facilities in the urban centre.

Since a part of the transport system is built on services owned by global companies, honouring the service promise given to the consumers requires the physical urban environment to have sufficient space and areas for passengers' embarking and disembarking actions, both in numbers and regionally. This need for space is highlighted in particular in the key areas of the city centre, where there is a great deal of passenger demand for dedicated use of both passenger and cargo traffic. Massive parking facilities are built around the edges of the city, where automated vehicles are charged and stored over-night, when demand is lower.

Separating the modes of transport has been implemented through different street classes (Source: Toyota). At main streets and collector streets, ensuring the smooth operation of automated vehicles requires separation of cycling and other, lighter modes of transport into their own lanes. The busy pedestrian and cycling traffic in the centre areas limits the chances of creating a well-functioning operating environment for automated traffic. On main streets, in particular, there may be pressure to increase traffic light control to ensure smooth operations for automated vehicles. The traffic on plot streets is mixed traffic, and to calm it down, the traffic speed has been determined on the terms of lighter modes of transport, to 10–20 km per hour. The functional division of street space is highlighted on these streets, where space is allocated to walking and recreation as well as faster modes of transport that utilise the driving lane.

Strong automation requires communication to be organised between the street infrastructure and vehicles. Digital infrastructure in a city environment is a requirement for the efficient operation of automated transport services, which is why it is mostly built on market terms. With regard to the physical need for space, the demands of digital infrastructure are not very high. Towards the city's border areas, digital infrastructure has been partly built with public funds to improve the service selection.

The automated drone transports of global logistics operators are a part of the logistic last-mile transportation of time-critical goods, and space has been reserved for them both on the roofs of buildings and in public spaces at street level. City district-specific centralised loading spots are also implemented for air deliveries at street level while taking into account the noise and safety perspectives of drone deliveries. Additionally, deliveries are managed at street level with automated delivery carts and bicycles.

SCENARIO B 'Private autonomy'

Transportation based on privately-owned automated vehicles

Human in the city

Privately-owned autonomous cars are rapidly becoming more common. New autonomous cars are acquired in particular outside the city cen-tres, where the public transport system's service level is low. The cars' autonomous functionalities facilitate a rising service level for the various transport needs of households while also increasing the vehicles' usage rate. In part, this decreases the need for a second car in many families.

In denser centre areas and along the main connections of public transport, there isn't as much demand for automated cars as in suburban areas. Walking, cycling and various modes of micro-mobility have maintained their position in everyday mobility in these areas. In particular residents living in the inner city mostly use cars in shared use, as a part of seamlessly operating mobility services.

The increasing automation facilitates traffic safety. Speeding, for example, is clearly less frequent than today, thanks to the vehicles' advanced automation. Accidents between motorised vehicles and pedestrians or cyclists have decreased a great deal. Traffic accidents causing damage to property are also becoming increasingly rarer.

Most orders from online stores are usually picked up personally from local delivery points. Home deliveries are also used frequently, in which the delivery is dynamically controlled to a place chosen by the customer. In certain cases, customers can authorise their autonomous car to pick-up a delivery from a certain pick-up point.

Mobility and transport services

Motor vehicles are mainly privately owned. Main public transport routes have maintained their position in the transport system. (Source: McKinsey) Current cars are replaced by autonomous cars. Mobility is largely based on public transport in centre areas and rail transport corridors, but private driving threatens to replace public transport services in areas with a poorer service level. The definition of a 'car' has expanded and covers both small and large vehicles operating automatically and with sustainable powers. The high automation rate has changed car ownership. Anyone can own and use a car, regardless of their physical condition or age, The selection of mobility services is limited and traffic is focused on individual, privately owned modes of transport, although the different ownership methods developed by car manufacturers and peer rentals increase the rate of vehicles' shared use.

The highest demand is for services such as robot taxis, but there are no significant demand for other services, especially outside the denser areas. Pick-up point services are a key part of urban delivery services. Customers can send their own vehicle to pick up deliveries, such as groceries or items bought online. The pick-up point network is flexible and not bound to any delivery routes.

Data is not open and utilising it is challenging. Car manufacturers own a large proportion of the data and may use it for their navigation services. Therefore, they can impact the functionality of traffic arrangements and the user's mobility. The routes and stopping and parking needs of vehicles are difficult to predict. Despite this centralised collection of data, the companies are aware that practical street traffic requires them to share the data. This gives rise to new forms of data economy, as user licences and pricing principles are adjusted to suit the system.

Public transport system

Automated vehicles are available for almost everyone, if it is financially possible. This reduces the demand for public transport outside city centres and the areas outside the main network of rail-based public transport.

Public transport mostly consists of rail transport, which is used by large masses of people between the regional centres. Tram and metro traffic as well as local and long distance train traffic have all grown from the level of 2020. Robot taxis complement the public transport system. The automation of public transport increases its cost efficiency, reliability and safety.

However, public transport's service level drops in areas with a less dense population and the services may even be stopped. Competitiveness is maintained in the city centre and the service area of rail transport, and there are still enough public transport users in the area.

Urban space and digital infrastructure

Automation makes optimising the transport network capacity easier than now, but the increasing amount of traffic threatens to congest the traffic even more. Simultaneously, the pressure to increase the capacity of street and road network grows, for example by adding more lanes and tunnels. The City has attempted to utilise the advantages of automation to the maximum extent, especially on the main car traffic networks by assigning separate lanes for automated vehicles. The street space can be divided dynamically based on the traffic situation, especially in the lanes assigned to automated vehicles. Lanes with alternating traffic direction have been used on certain selected main streets. Streets that are not part of the main network are divided functionally into two parts: a walking and recreational area and an area for faster modes of transport.

The demand for parking spaces grows as the number of vehicles increases. Parking garages have been built near the borders of the city, in noisy areas and other areas with a lower utilisation rate. Some cars can be directed there for the night. In the inner city, the amount of parking areas has been limited in certain areas and, respectively, it has been accepted that the vehicles of passengers travelling to the area will then drive empty further away to park, which increases the amount of traffic. In suburban areas, vehicles are also parked on plots of residential buildings.

Strong automation requires communication to be organised between the street infrastructure and vehicles. The impact of automation on street capacity is not large in centre areas, as large amounts of pedestrians and cyclists set boundary conditions for optimising the throughput of cars

SCENARIO C 'Open and shared'

Local service providers operating based on open data

Human in the city

The rate of automation has risen to a high level, especially in public transport. A public transport system built on rails is efficient and the demand for it is high, especially for longer everyday trips. However, shorter trips and park-and-ride trips in particular are taken by foot, on city bikes or by various micro-mobility services. A guide based on artificial intelligence familiar with the consumers' preferences and needs is used to support the choices. The prices of transport services are high, but they guarantee the high level of services. There are several mobility options available in urban centres with a large number of people.

The increasingly common advanced safety automation on cars has improved traffic safety by reducing speeding and collisions. Accidents between cars and cyclists or pedestrians have decreased notably, which is also reflected in the improved sense of safety among cyclists and pedestrians.

Most orders from online stores are usually picked up personally from local delivery points. Some store deliveries will be delivered to the customer's front door.

Mobility and transport services

A public transport authority manages the main service based on rail transport, as well as the interfaces for supplementary services. Open data facilitates high-quality information and guidance services and situational awareness, as well as the optimising of traffic flows at regional level. An open mobility ecosystem with its advanced service sales interfaces creates opportunities for companies to provide high-quality, comprehensive and affordable mobility services. However, public administrative-driven open data does not significantly increase the interest of market operators, as the potential market share is too small and production costs too high without a high level of automation. There are a couple of global companies on the market as well as smaller pop-up operators, but the transport system cannot depend solely on their services. The service selection of public transport is improved by various city bike systems and other services based on lighter modes of transport.

Public transport system

The role of public transport remains significant and has even grown its importance in trips to the inner city and the other urban centres. Private cars have a major role in the mobility of suburban areas, especially on regional trips. Car sharing services complement the mobility services, especially in dense areas with a high public transport service level. There are plenty of micro-mobility service operators on the market in Helsinki. Local companies with business and social interests in developing the transport system in Helsinki develop the information and guidance services based on open data.

The basis for public transport is rail transport, organised by the public sector, which takes large masses of people between the regional centres. The role of areas surrounding the stations is highlighted and the role of rail transport strengthens. The public transport system has received significant subsidies, because it takes resources to arrange the connections of the main traffic routes in a competitive way. Park-and-ride trips are also made by bike and other small vehicles. Market-based competitiveness has not been achieved in the costs of on-demand transport services.

Urban space and digital infrastructure

The physical urban environment also caters to the competitiveness of public transport and the accompaniment and waiting areas necessary for the publicly available mobility services. The open data policy and the service ecosystem built on it increase the need to equip the street space with various sensors and data collection systems that facilitate accurate situational awareness of traffic. Even though automation has not progressed far, vehicles do transmit situational data to each other and exchange information with the infrastructure through various cooperative services.

The model of assigning dedicated areas for parking, stopping, deliveries and other operations has been changed into a more flexible model, where the street space operator controls space reserved for stopping dynamically based on the time of day and demand, also assigning some of it for logistic needs, for example. Street-side space and its use are monitored and controlled extensively and automatically in real-time. Managing the street-side space has become more important, and, as the space is limited, various ways have been utilised to make its use more efficient. The use of street-side space is managed and priced dynamically, which allows it to be used for other purposes.

Data guides choices more strongly: when should you depart, what vehicle should you use and which route should you take. Walking has a major role. Utilisation of bikes and small electrically-assisted vehicles is significant in urban mobility.

Appendix 2. Impacts of megatrends and scenario stories in relation to the City's goals

Healthy, safe and attractive environment

The City of Helsinki's strategic goal	Megatrends	a. Seamless market-driven	b. Private autonomy	c. Open & shared
	Megatrends Climate change, change of work, urbanisation, aging population	*City transport driven by global companies, based on automation*	*Transportation based on privately-owned automated vehicles*	*Local service providers operating based on open data*
Traffic emission reductions are achieved by increasing the proportion of walking, cycling, electric transport and public transport on rails.	• Mitigating climate change. • In principle, urbanisation facilitates achieving emission reduction goals.	• Automated, affordable robot taxis reduce the proportion accounted for by conventional, sustainable modes of transport.	• A privately-owned automated vehicle is used for most of a household's transport needs.	• Muscle-powered modes of transport are popular.
The transport system's emissions decrease, the noise pollution detrimental to health is reduced significantly and air quality improves.	• Mitigating climate change. • Urbanisation increases noise pollution and local emission challenges.	• The utilisation rate of vehicle stock is high and the vehicles utilise renewable sources of energy. • Drones will add to the noise pollution in the City.	• Local emissions of electric vehicles are low. • Lifecycle emissions can become high when vehicle stock grows, depending on the technology used.	• Rail transport is the basis of the transport system and it remains highly competitive.
The urban environment is developed to encourage exercise and everyday physical activity.		• Affordable door-to-door transport services compete with muscle-powered modes of transport, which threatens to decrease the positive health effects of walking and cycling.	• The space required by motorised vehicles may grow.	
No one dies or becomes severely injured in traffic. Transportation is considered safe.	• The elderly are a vulnerable group in traffic.	• Automation ensures a high level of traffic safety. • Accidents caused by human error and sensor defects, for example, can still occur.	• Safety is at a high level, but, due to the high driving performance, accidents decrease at a slower rate than in scenario A.	• Traffic safety has improved but not as notably as in other scenarios, as not all the advantages of automation can be realised.
High quality, attractive and recreationally inviting urban environment.	• Climate change increases extreme weather conditions and rainy winters. • Urbanisation increases the 'competition for public space'.	• Automated vehicles and drones require space dedicated to them. • The City's unique features are replaced by corporate modular standard solutions.		

Impact that supports the goal No direct impact on the goal Impact that contradicts the goal

Growth and the conditions of business life

The City of Helsinki's strategic goal	Megatrends	a. Seamless market-driven	b. Private autonomy	c. Open & shared
	Megatrends Climate change, change of work, urbanisation, aging population	*City transport driven by global companies, based on automation*	*Transportation based on privately-owned automated vehicles*	*Local service providers operating based on open data*
Facilitating the City of Helsinki's growth. At least 85% of the population is located within the zone of sustainable transport.	• Climate refugees may facilitate the City of Helsinki's growth. • Urbanisation facilitates growth; the issue of regionality emerges. • Aging people move close to services.	• The availability of commercial mobility services in the centres increases the attractiveness of these areas.	• Prerequisites for a decentralised urban structure, decreasing significance of city centres.	
Stronger and more attractive centres, growing inner city.	• Some of the 'new' work is centralised in city centres. • Urbanisation facilitates growth. • Aging people move close to services.	• Public services can be centralised in city centres, because transporting the customers is easy and affordable.	• Prerequisites for a decentralised urban structure, decreasing significance of city centres. • The commuter area of Helsinki grows.	• Local services are arranged on a decentralised basis. • Land use increases at public transport hubs.
Convenient commute and cargo transport.	• Climate change affects the reliability and supply security of transport chains. • Commuter traffic diversifies, creating a need for 24/7 services. • Urbanisation leads to the challenges of growing congestion.	• MaaS operator ensures door-to-door transport chains. • The service level of small-scale logistics is high due to automation and drone transportation services.	• An automated vehicle in personal use allows users to work during their commute. • Congestion of road networks is possible, although the utilisation of capacity improves.	• A wide range of mobility services for commuter needs.
An ecosystem of smart mobility, an on-demand transport system, a test platform for smart mobility services, sharing information.	• The change of work makes it more challenging to predict transport demands. • Urbanisation increases user numbers, facilitating various services. • Digital accessibility is required for the elderly. • A growing potential will emerge for combining rides.	• Global platform economy operators create a commercial ecosystem, which also has local operators along with the global companies. Information is shared within the ecosystem.	• The increase in using privately-owned vehicles does not necessarily facilitate the transition to an on-demand system.	• On-demand services are available, but only profitable in the densest urban environments.
Decreasing differences between regions, parking policy to support affordable housing.	• Working from home grows more popular. • Typically, urbanisation highlights the differences.	• Commercial services are not profitable in the suburbs: segregating service levels.	• Not all households have the option to get an automated vehicle.	

Impact that supports the goal   No direct impact on the goal   Impact that contradicts the goal

Sustainable city 1/2

The City of Helsinki's strategic goal	Megatrends	a. Seamless market-driven	b) Private autonomy	c) Open & shared
	Megatrends Climate change, change of work, urbanisation, aging population	*City transport driven by global companies, based on automation*	*Transportation based on privately-owned automated vehicles*	*Local service providers operating based on open data*
Different kinds of users are taken into account. The services are targeted at those requiring special support and at high-risk groups. Comprehensive financial, social and ecological sustainability.	• Adapting to climate change. • Change of work creates pressure for social equality. • Urbanisation may manifest as the segregation of city districts and different lifestyles. • The transport behaviour of seniors is different to that of working age people.	• Selective choosing of customers as a risk. • Feelings of a lack of safety in a transport vehicle as a risk. • How well is the senior population able to use automated services?	• Private ownership may increase social segregation unless the public sector (proactively) takes all user groups into account. • Personalised automated cars support the independent mobility of children and the elderly.	• Socially fair transport system. • The heterogeneity of mobility services may cause challenges with the services' accessibility (different services and their clarity).
A dense, functionally heterogenous urban structure creates a basis for a good urban life.	• Adapting to climate change. • Short distances between the different activities. Most trips are taken by foot. Public transport services transport a large number of people at the same time. • Services are close by and accessible.	• The service level of commercial services is lower in the City's border areas, as there is not enough demand or sufficient liquidity.	• The space required by motorised vehicles may grow when striving towards the smooth operations of automated vehicles.	• Many spontaneous encounters occur in the street areas.
The planning process of the transport system is guided by the efficient use of resources and the City's functional needs.	• As work changes, flexible mobility supports the efficient utilisation of lane infrastructure. • Urbanisation requires efficient planning. Changing needs are challenging for resourcing.	• Business interests are one of the major drivers, and they may conflict with the goal with regard to both investments and traffic control.	• The growing number of automated vehicles requires investments.	
Transport is organised as efficiently as possible with regard to the use of urban space and the City's financial resources.	• Adapting to climate change. • Urbanisation increases the 'competition for public space'. • The mobility of senior citizens is not tied to a certain schedule.	• The service level of commercial services is lower in the City's border areas, as there is not enough demand or sufficient payment ability. • Personal robot taxi transport conflicts with the goal.	• The space required by vehicles may grow.	• Many spontaneous encounters occur in the street areas.
The arrangements of cycling transport form a seamless, comprehensive service that facilitates smooth, effortless and safe travel.	• Milder winters increase the popularity of year-round cycling. • Extreme weather conditions as a challenge. • Urbanisation increases needs.	• The space required by motorised vehicles may grow when striving towards the smooth operations of automated vehicles.	• The space required by motorised vehicles may grow when striving towards the smooth operations of automated vehicles.	
Transport investments ensure the functionality of the entire transport system. The principle is that the user/polluter pays.	• Climate change creates challenges for road network maintenance. • Change of work balances the peak hours of traffic.	• The charging points of robot taxis are built by commercial operators, centralised to a few large parking and charging facilities.	• Decentralised charging in private buildings.	

Impact that supports the goal   No direct impact on the goal   Impact that contradicts the goal

Sustainable city 2/2

The City of Helsinki's strategic goal	Megatrends	a. Seamless market-driven	b. Private autonomy	c. Open & shared
	Megatrends Climate change, change of work, urbanisation, aging population	*City transport driven by global companies, based on automation*	*Transportation based on privately-owned automated vehicles*	*Local service providers operating based on open data*
Carbon-neutrality and growing proportion of sustainable modes of transport.	• Mitigating climate change. • The City's growth cannot be directed to car traffic alone. • Improving customers' health is highlighted among the elderly.	• Robot taxi services complement but also challenge public transport through aggressive pricing. • Car ownership numbers plummet, but car use does not.	• Privately-owned automated vehicles are used for most of households' transport needs.	• The competitiveness of sustainable modes of transport is at a high level.
Accessibility by sustainable modes of transport is competitive on everyday trips compared to the accessibility by car transport.	• Mitigating climate change. • The need for improving accessibility is highlighted among the elderly.	• The high service level of robot taxis and their affordance prices cut down the proportion accounted for by walking and cycling. • Robot taxi services with high utilisation rates are more sustainable than personal ride services.	• Electric vehicles can be seen as a part of sustainable modes of transport (?) • The proportion of cars as a mode of transport maintains its current level and even grows, depending on the area (?)	
Predictable travel times with all modes of transport.	• Climate change may increase transport disruptions. • The change of work makes predicting needs more challenging.	• Mobility services offer a high-quality situational image and they use data to support customer choices.	• The possible congestion of the road network decreases predictability – smart traffic control at network level?	
Rail traffic is fast, reliable, efficient and disruption-free.	• The operational security of rail traffic improves, if winters grow shorter. • Extreme weather conditions become a challenge for the functionality of rail transport. • Ensuring high-quality rail transport in increasingly denser city requires space.	• High service level of rail transport.	• High service level of rail transport.	• High service level of rail transport.
The different needs of residents, companies and other users are taken into account in parking.	• The change of work makes predicting needs more challenging. • Urbanisation increases the challenges of utilising space.	• Robot taxis do not require much parking space (centralised charging facilities in border areas).	• Parking space is needed for automated vehicles, mainly in private facilities.	

Impact that supports the goal   No direct impact on the goal   Impact that contradicts the goal

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