REPORT

Trends in Mobility: A literature study of macro and current trends in mobility of people and goods with a focus on urban environment

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Bakgrund

Nästa generations resor och transporter ur ett stadsbyggnadsperspektiv är ett Vinnova-medfinansierat projekt med lokal förankring i Umeå kommuns stadsplanering. Projektet ska undersöka hur kunskap om morgondagens mobilitet kan tillvaratas för att bidra till måluppfyllelse. Detta ses som en del i att öka beredskapen för att möjliggöra en omställning mot hållbara transporter – en *framtidssäkring*.

Här används ett av Umeå kommuns större stadsutvecklingsprojekt, Norra Ön, som testbädd för hur man i detaljplaneprocessen kan bibehålla en handlingsfrihet alltmedan teknikutvecklingen sker parallellt och i snabb takt. En central frågeställning är vilka verktyg, åtgärder och styrmedel som finns inom den kommunala samhällsplaneringsprocessen som kan bidra till att främja morgondagens mobilitet och uppfyllelse av kommunens målformuleringar.

Delprojektet ska:

- Undersöka hur man inom ramen för detaljplaneprocessen kan planera för en transportinfrastruktur som möjliggör flexibilitet för morgondagens mobilitet, med fokus på måluppfyllelse.

- Utvärdera policyimplikationer av genomförda utredningar samt formulera en övergripande metod för framtidssäkring av detaljplaneprocessen.

Projektet befinner sig nu i en kunskapsbyggande fas och behöver skapa sig en uppfattning om den aktuella kunskapsbilden innan man går vidare i processen. Aktörer, inom såväl resor och transporter som samhällsplanering, blickar ständigt framåt och spaningar om morgondagens trender är inget nytt. Beroende på vem som gör dessa spaningar kan dock slutsatserna variera och Umeå kommun valde därför att ta in extern expertis för att lyfta blicken och bredda perspektivet.

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Sammanfattning

I takt med den urbanisering som pågått under lång tid ställs allt högre krav på förbättrade och mer effektiva lösningar för människors resor och transporter av varor och gods. Med teknologier såsom automatisering, digitalisering och elektrifiering finns möjlighet att möta dessa utmaningar och skapa hållbara och effektiva mobilitetslösningar.

Mobilitetfrågans roll i stadsplaneringen

Mobilitetfrågan spelar en avgörande roll i stadsplaneringen och är en av utgångspunkterna vid utformningen av en urban miljö. Fokus för planeringen läggs på att skapa flexibilitet för framtida mobilitetsystem för både människor och varor. Element såsom exempelvis transporthubbar för kollektivtrafik och logistik måste beaktas redan under planeringsfasen för att staden ska vara redo redo för framtida utmaningar.

Vilka makrotrender inom urbant resande och transport förväntas ha inflytande på stadsplaneringen, enligt befintlig litteratur och experter?

Med hjälp av en litteraturstudie och intervjuer med experter har fyra makrotrender inom mobilitetsområdet identifierats. Dessa trender är följande; *Automatisering*, *Elektrifiering*, *Uppkoppling, digitalisering och data*, samt *Delad mobilitet*. Automatiseringen av fordon förväntas bidra till ökad säkerhet och optimering av trafiken i tätbebyggda områden. Elektriska fordon erbjuder hållbarare mobilitet med minskade lokala emissioner och koldioxidutsläpp. Digitaliseringen, och i synnerhet Internet of Things (IoT), förväntas också ha inflytande på framtidens mobilitet. Genom nya digitala lösningar med uppkopplade enheter kan en kontinuerlig kommunikationskanal mellan olika aktörer sättas upp vilket kan bidra till ett smartare transportsystem. Möjligheten att dela data genererar även möjligheter för utveckling av nya mobilitetstjänster. Tanken bakom delad mobilitet är att mindre resurser används och i gengäld blir resan för användaren billigare och mer tillgänglig. Ett sätt att öka attraktiviteten för delad mobilitet är att kombinera olika tjänster vilket brukar kallas Mobilitet som en tjänst, eller Mobility as a Service (MaaS) på engelska.

Nuvarande trender som formar makrotrenderna inom mobilitetsområdet

Det finns även pågående trender som inte är lika tongivande som makrotrenderna men påverkar utvecklingen inom mobilitetsområdet. Exempel på sådana trender är; *Lösningar för last mile-problemet och mikromobilitet*, *Förändringar i resebeteenden* samt *Utvecklingen av smarta städer*. Med mikromobilitet skapas ytterligare en nivå av modalitet som är effektiv och hållbar. Last mile-tjänster gör transportsystemet mer tillgängligt för fler människor och kan även effektivisera varudistribution. I takt med detta ändras människors resebeteende. Det blir allt vanligare att välja färdmedel och reseätt utefter ändamål och vad som passar för situationen. Detta kommer leda till nya segment av specialiserade fordon designande för mer specifika behov. En del i kärnan av en smart stad är att den är uppkopplad, välplanerad och innehar en smart mobilitetslösning. Vidare finns det andra trender som har dykt upp under de senaste åren. Däribland mobilitet som en tjänst/Mobility as a Service (MaaS), Frakt som en tjänst/Freight as a Service (FaaS), Logistik som en tjänst/Logistics as a Service (LaaS), leverans med drönare, mobilitets- och transporthubbar, personlig flygtransport etc.

Insikter från expertintervjuerna

Mobilitetsfrågan är en grundsten i moderna stadsplaneringsprocesser och experterna anser att för att skapa en effektiv och hållbar mobilitet är det viktigt att ha optimerade transportsystem, smartare trafiksystem och mobilitetslösningar som skräddarsys efter behov. Betydelsen av data lyfts också fram som en viktig del i detta, men även oro för säkerhet i samband med öppna och delade data. Mobilitetstjänster förväntas bli smartare med hjälp av prediktiva algoritmer som kan leverera anpassade lösningar för att möta behoven kring användares resande eller transport av varor. Experterna föreslår också att det traditionella kollektivtrafiksystemet kommer bli omodernt i urbana miljöer och att nya mobilitetslösningar bör utforskas. Ett förslag var att integrera linbanor (Cable propelled transit) som en mobilitetslösning för Norra Ön.

I rapporten diskuteras även vikten av infrastruktur, att ha ett samarbete mellan privata och offentliga aktörer för att leverera hållbara mobilitetslösningar samt effekten av anpassningen till nya teknologier och innovationer för framtidens mobilitet.

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1 Introduction

While the movement of people and goods is a prerequisite for economic development, non-movement – i.e., traffic congestion – constitutes for being the biggest speed breaker of households and businesses. The overall rate of road-traffic congestion is continuously increasing in urban areas across the world (Arthur D Little & UITP, March 2018) and as that happen, comes a requirement or rather a duty to adopt more effective, efficient and most importantly sustainable mobility options both for people and goods.

Automobile mobility today constitutes for the biggest portions of contributors to what we term as urban mobility. Hence it is crucial to see what direction the automotive industry is moving into. There are, in the views of automotive experts (Kaas, 2016), four major forces of disruption happening which are driving trends, and that they are happening simultaneously. Number one is **electrification** of vehicles, it is something that is not new, but a still-relevant force of disruption in terms of a more efficient, environmentally sustainable power train. Number two, **connectivity or digitization**, with wireless technology, the amount of information being able to be transferred between different constituencies - it could be a car, a third party, could be between two cars, etc - obviously opens new prospects in technological opportunities, possibilities and hence development. Third, it is about what we call advanced driver-assistance systems, leading the pathway towards **automated vehicles**. Last but not the least is **shared mobility.**

There are many diverse forms of mobility from privately owned to shared to public transport, from cars to trains and even something as simple as electric scooters and even walking. In other words, mobility is everything which helps us get from A to B and the same goes for goods. The first three technological forces mentioned above have the potential to accelerate mobility, both the adoption and diverse forms of mobility, but they're not necessarily needed to push new mobility forms. Worth noting are those inter-relationships (Kaas, 2016), trends and user needs also drives mobility even in the technological prospects. In the automotive industry, carmakers on one hand are cautiously exploring in their own way. They sometimes mentioned it as experiments or pilots, to see which of those future mobility forms might be willingly adopted by consumers. While on the other hand, they are making clear bets with equity investments and investments into partnerships. In many cases, they involve capital, or they involve intellectual property-sharing (Kaas, 2016). If we stretch it a little bit further, when we look at technological players—whether Google, Apple, or mobility providers like Lyft or Uber—they also reach out to the incumbents and understand what type of domain knowledge in the auto industry is critical to actually define an offer of viable services.

This report talks about these macro trends in mobility as well as sheds light on current trends some of which are still in infancy. This is done through an intensive literature review from recent studies from reputed experts and research groups. The report later follows on insights given by experts inhouse from Sweco. These experts come from diverse fields with a commonality of working with/around sustainable mobility in an urban environment.

2 Trends in mobility

This section mentions and describes the macro trends as well as the current trends in mobility but also that affects mobility. These trends have been found out using an extensive literature study and expert's opinion. There has been a clear indication of macro trends in the literature. The section also includes certain trends which are currently present and does not fall under the category of a macro trend but are closely connected to the macro trends which was also highlighted in many literatures. For some of these trends there is a fine line between which have been a macro trend, and which are shorter trends, but this overlapping is certain.

It is difficult to put a title of calling these trends as short, medium and long-term trends as there is a lot of overlap and not a clear indication of when the trend first arrived. With macro trends, these trends might last up to a decade while the current trends indicate the ongoing trends in mobility.

2.1 Macro trends affecting mobility

A macrotrend is a pervasive and persistent shift in the direction of some phenomenon on a global level. (Burch, 2018) *Examples of current macro trends include urbanization, automation and changing demographics. At the low end of the scale are fads: widespread but briefly prevalent phenomena, typically lasting a few years or less. While on the other end these trends can last around a decade and even more.*

This section describes the macrotrends in the field of mobility; Automation, Electrification, Connectivity, Digitalization & Data and Shared mobility & Mobility as a Service (MaaS).

2.1.1 Automation

As an end-user product, the 20th century motorcar changed the ways that cities worked, how people moved about and interacted, and how goods and services were transported. To facilitate these changes, governments adopted policies, regulations and investments that – for example – assigned road primacy to motor vehicles, expanded the road network, addressed traffic circulation. Information and computer technologies (ICT) have played a growing role in human-driven cars for the control and management of core vehicle functions, driver assistance, and external communications.

What does this trend define?

The human driver and traditional motor vehicle engineering have remained dominant. This is about to change dramatically, and with significant potential implications for urban policies and investments (Ticoll, 2015). With this - not so far - future of introduction of automated vehicles a major disruption driven trend would follow. An automated vehicle (AV) is essentially a type of robot – a machine that can sense its environment, assess and plan what to do, act on that plan, and communicate with people and other devices (Ticoll, 2015).

Certain ICTs – for example, a dashboard animation of traffic-efficient routing – will be part of the “end user” AV experience. Less visible underlying applications – such as Vehicle to Vehicle (V2V) communications – will support conditions for safety and optimized traffic. To achieve the full potential of AVs and their benefits, cities will have to implement policies, programs and infrastructures that maximize end user functions, underlying technology capabilities, energy efficiency – and broader social, urban planning and fiscal objectives. In every AV, each of these activities requires a set of innovative physical technologies, massive data resources, advanced algorithms, and blazing processing speeds to make it work.

Communication is another core activity for an AV, Digital communication with other vehicles (V2V) and, potentially, traffic infrastructure (V2I) can improve an AV's decisions. For example, researchers have designed and simulated infrastructure-based models for AV efficiency in traffic intersections. These include algorithms for managing fully autonomous vehicles, evasion planning protocols, and for managing semi-autonomous vehicles (Ticoll, 2015). All these depend on sending, receiving, processing and acting on digital communications with transportation infrastructure and, potentially, other vehicles.

What drives this development? Incentives, challenges, goals or other?

Autonomous vehicles (AVs) could play a key role in the transformation of mobility or how people commute. But the industry tends to view the phenomenon mainly through a technology lens, which, while important, only addresses parts of the challenge. (McKinsey & Company, 2017). The goals with autonomous vehicles could be to provide completely driverless operations of the vehicle which would result in an efficient and safer transportation system, one that is optimized for maximum capacity and focuses on providing sustainable modes of mobility. The major challenge to this vision is also one of the major driving forces, technology as well as infrastructure. Technology to provide completely driverless operation is fairly new and need to be tested out in real world extensively to be seen as a confident choice of users which is also safer in its operations. The infrastructure is also a core part of making autonomous a reality, implementing and adopting correct Operational Design Domains (ODD) would be a requirement in this development.

Current developments

Waymo, subsidiary of Google's parent company, Alphabet Inc., has launched the world's first commercial driverless car service in December 2018 (Waymo, 2018). It operates as Robo-taxi/ autonomous on-demand service by the name Waymo One and currently runs in Phoenix, Arizona only with passengers from their early rider program. The company plans a future deployment of autonomous shared vehicles, with deployment planned for 2019, 2020 and 2021.

OEMs are also developing driverless technology. GM, for example, purchased Cruise, a company that was developing a driverless vehicle. Goldman Sachs Group Inc. predicts that robo-taxis will help the ride-hailing and -sharing business grow from $5 billion in revenue today to $285 billion by 2030 (Welch & Behrmann, 2018). There are grand hopes for this business. Still, Waymo's head start isn't insurmountable. GM plans to start a similar ride-hailing service in late 2019, while Tesla, Daimler, Volkswagen and other competitors aren't far behind—each with their own approach to solving the technological and social challenges of taking human drivers out of the car. But firms such as Bloomberg (Welch & Behrmann, 2018) and McKinsey (McKinsey & Company, 2017) predict that other leaders like GM are probably more than a year away from doing this which is very impressive from Waymo's point of view.

Waymo's website also shows their plan to introduce the same tech as in their cars to drive commercial vehicles. Given that they have the right set of hardware at their disposal, this service can mean big deal for services in which commercial vehicles play a big part for example; urban logistics. However, Waymo has not revealed more of their intensions with their service for commercial vehicles. The service Robo-taxi is too new to see its true impacts on driving externalities, as with other technology adoption process, we are in the early adoption stage and while the tech has a long way to go for being flawless and trustworthy by majority. The service can increase the traffic through increased ridership which also includes addition of new riders which were not contributing to road traffic before.

How can this affect the urban transport infrastructure?

Clearly mobility solutions are advancing rapidly. Nonetheless, driverless vehicles are expected to begin to appear in meaningful numbers within the next 3 years (2020-2021) and could achieve broader market penetration within 10 years. Instead of an individual driver, these vehicles will be managed by a central controller as fleets of interchangeable vehicles that can be dispatched to serve individuals and groups of riders originating at about the same place at the same time going in the same general direction. This shared ride functionality will lead to improved utilization of infrastructure and efficiencies. Importantly, this means that the ownership model will be different from that which exists today. Use will be by many individuals rather than by a single owner. Instead of individual owners as the dominant model, a fleet owner will be more practical. Demand will be affected by pricing and service, which may well be best in moderately dense, so-called transit-oriented land uses. Person miles travelled are likely to increase, while vehicle miles travelled are likely to decrease proportional to the growth in ridesharing.

There is a need for the transport infrastructure to support increased travel and smarter, connected vehicles on the road. Infrastructure for automated modes of transport must be considered in urban planning and enough flexibility or room should be provided for future development while designing an urban environment (Huss, 2019).

Autonomous mobility is also expected to significantly affect city planning and considerably change the laws of real-estate markets (Arthur D Little & UITP, March 2018). A self-driving smart city would not need as many parking spaces as cities need today and be able to make better use of areas freed up from parking. Many existing garages could be converted to retail facilities, for example. The demand for on-street parking will decrease drastically too. On the other hand, cities will have to provide large-scale pick-up and drop-off zones for robotaxis (Arthur D Little & UITP, March 2018).

The levels of autonomy promise an improved car with lesser human interference and safer operations. All that would cars more attractive for buyers and a concept of owning a completely autonomous cars would introduce new type of users on the road (elderly, handicapped, people without a driving license etc.). This has the potential to increase the number of cars on the road making the cities more car dominant unless we plan and prepare for an opposite scenario.

2.1.2 Electrification

Electric vehicles (EV) are not a new technology, they have been around since the dawn of automobility. In fact, in the early 20th century they were actually preferable to Internal Combustion Engine (ICE) vehicles. (Sprei, 2018)

What does this trend define?

Electrification refers to shift from fossil fuel to electricity as a source of energy for various modes of mobility. Electrification in mobility usually refers to electrification of vehicles which contribute to the majority of portion in all modalities of transport. Hence rise in development and adoption of EVs is considered as a macro trend in mobility. The introduction of Nissan Leaf in 2010 seems as the moment of a breakthrough for EVs. As of 2017 2 million EVs are rolling on the roads (Lutsey, 2017) and these numbers are rapidly growing with many leading car manufacturers offering EVs to consumers. Scenarios point toward a steady growth with automotive companies' cumulative announcement estimated around 60 million vehicles in stock by 2025 (IEA, 2017).

What drives this development? Incentives, challenges, goals or other?

An EV has the potential to be much cleaner at least considering local emissions and carbon emissions, but there is nothing in the EV that challenges the model of private ownership or the current transport system (Sprei, 2018), however changes are happening rapidly with providing the right infrastructure as well as advancement in the technology. While it might have attributes that are appealing to the consumer such as a silent drive, no need for refuelling trips and access to more torque, it is still a vehicle and will not per se solve issues such as congestion, space for parking and safety. In the worst case reduced cost of travel (with much more efficient engines the travel cost per km can be reduced) you can have a rebound effect that worsens urban sprawl and congestion (Fulton, Mason, & Meroux, 2017) while all this can be changed with the possibility of electrification of vehicles becoming cheaper and efficient. The more disruptive element of an EV is the connection to the grid and the point about it offering a significantly sustainable mode of transport is very well worth noting.

The possibility to connect an EV to the grid, often named vehicle-to-grid (V2G) can have implications to the electricity system in two different ways. It can facilitate more decentralized power generation making it easier for individual houses or small grids to be self-sufficient (Marc, Allerding, & Schmeck, 2012). In a report by Arbib and Seba (Arbib & Seba, 2017), they consider the EV to be a superior product compared to an Internal Combustion Engine (ICE) vehicle partly because the battery can power an average American home when parked. It can also facilitate the introduction of renewables such as solar and wind by mitigating their intermittency (Sprei, 2018). In this case EVs are not seen as individual units but aggregated together and can function both as provider of power and storage depending on the need.

Finally, the production on a massive scale of new, compact forms of energy, such as lithium-ion batteries, will also allow for economies of scale and extended journey range, which will drive the adoption of electric mobility solutions. (Arthur D Little & UITP, March 2018)

How can this affect the urban transport infrastructure?

The current transportation infrastructure is already implementing changes to support electrification and EVs. Cities are investing in addition of more charging stations and clean energy to charge EVs. Urban designers acknowledge the need by offering flexibility in their design and planning in forms of flexible spaces for electric lines and charging stations and also if in future charging won't be required the infrastructure can be altered for installing something useful (Huss, 2019).

2.1.3 Connectivity, Digitalization and Data

The major technological specifically data driven developments include big data, artificial intelligence (AI) and the Internet of Things (IoT). The "Internet of Things" (IoT) is defined by three characteristics: the presence of sensors, connectivity to networks, and the ability to rapidly compute incoming data (Mckinsey & Company, October 2016). IoT applications have quickly spread into mobility and continue to make impact.

What does this trend define?

Automation and connectivity being strong macro trends, the backbone of these trends can be rooted to IoT. IoT with its exponential development rate in the last few years can be seen as a trend in itself which indirectly affects mobility while having a direct impact on the macro trends in mobility.

Applications of IoT in mobility sector are many but it largely contributed to connectivity and digitalization part of mobility. Some examples of this could be in vehicle connectivity V2V and V2I. Meanwhile, infrastructure connectivity and other "hardware" elements enable further smoothing of traffic flows (Mckinsey&Company, January 2016).

Other examples include Volvo who are piloting a machine-to-machine social network that enables cars to warn one another about road conditions and other hazards and Tesla updates its vehicles smartphone-style – remotely over the air – including for such critical updates as automatic emergency braking, an approach which may spread within the automotive sector.

What drives this development? Incentives, challenges, goals or other?

Customer demand for car connectivity is increasing rapidly: the share of consumers willing to switch their car brand for better connectivity reached 37 percent in 2015, with China particularly keen at 60 percent (Mckinsey & Company, October 2016). This only ensure the ever-increasing role of IoT in mobility.

The growing efficiency of the algorithmic processing of big data, offered by artificial intelligence, is increasingly providing data-driven insight that foster creation of new mobility services, such as real-time journey optimization, which allow more efficient use of existing mobility assets. The great leaps made in artificial intelligence in recent years are a revolution, as it has enabled the emergence of autonomous vehicles. Internet of Things technologies are also significantly influencing the future of mobility as they introduce a new, continuous communication channel between mobility stakeholders, increasing the ability to capture and share data. (Arthur D Little & UITP, March 2018) Several recent studies anticipate annual double-digit growth of the Intelligent Transport Systems (ITS) industry across all its market segments – passenger information systems, smart traffic control, parking management systems, etc (Arthur D Little & UITP, March 2018).

Importance of Data sharing for benefiting automated driving and corresponding services have been pointed out at various events. Many road operators believe that more open data and having access to it is a key in driving the new trends of mobility. Availability of open APIs as well as availability of privately-owned APIs is said to have greater benefits than doing all by themselves (road operators) which then also differ in quality and quantity (Proceedings European ITS Forum 2018, Utrecht).

In a study made to formulate Mobility-as-a-Service (MaaS) maturity index, Goulding & Kamargianni (Goulding & Kamargianni, 2018) painted out the dimensions of this index from a Transport operator’s perspective, dimensions being data collection, APIs, open source, raw data, security and privacy. As for today, there are several security issues that need to be considered when automated vehicles are introduced. One example is, how will automated vehicles protect itself from system and hardware problems, what will happen if the automated vehicle’s system or hardware fails due to a cyber-attack etc. Questions like these can only be answered with time.

How can this affect the urban transport infrastructure?

As a trend its affect on urban transport infrastructure is mostly hidden. Connectivity with infrastructure would be possible with connected and automated vehicles capable of V2I connectivity. These infrastructures would usually be a set of road furniture with complex sensors that monitors the road and variables connected to it. The automated vehicles will then be able to interact with the infrastructure to make decisions. Hence it is of importance to provide infrastructure which has capability of connecting and sharing data.

2.1.4 Shared mobility and Mobility as a Service (MaaS)

What does this trend define?

Shared mobility is a term used to describe transportation services that are shared among users. It includes a variety of options from services where the vehicle itself is shared, i.e., various forms of car sharing ranging from the traditional (or station based) to free-floating, as well as bike-sharing, to services were the ride is shared. (Sprei, 2018)

The latter includes traditional shared modes such as public transport and taxi as well as car-pooling, ride sharing and ride hailing. There are various attempts to define all these services however, this is becoming more and more challenging since new services are emerging and the distinction between the services are also to a large extent blurring. While some of these services are new, shared mobility is actually nothing new: car rental, taxis and public transport have been available for a long time.

What drives this development? Incentives, challenges, goals or other?

The technology perspective

The convergence of different technological advances has made it possible to dramatically improve existing services and discover new ones. But it's not only technological improvements that have made car sharing services more attractive, even municipalities have played a role in creating prerequisites through e.g. favourable parking regulations (Sprei, 2018)

The business model perspective

Shared mobility has evolved rapidly over the past few years, as ride-hailing services now compete with more traditional car-sharing and car-pooling providers. Companies such as Uber and Lyft have enjoyed rapid uptake and compete head-to-head with local taxis, but increasingly also public transit and car ownership. Ride hailing in particular has grown rapidly, with a large number of venture-backed start-ups springing up around the globe. China, with the largest number of urban commuters in the world and low vehicle-ownership rates, has experienced particularly high growth. Local ride-hailing company Didi Chuxing, following its acquisition of Uber China, now has over 50 million active users and provides more than 100 million rides a week. (Mckinsey & Company, October 2016)

Across the world, cities are enhancing and expanding public transit networks. Eventually, autonomous features may reduce operating costs while network optimization can yield significant benefits in terms of reliability and capacity. New shared-vehicle networks solutions could help cities reduce the cost of underperforming public transport routes. Furthermore, on-demand services provided by minivans and buses create the opportunity to improve first- and last-mile options, and so channel more passengers onto existing routes (Mckinsey & Company, October 2016).

Riding the wave of e-hailing, many smaller companies have ventured into models such as bike and scooter sharing. These types of applications are present in almost all of our cities. Thanks to the ubiquity of GPS-based tools (such as Google Maps, Moovit, and Waze) on smartphones, people in most cities have access to real-time information that instantly maps the fastest driving route based on current traffic conditions or shows options using different modes of travel (McKinsey Global Institute (MGI), June 2018).

The Center for Automotive Research sees that in Europe car sharing members can reach 10 million in 2021 compared to about 2.2 million in 2014, with a slower growth rate in the US and a potential of one out of ten cars sold in 2030 to be a shared vehicle (Sprei, 2018). Thus, there seems to be a possibility for shared mobility to play a role in the future transport system especially in dense urban areas.

MaaS

One way of improving the attractiveness of shared mobility is to combine different services creating Mobility-as-a-Service, MaaS. The term was first coined in Finland and is a bundling of services such as public transportation, car sharing, bike sharing and taxis. The idea is to offer a subscription or pay-per-use service that will cover different types of mobility needs and create a seamless intermodal travel. It should be pointed out that the back-bone of a MaaS systems is existing public transport that would cover the bulk of the travel, even if for some of the schemes the idea is also to create a more efficient public transport system (Sprei, 2018). In addition, by supplying other mobility services in the same package mobility needs that can't be covered easily by public transit are provided for.

How can this affect the urban transport infrastructure?

Looking at the consequences for the energy system and transport system shared mobility is often seen as leading to fewer vehicles, fewer vehicle-kilometer-travelled per person, more efficient vehicles through a turnover rate of the fleet due to the higher utilization rate of the vehicles however it's not always true and that such studies might have some biases (Sprei, 2018). A recent report looked at ride hailing services like Uber in New York city and found that they are contributing to increased traffic and congestion (Schaller, 2017).

2.2 Current trends affecting mobility

Current trends as we would want to refer them as are the trends which are currently booming but are not as significant as macro trends but are very closely related to them. There is a fine line between these trends being a trend in itself rather than being a characteristic for a macro trend.

2.2.1 First/Last mile solutions and Micro mobility:

One of trends that has boomed in the recent years is the first/last mile solutions. Traditional public transit—bus, light rail, and metro—works best in dense downtowns and inner suburbs. Until now, those networks have often left large gaps as they move to lower-density neighbourhoods, forcing passengers to use their own vehicles or walk long distances for the "first and last mile"—the distance between their origins or destinations and transit stops. Last mile solutions are not just limited to mobility of people, they find the same if not more popularity among the logistics industry. Same day delivery, Pick-up, Drive through, Take away – the last stage of a product on its way into the customer's hands is keenly contested by retailers and logistics companies (Trend One, n.d.). The levels of inter-dependent variables, such as the traffic situation and delivery time or location, is a major challenge and last mile solution seems to offer services which can counter these challenges to gain satisfied customers. Equipped with innovative technologies, the new last mile solutions range from parcel boxes in apartment blocks, deliveries to car boots, autonomous delivery robots, through to delivery drones. In future, products will be designed to be "deliver ready" so that they can meet the demands of a seamless delivery route. (Trend One, n.d.)

Micro-mobility refers to smaller vehicles that can carry one or two passengers. Bicycles are probably the most common example. Other micro-mobility vehicles include small electric cars, electric bicycles, all sorts of scooters – generally small powered micro-mobility vehicles run on charged batteries. (Witzel, 2018)

In many larger cities, commuters don't always have to purchase their own micro-mobility vehicle. As the demand for alternative transportation has grown, quite a few companies have come up with vehicle-sharing schemes that let people "rent" their transportation with convenient, distributed, self-serve apps (Witzel, 2018). Customers can use their mobile phones to locate a vehicle, unlock it, and pay the fee. In the evening, workers pick up the vehicles to charge for the next day and then return them to designated spots. (Voi Scooters, 2019)

2.2.2 Changes in mobility behaviour

Consumer's mobility behaviour is changing, leading to up to one out of ten cars sold in 2030 potentially being a shared vehicle and the subsequent rise of a market for fit-for-purpose mobility solutions (Mckinsey&Company, January 2016).

Changing consumer preferences, tightening regulation, and technological breakthroughs add up to a fundamental shift in individual mobility behavior. Individuals increasingly use multiple modes of transportation to complete their journey; goods and services are delivered to rather than fetched by consumers. As a result, the traditional business model of car sales will be complemented by a range of diverse, on-demand mobility solutions, especially in dense urban environments that proactively discourage private-car use (Mckinsey&Company, January 2016).

Consumers today use their cars as all-purpose vehicles, whether they are commuting alone to work or taking the whole family to the beach. In the future, they may want the flexibility to choose the best solution for a specific purpose, on demand and via their smartphones. We already see early signs that the importance of private-car ownership is declining: in the United States, for example, the share of young people (16 to 24 years) who hold a driver's license dropped from 76 percent in 2000 to 71 percent in 2013, while there has been over 30 percent annual growth in car-sharing members in North America and Germany over the last five years (Mckinsey&Company, January 2016).

Consumers' new habit of expectations for fast, reliable, convenient and individualized mobility solutions are rising as fast as the mix of transport modes and services offered to them, and this trend is likely to continue. Even the number of journeys they take is increasing, the frequencies and amplitudes of these trips are changing, and even the purpose of mobility is evolving beyond the traditional function of work/school commuting).
This will lead to new, smart mobility services as well as new segments of specialized vehicles designed for very specific needs. For example, the market for a car specifically built for e-hailing services—that is, a car designed for high utilization, robustness, additional mileage, and passenger comfort—would already be millions of units today, and this is just the beginning.

Because of this shift to diverse mobility solutions, up to one out of ten new cars sold in 2030 may likely be a shared vehicle, which could reduce sales of private-use vehicles. This would mean that more than 30 percent of miles driven in new cars sold could be from shared mobility. On this trajectory, one out of three new cars sold could potentially be a shared vehicle as soon as 2050 (Mckinsey&Company, January 2016).

Driven by technology, mobility behaviours are also being transformed. A growing number of hyper-connected consumers expect customization and control, and there is increasing polarization of behaviour between "deal hunters" – with little brand loyalty – seeking the cheapest travel option, and experiential/aspirational consumers who place more value on the quality, time or convenience of their journeys (Arthur D Little & UITP, March 2018).

The access to mobility services must be easy, the travel chain must not be interrupted, and additional services designed to make the traveling experience smoother will be requested. The traditional model of car ownership is in decline, making way for a new sharing culture. The current generation of 18–25-year-old customers is increasingly willing to share, and more concerned with usage than ownership and multimodality, as long as the various offerings are meeting their individual needs. These evolutions trigger a number of opportunities, but also present key challenges for mobility solution providers – especially for traditional public-transport operators that need to bridge the gap between this new array of demands and the services they currently offer. (Arthur D Little & UITP, March 2018)

2.2.3 **Smart cities**

The interplay between modern information and communication technologies and wireless sensor networks allows cities to become smart cities (Trend One, n.d.). Goods, people and traffic flows can be managed in a decentralized and adaptive way. The tracking of energy consumption, infrastructure use and user behaviour enables the optimal planning of urban resources. A smart power grid is also an important aspect in this urban system. The connection and communication of city dwellers is also supported by platforms that allow people to share their knowledge and information.

Autonomous mobility is also expected to significantly affect city planning and considerably change the laws of real-estate markets (Arthur D Little & UITP, March 2018). A self-driving smart city would not need as many parking spaces as cities need today and be able to make better use of areas freed up from parking.

Some futuristic plans have already been produced that show how a self-driving city could look, with streets replaced by multimodal shared spaces, and parking spaces by parks (Arthur D Little & UITP, March 2018). New smart city planning approaches aim to create high-quality living spaces without sacrificing the land use mix to serve the needs of individual motorized transport (McKinsey Global Institute (MGI), June 2018).

As commuting will get cheaper and easier, many current city dwellers will decide to move to suburban areas, a trend that will lead to a decrease in city-centre house prices and an increase in the value of suburban residential real estate. Thus, the price gap between the centre and the periphery will get smaller (Arthur D Little & UITP, March 2018). Retail and entertainment destination locations, such as large mobility hubs and shopping centres, are also likely to profit from being more accessible to autonomous, shared, electric vehicles. At the same time, retail real estate, in the form of non-destination outlets such as convenience stores, is likely to lose value, as the importance of physical proximity will diminish (Arthur D Little & UITP, March 2018).

City leaders can also have an effect on how a city functions and what trends they want to set. For example, encouraging ride sharing, mandating night deliveries, or allocating dedicated lanes for autonomous cars. Individual cities will make their own choices about what kind of future to pursue. Cities on one end of the spectrum may exercise caution or resist change, while others could take bold leaps such as banning private vehicles from the urban core (McKinsey Global Institute (MGI), June 2018). They have a wide variety of policy tools at their disposal: they can set mandates, incentives, subsidies, and standards; they can convert government fleets; and they can support the build-out of vehicle-charging infrastructure. Cities would do well to engage with the public as they map out their implementation path and address concerns regarding safety, employment, and affordability (McKinsey Global Institute (MGI), June 2018). Ultimately, widely adopted autonomous driving technology could offer a more comfortable, pleasant, and affordable way for urban residents get from Point A to Point B—and because ubiquitous self-driving cars could operate at optimal speeds, they could eventually reduce commute times further. Every year more than a million lives are lost globally in traffic accidents, most of them due to human error. If self-driving cars live up to their promise, they could greatly reduce those losses.

Public transit has generally involved top-down decisions, long investment cycles, and expensive fleets with fixed schedules and routes. If population growth surges in a far-flung neighbourhood, adding a new subway or bus line with the accompanying fleet investments may take years. By contrast, a privately operated on demand minibus service could be up and running much faster. It can take years for a public or quasi-public utility to build a new power plant, and the decision will shape its business for decades (McKinsey Global Institute (MGI), June 2018).

2.2.4 Currently spotted future key trends

A report on the future of European Transport sector identified key trends using their methodology (Mckinsey&Company, January 2016). Based on the mentioned principles in their methodology, the key trend future transport concepts for passenger transport are; Automation, Shared mobility, On-demand mobility, MaaS, Electrification, Seamless transport chains (multimodality, intermodality), Personal air transportation, Smart use of travel time, High-speed rail and superfast ground and underground transportation.

The respective key trends for freight transport are; shared mobility, on-demand mobility, (MaaS, FaaS, LaaS), Seamless transport chains (multimodality, intermodality), Automation, Electrification, Delivery drones, Superfast ground and underground transportation and Freight consolidation hubs, freight distribution centres.

3 Interview analysis

The interviews conducted gave a deeper dive of experts thinking and opinion about mobility in near future and beyond as well as about the shift that would occur to promote sustainable mobility and counter climate change. The panel of experts included were from a diverse background with the commonality of working with or around sustainable mobility.

The experts included;

Andreas Huss, expert in urban planning and architecture

Carlos Viktorsson, expert in services for new and shared mobility

Cecilia Wallmark, expert in energy applications in transport system and electric vehicles

Jonas Sundberg, expert in ITS services and autonomous vehicles

Our experts in these interviews mention the same trends as are mentioned in the report above however it is interesting to capture their opinion on the dynamics of these trends with each other as well as other trends, business models, disruption and above all the experts' field. The interviews gave insights on a broader spectrum of variables in mobility which directly and indirectly affects the trends in mobility. These insights come from the field of urban planning, Intelligent Transportation Systems (ITS), energy sector, MaaS etc.

Experts agree with the importance of role of mobility in urban planning and all of them believed that mobility is not going to look the same in next coming years and that the rate of changes and development in this field would be exponential. While shared mobility is gaining popularity, it is great way of implementing sustainable means of travel be it for people or for goods. With increased urbanization the user needs would increase which in turn would increase the demand for a tailored solution for mobility. An important trend now is a mix of modes (Sundberg, 2019). In other terms multimodality is an effective way of catering to different needs and demands and is a necessary element in sustainable mobility.

Mobility in urban planning by Andreas Huss

Role of mobility is crucial in urban planning. In current situation there is a strong focus on transportation in urban planning as there is a lot of thinking, money and resources involved hence currently, transportation comes quite early in planning.

To understand the role of mobility in urban planning it is important to first know what is included in urban planning and when mobility comes in. In a usual urban planning project, green infrastructure (green resources, beaches, forests, wet lands etc.) is used as a starting base followed by landscape resources (resources related to landscaping like soil, vegetation etc.). In parallel development area planning is carried out to develop without affecting the above stated values. The next step is to combine all of them in a network through mobility solutions. There's an emphasis on avoiding heavy traffic through the city center rather have slow traffic instead and use public transportation to create density area. Use of reverse traffic pyramid (mobility pyramid), see Figure 1, and focus more on walking and biking.

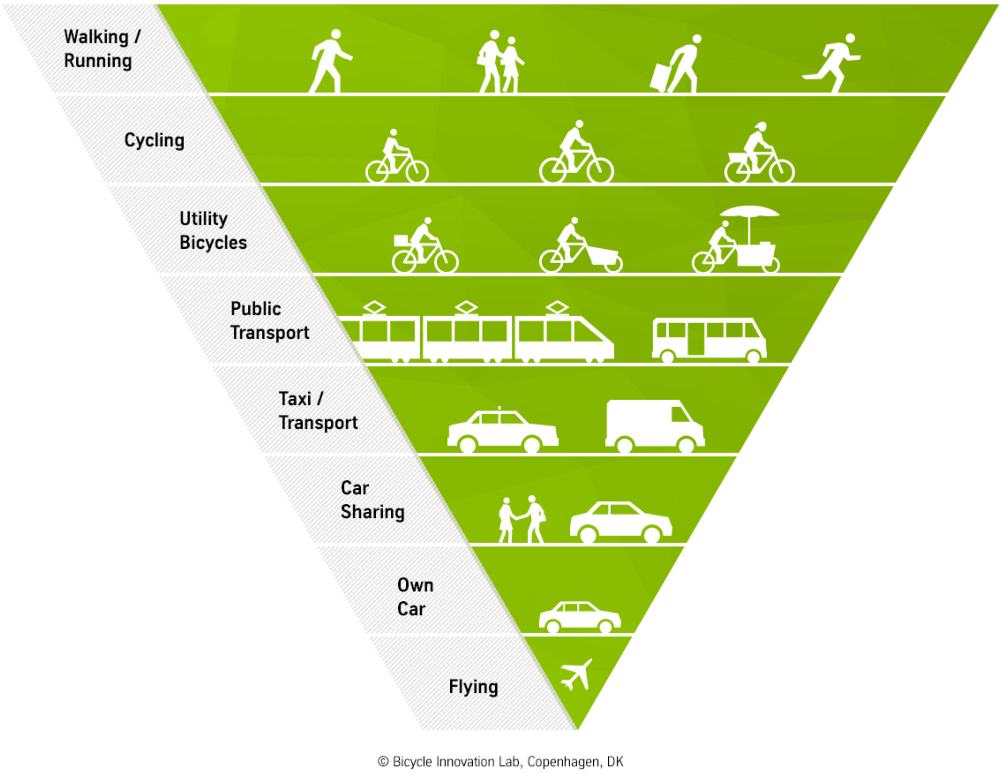

Figure 1: Sustainable Transportation pyramid Source: (Urban Hub, 2015)

Giving enough space for flexibility (cables, charging stations etc.) and future use for both people and goods. Having hubs connected by several transport systems, focus on density and multi-use in urban square meter and transportation which can be changed with time.

This process is carried out with an energy planner, mobility planner along with architecture planners to accommodate all the perspectives. For example, the floor height is something that is also thought of, in Sweden the most flexible buildings suitable for converting to transport hubs are industrial buildings from 20th century with strong structure and high ceiling heights.

For the goods the planning happens in circles (zones) with hubs for heavy logistics outside the city and then use other transportation system for deliveries.

Energy systems perspective on Mobility by Cecilia Wallmark

Looking at mobility from an energy use perspective, there are good goals set out for the future for example Fossil Free Sweden 2030. There are many variables which affect mobility from an energy perspective. Variables like policies, travel behavior, vehicle efficiency, fossil free fuels affect mobility. While macro trends like shared mobility, electrification, digitalization promises energy efficient mobility options it is also important to note where and how are those trends acting, where is the electricity for charging stations coming from?, are the systems optimized for efficient use?. Efficient, effective and sustainable transportation can be provided by having optimized transportation systems, smarter traffic systems and mobility solutions which are tailored for needs.

Importance of data and data security in mobility by Carlos Viktorsson

Mega/macro trends in mobility are already a real thing and are contributing significantly to global economy. Digitalization as one of the macro trends could be seen as both interesting as well as dangerous. The overly relying of data in mobility services as well as the use of information can potentially be subject to security issues if not carried out safely with all precautions. There is a focus on technology and responsiveness demanding quick, responsive and tailored services which then demands data and lot of information about the services, users and everything in between.

Technology is getting ‘mobile’ which also includes tools for managing mobility needs and demands in everyday life. There is a lot of data consumption i.e. in talking part and in using the services. Service quality has changed drastically as it has now become much easier to take and use information from the internet through open data.

There has been an increase in the trend of having everything, all the information at your fingertips in other words accessibility of information has gotten more crucial for an active user of mobility services. With access to all this information, services especially mobility services are getting smarter. Industry 4.0 is making the services more agile to response to ever changing requirements and demands of the user, this is affecting new business models as well as existing business models causing a shift.

Another aspect of mobility service is individualization. The users now have an expectation of having tailor made services, ones that give them tailored choices which meets their needs. To achieve that these services need data on their users hence they rely on data, (open data and big data). This arises a greater risk of integrity, security and exploitation of consent to use the information.

The possibility to automate things have increased with more data and IoT. There is a need to connect thing to automate them. This connectivity is good but dangerous if not treated with caution. Security and safety will be of importance here.

New outlook for mode of mobility by Jonas Sundberg

For a small urban area with 5000-6000 residents in Norra Ön (Fördjupning för Ön, 2008), connectivity to central, öst and södra is of great importance. Along with bridges and water ways, use of cable car can be proposed. Cable car otherwise termed as a Cable Propelled Transit (CPT) system can fit in this scenario of providing an efficient and quick mobility mode while connecting Ön with Central, öst and södra region of Umea.

An inspiration of this can be taken from Gothenburg. The city of Gothenburg in Sweden is discussing building a $137m (SEK1.1bn) 3Km cable car system to provide fast and efficient aerial transport linking the areas north of the Göta Älv river to the old city in the south. This is also a way for Gothenburg to invest in more sustainable public transport. The cable car itself is environmentally friendly and it will be integrated with other public transport services at each station. It will also shorten travel times.

It is important to not have a short-sighted vision of mobility with transportation; a car free vision should be adopted. It would be possible to limit access for specific type of traffic (cars or heavy trucks) with the help of geofencing. Providing accessible mobility modes while not affecting flexibility of the residents would be of essence here. We are also talking about the time when a diverse fleet of vehicles (different levels of autonomy, electric, shared as well as private) would share the same stretch of infrastructure.

It is for certain that traditional public transport, Bus Rapid Transit System (BRTS) etc. won’t be enough to cater the needs and demands of the residents in urban in coming 20 years.

4 Discussion

This section discussed some points which does not lie in a certain trend but can rather be seen as characteristics of some. Variables like infrastructure, stakeholders, new business models and technology have enormous effect on mobility and that certainly needs to be accounted for in urban planning. The section points out such variables and their effect on mobility both directly and/or indirectly.

4.1 Infrastructure: Cause and effect

Apart from the fact that self-driven vehicles will decrease mobility costs and increase the productivity of infrastructure thanks to the absence of associated driver “costs”, both production and maintenance costs are expected to be much lower than for traditional motorized transportation solutions (Arthur D Little & UITP, March 2018).

Autonomous driving will contribute to the performance of mobility ecosystems. From a socio-economic perspective, fully autonomous vehicles will have a revolutionary effect, especially in cities (Arthur D Little & UITP, March 2018). A customer survey performed by Arthur D. Little confirmed that owners of self-driving cars would expect to use their private individual vehicles significantly more often once autonomous features were available, thereby adding traffic to the streets. The study also highlights the prediction that half of the future users of autonomous vehicles will be current private-car drivers, and that, in an unregulated environment, self-driving vehicles could very well capture a significant amount of the traffic – both short and long distance – that is today carried by public transport.

Despite a shift toward shared mobility, vehicle unit sales will continue to grow, but likely at a lower rate of about 2 percent per year. (Mckinsey & Company, October 2016) Overall global car sales will continue to grow, but the annual growth rate is expected to drop from the 3.6 percent over the last five years to around 2 percent by 2030. This drop will be largely driven by macroeconomic factors and the rise of new mobility services such as car sharing and e-hailing. (Mckinsey&Company, January 2016)

4.2 Public-private collaborations

Today, a small number of cities, such as Amsterdam, Singapore, and Stockholm, are singled out as having effective mobility. With varying degrees of emphasis, they have efficient public transit, encourage cycling and walking, and have managed to limit congestion and pollution (Mckinsey & Company, October 2016). In specific terms, cities will navigate these possibilities differently. Local conditions—such as population density, wealth, the state of road and public-transit infrastructure, pollution and congestion levels, and local governance capabilities—will determine what changes occur, and how quickly.

To have a vision of developing a transportation system with benefits such as saving time, reducing congestion, and improving air quality and avoid the pitfalls, the public and private sectors would need to work together, while city officials would need to be willing to reconsider how they conduct their own business (Mckinsey & Company, October 2016). For example, sharing and autonomy could cannibalize public transport systems, and cities may consider whether it makes sense to partially shift ownership to private shared-mobility providers. Governments through right policies may also want to rewrite fuel and energy usage taxation and to use the opportunity of connectivity to revisit how infrastructure is priced.

4.3 Disruption and adoption of innovation

Disruption can happen very fast. Uber was established in 2009 and, Lyft in 2012, and after only a few years of operation, they have taken over 30 percent of taxi rides in many cities and caused several traditional taxi companies to go bankrupt (Arthur D Little & UITP, March

2018). This trend will continue, as the global market share of traditional taxi operators is expected to be halved by 2030 (Mckinsey&Company, January 2016). The next evolutionary step in transport systems could involve the Hyperloop and self-flying cars – if they can be developed successfully. According to Elon Musk, the founder of SpaceX and Tesla, who first came up with the Hyperloop concept, construction of the Hyperloop would be 10 times cheaper than building a railway line on the same route. If his costing estimates are correct, its impact on long-distance rail could be very disruptive indeed (Arthur D Little & UITP, March 2018).

Other significant disruption can come from flying cars, the mass production of flying cars would theoretically solve all capacity problems, as – instead of being restricted to roads or railway lines – they would be able to fly on a virtually infinite number of different layers. Over a dozen companies are currently hard at work on making vertical take-off and landing (VTOL) aircraft a reality, and several producers have even got to the point of testing prototypes. Some claim they may begin mass production as soon as 2020. In 2017, Dubai's RTA introduced flying drones (operating on fixed routes with qualified pilots manning the craft), and taxi services such as Uber are looking to develop similar machines (Arthur D Little & UITP, March 2018). Should they succeed, flying taxis could soon become the norm.

The adoption of innovation would be of key importance here. According to Rogers adoption curve (Rogers, 1983),see Figure 2 which describes how new innovation and ideas are accepted and adopted in groups and cultures, the diffusion happens in stages through groups of users, from Innovators to early adopter, early majority, late majority and finally laggards. These groups and the adoption against the time defines how adoption of an innovation has happened in a market. If we look at disruption in mobility, it could be possible that some diffusion might take some time to be diffused and hence succeed.

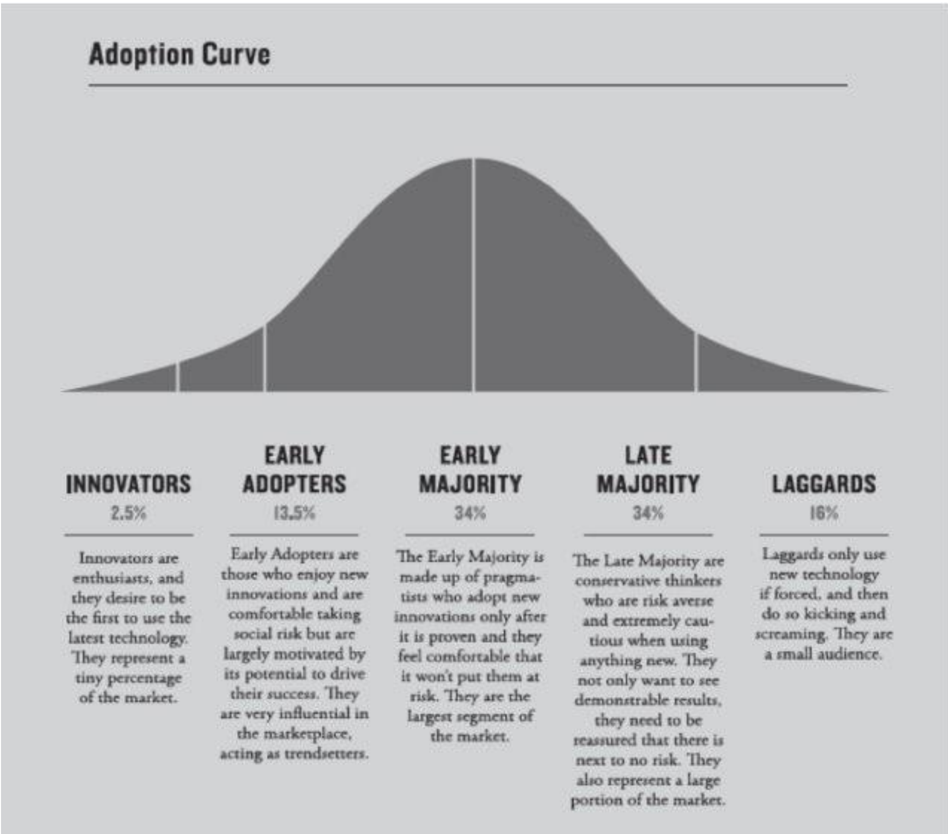

Figure 2: Rogers innovation adoption curve Source: (Rogers, 1983)

The question to be answered remains; *What can cities do to keep on top of these trends?* In the midst of all of this disruption, and in an era where new technologies are difficult to predict and regulate, how can municipalities be involved in urban mobility innovation? One of the answers is data and control. Municipalities are increasingly recognizing the need to move from an action-driven approach, where they manage mobility and public services to promote public transport usage, to a passive disintermediation or facilitation approach. It should also be recognised that with the speed of both technology innovation and societal changes it is diificult today to say which of the trends that will prevail. The importance of setting a vision, for example a car free area or climate neutrality, and then continiously monitoring the trends to see which need to be empazised to reach the vision or, if needed, restricted because they may worka against the vision cannot be stressed enough.

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APPENDIX

Term	Abbreviation
MaaS	Mobility as a Service
LaaS	Logistics as a Service
FaaS	Freight as a Service
V2V	Vehicle to vehicle communication
V2I	Vehicle to infrastructure communication
V2X	Vehicle to X communication (X may refer to any variable)
IoT	Internet of Things
AI	Artificial intelligence
EV	Electric vehicle
ICT	Information and communications technology
ODD	Operational design domain
BRTS	Bus rapid transit system
ICE	Internal combustion engine
V2G	Vehicle to grid communication
ITS	Intelligent transportation system
API	Application program interface
CPT	Cable propelled transit
VTOL	Vertical take-off and landing