How smart are smart cities?

How can big data influence the planning of sustainable urban mobility?

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Master of Science Thesis INDEK TRITA-ITM-EX 2018:340
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Abstract

The opportunities we have to move around the city, otherwise known as urban mobility, are intrinsically linked to both local industrial output as well as the physical possibilities of moving provided by the landscape of the urban environment. With the advent of automotive congestion solidifying itself as a reality as populations in urban centres continue to rise, the conspicuous question is: If we continue the way we’re going, what happens next?

This thesis explores the influence of new technologies and the data that drives them on the mechanisms of planning mobility in urban centres, as well as the potential of adoption of innovative mobility solutions that address environmental concerns through insights that higher resolution data can provide.

Statistical data sets have been used in the past in order to justify urban interventions and shifts in the established landscape, to collectively move citizens and their production towards spatial outcomes that hinge from directives of governance. More recently these shifts have been in a bid to address the overarching awareness of changes in the natural environment due to industrial (and therefore human) intervention.

Moving into a future when there is a higher resolution of quantitative data harvested from a broad consumer base it becomes possible to enhance the city planning process by linking close-to-real-time supply and demand. The central proposition of this thesis is that unique value propositions of mobility consumer markets should be driven by the needs of people, rather than the capabilities of technology and industry.

There are obvious real-world ramifications for changes in the way citizens move around the city; the sizing of streets, noise levels of automobiles, access and egress points, the distance between points of interest and the capabilities of the fixed built infrastructure to accommodate change. This body of research focus’ on the connection enabled by putting people, rather than technical solutions at the centre of the sustainability debate.

Key-words: Urban mobility, sustainable development, big data, innovation.
Declaration
We certify that except where due acknowledgement has been made, the work is that of the authors alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; and, any editorial work, paid or unpaid, carried out by a third party is acknowledged.

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13.06.2018
Dedication

Angela Marie Woda

To those that have been my sounding board, my brain and torchbearer through the times that I needed help but was not able to ask. You know who you are.

Luiza Teixeira Betarelli Cabrera

To my husband, Tiago, who always encouraged and supported me in my dreams realization, being always at my side with his love, wisdom and support. To my parents, who have always shown me the value of work. To my parents in law’s efforts in helping me get here and my family, friends, Brazilian professors and co-workers who supported me during this journey.

Acknowledgements

We would like to thank our interviewees for graciously donating their time and sharing their experiences.

We would also like to thank all academic supporters of this body of research including our class colleagues for helping along the way.

Vi vill tacka våra svenska vänner och kollegor för allt stöd under vår tid i Sverige.
Stort tack!

Angela Woda and Luiza Betarelli
Stockholm, June 2018
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List of Abbreviations

AI: Artificial Intelligence.
CMS: Combined Mobility Service - Maas, but as referred to by public transport providers.
ICT: Information Communication Technology.
IoT: Internet of Things.
MaaS: Mobility as a service.
SVEBO: Svenska Bostäder organization, formed by BOVERKET, the Swedish National Board of Housing, Building and Planning.

UN: United Nations.

VINOVA: Sweden's Innovation Authority, provides funding for innovative projects in Sweden.

**Glossary of Key Terms**

Collective Transportation (public transit): System of vehicles or other transportation modals to offer public transportation over a city. Its efficiency is based on achieving economies of scale through transporting large numbers of people. It includes tramways, buses, trains, subways, and ferryboats (Rodrique, Comtois and Slack, 2016).

Commuting: commuting refers to trips taking persons to and from work in another municipality.

Comprehensive planning: the process of determination of community goals and aspirations for the development of a community (Malmö stad, 2016).

Consumer Behaviour (human behaviour): The act of consuming a transportation service, carrying its prediction challenges due to the human behaviour unpredictability when acting as consumers due to non-rational decision-making processes and adaptability characteristics.

Density: The number of analysed items averaged over space, usually expressed as a quantity per distance.

Digital Twin: A digitized duplicate of physical environments whose parametric relationships are built to test interactions before solutions are deployed into the real world.

Freight Transportation: Movements of production and consumption from and for urban activities, mostly characterized by delivery trucks as well as from major terminals such as ports, railyards, distribution centres, and airports (Rodrique, Comtois and Slack, 2016).

Highway Capacity Manual (HCM): a collection of state-of-the-art techniques for estimating the capacity and determining the level of service for transportation facilities, provided by the Transportation Research Board and periodically updated (Transportation Research Board, 2016).

Individual Transportation: Transportation mode where mobility is the outcome of a personal choice. Includes automobile, walking, cycling and the motorcycle (Rodrique, Comtois and Slack, 2016).

Level of service: A qualitative measure describing operational conditions, based on service measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience (Transportation Research Board, 2016).

Mobility: The possibility for people and goods to move from one place to another.

Multimodal: A transportation facility for different types of users or vehicles (Transportation Research Board, 2016).

Open data: data that can be used and distributed by/to anyone, subject only to the requirement to attribute and share alike (IEEE-SA, 2018).
Smart cities: An urban development that is working to incorporate digital processes in the management systems of the city in order to increase efficiency and sustainability.

Sustainable Development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 1987)

Traffic condition: A characteristic of traffic flow, including distribution of vehicle types in the traffic stream, directional distribution of traffic, land use distribution of traffic, and type of driver population on a given facility (Transportation Research Board, 2016).

Traffic: Transport of people, goods and information regardless of means and infrastructure (Malmö Stad, 2016).

Transit accessibility: A measure of pedestrian, bicycle, automobile, and Americans with Disabilities Act accessibility to transit (Transportation Research Board, 2016).

Transportation systems: Modes of transportation, from private and public vehicles to new developments.

Travel Behaviour: User’s behaviour in relation to their transportation methods choice and measurement of the trip quality, from a traveller’s perspective.

Travel Corridor: better understand how people may be influenced by certain urban design, land use, or transport characteristics experienced along their journey to a certain destination (Appleyard, 2010).

Urban metabolism: flows of goods and people in a city environment (Shahrokni, 2015).

Urban mobility systems: transportation systems that are included in and serve an urban area.

Urban: An area typified by high densities of development or concentrations of population, drawing people from several areas within a region (Transportation Research Board, 2016).
1 INTRODUCTION

This chapter of the thesis positions the research with respect to its contribution to the discourse of industrial dynamics when dealing with urban mobility and the citizen consumers who interact with urban transport systems. The chapter concludes with a roadmap of the forthcoming research.

1.1 Background

“Cities shape us... and we, in turn, are shaped by the city.” Winston Churchill

Already by 2018, most of the world’s population live in urban areas (European Union, 2014). The impetus of planning of urban spaces has shifted little since the beginning of the 20th century, where the need to plan came from the need to ensure the success of the industrial dynamics of the local (O’Sullivan, 2018). However, methodologies that drive the planning of both hard infrastructure like buildings, roads and bridges, as well as the flows of goods and people (urban metabolism) have changed dramatically over time; from the linear process to a collaborative one which engages a plethora of stakeholders (Klosterman, 2013). The agenda associated with the need to plan has also shifted in recent years to that of sustainable development and consumption. While the literature surrounding sustainable consumption is mainly focused on indicators of behaviour, rather than frameworks that provide insights into behaviours of sustainable consumption, the general school of thought reasons that consumption needs to drop in order to meet global sustainability targets.

While reducing road congestion has the obvious payoff of moving activities in the city run more efficiently by reducing consumption of road space, it also contributes to tackling the need to reduce overall consumption of energy. The prevalent theory to combating road congestion is to remove the driver of the vehicle and make automobiles autonomous.

One element of planning the future that remains a constant regardless of planning methodology is forecasting the future. The need to dimension the physical structure of the city is centred on understanding the flows of how people and good move (Healey, 2007), which is invariably in symbiosis with the demands of industry and is limited primarily by the capabilities of the transport network. Like any network, reaching levels of full capacity place an operational risk of slowing growth, and distorting possible futures of the city itself. With the current growth rate of cities like Stockholm (+~1% population growth yearly) (Stockholmstad, 2017), the development methods that have functioned in the past will no longer stimulate predictable positive influence, and adjusting infrastructure to make it larger will only solve congestion issues for a limited time (Snickars, 2018). As such it has become important for cities to think of ways to become more efficient; using the resources it has in order to increase its competitiveness into the future (Camagni, Gibelli and Rigamonti, 2002).

Changes to the ways we use road networks are shifting away from product only offerings to value propositions of service packages offered in combination with new mobility products (like e-vehicles and bikes) under the coined titled ‘mobility as a service’ (Maas) as an answer to solving congestion problems. Scenario building of multi-modal transport systems in ‘activity-based cities’ are favouring the employment of autonomous vehicles to link traditional bus services to personalized door-to-door services in a bid to make owning a car less attractive.
Humans who live in cities are also consumers, with unique value propositions regarding their mobility needs. The value propositions of new mobility services should work to serve the human as a consumer, and their unique needs, if shift towards sustainable mobility, is to be adopted in the long-term. A shift to service-based offerings from industry will inevitably change the way planners consider the form and function of road networks—both in the case of retrofitting existing roads, as well as setting the guidelines for new ones, since these new service packages of mobility redistribute existing infrastructure, creating less of a need of support infrastructure such as parking spaces. The censored requirements of autonomous vehicles require distinct environmental conditions in order to function properly, for example, the capabilities of autonomous vehicle sensors, which will also lead to changes in the way urban roads are designed, and how buildings and public spaces connect to them.

Technological development has created new lenses from which to see the city. Data sets that exist now have the capability of showing us patterns of life that were un-seeable in the past. The notion of big data has two major concerns; firstly, the sources available to harvest data, and secondly the tools which are built to read it. Advances in the second are paralleled with new business opportunities for industry since it is when data stops being intangible and resolves itself as a value proposition. Today, global citizens have ever-growing digital footprints which could be useful in dimensioning services of urban mobility, as well as the designing the journey experience.

New data begets new theory (Suciu et al., 2013). Big data is rewiring the way we plan the city in order to deliver services, rather than make way for new big infrastructural interventions (Batty, 2012). It also means that cities will be dimensioned by the data made available to it (Thakuriah, P. Tilahun, N. Zellner, 2017).

Discussions around the future development of western cities have increasingly become one about smartness, and the notion of the ‘smart city’ (Batty, 2012). In policy agenda’s, smart cities are synonymous with using the potency of data in the form of Information communication technology (ICT), as well as the internet of thing (IoT) to manage urban networks including energy supply and recycling of materials, rendering services more efficient. But should efficiency, that is driven by quantitative data, be allowed to influence an eponymous definition of the life of the city?

Technology has changed the way we inhabit the city, but it has also changed the way we move around it and with it our expectations of mobility. If we really are to truly address problems of developmental sustainability it’s not enough to apply technical solutions to old problems. Moreover, it is not enough to continue to plan from a bird’s eye view. The human scale, human speed and human expectations need to be understood if we are to make progress.

The human experience should be the core principle of urban mobility, and technology alone is not the answer (Vinay Venkatraman, Ted Talk Copenhagen 2014). By concentrating too hard on adapting the automobile to provide an answer to congestion and consumption, are we missing solving the root of the problem; how humans move through the city.

### 1.2 Purpose & Research Question

Already by 2007, over 50% of the world’s population was living in urban environments and by 2014 over 80% of the populations of North America, Europe, and Latin America were living in urban centres. In 2017, cities were and still are in 2018, continuing to be the place where most people live. Cities also contribute to over 80% of the global gross domestic product, two-thirds of energy use and over 70% of greenhouse gas emissions (Bishop, 2017).
There is an inherent dichotomy in the action of the city where shifts to larger settlements are largely driven by economic forces; on the one hand, its inhabitants contribute disproportionately to climatic impacts and on the other, cities present wondrous opportunity for its inhabitants with rapid uptake and deployment of new technologies (Harsman, B., & Wijkmark, 2013).

In order to address the growing issues of unbalanced consumption, a strategy cities have come to adopt is to use available ICT to understand the roots of urban problems related to consumption such as congestion, while at the same time increasing the overall efficiency of geographical area understood as the city (Dubey et al., 2016).

Transport networks have a direct effect on the industrial capabilities of an urban cluster, placing urban mobility at the centre of the future of the city debate. It is for this reason that the authors have chosen to focus their research in this sector of the city.

Urban mobility is usually studied under the “smart sustainable city” framework; but how smart and sustainable these cities’ systems? Are technical solutions applied independently to address human problems what make cities smart? The procurement process of city development is not necessarily linear from planning to delivery to management; feedback loops between management data and planning agendas can be useful ways to bridge industrial intentions and citizen expectations of urban transport networks, using the latent potential of big data sources (Klosterman, 2013; Shahrokni et al., 2015; Wolfe, 2017). This is especially important in regards to finding innovative outcomes to common urban problems.

Interventions of economic and technical nature alone will not be enough to achieve sustainability targets set by global assessment agencies such as the UN (United Nations), nor will be dramatically shifted sustainability issues closer to daily routines such as traffic congestion. The paradigm shift calls for behavioural changes, as a collective (Hiselius and Rosqvist, 2016).

The culture of consumption is embedded social practices as well as behavioural norms (Shove, 2013), but it is also reflected in the availability of amenities and technology where the culture of consumption shifts is time with material circumstances. This suggests that editing the built environment can shift humans daily practices towards sustainable habits that become the “social default”(Manning, 2009). Peter Öm of the Swedish Green Building Council (SGBC) argues that participation is the key to achieving sustainable objectives since it is more powerful for users to push for change than for regulators and instigators.

A consideration of the dynamics of the city; infrastructure, structure and megastructure allow for a conversation about what kind of city inhabitants want to live, and what tools could be of use to achieve it. The symbiotic relationship between citizens and their environment are hinged on the activities that take place within the geometry of the settlement, which ultimately shapes people’s behaviour and decisions that shape how they live their lives.

There is an established body of research focused on the possibilities of transport supply of urban mobility. However, it is in more recent times that deeper qualitative investigations into the demand side of urban mobility are being commissioned to compliment explorations of supply. What do people expect of cities? What do they expect to gain from city life?
1.2.1 Research Question

The research question explored through this thesis is:

*How can big data influence the planning of urban mobility?*

It is approached through three angles of investigation:

1. Big Data
   
   By reflecting on citizens choices related to their locomotion needs and actions, it is possible to understand the urban metabolism as a response to the available infrastructure of the city.

2. Urban Mobility Planning
   
   - The barriers to the usefulness of big data to understand travel behaviour
   - Mechanisms in planning future mobility that encourage innovative solutions
   - Exploration of how people’s responses to the existing systems influence the development of new technologies to make the transportation systems in cities more efficient and sustainable

3. The Consumer
   
   Walkable cities, bicycles paths and broad reliable public transportation systems can “nudge” people to change their behaviour by choosing a modal with less environmental impact.

The subtitle of the authors’ research question: *How smart are smart cities*, intends to be an umbrella framework from where the research question will be unpacked. The definition of a smart city is essentially contested, however, in simple terms, it can be understood as an urban development that is working to incorporate digital processes in the management systems of the city in order to increase efficiency, as Hollands writes:

"...utilization of networked infrastructures to improve economic and political efficiency and enable socio, cultural and urban development" (Hollands, 2008).

Big data is one of the champions of the smart city movement, deeply embedded in both the contributors of urban data landscapes as well as being the substance that ensures the promises of smart cities. Specifically, the possibilities of how data influences one aspect of the urban landscape- that being the modes of movement via various forms of aided and unaided transport is the defined angle of this research under the umbrella of the smart city future so many cities are hoping to graduate.
1.3 Outline

In this section, the thesis outline and context are described. The thesis consists of six chapters.

Chapter 1 This chapter outlines the background, purpose and research question.

Chapter 2 Discusses a mixture of literature which provides the theoretical framework. The literature is a collection of academic theories as well as unpacking the existing research in relation to this study on big data, urban mobility and consumer behaviour. These three themes are discussed within the framework of sustainable development and the ‘smart city’ from the perspective of the future-now urban environments. Chapter 2 contextualizes this information in relation to notable impacts of industrial dynamics on methodological approaches to urban planning.

Chapter 3 sets the framework for the methodological approach to this body of research, with the aim to explore the subject areas as opposed to validating a hypothesis, by using the interpretivism paradigm. This framework is used for the collection of data and analysis that follows in chapter 4, 5 and 6. It outlines the process of the interviews conducted as well as the scope of investigation for the case studies.

Chapter 4 considers two case studies of planning documents outlining urban mobility objectives for new neighbourhoods located in two different major cities in Sweden: The Royal Sea Port in Stockholm, and West Harbour in Malmö. The chapter reflects on possible differences between the cities and the role of the consumer in the evolution of development process. Chapter 4 unpacks the notion of sustainable development and the ‘smart city’ covered in chapter 2 in relation to the case studies included in the study.

Chapter 5 analyses a series of interviews using a framework matrix which focuses on possible influences of new data sources in the management of urban mobility and the connection to future opportunities data bestows on sustainable urban development. The content of the interviews speculates on possibilities for future spatial conditions of public spaces, and modes of mobility in urban centres.

Chapter 6 leaves the reader with the paper’s conclusions. Links are made between the analysis of chapters 4 and 5 and the literature discussed in chapter 2. The chapter is then followed by outlining possible avenues for further research.

1.4 Delimitations

Sustainable development is a field of research which could be considered as essentially contested; whereby the definition of the words themselves fall under heavy critique from those that contribute to the discourse. This in itself has an effect on the potential scope of this thesis since the question itself is inducting the contribution of this research to discourse into the thick of the debate. The delimitations of this body of research are conscious decisions by the authors to establish a scope relevant to the outcomes of the thesis submission. Firstly, the authors have decided to narrow the scope of this research into the area of urban mobility within the Swedish context.

Since the necessary scope of specializations to consider when developing a neighbourhood in an urban context is immense, the authors have decided to narrow the investigation down to an element of the urban fabric which influences both the dynamic and fixed infrastructural elements of the city.
The capacity of road transport networks has a direct influence on the measured capacity of building and public space use that lay adjacent to them. The quality of these road networks is directly influential on the liveability of a city.

At the time of writing this thesis, many argue that there are no cities can proclaim they are truly a smart city (Hollands, 2008; Sterling, 2018), the main discussion is on how cities are getting smart (Carlsson, Hadenius and Ericson, 2006; Sanchez et al., 2014; P. Thakuriah, Tilahun and Zellner, 2015; Anthopoulos, 2016; Mosannenzadeh et al., 2017; Nathali Silva, Khan and Han, 2017). There are many cities committed to funnelling its capabilities and resources into becoming one. In April of 2017, Stockholm Stad released its formal strategy for becoming a smart city, which states that the policy guidelines are to be implemented into all of the city's operations, including urban mobility (StockholmStad, 2017a). Nationally the cities of Sweden are already members of numerous conglomerates of sustainable development agendas including C40, Digital Green Charter and the Alborg Charter, and has historically, and continues contemporarily to be recognized as a global leader for its policies addressing climate change as well as a self-promoting role model of sustainable urban development (Hult, 2017). A driving force of the 1972 UN summit on the environment, Sweden is largely recognized as laying the foundation for international cooperation for environmental matters (Hult, 2017).

However, perhaps we should be more critical of Sweden’s clean image. While the planning objectives outlined by major cities in Sweden, including Stockholm and Malmö, paints a picture of a vibrant and people-centred urban future there seems to be a lack of pro-active planning which looks to incorporate the rapid technological advancements made in recent years regarding mobility to and from and within urban centres. Instead, the future visions of heavy-weight industrial giants, old friends in the economic and political landscape of Sweden, are guiding the way in which people will move around the urban environment in the very near future. Without a clear definition of what a sustainable development is, or even a unified intention of what it means to live in a smart city, moving towards satisfying the 17 sustainable development goals defined by the UN is akin to herding cats. This thesis does not include an in-depth study of assessment criteria or performance indicators of sustainable neighbourhoods for this study due to that the authors felt it fell just outside the scope of this thesis because the nature of policy and certificate assessment is in its nature highly political and the authors wanted to focus on the consumer in the planning/management process. The authors have conducted research on this in the past however and have included it in the appendix for reference.

Limitations have also been drawn on the scope to which this body of work should contribute to the knowledge about cities and urban planning. This thesis takes at face value notions of complexity and its relationship to historic city planning including monolithic theory (Haken, 2012) which include mathematical models such as synergetic which aim to understand the mechanisms that underpin the behaviour of complex systems. The technical aspects of data systems architects in the urban environment are not covered in this thesis beyond a mention, since the focus of this project is human interaction within the built environment which includes a limited discussion of usability of technical devices and a theoretical discussion of how sensor systems operate, but the authors felt anything beyond this was not necessary for this project.

Philosophy of consumer behaviour is not represented in depth in this paper, due to its scope and with its inclusion, the authors felt it would shift the focus of the thesis. The thesis does, however, place focus on the human, in relation to the city and for this reason, the research question addresses exclusively the travel behaviours of individuals; it does not consider the movement of goods or information electronically, other than those in cases when these may impact on personal movement.
The research also doesn’t claim to solve current methodological problems with linking management and planning of urban mobility for reasons mainly concerned with the expected scope of a one-year master’s thesis, and of course time. Developing a theory for linking management and planning opportunities would be suitable for further research.
2 THEORETICAL FRAMEWORK

This chapter positions the thesis from the perspective of the human, the user as the consumer. It makes links between human nature and needs while contextualising the consumer within the urban environment. It has three subchapters addressing the three research fields; consumer behaviour, urban mobility and data.

2.1 The Consumer

2.1.1 Choice

“In science, when human behaviour enters the equation, things go nonlinear. That's why physics is easy, and sociology is hard.” Neil Degrasse Tyson

Human behaviour prediction is a subject that had been studied to understand, predict, and plan people’s activities (Solomon et al., 2006).

The act of consuming a product or a service is an important part of people’s daily activities, carrying within it its prediction challenges in consumer behaviour analysis. Historically, the first consumer decision making studies started to be developed around 300 years ago, by the economists Nicholas Bernoulli, with the first explanation over decision making. Later this theory was extended by Neumann and Morgenstern in the Utility Theory, presenting the proposition that the decisions made by consumers are driven by the expected outcomes of their decisions. Utility theory says that travel time differences between car and bus options can influence mode choice between origin-destination pairs (Cervero and Radisch, 1996). The theory also stipulates that a dense, mixed-use, pedestrian-friendly destination is more likely to induce modes of transport by foot or bike that an auto-oriented suburban environment, such that the characteristics of a trip end, and journey qualities, and not just trip interchanges influence travel behaviour. (Cervero and Kockelman, 1997; Ewing and Cervero, 2017)

As Utility theory models did not explain some key features about the decision-making process, new theories continued to be developed. Searching to fulfil these gaps, the Nobel Laureate, Herbert Simon, presented a new model called Satisficing in the mid-1950s. This model intended to prove that consumers stop their decision-making process when receiving an approximate outcome of their expectations. Following this, in the late 1970s, Prospect Theory was developed by the psychologists Amos Tversky and Daniel Kahneman, encompassing the best aspects of the previous theories and adding to them the concepts of value and endowment, representing the valuation between gains and losses around the achievement processes (Richarme, 2006).

As these early models considered the consumer as a ‘rational being’, it did not present some key features about the decision-making process due to a wide range of factors that may influence the consumer and the possibility of taking non-rational actions. Even though it can be considered rational in many aspects, there are a collection of decisions that are taken in an irrational way which are being influenced by a diverse range of surrounding factors, that most time, cannot be predicted (Bray, 2008a). Another fact that can affect customer behaviour changes is that human physical and philosophical needs are also under continuous change and adaptation over time (Dudovskiy, 2013). To cover these shortcomings, new theories are in continuous development, to understand through the analysis of data, applications of new technologies and practical studies for the processes involving consumption (Bray, 2008b).
2.1.2 Urban mobility choice making process

Even though urban inhabitants can adapt themselves to available modes of transportation, there is an opportunity to nudge people to change their habits by changing the disposition of the transportation systems and offering benefits for using an option that can result in more positive outcomes for the entire society (John, Smith and Stoker, 2009).

Influential bodies can offer a ‘choice architecture’ to encourage citizens to change their habits by nudging them towards civically minded behaviour. As an example, we can cite tax incentives over reduced carbon usage. These interventions can be imposed, but with limits concerning costs, acceptance, normative clarity and respect to people’s freedom of choice (John, Smith and Stoker, 2009).

The nudge approach is a result of a cognitive revolution in the psychology field, that has been recently used to change civic behaviour by Governments and/or policy makers, based on behavioural economics and the assumption of citizens as limited rational decision makers (John, Smith and Stoker, 2009). However, humans are also driven by non-rational decisions, that can be driven by perceptions, emotions and habits; their final decision will be something in the middle of the level of input information and their feelings about a situation.

On the other hand, a growing trend of Deliberative theorists affirms that empowering the participation in governance through people’s knowledge and access to information enhancement can lead them to change their civic behaviour by engaging them in thinking and interpreting better different situations (John, Smith and Stoker, 2009).

Government and policy makers should evaluate what are the best solutions for each case, based on the patterns of behaviour, cultural issues and other specific population characteristics. With the rise of the Internet of Things, apps and connected devices, engaging people with access to information and possibility to participate of the regulatory process open up new opportunities even for practitioners and planners to give feedback about situations they had faced in mobility planning and managing, in order to avoid common mistakes and wasteful costs.

Elizabeth Shove argues that the psychology behind the architecture of travel choice could be invaluable in truly shifting the practices of urban mobility (Shove, 2013). She argues for two strategies for promoting more sustainable lifestyles: firstly to persuade people of climate change to increase green commitment, and secondly to remove the barriers that stand in the way of a smooth transition to a new way of life (Shove, 2013).

A considerable body of literature exists on the relationship between the urban form and travel choice, also known as travel behaviour. Travel behaviour is dependent on travel demand which is dictated largely by urban form and includes hours travelled, frequency, and distance covered. (Fischer and Nijkamp, 2014). Travel demand calculations are done in order to help formulate planning policy as well as scale development proposals of both infrastructure and settlements, whereas behaviour is studied by private companies engaged in providing services to the consumer market.
2.1.3 Needs

People are users and consumers of the spaces of the city, and their everyday needs should guide the decisions of planners and managers of the urban mobility systems in the city (Appleyard, 2010). A relevant framework to employ in order to unpack people’s needs in relation to urban mobility systems is consumer behaviour analysis, which tries to identify human actions motivated for consumption, based on their needs. These actions are driven by a rational/non-rational (intangible variables) decision-making process, that must be analysed in the understanding of urban travel behaviour, as the final decision of urban citizens as consumers of the urban mobility systems (Meyer and Shaheen, 2017).

Abraham Maslow Hierarchy of Needs theory, dated from 1954, is still broadly used to describe people’s motivational needs and the order which must be achieved. This ranking is composed of a five-tier pyramid, and each layer stands for a range of needs, grouped accordingly with similar characteristics, that must be obtained to enable people to move on to the upper layer to the top of the pyramid from the bottom. A lower level needs to be satisfied in order for a person to move on to the next higher level, repeatedly until reaching the top (Meyer and Shaheen, 2017).

![Figure 1 - Maslow’s Pyramid](Simply Psychology, 2018)

According to Maslow, people’s actions are based on the processes surrounding the pursuit of their needs, from the bottom to the top of its hierarchy pyramid (Meyer and Shaheen, 2017). Based on the proposed hierarchy, it is possible to estimate the order of importance of the involved items in the process of choosing modal transportation decision making in an urban area. User-specific rankings about the importance of each of the available transportation mode need drive each individual decision in mobility (Meyer and Shaheen, 2017). First, at the bottom of the pyramid, people will look for attending their fundamental needs, related to basic survival, as access to work, schools, supermarkets and other basic needs, with comfort and time-saving options. The second level, related to safety, stands for stability and protection in their transportation steps. The third level relates to social needs and how the existing transport infrastructure can connect them with the whole city environment. The fourth level stands for how the population feels satisfied with the existing infrastructure and the last level represents how city inhabitants can improve their transportation modal choices.
In a complex environment such as an urban area, it is important to understand where consumer target groups sit in the pyramid since it is important to have a representative sample of each one of these groups in order to develop an integrated urban transportation system that can attend people from different incomes and necessities, in different areas of the urban environment. Clustering users-types, based on their individuality, as personality traits, demonstrated to have a most accurate predictive power than if they were analysed purely based on socio-demographic characteristics (Meyer and Shaheen, 2017).

To address these unique needs, it is necessary to verify which of the available solutions is applicable for each case and verify specific cases where new development is necessary to achieve a good level-of-service (Meyer and Shaheen, 2017). There are different alternatives to transportation modes that compose an urban transportation system. It is the role of urban mobility planners and managers to interpret existing patterns of behaviour in relation to the existing and potential demand of travel around the city, the density in existing and future neighbourhoods, areas to be developed and strategic land use. For example, in a poor area of a city, where people suffer from security issues, adopting transportation solutions that involve walking in isolated and dark areas can be a solution faded to failure (Meyer and Shaheen, 2017).

The modal choice is also based on its value proposition to the consumer. But in order to create value, is necessary to understand what value means for consumers, therefore its definition is based on needs (Ulrich and Brockbank, 2005). The customer value proposition is an analysis of how a company will provide its customers with added value to its products (Payne, Frow and Eggert, 2017). In the area of urban mobility, a new trend is gaining strength. Based on the product-service format of adding value to products through offering packages of services, the concept of Mobility-as-a-Service intends to add value to urban transportation by offering a new mobility ecosystem (Meyer and Shaheen, 2017). The utility maximization theory, used in travel demand models, also assign a value, related to the transportation mode utility, for each of the transportation available alternatives and assumes that the mode with the highest utility value it is the one that will be chosen (Meyer and Shaheen, 2017).

As consumers, they should be offered an opportunity to choose, accordingly with the variables surrounding that decision whether they be rational or non-rational. The citizen’s final transportation mode choice can be compared to the consumer final buying decision, which is made based on a collection of small decisions comprised of the information that they have of a product and whether it matches with their aims (Richarme, 2006). Therefore, an analysis of people’s needs and their interaction with the existing urban mobility infrastructure is necessary to understand what their needs are, what are their perceptions about the spaces they are included in and what they expect for the future in the city (Meyer and Shaheen, 2017).

2.1.4 Trust

The consumer is affected by several variables that are communicated through a variety of sources. In products, the construction of brand awareness is made through the tool of the advertisement and directly through consumer contact. The variables involved are related to perception and learning phases related to the product that is being offered, based on the quantity of information about the product that the consumer has access to and how this information will be perceived based on consumer bias (Bray, 2008b). When the consumer finds themselves in the final stage of purchase, there are two main factors which can make an influence on the purchase decision. The first one is the attitude of others towards the product and the second one is unforeseen situational factors (Meyer and Shaheen, 2017).
In the urban mobility framework, an inhabitant’s final decisions should be evaluated in order to understand which of these two factors represented more weight for their decisional process.

There are a wide variety of reasons for a product to be purchased, and the identification of consumers motives, needs and wants represents the first and main important steps. The determinant factors of consumer behaviour can be grouped into cultural, social, personal, psychological and economical features (Meyer and Shaheen, 2017) that can frame the impact of non-rational variables such as the desires, involvement and underlying values surrounding the product that must be evaluated in order to understand how that product was first chosen and how this choice is re-affirmed when this product is purchased again and recommended to others consumers (Solomon et al., 2006).

Post-purchase behaviour is strictly linked with the satisfaction or dissatisfaction of the consumer with the product. The resulting feelings of satisfaction/dissatisfaction are related to the level of attainment of that product with the customers’ expectations (Meyer and Shaheen, 2017).

In urban mobility, the consumer as the urban inhabitant faces daily the challenge of purchasing a transportation mode as a product. Starting with the recognition of the main problem “How to go from point A to point B”, the consumer must find information about the available products that are the public and private transportation modes available. For this research case, the authors consider owning a car, walking and biking as private transportation. Information on time, cost, flexibility, comfort, accessibility, safety, convenience, privacy and even pleasure is evaluated in the decision making (Kaufmann, 2015). After the decision has been made, the choice is evaluated, and the consumer will verify if that mode attended his needs or if it is necessary to look for another modal.

Travel behaviour research used to have limits imposed by the available data, technology, and practice to capture urban environment details on an individual level. Non-rational decisions which are difficult to include in the planning analysis of the urban mobility environment make it difficult to understand how people can influence and be influenced by urban design, land use and transport characteristics (Appleyard, 2010). It can be said that the level of detail the data is capable of representing has a correlation to the patterns observable in consumer behaviour.

2.1.5 The citizen

The consideration of the citizen’s needs in urban mobility should acknowledge their right of choice, and also steer them towards decisions that can result in benefits for the whole society (John, Smith and Stoker, 2009). Citizen's choices when dealing with urban mobility result in impacts for the whole city environment, since CO₂ emissions from the fossil fuel vehicles, energy use and noise, time, congestion and cost influence the quality of life and health of all. Projections show that circa the year 2050, urban mobility systems will represent around 17.3% of total Earth bio-capacity, representing an increase of five times more in comparison with the 1990s (Meyer and Shaheen, 2017).

One of the leading theories explaining how to decrease human impact on the environment is the circular economy theory. The circular economy approach intends to encourage people to re-think the way things are done and to design waste out to minimize negative environmental impacts while maintaining the economy flow (Ellen MacArthur Foundation, 2018). Based on that theory, new models of transportation use started to be developed to maximize the efficiency of the resources as a way of redistributing existing infrastructure to reach more users. (Tukker, 2015). Sharing economy is one system where products and services are developed to be shared among others (Puschmann and Alt, 2016).
With the internet, rapid evolution and social web, new business models have started to appear, enabling the paradigm change of hiring goods or services instead of owning them. This is encouraged by the convenience of the service, accessible costs and the moral good felt by lessening environmental impacts (Puschmann and Alt, 2016). Temporary use, as opposed to owning demonstrates to be a very attractive business field as the well-known example of success in shared mobility services with bike rental, usually interfaced through mobile phone apps. There are several other models of shared mobility being developed, with the potential to challenge the existing transportation auto-oriented paradigm (Meyer and Shaheen, 2017). These models were enabled by smart technology and users’ awareness increase with sustainable issues, but also created a gap in the mobility planning processes due to an imbalance between new transportation models and vehicle congestion. Additionally, the fragmented management of mobility and lack of system-wide assessment make predictions for design purposes a difficult task for planners (Meyer and Shaheen, 2017).

The use of Big Data and the rise of smart and connected mobility systems are disruptive innovations in the mobility sector as the use of Big Data can fulfil the gaps surrounding users’ non-rational behaviour and frame the possibility of sharing mobility to be offered as a service (Holmberg et al., 2016).

2.2 Urban Mobility

2.2.1 Transportation methods and industrial development

The symbiotic relationship between citizens and their environment are hinged on the activities that take place within the existing geometry of the city. This ultimately shapes people’s behaviour and decisions which in turn shape how they live their lives.

A mapping of Europe’s densest cities shows a correlation of building typology and programming (what city services are located where) in connection to the industrial development of the region (O’Sullivan, 2018). As industrial capacities increased, so too did the capabilities for builders to build higher as well as commence infrastructural projects that encourage cities to sprawl.

Although the car itself was launched as a product by Carl Benz in Germany, it was the impact of the production process of Henry Ford’s “assembly line” of The Ford Motor Company, which saw an output jump from 7.5 cars per hour to 146 per hour; counting around 14 million cars between the years of 1913 and 1917 (Aceable, 2017). This mass production of cars made them affordable to common people, which lead to a change of behaviour around transportation issues essentially shifting the history of mobility worldwide.

Before the car, the bike was the first mechanised mode of individualised transport faster than walking (Geels, 2005). Geels explains that the history of driving and cycling are in symbiosis. As more people started to cycle, so too did the installation of infrastructure to enable it; the same infrastructural mechanisms that support the automobile, road surfaces and production capacities (Geels, 2005). As the availability of cars to the masses extended, there was a sharp decline in bike use. Streets were increasingly designed for the speed of the car, and not the bike, making it the more preferable choice of mobility (Ghel, 2010). It also as Shove explains, laid the foundations for expectations of personal mobility; which was both highly flexible and motorized (Shove, 2013).

Around 1940, with the increasing rate of car ownership, signs of failure from existing transport structures reflected an existing urban infrastructure was not ready.
Consequences of congestion appeared globally but were concentrated mostly in cities where existing systems faced the challenge of adapting the traditional physical structure to be able to absorb new movement flows and urban sprawl in the city fabric that happened as a consequence (Batty, 1976). The increase of private car ownership resulted in a paradigm shift in patterns of behaviour in several areas of daily life including social interactions, employment prospects, residential areas distribution and manufacturing and consumption patterns (Francis and Winterthur, 1986). With the urge of congestion as a new problem in cities, resulting from the introduction of the car as a new actor in the transportation systems, the first studies surrounding transportation issues started to be developed, being the predecessors of the transportation planning processes that we have today.

As public transport networks developed, urban corridors stretched to connect places of production with suburban areas synonymous with cleaner air and overall higher quality of living, compared to the squalor of the inner city. As the capability for independent automobile movement became accessible to the worker coupled with an increasingly connected road network, urban areas become less dense through a phenomenon known as urban sprawl (Church et al., 2012).

In these early planning developments, spatial distribution and the study of movements started to be modelled with the support of Statistical Analysis, as linear regression and the gravity model. But these studies did not consider human interaction due to land use.

Transport infrastructure is strictly connected to economic development. High levels of development are reached through efficient transport systems, within connected networks and high-density transport infrastructure which enables social and economic opportunities. Even though congestion is one of the non-intentional consequences of having issues surrounding the provision of transport infrastructure to its users, it is also an indicator of a growing economy where the infrastructure needs to be adapted to rising mobility demands. (Rodrigue, Comtois and Slack, 2017)

2.2.2 Travel Demand & Travel Behaviour

Around 1960 land-use planning methods started to be used in traffic planning, and the arrival of other methods based also on economic studies started to be applied also in order to calculate travel demand.

There are three main factors that affect the relationship between the form of the built environment and travel demand: density, diversity and design (Cervero and Kockelman, 1997). Cervero and Kockelman attest that even though there has been a strong lineage of research into the effect urban fabric’s density has on travel demand, diversity and design have been understudied. Diversity is related to the number of diverse choices available to a person, whereas design relates to the attributes of an environment that encourage or discourage modal transportation choice. Density is related to compact neighbourhoods, where non-motorized travels can be encouraged by a travel distance decrease between points of interest (Cervero and Kockelman, 1997).

The methodologies used to study travel demand greatly influence conclusions made about the relationship between the built environment and the demand for modes of mobility. Historically, the theories of travel demand and behaviour have focused on quantitative data including those of Ewing and Cervero, Souche and Quandt (Quandt, 1976; Leck and Leck, 2006; Ewing and Cervero, 2010; Phanie Souche, 2010), whose analysis fall short of reflecting the complex nature of urban mobility, including how humans make decisions (Mars, Arroyo and Ruiz, 2016).
More recently it is being recognized that a mixture between qualitative and quantitative methodologies are needed to bring numerical data to life and speculate on the complexities of why things are the way they are (Clifton and Handy, 2001). The work of Daniel Mcfadden in the field of discrete choice theory has emerged as the model of choice for studies on individual household travel behaviour (Vij, Carrel and Walker, 2013), because the model allows for the use of rules as agents of preference and it can describe most economic choice behaviour in surveys and markets (Daniel Mcfadden et al., 2012).

On reflection of the variables used in quantitative analysis of travel demand in the literature reviewed, there was a stark delineation between travel for work, and non-work activities, with an emphasis on non-work activities, since it was assumed in most of the literature that work entailed a location more often than not located at a place different to the home location, and that the hours of ‘work’ were nominal business hours of 9 to 5. Aguilera, et al’s study of travel patterns in Paris over a 20 year span showed a differential between the break-up of travel use between 1981 and 2001 where the authors considered a regular workplace no longer an appropriate measure as the unique destination of work-related trips due to changes in the way people ‘worked’ (Aguiléra, Massot and Proulhac, 2009).

Throughout literature, including Aguilera, et al, non-work trips are nominally allocated to trips taken outside ‘work’ hours, to locations between home and ‘work’. However, this classification of ‘work’ and the locations it entails may be a limitation of the previous studies centred on travel behaviour, and therefore travel demand. There seems to have been a definition of work that has left out a significant part of the citizen body who is engaged in unpaid work. Paid work in traditional places of production versus non-paid work of home careers and parents should also be considered in the analysis. Most importantly perhaps because it is this segment of the citizen body which require travel structures that meet needs which fall outside the mean (for example on and off ramps, extra space for hand luggage (including shopping) shorter local trips and specific-seating conditions to ensure safety. Mars et al also note the data collection methods of existing research rely heavily on surveys, of which many include focus group which consists of predominantly middle to higher income traditional family units and heterosexual couples(Mars, Arroyo and Ruiz, 2016). Using research methods (both delimitations and processes) to adequately represent the citizen body, as a whole, should be a fundamental to future research if urban mobility modes of future cities aim to functionally inclusive and democratic as scenario outcomes suggest.

2.2.3 Reduce Congestion

The phenomenon of congestion in cities has effects much broader than vehicular traffic. Since cities are important drivers of national economic growth (Meyer and Shaheen, 2017), the arterials that allow people to move themselves, goods and services through the network dictates the opportunities of innovation and the rate of growth. Congestion reduction caused by road transport is a strategy employed globally by cities to increase the amenity (Fischer and Nijkamp, 2014) of urban environments to not only to allow for the sustainable flow of people and goods, but active strategies to decrease congestion is also reduced emissions and noise levels which threaten citizen health(Carlsson, Hadenius and Ericson, 2006).

2.2.4 Collective Transport

Collective transportation is often pointed as one of the most reliable ways to mitigate congestion since the ratio of space occupied by vehicles and infrastructure per passenger far outweighs the ratio of one person per car (Correia and Viegas, 2010).
For this discussion, this includes traditional forms of collective transport commonly known as public transport, but in recent days can also include shared mobility modes such as carpooling. Further, dense cities are more able to support public transport due to demand. (Rassia, S. Pardalos, 2015). Status and comfort play a huge role in travel choice and behaviour patterns. Carpooling and other shared vehicular transport modes attempt to tap into the status and safety afforded by car travel with a promise to reduce congestion. However, as Correia et al. (2013) write: “Carpooling systems have never been able to achieve significant reductions in the use of private vehicles” since “the psychological barriers associated with riding with non-acquaintances and losing the flexibility of using one’s private vehicle as a single occupant are ... not easy to quantify.”

Vehicle sharing programs have started to become a serious alternative offering, seen as a way to plug the gap between personal car ownership and collective transport (Thakuriah, P. Tilahun, N. Zellner, 2017). Such programs facilitate the gradual reduction of individual household infrastructure and see the functions of the car instead as an on-demand service, aptly called Mobility as a Service (MaaS). Currently this new offering found in variations in cities globally are station-based car sharing programs made available to members of the service.

Carpooling programs however are still under the influence of the opportunities allowed by local governance (Correia and Viegas, 2010), where for example Stockholm’s Car2Go recently folded due in part to the fact that Stockholm City council did not make provisions for the program to be exempt from parking fees, as is done in most other cities where the similar services are offered.

Another branch of current research into the notion of Multi-Modal Transport travel corridors. Travellers have individual corridors which are understood as a series of chain links, whereby a traveller might begin by bike, then take a bus, then take the last leg of the journey by foot. Appleyard notes that travellers journey with much higher sensitivity to changes in the travel corridor when they are outside the envelope of a car (or bus) (Appleyard, 2010). This sensitivity has a large impact on the possibility of making a switch between car travel, and taking one which is multi-modal which is just as much about the quality and dignity of the time between point A and B, as well as the time taken and the reliability of making changes along the chain (Church et al., 2012). Research has been conducted on the relevance of reliability of multi-modal transport corridors on sociodemographic democracy, called “travel disadvantage”; where distances from the urban centre are relatively aligned with a lower reliability of multi-modal transport travel corridors and effects citizens access to employment, education and social interaction (McDonald, Communities and Families Clearinghouse Australia. and Australian Institute of Family Studies., 2011).

### 2.2.5 Planning Urban Structure

In cities across Europe there are central areas of cities in which older buildings were raised in order to make way for much wider streets to accommodate the relatively new technology of the automobile (Rassia, S. Pardalos, 2015). This language of planning came as a reaction to the influence of the industrial practices of the inner cities- where the majority of factories were located. In a bid to move people to healthier living conditions with light and air, new sections of the city were built with this main objective. Jahn Ghel argues that these city systems were studied from the vertical perspective- a bird eye view- led to cities being designed for the systems that moved humans through the city, rather than the humans themselves (Ghel, 2010). Planning in the post-war era aimed to sweep away the old city structures and set a new one on a tableau rasa, establishing a simpler geometry of streets in a bid to reduce complexity, (LeCourbusier, 1929) (Marshall, 2012).
The failures of modernist planning; place-less streets, volumes which were not scaled to the human, has been linked to this reduction (Jacobs, 1961; Alexander, 1966).

These physical outcomes of the city can be attributed largely to the methodological approach planners employed which on one hand is praised for its simplicity, and on the other criticized for being autocratic, with little public participation and difficulty of accounting for multiple stakeholder interests (Healey, 2007; Batty and Marshall, 2012; Klosterman, 2013). Healy argues that the city cannot be planned in a liner top down the way from the sole guidance of intellectuals and professions who sit at the top (Healey, 2007). This assumption began to fall apart by the 1950s as soon as the megastructures were being realized (Batty and Marshall, 2012), with the residue still being felt in cities today through social segregation and congestion enforced largely by the layout of transport arterials (Camagni, Gibelli and Rigamonti, 2002).

2.2.6 Bottom-up

“The settlement scale is the battleground between top-down and bottom-up”
(Batty and Marshall, 2012)

Contra to the top-down ideology of planning therefore is understanding the city from the bottom-up, largely explored through the notion of complexity (Crawford, 2016). Patrick Geddes was one of the first to address the complexity of cities (Batty and Marshall, 2012). Formally trained as a biologist by Thomas Huxley, Geddes championed the notion of planning within the context of local geography and historical development growing out of a web of causes and effects over time and therefore could not be designed tableau rasa (Garau, Zamperlin and Balletto, 2016).

There are a great many ranges of theories that attempt to depict a city as a complex system (Portugali, 2012). Complexity theory began to be used in the study of cities when physicists Herman Haken and Ilya Prigogine initiated studies of physical material systems that exhibited phenomena that were previously only attributed with non-physical systems like social-cultural or organic networks like emergence and self-organisation (E. Tan, 2012).

A complex system is one where elements interact and affect each other, such that is difficult to separate the behaviour of elements and their relationship to other parts of the network which are generally nonlinear in nature (Gershenson (2008) in (Haken, 2012)). Since the scope of complexity theory is so wide and the applications so diverse, the theory has become a toolbox for dealing with systems that are complex (Haken, 2012). In the case of cities, this means population dynamics, energy consumption, city growth and the flow and structure of transport networks.

The benefits of complexity are explored through Jane Jacobs seminal book “The life and death of great American cities” (1961), which treats cities as complex adaptive systems that boast a host of benefits for inhabitants. Jacobs places the human at the centre of the debate, championing an urban environment of diversity. Four factors contributing to diversity are; a mix of primary uses, short block structures, a mixture of new and old fixed infrastructure (buildings), and population density(Jacobs, 1961). The main outcome, therefore, is synergy, which creates the possibility that the whole is greater than the sum of the parts (Alexander, 1966; Marshall, 2012; Crawford, 2016)
2.2.7 Planning Urban Environments

“All models are wrong; some models are useful” George E. P. Box

The study of cities sits on the fence between social and physical science, but unlike the physical sciences, researchers cannot test theories on the subject matter of the city itself, for ethical reasons (Batty, 2017). Computational modelling is the predominant methodology for testing theories on what makes cities tick, particularly when it comes to how people move. This could be due to two reasons; firstly, that computational models are ethically viable when testing interventions in public spaces, and secondly because data sets are boasting increasingly higher resolution allowing for greater control of variables in order to build more accurate models. Environment interaction can be modelled at three scales; immersive models (frequently used in video games), semi-immersive (considers a group of individuals) and remote (allows for the observation of phenomena) (Thériault and François Des, 2011).

Complexity has implications for the practice of planning (Crawford, 2016). The paradox of planning complexity is epitomized by the concept of ‘unknowability’. The challenge of planning then becomes one of how to arbitrate a system which hosts a myriad of variables, where knowledge of the system itself is unknown and the outcomes of the intervention remain volatile (Marshall, 2012). Urban theorists have split into two broad approaches; the first approach aims to base development of a few simple but strict rules (Crawford, 2016). The reason being that complex order can arise out of the persistent application of rules over time. A second approach is a participative-collaborative-iterative approach to development planning, which recognizes that no one actor can control system outcomes. It heavily relies on a shared understanding of objectives and trade-offs to be made in order to achieve those objectives (Crawford, 2016).

The science used in city planning needs to be adapted to context, which is why there needs to be a separate model for the structure of a city, and another for the best ways to plan one (Batty, 2017). However, it should be remembered that these models are truly only a representation of a reality.

Complexity theorists point to Karl Popper’s idea that the future is fundamentally unpredictable, and when considering Darwin’s argument of evolution with the absence of a master designer implies that there is no target destination; the interpretation of developmental success is relative to context (Batty and Marshall, 2012). This is relevant in regard to the objectives of city planning, particularly with a contemporary preoccupation with sustainability. What is sustainable now, might not be in the future.

2.2.8 Sustainable Smart Futures

Sustainable development itself is complex (Anderson, 2017) but understanding the constraints that affect action marks the beginning of defining strategies to address it (Kirby and O’Mahony, 2018). The term “sustainable development” is ambiguous of contemporary politics as well as real estate markets, but a reflection on the literature discussing the meaning in light of future visions of the city point to negotiations rather than a concurrent definition (Parris, T. M.; Kates, 2003). Since the definition for sustainable development has come to encompass economics, politics, social structures, culture and resource use that it has become the ultimate culmination of development theories, refer to figure 2 (Bell and Morse, 2008). Accordingly, the term sustainable development could be unpacked as an essentially contested concept (Connelly, 2007), where there is an agreement of the goals, but disagreement on how it should be defined and therefore measured (Gallie, 1956).
Bell and Morse note that there is a volatility in the very phrase itself (Bell and Morse, 2008), where the notion of sustainability reflects the need to maintain balance, and the term development reflects the pursuit of growth—often at the mercy of the pre-existing environment (either man-made or natural).

Although vague, the key principle of sustainable development integrates three pillars of the sustainability: economic, social and environmental. For the purpose of this research, the authors have adopted the UN Assembly 1987 definition of sustainable development since it is this definition which underwrites the planning guidelines:

“...development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations, 1987)

The UN has outlined seventeen sustainable development goals (SDG’s) which are rooted in the three sectors; social, economic and biological (UN, 2018). National policies like Sweden’s Vision 2030 and Stockholm’s own Promanadstaden are built in order to address the call to action of the UN’s 17 SDG’s (Gunnarsson-Ostling, U; Edvardsson Bjornberg, 2013).

2.2.9 Urban Metabolism & Smart Cities

Understanding of material and energy flows lie at the heart of developing sustainable cities (Ibrahim et al., 2012). Urban metabolism studies these flows with the aim of offering intervention measures which work towards shifting mechanisms of the urban landscape to more long-term, sustainable metabolism.
Automation through the channel of Information Communication Technology (ICT) systems of energy flows and materials are today commonplace, which functions not only to serve traffic systems and buildings, but enable the ability to monitor the city’s functions as a way to improve efficiency and affect planning scope of works (Batty et al., 2012). The notion of the smart city emerged over the last 20 years in parallel to the explosion of the availability and compatibility of ICT systems and interfaces, and while city automation is taken for granted in many contexts, having transformed many urban contexts economically, socially and spatially, Hollands argues that the use of the term “Smart City” could create assumptions about the transformation while at the same time overlook underlying urban issues (Hollands, 2008).

“What city doesn’t want to be labelled smart?” Hollands, R G, 2008

Globally, ICT’s are seen by some as major factors which contribute to the success of a city. Stockholm Stad states:

“The smart city is made possible through connectivity and open data, integrated platforms, sensors and other technologies” (StockholmStad, 2017a)

The focus on achieving smartness through ICT is evidenced by the plethora of funding initiatives from both the public and the private sector, culminating locally in the Digital Agenda for Europe (European Union, 2014). Many of these initiatives, however, look for a top-down strategic approach to sustainability, and citizen-wellbeing (Haque, 2012), all the while this process overlooks the those who contribute to the complexity that makes cities what they are—people. While the commercial sector has plenty of room to capitalize on the opportunities of the digital economy, which is growing at several times the rate of the rest of the economy (European Union, 2014). Haque suggests that since it is citizens who collectively form the fabric of the city, a smart city should “actively and consciously enable us to contribute to data-making (rather than being mere consumers of it), and encourage us to make far better use of data that's already around us” (Haque, 2012). Hollands reiterates this, asserting that the digital economy has many opportunities to simultaneously ignore the welfare needs of more disadvantages residence who fall outside the characters of the mobile, creative businessman through the very mechanisms that reiterate the success of cities through corporate information portals and services (Hollands, 2008).

2.3 Data

There are two different interpretations of data description and its relationship with information development. A broader interpretation delineates that data can be defined as any set of simple and isolated facts, about events, that were not interpreted yet and can be transformed into information when combined and organized accordingly with the purpose they were collected for, as an example we can cite data gathered from performance measurements in management and operation activities like quantities of passengers that pass through a ticket gate which will be analysed in travel behaviour studies, later on, being analysed mathematically and statistically, accordingly with the research objective.

On the other hand, when talking about data that will be collected and transformed by a computer system, it is necessary to set a data structure even before the data is collected, based on the purpose and meaning that this data will have. Therefore, in this case, data can be described as the outcome of the process of interpreting the involved information, based on the data collection purpose, and developing a computerized structure that enables its automatic collection and/or processing (Tuomi, 1999).
As an example, we can cite a travel behaviour survey made with people, when there is a defined structure of questions to be made in order to gather specific information from a specific group of people, to attend the research data’s needs.

![Figure 3 – Examples of types of data (João Batista Neto, 2015)](image)

2.3.1 Statistics

Statistics is the science involved in analysing large quantities of numerical data, from collection, classification and interpretation, through the use of mathematical theories of probability and hypotheses’ testing (Brown and Kass, 2009). There are some terms that are regularly used in statistical analysis. First, the “statistic” term itself can be described as a quantitative numerical analysis, as an average, which can represent the main characteristics of a sample. Secondly, the “population” term refers to the cases of interest in an analysis. Thirdly, the “sample” term description it is a collection of data that represents a part of this population. Fourthly, the “parameter” term can be described as the outcome value of population’s characteristics, which it is difficult to obtain in large population quantities. Consequently, it is more common to have an estimative of parameters (Welkowitz, Ewen and Cohen, 1971a).

Statistics can be defined as a behavioural science, as it offers the rationale underneath behavioural science research is based (Welkowitz, Ewen and Cohen, 1971a). Can be divided into Descriptive and Inferential Statistics. Descriptive Statistics main purpose can be defined as a method to describe or summarize a collection of data in an organized and replicable way, with the main goal of making them understandable. Inferential Statistics purpose it is to describe a population behaviour accordingly with was observed in a sample of these population data.

The sample spare of the population is necessary for Inferential Statistics to demonstrate some patterns of behaviour in a smaller collection of data with similar characteristics, but this data must be gathered correctly to avoid misunderstandings in a previous analysis. The design of statistical data must be done before the data is collected, to guarantee that it will provide all the necessary elements for the study of one population, based on the purpose of the research.
The time spent to collect the sample data can be slower than its behavioural changes, which can impact in the analysed sample, resulting in an outdated sample and the monetary value spent in these processes may be not worthwhile (Welkowitz, Ewen and Cohen, 1971b).

Sweden and Norway were the first countries in the world to establish a compilation of statistical tables about their national population statistics (SCB Statistiska centralbyråns, 2016). This happens around 1749 when Tabellverket was created. But even before that, in 1689 a law defined that the church would start to control the population statistics. In 1756, Tabellkommissionen was created as the world’s first statistical agency, controlled by the government. In 1764 was the first time that information about Sweden's population was published. After that, some changes happened until 1995, when the Statistics Sweden launch its website and through that is working continuously to provide access to a collection of data, representing the main sectors of economy, industry and society of Sweden (History of Statistics Sweden, 2016).

Statistics behavioural analysis is used in urban mobility to draw patterns of travel behaviour for planning, managing, operating, developing and predicting activities that are necessary to develop the city environment (P. V. Thakuriah, Tilahun and Zellner, 2015).

2.3.2 Big Data

Big data is a considerably new term to describe a not so new problem, how to deal with large collections of available information. But since the beginning of the digital age, in 2002, digital data storage capacity has been increasing exponentially, opening new horizons for data and statistical analysis (Hilbert and Lopez, 2011).

The Big Data term is used to describe a wide quantity of data that has been collected from daily activities by different mechanisms, related or not with research parameters. There are three main channels for big data (One Point IQ, 2017):

1. Transactional data- including invoices, payments and storage records;
2. Machine Data- data gathered from industrial equipment;
3. Social Data- gathered from social media services.

Emerging technologies and innovations in different fields lead to the increasing development of devices that can collect and share data, as well as devices that can mine it for relevant patterns (P. Thakuriah, Tilahun and Zellner, 2015).

Internet of Things (IoT) appeared with the possibility to have daily use objects or web-based activities equipped with connected devices or functions to emit data from a person or activity routine (P. Thakuriah, Tilahun and Zellner, 2015). The enormous amounts of data that are being collected from these devices keep feeding a Big Data digital storage that could be used in ways that are still unknown and result in disrupting developments in diverse areas, including urban mobility.

2.3.3 Big data in urban mobility

“What if you didn’t need to simulate any more buildings? What if you could just know a building’s performance statistically by having access to massive amounts of building performance data?” Dr Chris Pyke, Copenhagen Climate Conference 2009 (Shahrokni, 2015)
The representativeness of the necessary patterns of behaviour research in a travel behaviour sample is limited by the amount of data that can be gathered, in relation to the time and cost-efficiency of this task. Historically, urban analysis’ quantitative research (including the mobility sector) was based on data from censuses, surveys, sensors and ITS (Intelligent Traffic Systems) devices. These data have enabled positive outcomes in all the involved areas, but also impose limitations for its development, based on biases that interfered in their collection and manipulation, interests of stakeholders behind the research, increasing costs to administer updated census and maintain sensors, among others (P. V. Thakuriah, Tilahun and Zellner, 2015).

In the area of urban management, IoT devices enables a new range of activity-based analysis, where the urban citizen’s behaviour and the management of complex sectors, such as transportation, housing, economy and environment, can be analysed in a deeper way than ever before through Urban Informatics (P. Thakuriah, Tilahun and Zellner, 2015). In the transportation area, Intelligent Transportation Systems (ITS) are already a reality, collecting data from traffic analysis through sensors installed in roads, streets, traffic lights, etc.

Big Data can be used in new ways to redesign existing models, designed in the past based on the characteristics and amount of the available samples that eventually could not demonstrate some patterns of behaviour in result of its limitations, that can be now analysed accurately through the variety and volume of available data, resulting in concept changes (Babar and Arif, 2017).

In urban management, there are a collection of variables capable of being collected from dispersed data sets that are correlated with the mobility environment. Accordingly to the Highway Capacity Manual, a worldwide manual used for traffic planning, operation and management uses, traffic issues can be described through three main variables: volume or flow rate, speed, and density (Transportation Research Board, 2016). Based on the existing understanding of the needed variables (data) is possible to design new methods of gathering information from big data sources.

Other examples of urban mobility data that must be collected are related to the analysis of urban citizens as consumers of the urban mobility systems’ service (Mobility as a Service), the influence made by the existing transport infrastructure in people’s travel behaviour; people’s travel behaviour motivation; the level of service available at the existing transportation systems, as buses, subways and trains lines, ferries, taxies; and other involved factors, depending of the size of the city mobility system to be managed (Rodrigue, Comtois and Slack, 2016).

Now, with Big data, ICT and IoT it is possible to gather data from people’s directly behaviour and confront them with the existing physical sensors to understand the interactions between the urban mobility environment and people’s real needs.

2.3.4 Data flow in urban mobility

The use of data in urban mobility has the main objective of informing people’s travelling behaviour in cities. In recent past, data, technology and practice imposed limitations for achieving individual-level details of behaviour in urban environments (Appleyard, 2010).

The Government needs information about its residents in order to manage, plan, develop and improve the overall quality of life in the city. This data can be called Administrative Data (P. Thakuriah, Tilahun and Zellner, 2015). This information forms national statistical information banks, as the Swedish institution SCB, Statistics Sweden.
In SCB, this information is gathered through quantitative research methods about members of a given population, that form the sample that will be used in the census researches, usually update periodically. The SCB website offers free information from Statistics Sweden and other 26 other authorities grouped in the areas: Agriculture, forestry and fishery; Balance of payments and international investment position; Business activities; Culture and leisure; Democracy; Education and research; Energy; Environment; Financial markets; Health and medical care; Household finances; Housing, construction and building; Judicial system; Labour market; Living conditions; National Accounts; Population; Prices and Consumption; Public finances; Social insurance; Social services; Trade in goods and services and Transport and communications (SCB Statistics Sweden, 2018). The statistics about transport are gathered by one of the 26 involved specialized government authorities, the agency Transport Analysis. Transport Analysis is responsible for evaluations, current status assessments and policy instrument analyses for the Swedish transport sector (Transport Analysis, 2017).

This information is accessible to the overall population as shared knowledge. However, one of the main goals of it is its use for planners and policymakers in the valuation of proposed and implemented measures, requested by the Government (Transport Analysis, 2017). These census researches are the main tools for urban analysis, but its escalating costs also demonstrates a challenge to its periodically update and a concern for those who depend only on this information (Shahrokni, 2015).

There are also other sources of information that intend to demonstrate the behaviour of a specific population, gathered accordingly with the final expected outcomes of the analysis that is being made. For urban mobility purposes, information’s about travel behaviour, traffic management, safety and attendance in roads, among other information necessary for real-time monitoring, management, operation and planning, can be gathered through static sensors, cameras, Intelligent Traffic Systems (ITS), and others that can be developed accordingly with specific necessities, to analyse patterns of behaviour capable of being reproduced in posterior analysis (Shahrokni, 2015).

2.3.5 Information access

Therefore, for complex studies as the planning processes involved in urban mobility systems, is necessary to have data from different sources, which can result in different formats and patterns that are difficult to compile and analyse. This usability issues surrounding heterogeneous data formats can be barriers to its usage by urban planners, that in the vast majority, do not have the knowledge about developing computer programs for the manipulation of the data (Shahrokni, 2015).

A solution for planners and stakeholder involved in urban mobility issues is to have a platform with real-time information from the connected traffic sensors in the city infrastructure and big data surrounding mobility issues in one accessible platform that can offer this information in an integrated manner (Shahrokni, 2015). First, is necessary to determine the existing types of data available that are used for the involved actors. After data integration, is necessary to structure and organize it accordingly with the sectors that can represent the city’s aspects and then it is necessary to determine how this access will be offered and controlled (Shahrokni, 2015). These open platforms can be important tools to enable discussion and views exchange about the urban mobility environment, within all the involved parties. As a result of the higher rates of information disposal in platforms that can be easily accessed, the participation of planners and citizens in governance would be empowered, based on their understanding in relation to their experience and leveraged by the people’s engagement in changing the city towards a more sustainable environment (John, Smith and Stoker, 2009).
There are still a lot of uncertainties around the use and maintenance of data in urban mobility and how to enhance civic participation in its development processes. These questions will be answered as long as the technological advances related to big data offers solutions to the actual barriers to its use (P. Thakuriah, Tilahun and Zellner, 2015).

The authors’ research question point out that one of the main uses of big data in urban mobility planning is about gathering the individual-level patterns of travel behaviour to fulfil the gaps of understanding surrounding people’s transportation needs. However, one of the actual biggest barriers to big data usage is about personal data privacy and control of use.

How to maintain the needed information for developing a statistical behaviour research without trespassing people’s privacy boundaries?

Big data anonymization is one of the main issues of the actuality and companies around the world are trying to take the lead in its development, to be able to protect people’s privacy and still be able to share their information and fulfil the information gaps with big data sources (Xindong Wu et al., 2014).

The Europe Union (EU) General Data Protection Regulation (GDPR) is the Regulation (EU) 2016/679, that was settled for all the EU members (including Sweden) in order to establish data protection rules and punishments to enable European citizens to have more control over their personal and commercial information usage by others (European Union, 2018). The GDPR rules apply since 25 May 2018 and will enable improvements surrounding data violations. Another important factor in the data standardization process is the IEEE-SA Standards Association, that announced in December 2016 the standards development project called IEEE P7002™, whose purpose is to develop an overall methodology to specify practices in the management of issues surrounding privacy in systems/software engineering life cycle processes (IEEE-SA, 2016). Actions like those will be performed in the next years, by an increasing number of involved entities, in order to establish standards surrounding big data issues in its usage.

The authors’ conclusion after this literature review is that big data complex and evolving relationships/usage are still being developed (Xindong Wu et al., 2014) and other solutions similar to the EU GDPR are yet to come. In a short to a midterm horizon, some of these questions and barriers will be answered and solved, but the question that remains is that big data is not the solution for everything. Consumer Behaviour is an inexact science, due to humans being the main actors in it. The consumer behaviour predicting variables, adaptation and non-rational decision-making process, result in unexpected outcomes in diverse researches.

Developments addressing individual-level travel behaviour in urban mobility systems must maintain its flexibility as their core characteristic, to evolve and follow people’s evolution, as a “living” system.

“Intelligence is based on how efficient a species became at doing the things they need to survive.” Charles Darwin
3 METHODOLOGY

3.1 Research Paradigm

The course content for the master’s program of Entrepreneurship and Innovation Management within the INDEK department at KTH set the precedent for the research that was undertaken for this thesis paper. Similar to the process of undertaking complementary subjects throughout the course, this thesis takes three bodies of knowledge; Urban mobility, Big Data and Consumer behaviour and unpacks the gaps with the predominantly siloed literature. Qualitative methodologies are used in sociology and psychology domains which explore topics including household choice, but in the transport and planning domain it is still infrequent to find studies that explore travel decisions based on qualitative techniques. The research aim is to explore the subject areas as opposed to validating a hypothesis, and for this reason the authors used the interpretivism paradigm to frame the content of the work.

3.2 Research Design

Since the nexus where this thesis lay is a relatively new field of enquiry, the research for this project was designed such that it could collect and attempt to corroborate the three siloed fields of knowledge. For this reason, this project is considered by the authors to be qualitative, using an inductive approach with a design strategy that is exploratory in its method, since the project aims to draw parallels and opportunities between the three silos of knowledge in order to gain insight to the research problem. Even though, the existing literature covering the topic of big data and consumer behaviour when dealing with planning objectives for urban neighbourhoods is expanding, the authors consider that they are approaching the research problem from within the field of enquiry. Both authors have over 10 years of experience in their respective fields of specialisation (urban design and road engineering) which have enabled insights into consumer behaviour and the opportunities of big data from the perspective of urban planning and road engineering, the two areas of the authors experience. The inherent embedded nature of this research therefore drove empirical analysis of the available data.

3.3 Data Collection

Two case studies and six open conversations form one component of the empirical data collected for this thesis; the case studies allow for a historical contextual perspective of measures put in place in two major cities in Sweden, and the interviews allow for a closer to real-time probing of urban mobility today looking forward, since the field of study under the influence of big data is currently emerging in parallel with new uses and sources of data. The unit of analysis for the qualitative research is the relation between Big Data usage and mobility urban planning in road networks within the neighbourhood scale. The scale of a neighbourhood as opposed to an entire city is significant since at neighbourhood scale local politics and economic impacts can have an effect on an area and a demographic large enough to measure. Also, neighbourhoods tend to be built at one time, which means the implementation of technology connected mobility systems is focused primarily on these types of urban sites. Remedial work on existing neighbourhoods is however a more realistic concept of the future, of which a case study has been included in the case of Malmö.
3.3.1 Primary Data – Case Studies

The case studies are used in order to establish the context of the current situation in terms of how future planning objectives for neighbourhoods are incorporating and implementing the use of big data as a strategy for urban mobility, as to address sustainable development goals as set out by the UN. The scope of the studies will not include recommendations or suggest resolutions for problems unpacked during the research. Rather, the value of the case studies allows for a contextual interrogation of a collection of variables within the timeframe set for the scope of this thesis, which is generally the present. The case studies cover two major cities in Sweden; Malmö and Stockholm. The latter since it is the capital of Sweden and has had clear objectives for some time to connect future planning agendas with technology and engineering solutions. The authors have chosen to include Malmö since the city has been pushing a rapid and aggressive building program of housing and mixed-use projects, in conjunction with it being a member of the Green Digital Charter (GDC). Cities involved in this charter are committed to working together to deliver EU climate objectives through the use of Information and Communications Technologies (ICT). There is a large amount of active work currently underway across both Stockholm and Malmö, which consequently aligned with the current work portfolios of those persons chosen for interviews by the authors.

The two case studies put into focus two neighbourhoods within these Swedish cities; The Royal Stockholm Sea Port (Nora Djurgårdsstaden) and West Harbour (Västra Hamnen). Both showcase alternate approaches to a sustainable future development; where Stockholm Royal Sea Port can be understood as a more reactionary piece of guiding policy and West Harbour positions itself as a living lab of urban informatics (Malmö Sege Park - a resilient urban playground formed by a local sharing economy | URBACT, 2016).

3.3.2 Primary Data – Interviews

Additional empirical data has been collected from a series of semi-structured qualitative conversations with six interviewees. For the purposes of this paper, the authors will refer to these conversations as interviews. The interviews are used as a data source to investigate the relationship between consumer behaviour data in urban mobility and their data usage to track, analyse, plan and project urban mobility spaces and developments that could interfere in it. Scouting interviews conducted in Stockholm in the period prior to the research proposal of this thesis deduced that consumer behaviour is being considered by a large number of projects within public-private partnerships frameworks between academia, industry partners, the city and innovation funding bodies such as VINOVA. Papers detailing ongoing experiments are only just this year being released for publication. For this reason, the interviews were vital for the authors to obtain primary data on the research problem. Interviews, however, may be subject to biases based on research field, self-presentation, and confirmation bias (Rabin and Schrag, 1999). In an attempt to minimize these bias’s real-time interviews were conducted with a range of specialists from overlapping fields of knowledge in either the planning, delivery or management stages of urban mobility at a neighbourhood level. In this way, a bias towards particular solutions could be traced loosely back through the academic and professional agenda background of the interviewee. As aforementioned the authors have over 10 years of practice experience in the field which allows for a more in-depth discussion about urban mobility in such a short time frame which this body of research encapsulates. However, the authors are aware that this also means that they cannot claim neutrality in their investigations.
3.3.2.1 Interview Selection and contextualization

Using the interpretivism paradigm, our non-random sample of interviewees were selected from main actors in the urban mobility discourse in Sweden. Industry, academia and representatives from private companies were selected in Stockholm from both an initial desk-based search and introductions through contacts of the authors to relevant industry contacts.

The choice of participants in the interview series was made based on their sector of speciality in urban mobility. It was important to include a variety of perspectives on the future of urban mobility in order to triangulate the data, and within the short time frame of the thesis, this was achieved from a broad sample group.

The cross-section of those interviewed for the research was located through a collection of personal contacts at a private transport manufacturing company, as well as through desktop research of institutions and companies currently working on areas of the research problem in Stockholm. A few interviewees were located from conversations with interviewees in the pre-study period.

The purpose of the pre-interviews was to first ensure that the research problem existed and second if it could be pursued in the time frame made available. As aforementioned, those interviewed are recognized as high-level experts in their field, reflected in their status of career title. Expert opinion is ideal in highlighting keystones of the research problem and suggesting alternate but founded opinions. Those interviewed for this study possessed a diverse professional background, which for the purposes of research stimulated conversation and provided a depth to the content of the data conversed in the interview. A list of the participants of the interview are anonymised and included below; the interviews’ documents are located in the appendices.

<table>
<thead>
<tr>
<th>Identification in Research</th>
<th>Type of Organisation</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewee 1</td>
<td>Private Company 1</td>
<td>Head of Strategy &amp; Business Control</td>
</tr>
<tr>
<td>Interviewee 2</td>
<td>Academic</td>
<td>Research Engineer &amp; Project leader</td>
</tr>
<tr>
<td>Interviewee 3</td>
<td>Private Company 2</td>
<td>Analyst &amp; Project Leader</td>
</tr>
<tr>
<td>Interviewee 4</td>
<td>Academic</td>
<td>Head of Research Department</td>
</tr>
<tr>
<td>Interviewee 5</td>
<td>Academic</td>
<td>PhD Researcher</td>
</tr>
<tr>
<td>Interviewee 6 a &amp; b</td>
<td>Public</td>
<td>Statistician &amp; Investigator</td>
</tr>
</tbody>
</table>

3.3.2.2 The Interview Process

The interview process was kept as similar as possible to reduce bias. All interviews were conducted in person, except for Interviewee 4 which was taken as phone-interview. All other in-person interviews were conducted at their place of work and prior to the interview, the participants were sent the interview guide (located in the appendix). The interview guide contained a current abstract of the thesis, the thesis question and a list of questions broken into two parts. Part A listed 6 core questions, and part B listed sub-questions that could be used for additional piquancy during the interview if needed. Splitting the questions into two parts incentivised the interview environment to become less structured, in order to allow space for the interviewee to follow unpredicted directions relating to the research problem. It is an important aspect of the design research that the interviews allowed for information to present itself organically since the subject discourse is in the process of transformation at the present; often additional information came to light by asking tangential questions. Each interview lasted between 30 and 60 minutes.
Interviews were recorded (per interviewee’s permission), transcribed and analysed. The framework for the analysis is described in Chapter 5 and is included in the appendix along with the transcribed interviews.

The interviews were conducted using a critical incidence critique, to encourage the participants to give relevant information about specific activities or events related to urban mobility and data usage, based on their own experience (Collis and Hussey, 2014).

3.3.3 Secondary Data

Since the nexus of enquiry is under a shift in academia, secondary sources were vital to building a substantiated argument for the research problem. Relevant literature databases were accessed via deskbound research largely from the KTH database and Google Scholars collection online. Web searches for industry published source material were also consulted, particularly in regard to governing documentation published by Stockholm and Malmö city. Documents published by private companies from their own internal inquest into the future of urban mobility were also used as a data source as a basis for critique on the contextual happenings of an engineered future-now scenario. These sources of data, in particular, were significate components of the critical research data due to the increasing fight in the urban landscape for public space (including roadways) to stay in the hands of public regulation.

3.4 Data Analysis Framework

The authors selected a framework analysis methodology by analysing the data collected from the case studies and interviews. This methodology for analysis was chosen since framework analysis allows, for the patterns between individual cases and content themes, to be cross reviewed and synthesised through summaries. This is important for this thesis since the data streams are cross-sectional, being collected from a variety of sources and from a collection of three silos of knowledge. The second reason why framework analysis was chosen is due to the advantages of the method that allows for transparency of the researchers’ interpretations of the interviewees content (Spencer et al., 2003).

Evaluation of data analysis and collection method had a low level of transferability since the data and the sources of data are highly contextual and independent. These same sources, however, pose a high level of credibility reflected in their professional roles within internationally recognised companies. Generalizability of this research project is considered low to medium by the authors since while a dynamic selection of data sources has been used, the study is still inherently limited. The smart city agenda which is gaining traction globally is still a largely miss understood and miss represented enterprise due in part to the speed at which technology and the way we communicate evolves, and the disjunction this has to the time planning framework of construction work (Bessant and Francis, 1997). Additionally, sustainability is complex (Wangel et al., 2016) and difficult to define. Nevertheless, cities from outside of Sweden are also working towards planning for a future or urban life which, at the rate and type of industrial change both west and eastern cities are experiencing, there is a drastic need to address city planning shortcomings, while reflecting on the relevance of technological solutions for human problems (Anthopoulos, 2016). For this reason, there is a moderate rate of transferability to other cities and their neighbourhoods globally, when researched in the context of the political of economical frameworks of the local. The validity of the data while using qualitative research methods concerns the honesty of the interviewee’s responses in conjunction with the interviewer’s maintenance of limiting personal bias. Validity has been maximised by using the framework analysis method along with are mentioned controls over the interview environment.
The interviews were made based on primary questions, but the aim was to have qualitative answers to confirm the author's propositions with real issues from the industry, government and academia. The interviews, however, were conducted in a semi-structured manner, in order to draw out relevant information useful for the research, of which some were not known to be relevant until discussed. In order to allow the information from each interview comparable, due to the relative freedom that the authors conducted them and the amount of valuable information taken from it, it was necessary to identify common terms that were identified in all interviews, named in relation to the three silos of knowledge of this paper. These terms were named “Related Hypotheses” and besides the qualitative approach of these paper, their representativeness was evaluated based on the sum of times they appeared in the interviews. The terms were then grouped in the three areas of research: Urban Mobility, Consumer Behaviour and Big Data, in order to verify its representativeness in relation to the research question.

3.5 Ethics & Sustainability

Since upholding ethical integrity while conducting empirical data research is of particular importance, the authors have upheld an ethical research process by addressing risks systematically through both the data collection process as well as the representation of that data in this thesis. This involved consent of participants of interview questions, as well as receiving consent to record, document and represent their words in this thesis by verification of their portrayal prior to publishing. Additionally, private information such as names of companies and personal names have been withdrawn in order to anonymize the data.

As a thesis submitted to satisfy the requirements of the Masters of Entrepreneurship & Innovation Management, the thesis address’ sustainability through the lens of industrial dynamics of cities and the interoperability of mobility networks and consumers. The city's mobility systems and infrastructure were first expanded around the industry, to feed it with manpower and goods. Travel needs of both products and people changed during the time, as the city passed through diverse pivoting phases and moulded itself after its own history. Transport infrastructure is strictly connected with economic development, that is reached through efficient transport systems within connected networks and high-density transport infrastructure. Social and economic opportunities in a city are enabled trough efficacy in urban mobility system and growing economies generate bigger transportation demands that must be addressed through an efficient urban mobility planning. These relations were discussed mainly in the Urban Mobility chapter of the theoretical framework.

The sustainable development approach in the planning phases of urban mobility systems and infrastructure was discussed in the Theoretical Framework as a target in the processes of nudging users towards a more sustainable behaviour in relation to their travel choices and its impacts in environmental, economic and social aspects of urban mobility.
This chapter considers two case studies of planning documents outlining urban mobility objectives for new neighbourhoods located in two different major cities in Sweden; The Royal Sea Port in Stockholm, and in West Harbour in Malmö. Neighbourhoods, as opposed to cities, are useful scales for testing innovative agendas for local governance, since they are large enough to have a buy-in determinant and small enough to assess and monitor new systems (Ewing and Handy, 2009). The authors have chosen to focus on the planning document as it is the road map that frames future goals and is used by practitioners and entrepreneurs to deliver future neighbourhoods (Holmstedt, Brandt and Rob Ert, 2017). From unpacking the planning literature, a local government’s approach to policy and implementation of data hardware for the management of mobility can be analysed and contextualized as the active framework the next wave of building projects in the two cities. While West Harbour positions itself as a living lab of urban informatics (Malmö Sege Park - a resilient urban playground formed by a local sharing economy | URBACT, 2016), Stockholm Royal Sea Port can be understood as a more reactionary piece of guiding policy for urban development. The case studies include a critical discussion on the case neighbourhood.

Hard data infrastructure like sensors are already operational in cities like Stockholm and Malmö (Carlsson, Hadenius and Ericson, 2006) within the public transport sector, however the practicalities of rolling out extensive data hardware to capture larger data networks is only relatively new due in part to the slow process of governance and issues surrounding the security of citizen information (Carlsson, Hadenius and Ericson, 2006). For this reason, real-world outcomes of policies that look to integrated data networks to solve current urban problems are still in their incubation stage with many ongoing projects active across Sweden.

4.1 The Royal Seaport, Stockholm

The Stockholm Royal Seaport (SRS) area includes seven (7) local neighbourhoods including; Gasverket, Ropsten, Hjorthagen, Södra Värthamnen, Frihamnen and Loudden under its juridistictive umbrella. Located within Stockholm, SRS also falls under broader planning policies of Stockholm including The Urban Mobility Strategy (Firth, 2012) and Vision 2040 (Stockholmsstad, 2017b), which construct the argument for developing the city using methodologies which assist in achieving sustainable development goals of the UN, in conjunction with addressing Stockholm’s consistent population increase.

Stockholm’s Urban Mobility Strategy is based on a population increase of 25% by the year 2030 (from the then current population in 2013) and on 570,000 people working within the Stockholm region (Statistics Sweden/the City of Stockholm’s Office of Research and Statistics, 2009). Already in the last year, and the population of Sweden has increased by 120,000 people 23,000 of those live within Stockholm’s city limits (SCB, 2016). The consistent increase of +1% population increase has put pressure on local authorities to address issues facing urban mobility and road congestion expeditiously. The data used in the SRS planning guide is based off census data as was current at the time of publishing – 2012.

The SRS is due for completion in 2030 and is to house over 12,000 new housing units and 35,000 new workplaces. There are five (5) strategies for sustainable urban development including (Stockholmsstad, 2017);

- vibrant city: a focus on mixed-use programming and flows of people;
- accessibility and proximity: a network of roads and streets and modes of transport;
- resource efficiency: efficient energy use and land use;
- **let nature-do-the-work**: connection to nature to complement urban qualities, and;
- **participation and consultation**: inclusive participation.

Urban mobility measures to address sustainable development performance indicators delivered in the report are focused on establishing a hierarchy of travel modes (figure 4) with the aim of achieving the city’s carbon emission targets two ways; by reducing the need to travel and encouraging travel modes which have a lower carbon impact. A clear strategy driven by the need to move more people and goods is outlined pointing to modes of transport which support higher capacities in the available space (like bikes, and collective transport). These are addressed primarily in the strategy for Accessibility and Proximity, however, acknowledgement of the connection between urban form and programming and the way in which people move is also evident in the importance placed on ensuring vibrant and inclusive street life and mixed programming of street blocks.

![Figure 4 – Hierarchy of Urban Mobility in Stockholm, to be incorporated into the SRS (Stockholmstad, 2017)](image)

The strategy for the dominant modes of transport are formulated such that the SRS should have reduced congestion within the development, and due to co-locating places of paid work and residential zones reduce the need to travel to other parts of Stockholm, contributing to the reduction of congestion to the city overall. The focus is on flows within the development (figure 5).
“Buildings, places and thoroughfares should be designed in such a way that spaces and functions for bicycles are integrated into the urban environment in a natural way. Some streets can also be virtually car-free, without compromising accessibility” (Stockholmstad, 2017)

The SRS planning guide outlines provisions to mobility should be a focus on providing access to local schools, shops and work-places, however, is there a little reflection on the impact of the occupants of 12,000 new homes will have on the mobility of the greater Stockholm mobility network. The planning document describes SRS as an enclave that is justifiably self-sufficient, yet perhaps this is also its weakest attribute. By collocating services closer to the home-work pendulum the mobility strategy is to establish a polycentric planning scheme (as opposed to monocentric). However, this same scheme might, in fact, restrict some people from living in the area since they have a poor connection to work if there are reduced services connecting to the rest of Stockholm. Some argue that this is already the case in existing neighbourhoods within existing networks anyway. Is there a difference between increasing mobility across the city, or decreasing connectivity within the city, which still calls for the need of the car? There also needs to enable a hierarchy of transport routes, like express buses and trains, that run to circumnavigate the city, as opposed to running all traffic through the centre as the metro system does at the present.

The SRS is not Stockholm’s first attempt at a sustainable community. Hammarby Sjöstad to the south of the city was the first to address sustainable performance concerns through a circular economic strategy for reusing and recycling materials within the neighbourhood. While the planning framework constructed for Hammarby Sjöstad excluded sectors like transportation, (Pandis Iveroth, Johansson and Brandt, 2013) the area is seen as a success of private-public partnerships of a sustainable development delivery model. The outcomes of Hammarby Sjöstad have been criticized, however, due to the lack of systematic assessment of the project goals during the delivery process (Pandis Iverot and Brandt in (Shahrokni et al., 2015). These criticisms were addressed through Shahrokni’s Smart Urban Metabolism (SUM) framework built for data management systems that formed the Stockholm Royal Seaport R&D project. (Shahrokni, 2015).
Shahrokni used the theories of urban metabolism to develop a data management structure whose aim was to provide real-time, high-resolution data feedback useful for assisting residents in making sustainable decisions dealing of their daily routines, as well as the management of urban systems.

### 4.1.1 Urban Metabolism & SRS

The core of the SRS-M methodology is the real-time calculation of selected Key Performance Indicators (KPI’s). The initial stage was to establish performance indicators which would underpin the monitoring and assessment framework named the SRS-M. A pre-study called “Urban Smart Grid” listed 150 indicators of sustainability that included transportation, energy management and social factors. The study found that the data needed to calculate the metrics needed for the monitoring program for the SRS (called SRS-M) were already being collected by organizations in the city, so the need for the installation of sensors were not necessary, rather a platform for interoperability that would allow for the integration of data sources would be required (Shahrokni et al., 2015). Another key feature of SRS-M was the interface created for the end user- the citizen. Shahrokni notes that it was vital that the data collected was put into a context from which users could make decisions relating to sustainable choices that were relevant to their daily lives. One such example is a dashboard that links actionable real-time data with sustainability metrics and transport data; where local congestion public transport routes are linked to an alert to wake up earlier to make an appointment, which is in terms linked with alerts in relation to weather changes such as “bring an umbrella”. Other than technical and operational issues with the IT systems, barriers to the SRS-M project were namely the integration of the many stakeholder groups and the suitability of the system for citizen groups which ultimately determined their potential uptake of the facility.

Shahrokni speculates that smart urban metabolism could be used as a policy instrument in the future, due to the nature of the data the framework reflects back to decision makers (Shahrokni et al., 2015). Further, he goes on to suggest that since citizen plays such a vital role in data contributions, smart urban metabolism could open up the opportunity for self-governance enabled by receiving the same real-time, high-resolution feedback loops of that human choices have on the system. For the time being the SRS-M is an ongoing project, but the relevance strikes at the heart of Stockholm’s’ recently adopted Strategy for Smart Cities, which aims to “provide the highest quality of life for Stockholm inhabitants and the best entrepreneurial climate.” The core of the strategy’s target vision shows the goal of the strategy and the City’s digitalization efforts – “to provide the highest quality of life for the Stockholm inhabitants and the best entrepreneurial climate” (StockholmStad, 2017a).

The SRS Sustainable Urban Development Plan seems reluctant to make any binding directives about urban mobility, outside the known parameters of walking, cycling and collective traffic in a bid to reduce cars on the road, opting instead to keep the agenda open for private R&D to establish services that facilitate aspects of the development plan. Ongoing research funded by VINOVA is continuing into the applicability of ICT in the SRS through RISE ICT (RISE ICT, 2017).
4.2 West Harbour, Malmö

The city of Malmö, located in the region of Skåne, South of Sweden, is the third largest city in the country in population number, and its growing population rates represents the biggest population growth in the country, at an increasing number of around 5,000 new inhabitants per year (Statistiska Centralbyran, 2017).

Malmö is an example of a city in financial recovery in its post-industrialized era, although seen success through urban planning developments. After a financial decline due to the industrial crisis in the 1990s, the city started its political agenda of Sustainable urban development in order to increase its growth and became an eco-district (Malmö högskola, 2017). The adoption of a sustainability focus on the development of solutions for the city is connected directly with the city participation in the European Millennium Housing Exposition, in 2001, within the project Bo01 “The City of Tomorrow” (Supervisor and Mccormick, 2017). The Bo01 translation from Swedish: Bo stands for “to dwell” and 01 stands for the year of 2001. (Supervisor and Mccormick, 2017).

The Bo01 project was the first step to the revitalization process Västra Hamnen (Western Harbour). This process started in 1995, as a part of the development of the City of Malmö comprehensive plan (Supervisor and Mccormick, 2017), addressing solutions for this 140 hectares area on the Öresund Strait (Fraker, 2013). This area used to have a dock and a port for the Kockum’s shipyard, closed in 1986 due to the oil crisis, started in the late 1970s (Malmö stad, 2016). Followed by it, this area was used as a site for the Saab vehicles factory in 1989 (Holgersen, 2014), also closing in 1990.

The 1980s industrial crisis saw a general population and immigration rise, and decreasing tax income resulted in the deterioration of municipality finances (Andrén, 2009). The city’s recovering process, together with the new opportunities that came with the Öresund tunnel and bridge construction, connecting Sweden and Copenhagen, resulted in the application of Malmö for one of Sweden’s housing expositions, being chosen in 1996 to become the first European Millennial Housing Exposition with the Bo01 project. Followed by the selection, the city purchase the Western Harbour and started its development (Fraker, 2013).
The innovative processes surrounding Bo01 were possible due to a top-down government policy and funding initiatives from Sweden, SVEBO and the Europe Union. This project was the first of a series of others in the city, with the predicted conclusion for 2030, within the capacity of 20,000 residents and equivalent workspaces generation for the city (Malmö stad, 2016).

4.2.1 Malmö mobility systems

The Bo01 concept had a positive impact in the whole Malmö city traffic system, acting as a model for its restructuring process. The used strategy was to use the city design, incentives for the population and information to encourage the city inhabitants to change the priority of their transportation modes choices, changing the use of private cars for walking, biking, car sharing, public transportation, etc (Fraker, 2013). These initiatives transformed the ways people move around the city, with their complete array of services, and their integration with the public transport.

4.2.2 Nudge people to change transportation behaviour

An example of how the mobility structure offered for the population could nudge them to change their behaviour, the city can cite that 40% of the city commuting is made by bicycles, through 420 kilometres of bike paths (Fitzgerald, 2016) and that the bus systems was planned in a way that the residences have a maximum distance from the bus stops of 300 meters, with a time lapse of 6 minutes between buses. All of this information is available online, and offered reliability and flexibility as incentives for people to use the system (Fraker, 2013).

4.2.3 Malmö Sustainable Urban Mobility Plan

“Walking, cycling and public transport are the first choices for all who work, live or visit in Malmö. These travel choices, together with efficient and environmentally friendly freight and car traffic, are the basis of the transport system in our dense and sustainable city - a transport system designed for the city, and for its people.” (Malmö Stad, 2016)

The Sustainable Urban Mobility Plan (SUMP) is divided into four areas in order to reach its target to make commuting more economically, socially and environmentally sustainable (Malmö Stad, 2016). Firstly, the Holistic Approach has the aim to link all the three aspects of the sustainable pyramid with movements and traffic planning. Secondly, Target Planning of the area frames the planning mobility projections accordingly with the city’s future goals. Thirdly, commuting is the sector focused on developing sustainable and robust options for commuting issues. Fourthly, Urbanized Main Roads, with the aim to understand how urban streets act accordingly with citizen’s needs(Malmö Stad, 2016). The figure below demonstrates how the SUMP is correlated with other sectors in the Malmö eco-district development.
The guidelines of the Comprehensive Plan consider the growth of the city in a denser way, decreasing distances and person miles travelled, increasing opportunities and using the urban spaces in a more efficient and integrated way.

### 4.2.4 People at the centre

Applying a method developed by VTI (Swedish Transport Research Institute), a survey was taken to a group of 2,500 inhabitants of Malmö, where they were asked what kind of traffic environment they wished for the inner city. The results showed that the target goal of the SUMP program is aligned with peoples wants and needs, as 47% of the responses were surrounding the desire of having more space to walking, cycling and public transport.

These actions bring benefits not just for the population mobility issues, but also for their health and the environment of the city. Projections for 2030 shows public benefits trough increase of trips on foot will count 505 million/year and of trips by bicycle and a higher share of cycling in 1,120 million/year, demonstrate also how these strategies in a long-term analysis period can return the made investment as positive outcomes in different sectors, as the health-care systems.

Mobility management activities are about analysing demand and possibilities for transport modes available in the city. With the development of new combined strategies of transportation modals, the city must be aware of the behavioural influence over people’s conduct, for individuals and business.
City streets and general urban spaces are being reorganized and redesigned in order to attend these new demands of people moving on modes other than the car, with the development of urbanized main roads marking a paradigm shift of their usability, since the car is not the main generator of travels anymore (Malmö Stad, 2016).

4.2.5 Government and city planners in touch with society

In order to achieve its eco-district goals with the Bo01 project, the city developed a participatory planning process called Building and Living Dialogue; to engage all people involved with city representatives, planners and investors and talk about their expectations and necessities and to facilitate cooperating work (Fitzgerald, 2016). Between the factors that can describe Malmö’s success, effective urban planning can be pointed to as the main reason for the positive results, together with knowledge sharing and innovation experimentation.

There is a web-based map tool integrated into the Comprehensive Plan that presents information about today and future guidelines for urbanized main roads. This information represents a powerful tool to support planners and practitioners in urban development projects that involve broad future targets of the city, accordingly with Government and population needs to be aligned into a strategy to develop an efficient and sustainable mobility system (Malmö Stad, 2016).

The implementation of this project happens in cooperation with the regional water and sewage company (VA SYD), civil protection (Räddningstjänsten Syd), the regional public transport authority (Skåne-trafiken), Region Skåne, the project HMSkåne for sustainable mobility, the Swedish Transport Administration (Trafikverket), inhabitants, national agencies, universities, business and other stakeholders (Malmö Stad, 2016).

4.2.6 Malmö Evolution History


“Malmö is a city without memory. The city tears down its history, bit by bit, day after day. It’s laughable.
The statement above, made by the local author Kristian Lundberg, question the ways the city of Malmö has been redesigned over time, reacting to two different crises over time.

Questions about the city history erase through time due to the development of industry’s interests question its influence over the city development priorities (Holgersen, 2014).

The development of new modes of transportations and mobility systems seems to be forged by the industry, according to their own objectives and to be integrated into the growing product-service trend. Understanding who is responsible for the changes, what their interests are and how they are really connected with the city targets it is a role that must be taken by Government authorities. The development of mobility technologies and systems must be regulated by an authority that is focused in the wellbeing of the city and in its future goals, aligned with all the three facets of the sustainable pyramid, in order to keep them in balance. As an example of imbalance, we can cite that it is possible to observe negative daily news surrounding social aspects in the city of Malmö, showing that the social side is still somehow left behind as the areas that are not covered by these revitalization projects are being neglected and people are being pushed outwards to the city due to the high prices imposed by real-estate speculations surrounding the new areas.

4.3 Case studies comparison

Sweden is one of the world leaders in overall sustainability, and its future strategy to make mobility in urban spaces more sustainable can be well represented by the analysis of the fastest growing and biggest cities cases: Stockholm and Malmö.

Stockholm, as the capital of the country, presents a broader range of stakeholder’s interests, and the development of new strategies occur in a more complex environment which delimitates its actions in separated areas, such as the Royal Seaport. Additionally, the initiatives for the application of sustainable measures in urban mobility are driven by the future national goals. It will be interesting to watch how Stockholm resolves conflicts of interest in the future between industry offerings and national directive or is perhaps an increase in transparency of this directive in the coming years will drive more diverse innovative solutions to urban problems.

Roadmaps for the future of urban mobility such as the European MaaS Roadmap 2025 (Eckhardt et al., 2017) are being drawn up by public-private collaborations to investigate the prerequisites for future systems from usability, the role of industry, value networks, business and operator models, environmental impact assessments and technological requirements.

Malmö’s urban development has happened in a more noticeable reactive manner, which operates in parallel to industrial crisis’ which occurred throughout the years. Consequently, the city could re-design itself and absorb new technologies in its processes and was able to develop projects that could englobe almost all the city with actions that resolved different areas. Malmö is also a much smaller city than Stockholm, and as such can perhaps afford to allow for this process to happen.

In a global context, planning processes in Sweden are relatively bottom up and reactive. However, a comparison between the two cities reveals alternating approaches to planning bodies to include citizen demands in the formation of development directives. Where planning processes in Malmö have the mechanisms to mediate between industry and citizen feedback and demand, Stockholm’s planning process places a stronger focus on collaborations between public and private groups, where the international focus of industry means there is potentially less interaction with the local.
However, both cases present the need to understand the citizen and the aim of the city with its urban spaces use and development to offer more people-centric transport systems options in order to increase sustainability and decrease people’s negative outcomes over urban mobility issues. This could be interpreted as having origins in Sweden’s wide and flat hierarchy in the decision-making process which is the dominant process deeply rooted in governance.
In this chapter, the authors make links between the theoretical framework, literature and the empirical data of the interviews in order to draw conclusions about the potential influences of big data on urban mobility networks and speculate the possible role of the citizen in urban mobility analysis for the future of mobility systems, through their contributions to the landscape of big data.

5.1 Interview Framework Matrix

The interviews form the foundations of this body of qualitative research, which drove the investigative agenda of this thesis. The interviews were conducted with the objective of understanding the role of data in both public and private sectors that work with urban mobility networks. Since the interviews were open conversations which covered a broad range of topics and observations on the influence of data on urban mobility planning, a matrix was designed based on analytical procedures (Collis and Hussey, 2014) as a way of collating the spectrum of data collected in a graphical format which could be easily ready for dominate themes and observations in relation to the context of the source. The matrixes used to analyse the interviews are included in the appendices. There is one matrix per interview which has been aggregated into a graphical output to reflect the findings from the interviews.

The matrix design breaks up the interviews into their question and answers components, which are then interpreted by the authors and summarised into a number of key themes which the authors have termed Related Hypotheses. The appendix has a summarised version of the matrix. Below is a table that describes the hypotheses used to unpack the discussions of the interviews:

<table>
<thead>
<tr>
<th>Related Hypotheses</th>
<th>Explanation of terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility as a Service</td>
<td>Based on the concept of adding value to a product with a service. Mobility modes are packaged as systems are offered as a product group with attached services. E.g.: options for having different platforms for accessing its information, different split modals, door-to-door transportation, etc.</td>
</tr>
<tr>
<td>Smart city</td>
<td>A city where connected devices supply the management systems with data that are used to improve efficiency to the city by digitizing the mechanisms for new sustainable methods in urban networks, related to waste disposal, energy use, water, health, mobility, etc.</td>
</tr>
<tr>
<td>Open Data</td>
<td>Data that can be available through an open web page or open source to be gathered in an easier and accessible way. It does not have restrictions on accessibility, and can be redistributed by anyone (as long as the source is attributed)</td>
</tr>
<tr>
<td>Autonomous Vehicles</td>
<td>Vehicles that are driverless and are pointed as one of the solutions for future improvement in order to decrease traffic congestion rates.</td>
</tr>
<tr>
<td>Shared vehicles</td>
<td>In urban mobility, relates to vehicle sharing and other alternatives that intends to minimize waste, increase efficiency and empower people.</td>
</tr>
<tr>
<td>Consumer behaviour</td>
<td>How decisions and actions made by people, driven by human behaviour, suffer influence by the conditions in which products and services are offered. E.g.: decision making and the effects of those decisions; city-citizens as consumers of transportation services.</td>
</tr>
<tr>
<td>Hard city infrastructure</td>
<td>For urban mobility, hard city infrastructure stands for the structure of streets, avenues, sidewalks, bike paths, and urban roads. The necessity of adapting it towards new developments that affect its usage.</td>
</tr>
</tbody>
</table>
By unpacking the interviews in this way, it was possible to make clear connections between the literature, the motivation of the interviewees and the topics discussed in relation to how data can influence the planning of mobility in urban places.

The authors wish to acknowledge that there are potential biases in the interview matrix, due to the nature of classifying answers into themes (called related hypotheses), as well as what those themes mean in relation to this thesis (i.e. the hypothesis definitions). The role of the graphs was the way the authors decided to represent their inductive findings and does not implicate the research as being quantitative, rather it is a simple representation of the interview findings and should be interpreted by the reader as such. Further discussion of the interview findings follows the matrix analysis.

5.1.1 Interview Findings

The aim of the graphical analysis is to verify visually the exploratory themes discussed and find patterns that correlate to this paper’s propositions. The matrix was used to associate hypotheses to the interview contents are available in the appendix. From the overall findings, the interviews could then be combined to produce two types of graphs; one that gives a total overall view combining all interviews, and the other for individual interviews. The Related Hypotheses across all the interviews were compiled into the visual output shown below, illustrating the dominant themes covered across the interviews included in this research.
Overall findings from the interviews showed that predominantly Consumer behaviour, Industry initiatives in mobility development, and Hard city infrastructure led the discussions. It was clear from the discussions with both academic and public interviewees that even though their position was not from a private company viewpoint, in their majority, a large proportion of their projects were completed in collaboration with private industry through public-private partnerships. These are collated under Experiments based on research and also represented by the Shared Vehicles proposals from these projects, where they adopt a Value proposition for their businesses. These topics were of similar prominence as Not disclosed results, which catalogued ongoing research which is at the time of writing unpublished. Research into the uses of data to plan urban mobility is multifaceted and touches diverse aspects such Open data, Travel behaviour, Mobility big data and Governance, however were of medium recurrence. Overall, discussions about Smart Cities, Mobility as a service, Autonomous Vehicles, Feedback loops and Privacy issues around big data were discussed in relation to primarily the topics covered in greater recurrence, since the fundamental usability and characteristics that define that usability underpins a majority of research of transport mobility which was identified through the interviews and is active currently. The topic neighbourhood certificates were not covered in detail due to its own complexity, and they sit outside the scope of this thesis.

5.1.2 Individual Interviews

Each interview is summarised in graphical form, allowing for a visual link between the interviewee and the topics discussed. Below are the hypothesis graphs for each interview, showing the main themes touched on in the interviews.
5.1.2.1 Interview 1

Head of Strategy & Business Control
Private Company 1 – Industrial Transport Manufacturer

Interviewee 1 works with corporate mobility, as the Head of Strategy and Business Control at an industrial transport manufacturer. One of the major projects underway currently is focusing on developing a multi-modal transport system including mobility by bus and bike, transporting employees within the factory campus and interfacing with these users through an app. Company 1 are collaborating with Academia on the travel behaviour aspect of the project, which they hope will one day be able to be packaged for sale to other company campuses. The benefits of testing the service ‘in-house’ are that Company 1 are free of municipality regulations and coordinating with public transport providers. This leaves the program more open for experimentation. There are however ongoing complications with capturing and utilizing data sets from users, particularly in relation to new GDPR laws regulating use. There are conflicts with rolling a service like an app to the wider public since it would mean sharing data with other providers lessening the effects of a competitive advantage.

![Related Hypotheses Chart]

5.1.2.2 Interview 2

Research Engineer & Project Leader
Academic Institution

Interviewee 2 is a researcher at an academic institution in Sweden focusing on research and development of technical devices as autonomous vehicles and pods. Their work mainly involves experiments within ongoing research which incorporates the technical aspects of developing driverless vehicles, working with how digital twins of the urban environment can be used to understand travel choice. Interviewee 2 is also a researcher on the app project at Private Company 1, where the focus is trying to understand what encourages people to travel in a sustainable manner, and what could cause them to change their behaviour from one mobility mode to another. Interviewee 2 notes that there are challenges due to governance and policy and has doubts on the scale of production of another project in Stockholm- where a driverless bus network is servicing a people within a set urban space. They noted that changes are needed, which involve transport and telecom infrastructure in order to enable Autonomous Vehicles, sensors and other connected devices.
5.1.2.3 Interview 3

**Analyst & Project Leader**

**Private Company – Engineering, environment, and architecture’ sector consultancy company**

Interviewee 3 has a background in anthropology and the history of technology, working currently for an urban-specialist department within a company working with engineering, environment and architecture sectors. Currently, the department is researching the future of the city, and how a city can make itself smart through connected mobility, self-driving vehicles and ITS (intelligent transport systems). They are also looking into intelligent systems that promote safer mobility, including vehicle sensors and shared economy networks. Additionally, Interviewee 3 is unpacking how to leverage the risk of a rebound congestion effect- where congestion actually increases if there is a mass uptake of MaaS (which could include driverless vehicles). Questions around mobility big data and open data drive investigations into how to measure mobility patterns while upholding anonymity of data sources.
5.1.2.4 Interview 4

Head of Research Department
Academic Institution

Interviewee 4 is the director of a research centre embedded at an academic institution where their research focus’ on how new technology can contribute to a sustainable transport system. The research centre aims to integrate different types of knowledge and combine different types of technologies together with user behaviour to analyse system-level effects of policies and business models. Most of the research related to technology is concerned with electrification and automation of vehicles as well as mobility as a service and logistics as a service. Understanding the relationship between the hard city and suburban infrastructure and the notion of ride-sharing is being investigated through a number of studies which are currently gathering results. Thus far, the studies have shown that namely, flexibility is the biggest attribute to mobility that effects travel choice and behaviour and that there are many facets to developing mobility services that are complex due in part to the complex daily life relationship networks which haven’t any one driver.

![Related Hypotheses Chart](charts_chart.jpg)

**Chart - 5 Related Hypotheses Interviewee 4**

5.1.2.5 Interview 5

PhD Academic Researcher
Academic Institution

Interviewee 5 is a PhD candidate in Product and design at an academic institution and has been involved with the research collaborations with public-private partnerships. The focus of Interview 5’s research is ride sharing for commuting in suburban regions of cities, as well as product service design related to an app at private company 1 and their mobility service system located in South Stockholm. There is a strong theme in the work that interrogates how behaviour change might happen; not dependent on the range of options available, or choice architecture but understanding how that perhaps we live in a much more structured society than we might think, where the way we do things are deeply ingrained in a complicated network more influential than options alone.
5.1.2.6 Interview 6a and 6b

Statistician & Investigator
Two members of staff from a public funded traffic data collection organisation in Stockholm

This public organisation is an independent national agency which processes data and is responsible for the national statistics for the whole of Sweden, under the directive of the Swedish government. They operate mainly with surveys conducted over the phone or in person and do not work with sensor equipment similar to what private companies such as Telia and Ericsson might work with. They cover all modes of transport and mobility, including public transport and release results over longer time frames due to the mode of collection. They engage in cooperation with private mobile operators, however, their operations could be viewed as reactive to the pressures of private company agendas of uncovering valuable data, where conflicts of interest over data ownership and access filter through most of these collaborations.
5.1.3 Interview Summary

To summarize the results showed above and to reflect on the area affecting the relationship between data and mobility planning, the hypotheses used in the matrix were grouped according to the three areas of the research proposition (big data, urban mobility and consumer behaviour) in order to be represented in the graph below:

The graph shows that urban mobility and issues surrounding big data were discussed to similar extents throughout the interview process, with consumer behaviour having a dominant presence throughout the interview discussions: either directly through candid questioning, or secondarily through discussions about other factors which involve an element of consumer behaviour theory.

Chart - 8 Aggregated findings according to research stream
The graph reflects that the consumer and their travel behaviour is of the greatest influence on how data can be used to influence future planning of urban mobility, since at least in the context of those interviewed it is how people are encouraged to move by more sustainable modes, and the ability to provide those options to consumers as well as package them so they are desirable and reflect consumer demand.

The findings reflect that the effects of change on planning for future mobility are driven by the producers of data and the users of services. It also acknowledges that it cannot be successful if there’s limited value proposition for the consumer. The industry is currently ruminating the potential link between new resolutions of data and its usability in designing new service streams in order to capitalise on the availability of data. Those companies where data is at the core of their established value propositions are arguably at the forefront of the data/mobility race since they have it within their established capacities to use the data infrastructures available to them to form new value propositions for customers. For those industries pivoting into data-based offerings, the drive of the value still lies in their core offerings, for example Private Company 1 are at the forefront of vehicle design, where-as they rely on partnerships with other industry partners to further their own capabilities in terms of delivering full services to which incorporate new end customers who currently sit outside their B2B offerings of hard infrastructure of vehicles.

5.2 Discussion of the Interviews

This section discusses the interviews from the perspective of the three themes of this paper:

1. Big data;
2. Urban Mobility;

5.2.1 Big Data

5.2.1.1 Siloing of Knowledge

The professional split of expertise between engineers, planners and in recent years IT scientists campaign for the siloing of specialist knowledge needed in order to address the ongoing (and seemingly ever-present) problem of road congestion. In a traditional sense, urban form is attributed to urban planners and real estate markets, where roads and transport networks fall to the jurisdiction of road builders and transit operators(City Observatory, 2013).

The interviews pointed to the siloing of knowledge and specialisations as a barrier to solving congestion problems with innovative and long-lasting solutions. New practices of urban planning favour processes that allow for larger stakeholder groups, so the specializations needed to make decisions are able to influence directives that have long-reaching effects. Collaborations between public and private organisation also work to bridge barriers of siloed knowledge, including that of the academia who engages in projects that bridge academia and industry. Through the discussions of the interviews, however, it was clear that there still were barriers to bridging knowledge between specialists with engineered solutions that are highly technical and the ‘softer’ qualities of human interaction. Interdisciplinary modes of practice are however becomingly highly popular due to the process’ ability to enhance innovative problem-solving environments, adopted by companies such as Private Company 2 in collaborative, multi-disciplinary teams.
5.2.1.2 Purpose & Intention of Capturing Data

For a private company, the purpose of capturing data is to find a match with a potential value creation, which leads to the intention of capturing data to make a profit. There are conflicts of interest to capturing data depending on the intentions of those organisations collection and storing data. Collaborations between public and private groups are beneficial to sharing recourse and knowledge, but it is only possible if the intentions that those resources are used for are aligned. The Public organisation interviewed for example finds that collaborations with private vendors leads to complications of data end use which more often than not is contrary to TA’s intention of data collection- which is by government mandate to gather statistics on the Swedish population, which should be publicly accessible. This is contra to the intentions of private organisations who intend to capture data in order to deliver value for a profit. Data collected under this perspective is inherently subject to privacy, since it is directly related to a company’s business directive and end profits. The research gathered through the interviews made it clear that private industry was at the forefront of laying the foundations for future modes of urban mobility in Sweden. By not engaging in collaborations with private organisations, there could be a risk that public organisations could be left behind in regard to the use, security and structure of data platforms in the future- particularly because advancements in data capture and creation is a rapidly evolving movement.

5.2.1.3 Security of Open Data

It goes without saying that maintaining data security is of paramount importance with regards to both public and private data content, and sources. One of the most important aspects is anonymity of data, which along with the recent GDPR regulation enforcement has made it more complicated to turn open data into a usable commodity. There is space therefore, for enterprises to focus their value creation on making data valuable as opposed to capturing data of which there are few active in Sweden currently. Licencing data accessibility due to proven capabilities to manage data security restricts incumbents in the market, which accordingly means these types of operations will become increasingly in demand as uses for data in planning frameworks becomes mainstream practise.

5.2.1.4 Platform of Data Structure

There is a lot happening in the way of data collection, but not so much in the way of data connection, or a platform where the data is stored and made usable. Technologies are changing fast, and to have standard data formats could be a barrier to its technological development. From the interviews, a time frame of 10-15 years was estimated whereby there will be a universal platform format for dealing with big data sets. During the transition phase to this point, The Institute of Electrical and Electronic Engineers (IEEE) is leading the standardisation process for big data, and a similar approach will probably be used for mobility and transportation platforms in the future. Other private companies are attempting to include universal platform structures incorporated in their value propositions, for example ‘data clouds’ with the aim of providing a platform for mobility services that providers could aggregate the data on their platform, so they can either sell it or use it to inform a service offering.

5.2.1.5 Data and the physical world

Data structures allow for usability of available data; it needs to be specific so that patterns are readable for identification and interpretation. Digital Twins environments are those that build a replica of the physical world with programmable parametric parameters that allow for the testing of specific interactive situations as a way of ‘predicting the future’.
Data with higher forms of resolution make it possible to build digital twins of urban environments in order to test scenarios of interactions between humans and vehicles before testing in the real world. This capability is useful for testing interactions between different types of modal transport and interaction of vehicles and humans in relation to safety, efficiency and spatial requirements. Digital twins are directly applicable to the planning phase of urban mobility for this reason but have obvious limitations such as spatial area modelled, computing power and quality of data used. Limitations also include aspects of the intention of the process, which is essentially to see into the future. Outcomes of scenario testing from digital twin simulations cannot be taken as the truth but do work as a guide to understand the mechanics of the system at work.

Time factors heavily in the relationship between data and its related infrastructure, and the hard infrastructure of cities (roads, buildings and the procurement processes associated with them). Cities aiming for ‘smart’ status have forged ahead to embed public space with sensor technology which is outdated at a faster rate than the hard structure it is embedded in. Ownership of these infrastructure systems calls into question who owns the physical public space of urban places, becoming more obvious as private organisations can leave more obvious digital footprints in the public realm.

New technologies propose new guidelines for data governance, including its openness. A broad range of possibilities exist on the level of access and types of access interested parties have in regard to open data. However, it is dictated according to a company’s value proposition or data commissioners’ research goals. Challenges are beginning to start to experiment in a bigger and complex scale, such as the urban environment. Decisions around initiatives are sponsored by industry and made by academia or industry itself, this is in contra to traditional building laws surrounding the built environment where government-imposed guidelines to make structures safe to inhabit. At the present, the data needs to be anonymized, but it also needs to be specific so interested parties are able to identify patterns.

5.2.2 Urban Mobility

5.2.2.1 Governance and Policy

Timing is crucial for policy intervention since it takes place within a locally specific context of history and not outside it. When interventions by policy reconfigure the hierarchy of modes of mobility (such as bikes over cars, and vice versa), it can set a loop of positive feedback effects which, due to human behaviour, are unpredictable in terms of extent and depth of uptake (Shove, 2013). The time frame of potential change is also a heavy influencer of what types and extents of change are enabled to occur. Longer time frames allowed through policies that span beyond a traditional political cycle have the potential to be more effective at reaching set targets since fundamental changes in the way behaviours shift need time to gestate.

The culture of political decision making is deeply embedded in how data might influence the planning of mobility systems of a city. Different opportunities come from a reactive verse a proactive approach to governance, as well as a top-down versus a bottom-up culture of decision-making hierarchy. There is not a one-solution-fits-all, and there will be different solutions depending on who you are and the priorities of where you live (country verse city, the location of the city). In Sweden, currently it’s not completely clear who will take the lead; there are two main uncertainties: whether we will buy into the shared economy and shared data and sharing everything. Or whether we will continue and maybe even develop even more the individual approach.
A careful mix of incremental and radical change is necessary to make new mobility modes stick, since habits of movement cannot be too far from how the majority of people move now, but at the critical point, radical changes of infrastructure make new modes possible.

5.2.2.2 Effects on the urban fabric

The hard infrastructure of the city will need to undergo a change due in part to the need to accommodate the substructure for new types of transport to operate; such as specialist sensors and roadways that can be maneuvered by autonomous vehicles as well as a change in the way we interact with transport modes. Multimodal transport systems might call for alternate pick up points in front of houses and apartment blocks, or even a series of separate but integrated access routes through the urban fabric custom designed for a singular mode of transport. A backlash against living in urban centres could be possible in the coming years as citizens who are dissatisfied with city life move further away from dense areas to smaller village towns. The beginnings of this movement are already visible with those wanting a life more connected to nature and their neighbours becoming popular among many demographics. Property prices in the city centre are also encouraging the move away. Living in smaller local, but better-connected hubs could also contribute to alleviating congestion problems.

An interesting consideration is with the advent of higher resolution data sets, it might become possible to match particular data patterns with desirable neighbourhood characteristics. This process is already adopted by companies whose value proposition include the development of new homes and neighbourhood areas, but with the use of big data, it may be possible to design very specific physical conditions within the urban fabric.

5.2.2.3 Mobility as a Service

Mobility as a service (MaaS) is a term used to describe service packaging with multi-modes of transport; for example, busses, bikes and cars. There are three aspects seen as crucial to the function of MaaS; shared mobility, booking/ticketing and multimodal traveller information.

Concepts of shared mobility are discussing in the following subchapter of consumer behaviour. An important contemporary enabler of the transition to MaaS is new payment systems including digital platforms used by services to the likes of Uber (Holmberg et al., 2016). There are two main branches considered as distinct typologies of MaaS due to their payment schemes: Combines mobility services (CMS) in which users pay a subscription for a range of services connected (usually) by a digital interface to physical vehicular modes, and Integrated public transport (IPT) which most common in larger cities like London but being investigated by many smaller cities in regional areas, where users can use multiple modes of transport on one ticket, both use ease of payments as an incentive to use the service. The former actively works to make a profit by providing a service that is an alternative to car ownership, while the latter simply provides a better transport experience.

Another consideration is who is coordinating the service. Public transport operators have greater accessibility to existing infrastructure available to be re-connected in a service-based model, however, they do not have the same level of flexibility as a commercial MaaS operator. Additionally, they might attract more public transport users than car users, which ultimately would have a negative overall effect on city congestion (Holmberg et al., 2016). The interviews also touched on the possibility of subsidized services which could have both a positive effect on usage, while at the same time potentially negative effect for operators.
Other factors that could affect the uptake of MaaS is the age range of users. Between the ages of 18-24, only 58% of Swedish people have a driver’s licence. This age range is considered by the transportation agency of Sweden as prime for developing new transport habits since it usually coincides with potential users leaving home and starting jobs or studying, where a shift in daily habits could also include a shift to an uptake of sustainable modes of transport.

5.2.2.4 Barriers to Mobility as a Service

There are of course barriers to the uptake of MaaS. In a project entitled *A Car Free Year*, the subsidiary function of vehicles resulted in previously unexpected barriers. The project consisted of ‘kidnapping’ three family’s cars for a year and issuing them instead with a subscription service which gave access to a collection of e-bikes and e-vehicles (Hesselgren *et al.*, 2015). The removal of refuse was documented as an unexpected barrier to MaaS adoption which included large broken household objects, as well as the weekly recycling garbage which was difficult to transport to local deposit stations with the available e-cargo-bike.

In order for change to occur, people need to possess the skills required of change. These skills could include both technical and social aspects of change including the ability to ride a bike, and the ability to socialise with people who are unknown to you. This latter skill is of particular importance in regard to vehicle sharing with strangers. All users are different, at different stages of the day or depending on the purpose of the trip taken. Sharing within super-local hubs of commuters might make the transition to ridesharing more popular with respect to crossing social barriers of ridesharing since there is a higher possibility of sharing more than a destination in common.

5.2.2.5 Effects of Accessibility

The transportation agency reports that accessibility to mobility can have a beneficial effect on opportunities for employment for individuals and overall financial benefits for urban centres due to an increase in efficiency. This is due to how a decrease in proximity (both travel time and geographic) make it simpler to share costs and risks and increases matching in the labour market exchanges of knowledge.

5.2.2.6 Autonomous vehicles

Autonomous vehicles are already being rolled out in piolet programs across Sweden. The removal of the driver cites a 50% drop in ongoing costs mass transport types such as buses, however, the hard infrastructure needed to accommodate driver-less vehicles is steep. The goal of interested bodies is to integrate driverless vehicles into a multi-modal transport system, as a part of a mobility as a service package. Potential changes to the structure of the city and sensor technology development speed are limits to the uptake of autonomous driving, as is also the human factor. Trust and safety are paramount characteristics that passengers expect from automobile transport, and while the technology may exist for moving a vehicle without a driver long-term studies including the ability to hack the programming of a car, mishaps with sensor reading and the overall effects on the road when there are a large number of driverless vehicles interacting are yet to be tested.
5.2.3 Consumer Behaviour

5.2.3.1 Collective Consumption & Flexibility

Product service systems are a type of consumption where one pays for the use of a product without the need to own it, hiring and subscription services fall under this definition. Engaging in these types of service systems requires a collaboration of varying intensities from participants, where sharing is based on social interactions to an extent, so trust among users of the system is a requirement. In the studies conducted by the various interviewees, product service systems were established among groups of participants with commonalities such as place of work and location of the home in order to test the possibility of ride sharing to and from work, in a bid to reduce congestion (Pernestal Brenden, Hesselgren and Bauer, 2018).

One of the main barriers to collaborative consumption is the notion of flexibility; the case of the studies discussed in the interviews both perceived flexibility of travel and actual flexibility of the product service system. The study showed that above all people value flexibility higher than other values parts of the system such as saving money and reducing emissions.

Since flexibility means different things to different people, big data is more directly about the quantitative effects of location and character profile, big data alone could not be used as a way to solve the problem of flexibility. The strongest sentiment from the study was that participants wanted the opportunity to be able to change their minds when they wanted. Self-reliant-independency were noted as drivers to the decision making of process of travel choice. Therefore, if change is to be implemented and patterns of behaviour kept (Elizabeth shove) then there is a need to address these human factors, and they need to be more evident in planning documents which have a higher level of transparency; it’s not just about delivering (supply) it’s also about the demand.

5.2.3.2 Rebound effects of MaaS

The rebound effects described by Mokhtarian (1998) imply that advances in telecommunications that make for telecommuting and other ostensibly travel-reducing effects may, in fact, lead to more recreational travel or to more energy use being transferred to the lighting and heating of homes (Snickars, 2013). In Stockholm, only 43% of eligible inhabitants have a driver’s licence, which means that they are less likely to drive anyhow. This put Stockholm at an advantage of shift people from car trips to shared mobility, or other mobility modes such as door to door services, or e-bikes. But also has a high potential to increase car use if there was a dramatic uptake on car sharing services. Interviewees noted that there is limited research being conducted on the sustainability effects of MaaS beyond congestion calculations, where there is concern that a badly designed MaaS would have rebounds effects on urban space.

5.2.3.1 Value Propositions

Industry achievements tend to be shaped by company strategies and their expectations of the future are shaped by these strategies. Through the discussions, the outlook was that it is in the interest of the industry to find technical solutions to problems, but it doesn’t necessarily mean it’s value creation for the customer. Additionally, it was interesting to gain insights into the difference between ‘choice architecture’ and understanding the environmental conditions in which consumers make decisions based on unique notions of value.
5.2.3.2 Expectations of movement from the consumer

The bike is widely recognised as a mode of mobility that is not only good for the environment but also good for human health (Ghel, 2010). There are a number of studies which have been later underwritten by the EU citing that it is beneficial for cities to seriously explore multimodal transport which includes cycling and walking since the infrastructure is relatively cheap, and they are extremely space efficient. Prior to the development of public transport networks of cities, travelling by bike used to be a lot more popular as the mode of individual transport, which then in the early 20th century, faster than walking (O’Sullivan, 2018).

There is a similar phenomenon in more recent years with the advent of road congestion taxes and limitations made on parking in urban centres. A switch back to bike riding as the preferred mode of transport is gaining traction globally, most often epitomized by Copenhagen and their cities bike highways, which as Ghel mentions, was not always the case in the Danish capital (Ghel Institute, 2018).

Ghel puts emphasis in his writing about the speed of personalised mobility, whether that we are walking, biking or by car. Whether cycling is characterised as slow or dangerous, is a matter of personal opinion (Shove, 2013), especially when the two modes take place side by side- for example a bike lane located directly adjacent to fast-moving traffic.

Shove attests that past and present interaction is relevant for the accumulation of ‘material arrangements’ (roads & public spaces) along with habits, expectations, conventions and routines.

The interviewees noted that could be interesting to understand the role of the consumer early in the process, but for this remains the challenge of how to choose a sample.
6 CONCLUSION

This thesis was an exploration into the influence big data can bestow onto the planning process of urban mobility systems. This exploration took into consideration the citizen as a consumer of products and services in the city environment, including those that sit physically at the periphery but are digitally incorporated, since it is they whom the system is engineered for as actors of the mechanisms that allow cities to exist. In this chapter, conclusions are drawn from the findings of chapter 5, and the authors summarise the key research findings of the thesis: the influence big data will have on planning urban mobility systems relies on the relevance of behaviour patterns found in big data sets to the value creation offered by companies that are willing to engage in exploring potential future visions of the city.

6.1 Conclusions & Implications

The physical form of the city might shape us to an extent, but we shouldn’t underestimate the power of industry and the culture of the consumer. Commercial pursuits that shape the future are made possible by the increased density of cities. Changes in the programming of urban space brought on by shifts in modes of mobility also need to be considered, since mobility systems and networks only exist in the framework of the hard infrastructure of the urban environment. It is not enough to think of pockets of space made available for reuse by reprogramming local transport, such as the rebranding of parking spaces into a play area for children due to the many layers of networks and systems that constitute the complexity of the built environment. The act of consuming urban mobility services is an important part of people’s daily activities, carrying within it its projection challenges due to the unpredictable nature of human behaviour.

Alexander notes that’s relegating space to acts of human behaviour reflects a misunderstanding of the nature of human nature itself. (Alexander, 1966) If smart cities are about using their resources more efficiently with the help of ICT, the platforms that serve them limits the capacity of ‘smartness’.

Big data (like regular-sized data) is an eco-system. It’s composed of not only the quantitative dossier of movements, transactions and social likes, but also subject to qualitative diversification through who has access, who has commissioned the collection, what platform integration is being used, who is calibrating the dossier and who sets the priority of some sources of data over others. New opportunities to manage and plan for future urban mobility have become obvious in business areas where there is freedom to re-use the commodity of data being gathered out of the pretext of tracking economic interactions and the ability to record social ones.

The potential future information flow, through data, in urban mobility management can be demonstrated by the following figure. The Government makes policies in order to offer guidelines for mobility operation in cities. These guidelines are used for planners in the design phases of mobility systems and for operators in the management of already existing mobility systems. This information flows could be retrofitted with constant feedback loops between these areas, using Big Data sources in order to maintain itself constantly updated.
Planning for the future is also synonymous with the need to imagine the future. If it is companies imagining the future of cities, it is they who are then somewhat at the helm of planning the future in which we will live. A successful paring of corporate intentions with consumer demand is a major contributor to commercial success. There is an obvious difference in the transportations of goods, to the mobility of people being the complexity of human behaviour. This is particularly conspicuous in the form of a collective, as is a requirement of shared transport modes. More than the illustrative capability of computing platforms that process big data, there is an intangible aspect to the urban mobility of people which is legible through qualitative investigation.

Value propositions vary from one consumer group to other consumer groups, as such a number of value propositions should be formed by companies aiming to shift users away from car use other forms of urban mobility, in the case of the product range composition, as well as the service package that accompanies them. In some cases, an automated vehicle may not be the solution to a customer need. Although, as this project explored, it is in the interest of pro-active companies to develop services and products that fit their business directive and shift the behaviour of future consumers to fit commercial needs. These commercial needs may not be the best solution in given circumstances to the end consumer, and with reactive process’ of governance concerning urban mobility there is a higher chance that we might end up living in cities that are not inherently ours.

Perhaps it is academia that plays a role in the feedback loop between industry and the consumer in Sweden through the various consortia of current collaborative initiates where academia act as a ‘neutral’ bridge between the pro-active actors of industry, and the reactive systems of the state. This is the role they appear to be playing today.

The need to innovate mobility networks in urban centres in order to allow the city to continue to grow is accepted. Car congestion is one way to address sustainability objectives stipulated in planning policies, with the dual aim of reducing CO₂, as well as noise levels.

Parallel to sustainability concerns is economic ones. Studies from Private Company 1 (Lundberg, 2018) estimates driver removal from vehicles will reduce public transport costs by 50%, and reduce the number of cars on the road by 80%; since driverless cars don’t need to park close to drop off and pick up points, and the system is readier for sharing capital under a MaaS model. There are however some problems with the proposed scenario. The models assume technical solutions of today for a complex problem which won’t be fully realized until we arrive in the future.
Secondly, the model also assumes that implementation of a driverless infrastructure will happen radically and rely on a completed network of driverless pods and a citizen body who are readily willing to share.

It is through an urban environment which is diversified which creates the potential for urban systems to be open to evolution and therefore be long-lasting. This is one of the reasons why a consideration of the level and the openness of access to big data sets is important as we move forward to ensure a monopoly of value propositions does not prevail. The history of urban planning methodologies has taught us that when only one flavour of the proposition is on offer, the human ingredient of the urban environment tends to react poorly. Diversity, however, can easily be tricked into the fabric of everyday life, even more so with the ability for more of the interfaces between the physical and the digital tapping into the uncanny valley. Feedback loops run the risk of resembling a system closer to known methods of surveillance, only now with the data resolution available are finite patterns decodable to predict the future we didn’t know we wanted, yet (Sterling, 2018). The question remains to be solved over the coming period; who has access and what is their intention? The relevance of behaviour patterns found in big data sets will influence the value creation offered by providers who future-focused and see a connection between the opportunities latent in the planning of urban mobility.

6.2 Limitations

Firstly, this research project covered three areas of enquiry which in itself was a limitation on the scope of research which could be covered over the course of the research period. Interviews with consumers were not included in this research since a large sample group would be needed and there was only limited time for this study. Therefore, we instead spoke to specialists who work extensively with the link between consumer behaviour and urban mobility in order to gain insights.

GDPR was effective from the 25th of May 2018, right on the cusp of handing in this thesis. It could be seen as a limitation not having the influence of this on the research currently since it will change the way data is managed and accessed from individuals.

The opinions and experiences of policymakers and other directly involved government agencies would be of great value for understanding how the feedback loops could be fulfilled, but as we did not get any return from the contacts we made and due to the scarce time of this research, interviews were not possible.

Articles surrounding the subject are being held in Sweden at the moment the authors wrote this paper. However, these articles do not have disclosed results that could be analysed and compared with the authors’ findings.

The author’s fields of specialisation in urban design and traffic engineering did not provide background for analysing in deep Big Data platforms development, data gathering and data anonymization, which were approached superficially in this paper.

Due to the scarce time of this research, surveys regarding social aspects of consumer behaviour urban mobility systems’ users were not conducted directly. However, surveys disclosed in articles were analysed together with the literature review.
Understanding the city as a complex system, where elements interact and affect each other imposes implications for the practice of planning due the ‘unknowability’ factor and myriad of involved variables, including human behaviour within its adaptability tendency and non-rational actions. The future is fundamentally unpredictable and besides the contemporary preoccupation with sustainability, what is sustainable now, might not be in the future. Concluding, urban mobility planning is made upon projections about a photograph of the moment. Having more data to plan is like having a panoramic photograph, however, that still represents a moment in time that will change, so it is important to keep the feedback wheel rolling to decrease this planning-time paradigm.

6.3 Future Research

It would be of interest to conduct future research into the metrics for engagement, and how to make better experiences in order to disrupt the transport industry. Further, the authors think it would be interesting to conduct further research into the connection between specific data patterns and their relationship to what makes physical environments unique.

The feasibility and technical issues surrounding the development of an open data platform for urban mobility planning could be deeper analysed, within its issues evolving standardization and anonymization of data without losing the needed details for achieving the individual-level behaviour of urban mobility users.

The consumer behaviour approach in urban mobility systems represents an enormous potential for the development of research and surveys surrounding the decision-making process in relation to transportation methods choice.


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APPENDICES

8.1 Interview Guide

The opportunities we have to move around the city are intrinsically linked to both local industrial output as well as the physical possibilities of moving provided by the landscape of the urban environment. With the advent of automotive congestion solidifying itself as a reality by the year 2023 - a mere 5 years in the future, the conspicuous question is:

*If we continue the way we're going, what happens next?*

This thesis investigates the role the citizen plays in contributing to the future of urban mobility through the lens of consumer behaviour. Statistical data sets have been long used in order to justify urban interventions and shifts in the physical landscape which collectively move citizens and their production towards spatial outcomes that hinge from governing directives. More recently these shifts have been in a bid to address the ever-overarching awareness of changes in the natural environment due to industrial (and therefore human) intervention.

The central proposition of this thesis is that by studying consumer behaviour within a defined sector of the city such as the urban transport network, it is possible to draw links between urban mobility-management data sets and the data that motivates innovation within planning outcomes of sustainable urban neighbourhood development. There are obvious real-world ramifications for changes in the way citizens move around the city; the sizing of streets, noise levels of automobiles, access and egress points, the distance between points of interest and the capabilities of the fixed built infrastructure to accommodate change. The research focus’ on the connection between shifting consumption patterns over time by providing an effectual spread of mobility choices which are designated not by governance alone, but by the usage models of citizens; whose needs are understood by collective data-sets, otherwise known as ‘big data’.

*How can the use of big data in the management of urban mobility influence future planning of sustainable urban developments?*

Definitions

Big Data: is the term being used to describe a wide spectrum of observational or “naturally-occurring” data generated through transactional, operational, planning and social activities that are not specifically designed for research.

Smart City: Difficult to define, but by UN definitions, a city that uses ICT to improve quality of life for inhabitants.

Sustainable Development: Brundtland Report: "Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Urban Mobility: Ways of moving through urban spaces- by foot, cycling, automotive transport.

Urban Transport Network: Includes: (1) Collective transport like buses, trains and ferries; (2) Urban transport infrastructure like streets, avenues, sidewalks; (3) Road transport like highways and roads.
Questions

1. What kinds of urban mobility are you working within your line of consultation currently?
2. In what way are the types of urban mobility you’re working with tied to either local government or private company objectives?
3. What is the role of the consumer in your line of work considering urban mobility?
4. What links do you see between management and planning of urban mobility strategies?
5. What are the biggest barriers to your professional consultation work in regard to urban mobility?
6. Does your company participate in any events to share and compare your visions for the future of the city which major future goals for Sweden, Europe and even the world?
7. Do you work with certificates or other assessment tools that enable you to compare your work outcomes with worldwide accepted practices?

Other questions

8. What kind of data do you use in your line of work?
9. Where this data comes from? Do you use national census data or does your company owns sensors or hire researchers to obtain data?
10. What kind of time scale are you working towards?
11. Do you use or intend to use data from mobile connected devices from people’s mobility behaviour? Do you think this could be a disruptive innovation comparing to the way things are done now?
12. What are the biggest barriers in your professional consultation work in regard to urban mobility?
13. Which part of the procurement process do you normally work with (planning, delivery or management)
14. Do you use any worldly or nationally accepted manuals that define the guidelines for supporting your planning/design or operational analysis?
15. What links do you see between management and planning of urban mobility strategies?
16. Do you receive feedback of previous works performance and work based on previous results, or are the projects are made independently?
17. How do you see road spaces changing in the future?
18. What are the biggest barriers to multi-modal transport?
19. What role do you think urban mobility plays in the livability of a city?
20. What role do you think technology plays in solving urban mobility challenges?
21. In what way is your working considering the human factor in urban mobility?
8.1.1 Interview Document 1 – Head Strategy and Business Control Sustainability

Interview 1

Private Company – Industrial Transport Manufacturer

In person interview, Company’s office Stockholm, Sweden

Thursday 18th May, 09:00

1. What kinds of urban mobility are you working with currently?

One part is about corporate mobility, with employee’s transportation from our factory’s city centre to the site and inside the company site, between different buildings. The other part of the project focus on futuristic projects involving autonomous vehicles, to learn how that can be implemented in the public transport.

2. Are they like existing experiments?

No, the experiment is similar but using large buses instead of small pods.

3. How do you get to that projects? Was the initiative based on taking out the cost of the driver to enable a better service?

Thinking about autonomous vehicles and taking out the driver, that of course was not going to happen tomorrow, that is a few years away. Right now, this is being tested in the factory’s city. The idea is that it would make the traveling to and from work more efficient, which will attract more employees to work, outside the city centre, because the public transport in the area is not very good, so we can make to work at our company more attractive as we can provide transportation to and from work, we should minimize the time it takes to go from different meetings in different buildings, creating a more efficient working day.

4. How are these initiatives related with the academia work?

Academia is involved in research, they made a survey where they had interviews with around 1,000 employees before we launched the service. These are being analysed now, with results to be released at the beginning of June and a follow-up after the summer to see changes in the travel behaviour as an effect of this service. The project is divided into different work packages, and academia is related to the package related to the analysis of travel behaviour.

5. What are your relations with the Government and policy-making in Sweden?

Not more than the informational level. We are having some discussions with the municipality of the factory’s city to present what we are doing, and they are interested because they think the traffic situation in the South of the city is not that good and they want to understand if our company’s solution could make this situation better, but we are more on the discussion level. We don’t need any permits or those kinds of things as we are driving with our own vehicles and inside the site.
What is the role of the consumer in your work? Do you have feedback from them?

We have three channels to communicate with the website which is a more static way of communicating with people, that need to go to the website and read. Then for more dynamic information, we have push notifications in the app, where you have more urgent information. And inside the app, there is a function that you can send a feedback through an e-mail.

We got 10 to 15 e-mails per day, involving around 200 people. There is a chain of support that works for solving the claims, correcting problems in the app or analysing the improving proposals.

Do you want to expand that service to the municipality?

Not sure about that, we are not directly targeting the municipality. Could be, as they have employees too. But it is more about the construction of a dialogue to show that we care about the users, that we take their feedback seriously and we can also get some proof of what people think about it. And in the long term, this could be used for us when approaching other companies with the same solution.

There is a possibility of selling these services to other companies?

That is the idea. In the factory’s city, we have our own system, that is quite easy to operate that and quite a suitable site to start. But sooner as we prove that we can do it, then the idea is to have a business to apply it to other sites and companies.

What are the main barriers right now, that you are facing with the launch of the service?

There are different levels of barriers. You could easily spend a lot of money in this type of system because there are always things that you can make it better, you can add functions to the app, additional vehicles, bus stops and those kinds of things. It’s always a trade-off how much money do you want to spend and how much will you get out of it. It’s a bit of a balance right now to see. We had launched the first version and how far do we want to go with versions 2, 3 and 4 and so on. Added features in the app, added services to users and so on. Hypotheses that we are working with is that we want to increase the number of users of the system, course it comes down to each of the individuals to see if they are ready to instead of taking the car to this meeting go by this service’ system, it is also about marketing and then also to prove that it is functioning well. We have a lot of companies on our list that we approach now, to see if they are interested or not. And of course, until we have not the first customer, then we still have not proven that it is a good business to do and if there are companies willing to pay for this kind of services.

Are you planning something with the Government for autonomous buses? Is there any interaction to set the guidelines for the future?

If you want to run a bus line in Sweden or the most parts of Europe, or if you also want to use it the public system, you will automatically have to deal with the authorities and municipalities, because it is how the system is set up. And we are discussing this because we're coming to understand what type of infrastructure they have, roundabouts, how does the bus stop look like, how do you merge the bus into the traffic, manoeuvrability, connected traffic lights, because the bus will not be able to see if it's red or green, so you need to have a digital signal instead.
11 Has the government shown to be open to this change?

In the municipality level, I think they have realized that they need to be open for it, otherwise they will not be able to have this type of buses and municipalities want to show that they are in the front when it comes for innovative solutions for the people in the municipality. So, they are forced to do some changes in the infrastructure to make this happen. And then on a government level, there has been some statement from the government on how we see it for autonomous vehicles, it was 3 months ago and big team with a report of more than 1,00 pages, but more in the generic level. We need to have detailed discussions with the people that are doing the traffic planning in the municipality.

12 Do you gather data from people or apps, to project consumer behaviour?

It is possible to do, but then you have the problem of how you will handle personal data issues and GDPR regulations. We could do a lot of things, but we do not do it to respect the GDPR rules, and that is something that we are discussing, how much information are we allowed to get from the users. There are also some successful examples, you know about the Telia, they have a system where they can investigate the travel behaviours for all the people in certain area, that has a Telia subscription, and they have been able to do it and the data it is anonymous, so they can track how people travel, where do they start, which time of day, and they can really understand the flow of people move and then are able to manage that in an anonymous level, so there are not infringements on GDPR regulations, that is something they are successful in doing. Since they are the mobile operator.

13 And then you can get this information from them?

You can have joint projects, or you can buy this type of information.

14 Do you have a projection for when autonomous buses as public mass transportation vehicles, will be running in the streets?

In Kista, autonomous pods are already running, and big buses will follow. I cannot say exactly when, but it will happen. The question is that how well they will be receipted by the ones running the systems and the travellers. And then you have regulations, but for the fully autonomous level, you will need to have a completely different legislation. Who is responsible if something happens if there is no driver onboard, etc. There is an unpublished roadmap for the group Drive Sweden, they say that around 2025 this change will happen.

15 And then, till there the issues evolving the accessibility and use of data can be solved, making it easier?

There is a lot of data available, but the question is how you can handle it when it comes to the questioning of personal integrity. It is also about the availability of data if you track one of our company’s buses you will get a lot of data, but the question is do we want to share it with others? In the case of public transport in Stockholm, you need to share a certain amount of data, and there is a lot of data that we do not want to share because it seems as a competitive advantage.

16 There could be an open platform where companies could share the data somehow

You have platforms like Google, with enormous amounts of data. It could be made available but at a certain cost. In the case of public transport in Stockholm, the different transport operators, SL, SJ and Nobina, need to share data, and that data needs to be available. There are services and apps attached to that, not only made by the operators. And SL also makes available the data from the purchase of the tickets.
8.1.2 Interview Document 2 - Research Engineer & Project Leader

Interview 2

Academic Institution

In person interview, Academic Research Offices Stockholm, Sweden

Friday 4th May, 11:00

1 What kinds of urban mobility are you working with in your line of research currently, and what perspective are you interested in it?

We’re mostly concerned with self-driving vehicles and pods, which are vehicles which take 8-14 people and how can we integrate shared pods with shared electric bikes and electric pods options.

2 In terms of looking at self-driving pods and cars, are you more focused on technical aspect? What aspects are you looking into?

I am working in the system and societal level. But we also look at sensors information. We put sensors to orient autonomous vehicles’ technical setups and to do user studies. But most of the projects we are involved in are about what will these new mobility services offer, on a service level, and their impacts on policy or business level. Also, about the high-impact level on how it will change people’s behaviour.

3 What are you finding of the main themes that you’re dealing with at the moment with particular with Mobility as a service, or barriers you’re facing?

The main challenge is about policymaking and governance adaptation. It is policy demanding to put self-driving pods on the streets. However, we have made big progress already, there was a bigger challenge maybe a year or 2 years ago. Recently a report come out, in May 2018, which facilitates the guidelines and framework for what kind of new laws should be made. On the other hand, though one experience of putting a self-driving pod on the street, we have learnt a lot from an experiment made in Kista about what problems and challenges we might come up against. So, I think that is what we have overcome. Current challenges are mostly involved in taking a small pilot project and scaling it up. We can measure something around one vehicle, but it is difficult to make any estimates of how that will behave in a larger context. So that is one of the challenges now, how can we scale things up to make any estimates. Is it something industry should do already, or is it something we should finance in academia?

4 So, in Kista, for the pilot program, what were the main findings there?

There is not disclosed results.

5 Up until now?

What we learnt from now is that people learnt the befit of it, but maybe didn’t see the use of it for their daily routines.
6 And what was the system based on? What types of data did you used?

The data was on a survey base.

7 Was that a survey through an app?

No, it was an organized survey. There was a pool of 500 people and they were repeatedly questioned during different time periods, and then asked throughout the pilot project.

8 So, this service is available for everyone in Kista?

The service is open to everyone, and it is free. So, it means it is not a part of the public transportation network. So, it is a kind of hop on hop off service and has been used almost like an attraction.

9 What are the kind of mobility you are working with? Are they tied to government or private companies?

Mobility management is organized centrally in the Stockholm Municipality, which is partly governmental. It assigns or chooses different operators to work with. We do work with the municipality also, but most of the time we work directly with the mobility operators themselves, who take the lead. So, we provide discussions and work together.

10 And you work as consults to them?

No. The project I am working with it is a platform from which we aggregate different departments and to get into touch with the other partners or municipalities in the network. So, we provide a platform and discussions for them in a place where industry can come together and discuss projects, but also to attach research questions to that for academia.

11 Could you describe the project you are working now?

This project involves different industry partners and government, where they can demonstrate and showcase what they are doing and what kind of projects and research they are involved in. It is important to bring together and synergize the ongoing activities, so in these discussion sessions we discuss that what is going on at the moment and see how we can combine it to work together towards a more integrated mobility. But the involved ones are mainly working in their own verticals.

12 What about the role of the consumer in the project that you working in?

The consumer behaviour is not so involved in the dialogue we are having at the moment. The consumer has the role eventually, as consumers of the products and services we are making. But they get involved into a later stage, often when we talk about research.

13 What do you think they role will be later on?

Until now, it will be mostly about testing. There is not collaborative design.

14 Do you think you’re missing the consumer in your work process?

It would be interesting to explore if it is beneficial. As we are talking about practical problems of public transportation and consumers are very much there, it would be interesting to see if they could have a role early on in the process. But there are also the practical questions of who we can involve in these processes.
Who do you think would even be the facilitator of bringing people in?

The academia has chosen to take on that role. The academia takes the role of combining the partners often in projects in Sweden. I do not see industry doing this, but academia and non-for-profit organizations are doing this.

Why do you think that is?

The industry is more concerned about keeping its strategic secrets before sharing its innovations. The academia is more open to that.

So, industry is making money from their ideas, but in academia, your finding comes from a different source?

Yes.

There not any public sectors or non-profit organizations that are studying this also? So, they connect with the academy also?

I would not be able to know all of them, but there are a lot of organizations and initiatives organizing conferences and seminars regarding mobility and often, about sustainability mobility incorporation. Those are platforms where people meet. They also invite the academia to present on relevant topics.

In the project that you're working on a particular, do you see a link between the management of the management of the mobility system or the network and the potentials for that same kind of information or data to be used maybe in planning or to be taken by another group who’s more involved in the planning process?

Yes. A lot of the things we are looking at affects infrastructure and how it is given shape in urban areas. Also, in terms of efficiency and optimization, we are looking at how these shared vehicles can complement existing transportation and nodes. And a very important parameter in that is how the infrastructure is shaped. And also, how are the flows of people in the city.

When you describe how infrastructure is shaped, do you mean the physical architecture, or the IT architecture?

Both.

What are the most important characteristics of those systems: flexibility, a strategy of structure, adaptability...?

The digital infrastructure needs to be very dynamic, because it is still changing quickly. It has a lot to do with what kind of infrastructure, but there are new technologies coming in very rapidly. So, the digital infrastructure needs to be adjusted and adapted to these new technologies, maybe with the replacement of the existing infrastructure elements. We are starting to look at how the digital infrastructure and how the mobility flow will adapt to that changes. With digital virtual copies (digital twins) of environment is possible to be quick in adapting certain settings to see if a different set up could work, though digital simulations. We also incorporate that into the digital platform we are developing, so you have both the digital and real-world platform, in the virtual world.
Is there a data format or structure that will not change so much over time? How can you say to a company that they need to invest in a technology that can be easily outdated? Are there elements of data that can be timeless (standardization)?

What we are developing is quite innovative. We see the real potential to it be an accessible way of measuring performance of mobility system and their impact on the physical environment.

About standardization, I will make a comparison to web development, where there are some formats that have existed for quite some time, have been used quite often and are integrated into new technologies. However, the potential of new technologies is often limited by the existing data formats of this infrastructure. It might change when we come to more neurological based computer process, which are more adaptable, that maybe will enable data standards. But then we are talking about a time horizon of 10 to 15 years (speculation).

A lot of it depends on the standardization of computation, but also on the standardization of communication between vehicles and infrastructure. So, in that sense, what you need is to bring together a consortium. Within computer standards IEEE have lead or bring together a lot of important players in order get this standardization. We should see something similar to this within transportation and mobility, because we are also moving toward that kind of digital environment.

This is more influenced from industry, to be able to address computers beyond country boards. And what you’re going to see with mobility is the same. Maybe the EU can take a lead in that, they already did it with the GDPR. So, they provided regulations on privacy data and there is an opportunity to the government to do something similar, but I think it very much depends to the model that will be applied here in Sweden. That has to be with government and public organizations together.

For example, Singapore is different to what you can do in Sweden, Sweden is bottom up to the industry while Singapore sets its goals and impose them top down. It’s interesting that it’s coming from industry, since they are the ones seeing the potential in it.

It is hard to understand the complexity and all the factors involved in the physical infrastructure in the project I am working on. And I think that what is missing is a lot of research, that they only highlight the changes and effects from a narrow perspective. That is of course a start. Therefore, I believe that simulating in virtual environment is already a step forward in trying to understand how mobility iterates into different ideas.

Iterations are a very interesting concept. Do you feel in the research you are doing that the approach of the digital twins is done in an incremental way or the need for change will be dramatic? What kinds of changes are needed to really get this off the ground.

I think we will need big changes. Because currently the base in which the developments are going on the technological side are so revolutionary that the industry behind it will want to push it to consumers. Therefore, we will need to make these big changes. So, technology is being pushed, and we will need to catch up in the physical world.

We are looking at some suburbs in Stockholm and Malmö that are being developed, and they have very different ideas about how to integrate mobility, they are like living laboratories.

I believe a very important aspect now is that you could try it out and simulate how it could work. And it is difficult to simulate the human behaviour, but I think that you can understand it, so, that is the direction that we are going in. We have so much data to understand patterns and then trying to map that, on different environments.
Have you tried to use data from mobile devices, social media or other kinds to compare them with the sensors’ data, in order to identify other patterns of behaviour?

We had a thought to do that but given the regulations with GDPR that turns out to be really difficult. I think it is necessary, because the one data source we have right now will only be from one perspective and will not be enough, so I will be not completely able to understand the whole. So, I believe we have to find some way to collect more data about people’s behaviour without violating their right for privacy, yeah that is a very delicate case study to the even studied.

Our research question is: how can big data influence planning of urban mobility? We think that this question comes from the perspective of practice: how can you innovate data use to plan and what kind of data could you actually use?

It is important to simulate virtual environments by making digital twins in order to ideate. And in terms of data collection there are things going on lot, etc, more and more things are getting smart, but not connected, which is mainly because of privacy.

Although there is a company that are based on making a profit about something called the Innovation Clouds, and their aim is to provide a platform of mobility service by aggregating that data on their platform, so they can sell the data, for example. That would also be a way to centralize data. And they have probably found a way to standardize the data. Maybe they have thought of some rules to try and anonymize the data.

I think that is always the trade-off, the data needs to be anonymized, but it needs to be specific, and you need to be able to identify patterns. And if you have the data, it is key to bind it to a simulation environment.

It is a dual thing, and that is a research question in itself, what kinds of data match these kinds of physical space. I think this is very important because that is the reason why you want to incorporate that big data in the planning anyway, so that you develop companies that want to do that and talk to special audiences, groups or maybe governments because they want to make sure that the people living there like it.

8.1.3 Interview Document 3 – Analyst & Project Leader

Interview 3

Private Company 2 – Engineering, environment, and architecture sector consultancy company

In person interview, Company’s office Stockholm, Sweden

Monday 24th April 2018, 10:00

What kinds of urban mobility systems are you working within your line of research currently?

The company has a long tradition of looking at issues that concern societal development. We are trying to understand the demands particularly but not limited to current and possible future city developments which many times includes sustainability and smartness. In terms of urban mobility, I am looking at smart connected mobility, smart mobility in general not only in Sweden and also initiatives related to self-driving vehicles.
In terms of the urban environment I am at the moment looking into C-ITS (Cooperative Intelligent Transport systems and Services), that among other things ease safer mobility. For example, if we are looking at a self-driving bus, what sensors are around to aid the vehicle? Much of what we are looking at concerns future mobility scenarios which is why we are part of the discussion about shared mobility, and mobility as a service. Many times, people think about Mobility-as-a-Service (MaaS) as connected to self-driving vehicles. Which in part it is. But MaaS is much more dependent on public transportation than its cousin TaaS (Transport as a Service) and the aim is to avoid having to own a car. I am concerned with the question of how to leverage the risk of a rebound effect, an unsustainable situation, if you have more people leaving public transportation for single passenger in a car usage (regardless if self-driving or not). This relates to taxi services and what role apps or car-sharing concepts are having.

2   And then you still have congestion...

We are also looking at Urban Mobility in terms of data gathering. To answer your question, we are looking at big data and looking at how to measure mobility patterns for example with the use of data. There are companies who have come quite far in terms of using Wi-Fi connections en-route. When you use your smartphone for example and connect to the Wi-Fi, one could use that data to see where you are. But it is very important to anonymize that data. That is very important. You are looking at how to trace or in a sense measure mobility which can inform or be connected to urban planning. If you can see for example where people are moving, how they are moving, what the interaction is with the urban environment, then that could very well help in the decision making.

3   That is the link we are interested in our research. From what we have dug up it's too early to know what the exact impact is on planning yet. Are your company working with governing bodies who are interested in this? What about the role of the consumer in this? So, you are to gather data from the consumer, but how that plays into imaging future scenarios of how people are going to live.

An important aspect is to set scenarios. Many times, you need to understand what kind of setting in the future that someone is striving for. You almost have back casting elements in such a setting, in which the back casting involves trying to find the measures you need in order to achieve it, and then we work with that. For example, with regard to data for urban planning, in a 20-year time how will a park be used or accessed? – how are the parks being used now, is there an interest in having them being used now, based on the data we have.

Here we can work with envisioning and making workshops, or even hackathons which is also something we have had. The most recent hackathon was about social sustainability. I mention this because there you have an element in which you make use of different stakeholder’s views, for example when talking about consumer behaviour connected to usability. With anonymized data from people out on the field you could improve where you locate stores and shops. Helping stores to promote themselves better, where to place themselves and their marketing based on how people move. Just looking at the urban setting you might reason – we have our shop here, there is a big highway in the centre, that thing over there is disrupting – all are examples of making use of data in that sense, related to consumer behaviour. But when we talk about usability I’m thinking also in terms of the usability for city planners. How can they make sure our proposed solutions work? If not, totally our solutions these might be solutions we find and suggest. So, it’s also quite a lot about connecting, what I would call, the macro with the micro and the meso level. All those levels. And that’s quite important.
To mix them up... Do you find there are ethical conflicts between what companies want to produce, and what public space should offer? To what point are they open to suggestions that may impact their production expectations for the future?

There are so many examples on a meso level, companies that want to do this and that, and think that it is just about producing an app and then everyone will use it, but no. There are many examples in history of attempts via new technology which have been falling short – not reaching critical mass, not promoting enough user uptake.

Many times, when that happens, and it happens a lot, it may be about open data. There are many times almost a naive view of the openness of data. That all data is available, there is no problem in using it, it just takes collaboration since we have everything available, we just co-create and that’s the solution, but that is not always the case.

Sometimes it is not always good to co-create in that way because you have your particularities, you have your way of doing things that work well. The ethical issue can also relate to, if we keep in mind the micro, macro and meso level, for example on a micro level issues of integrity and the civil society – you must respect them, in terms of privacy issues, which also goes for the companies. On a meso level, it can involve what I call ‘reflexivity’, the way of reasoning over your actions. In terms of co-intention. That you try to see the same worth among stakeholders to pursue something, give or take and willingness to compromise if needed. I think the intentions should be as honest as possible from the beginning. I think many companies say they are going to do things, but they have not really thought how to do it and more importantly why they are doing something.

In the past when you were doing statistical analysis based on a small sample. It was easier to make these kinds of projections. Now there is so much data, but do you think the car is a solution? Where will be the breaking point?

This is something we have been looking at, roles and responsibilities for different services. For example, what you mentioned about a Swedish transport manufacturer when you have a service that is intended to maximize the profit for your company, based on a lot of qualitative studies and interviews about business models and means on interoperability and views on interoperability between different stakeholders. One role which is extremely important that we have seen, in terms of urban mobility, has been the role of road authorities or road administrators: how much should be their responsibility for installing new technology, 5G, sensors, in tunnels for example? There are so many scenarios – is the telecom industry or is it third party or OEM: s (original equipment manufacturers) who have the responsibility. If we are going to share the responsibility how do we do that without having the development “fall between the chairs” so to say, in which nobody does anything.

You have many cases where you have responsibilities towards society to provide for a working service but also an inclusive service in order to ensure equity, smartness, and in the long run a more sustainable transport situation. That is something we are finding a lot of in current questions about urban mobility, shared mobility scenarios, and in terms of roles and responsibilities.

Usually here in Sweden who takes the initiative for policy making? Who in the government is interested to make patents to help with this kind of development? To guarantee that companies’ development does not cause troubles in the future. What are the lessons learned?
We have for example the Swedish innovation authority, Vinnova, and institutions in general that strive for innovation. These are more and more promoting triple helix, even quadruple helix approaches for innovating. I think it is good to involve stakeholders from different areas. The Swedish government have been good at promoting a focus on collaboration between not only academia, industry, government but also civil society. As mentioned before collaboration might not always be easy or even good, particularly if there is a lack of co-intention. It would be good if there was more evaluation of all the projects that are facilitated by the above programs. There is a lot of incentive to talk about what you should do, and you need progress, but we also need to stop and reflect on where we are going and why we are doing what we are doing, have someone to stop, read and evaluate what has been and is being done. We need insights based on lessons learned. That is also a part of what we are going you could say. For example, we are looking at the EU commissions ITS directive from 2010.

We are evaluating how IT technology, motorway control systems, management systems have been and currently are being developed and how ITS related measures should be deployed that might improve them the mobility and transportation situation – such as to cut down on CO₂ emissions, having less fatal accidents, and getting the traffic to flow better. ITS is part of the four-step principle. Steps that you need to take before you build new infrastructure, hard infrastructure. The first two steps involve looking at how you can make the existing infrastructure more efficient. That’s where ICT and information related technology have become very important. If you can, for example, make use of one vehicle and have four people inside it instead of one person via IT or ICT related measures that’s an example of ITS. MaaS is one such example and we both exploring and working with those types of measures a lot. There’s a lot of evaluation of for example cost-benefit analysis, socio-economical assessment, ex-ante, ex-post analysis there’s a lot of governments putting a lot of money and effort into deploying these measures. We need to evaluate all of this – did they lead to less accidents? Did they promote shared mobility services? I am involved in that and I think that kind of evaluation is needed for other developments based on triple or even quadruple helix projects.

7 And do you think they should be held accountable for delivering on promises (development of triple helix projects)?

I think ‘failure’ can be good too look at, at least for a study on lessons learned and what happened. I think it would be good if such reports would be openly available. Maybe have a database that is available for everybody.

8 What about sustainability assessment tools, like LEED and BREAM. Are you working with those, in terms of urban mobility strategies?

I am not working with these. We have a group responsible for that, who are part of our company. We have many different people with many different backgrounds and skills – engineers, IT developers, statisticians, cultural geographers, architects, sociologists, ethnologist, the list goes on. Many works with statistical analysis.

There are many people working on social sustainability issues. Something you have in the transport sector also. When we evaluate ITS measures nationwide we are also producing reports that say, this is working, and this is not working. So, you could say our reports are a kind of certificates.

9 In the beginning, you spoke about working with making cities smart. Could you explain a little more about how your company define a smart city?
One definition I use is that a smart city is a city that make use of all the available data in a smart way. That definition is more operational at least for me. Making use of data that can become information. Looking at smart transport development. Since it is not only the city we want to focus on but also for example the countryside. With the smart city you have a lot of talk about density and densification, which has prompted the view of an opportunity to get sensors to make a city sense more and connect with all that technology that is part of a smart intelligent infrastructure. We are of course looking at that. But the smart city is also about signalling systems. And this is a very important aspect which I believe is a bit not looked upon. For example, when you talk about MaaS, who about the signalling systems and infrastructure (hard) how will it support this software app-based platform out in the traffic? Should for example traffic lights have a special programming to permit ride sharing, increased multimodality? Should we build special spots where you can pick up people who are part of a MaaS service? That is just an example of how you have companies that are looking at infrastructure to develop it in a smarter way.

Which is more the hard infrastructure, but it is very much connected to behaviour, and needs to be developed in tandem with behaviour and information practices. We are looking at both perspectives you could say. Because as I mentioned before there are many who develop technologies thinking that this is just to make an app, and everything is solved, but there are so many organizational and management issues connected to policy, planning and governance that need to be addressed to get the critical mass, and the uptake to get it to work. Not to mention cultural practices, business models and design issues.

10 Usually, the companies that look for suggestions, also look for feedback about the projects that are already built, to use this behaviour for their new projects? Do they look for feedback from planners through you, or by themselves?

There has been quite a lot of companies asking if we have experience doing this and that. But I would have preferred to talk to the ones in charge of the project. I want to avoid generalizations, and that is one issue. When you have these companies approaching you must try to figure out if they are genuinely interested, or they are just trying to get a new project. You also might need to look what happened before a project, and after the project. I think you also need to look at the effects it might have had. What happened? Did people continue to use the service or not? Did a measure within the project lead to a more efficient use or not?

11 But if we imagine that people will look to share their cars in the future, will they? What is the real behaviour of people? Maybe in the long-term future they will, but midterm or short-term future, what will the process of change be like? How could the structure of the city be built so people are nudged?

What you want is that your service is being used continually in order to reach necessary user uptake and in many cases a critical mass. How are people reacting to it? Will there be an uptake of the service? A smart information service you could say for smart mobility. For example, integrating social media likes or networkable things in a smart travel planner, regardless of being web-based or in the smartphone.

12 What can you “like” in a planner?!

An example, you can look for where you want to travel, and you can see that from your point A that maybe point B can be divided in different modes of transportation and maybe you are willing to use a bike most of the trip, which is healthier and more environmentally sustainable. You could then share that trip planning with someone else, such as via social networking media. An important issue for increasing the use of a service, the promoting via different networks.
The power of networking and sharing. But it needs structuring and one needs to be aware that there are many behavioural and preference issues to consider when designing such functions.

13 And so, you spoke a little about the structure of the city, and how that might change, in terms of hard infrastructure. What do you think are the barriers to adopting the infrastructure that is already there?

Well, there are pop-up places, not sure if you have looked at that, like for example in New York, USA. Areas where previously there have been a lot of cars they have had a discussion, no more cars on this street, and instead they close the streets to cars and put a food market there which attracts pedestrians, bicyclists. There are many of those initiatives happening. We are talking about repurposing existing infrastructure. Part of that is what we are looking at with ITS measures and the four-step principle but it is also about re-imaging how you could make use of existing infrastructure, via discussions, simulations, augmented reality, virtual reality, etc. You have a plethora of different solutions, different scenarios. In terms of mobility as an example, you could have ride sharing where you sing songs together. There are so many ways of promoting smarter uses, and more efficient use of existing infrastructure.

14 And then if you take the parking spaces away you need to put more money into the PT network to compensate. Sometimes people do not think with this macro look. And this causes a problem, a rebound. People will start to use it for a brief time, and then they get their cars back, and we will have a parking lot that is far away, and it will be more expensive.

Exactly, but it is also based on modes of transport that are trendy now. For example, the hipster culture where you have bicycle use, and environmental friendly consumption. Where everyone wants to be sustainable. You see a lot of it I those pop-up places in NY. There is a lot of that in Portland, Oregon, SF, you have young people who want to be hipper and things. Then companies cater to that. For example, craft beer brewed there which is IPA and they pop up a place. It is part of consumer behaviour, when you can make something attractive that is sustainable. I think that is good. Being vegan etc., buying second hand. Those are also fashions that are happening. The moment now we are seeing that it is becoming more popular with the sharing economy. All of that is very connected to be blunt, bragging culture, attention economy. I mean in the worst case. Of course. There are people who really believe in it, but there is a large sector of people who do it because it makes them look better. But it is a powerful force. And it is; good to cater to them, well you have the power of consumption. For example, a building owner, or road authority will be more open to pop-up places, or these softer measures around what you could call more grassroots initiatives. IF they see, wait. This makes us look better. We can put a label here. And, that this could also be good for the city. The community parts.

15 Profitability and density based on old statistics. In your company are you working with companies who are working with these new types of data?

The short answer is yes. I can’t really go into further details.

16 Do you have examples of that in the suburbs too?

For example, there was a household, a group, where you buy your apartment, we were asked to help them with their bike sharing program. It was cargo bike sharing program. A bike with a large box. We looked at how it was working out and came with some suggestions, particularly in terms of how to reserve it via an ICT based system and service.

17 So, then it really comes from local companies or collective of who are living there? But we need to have more data on who is living there?
Sharing could be a very good way at making more efficient use of what you have. If four people can make use of one bike, that is wonderful. And that’s one incentive to save space, but I think that sharing itself is popular, and in the worst case, solely as a marketing stunt. The question you posed, 1000 bikes and where to put them somewhere, might be addressed by having a ride sharing, or bike sharing scheme, that doesn’t require 1000 bikes but far less. But it really does depend on how you make such a scheme attractive and worthwhile for the residents. Here again enters user behaviour.

18 Then a lot of the owners, come back to the people working on the project to find PPP and having the contracts figured out so that it really does happen.

One might think that transport orientated development allows for a completely car free situation such as not being far from a bus station, the you can walk. But then you have all the people that need cars to drive to work, like plumbers or painters, and they started asking where are we going to have our company car? That is a situation where you cannot answer that we haven’t thought about that. I think you will have at least in the beginning, in many any cases, a need for transitioning, a mixed mode. More importantly, you need all stakeholders as part of the discussion from the start. And you need a means of reflexivity: we have this building, who are living in it, what are the needs of these people? What are they saying now, under different situations, in similar places? We could say, no cars, but then you could get a lot of problems if it’s not done in a smart way, involving the voices of those who will be living in the area.

19 And then what would you say about the role of the data and this reflexivity role?

I think one needs to be conscious that consumption is not as straightforward as one might be led to believe. We need to both understand and make it possible for stakeholders to reflect on the consumption or usage of data, how it relates to a particular social context, and on many levels.

8.1.4 Interview Document 4 – Head of Research Department

Interview 4
Academic Institution
Online Interview
Monday 30th April 2018, 13:30

1 What kinds of urban mobility are you working within your line of research currently?

I am the director of an academic research centre focused on transport researches. The main topic of research there is to see how new technology can contribute to a sustainable transport system. We work both with urban and all kinds of transportation.

If we focus on urban transportation, at the research centre we work to integrate different types of knowledge backgrounds and field. So, we combine different types of technology like transportation system optimization, automatic control, communication technology, vehicle design, together with user behaviour and looking at system level effects policies business models, so it is really integrating different knowledge and research. And that is quite broad. We have around 20 research projects in our portfolio. So that is one aspect really.
Then if we investigate in more detail into the types of technologies, it is mostly related to electrification and then automation and self-driving vehicles, and mobility as a service (logistics as a service) indifferent combinations of those three main trends (technology concepts) how they intergrade and affect each other.

2. **What are the attributes that make people want to change the way they’re behaving in relation to choosing another transport than the car?**

We are currently involved in research looking into ride sharing for commuting. In a suburban region. Where people would like to travel in a more environmental sustainable manner, but they prioritize their flexibility over any sustainability issues. So, I can send you that paper that we just presented at the conference last week actually. I think it could be interesting. In terms of result. There is another academic researcher at Service Design. She also is an author of the paper and is part of a project based on changing the main transportation mode of a family, where they kidnap the cars from families with kids. Super interesting project.

Digging into the behaviour of people and why people decide to do certain things. They have also looking to academia in subjects more related to using light electric vehicles in a shared setting. But more during daytime, during work office hours. A part of it was in the evenings and weekends. It is very complex question and it should be service that really works, but it’s not enough with only the service being good enough. We are currently working on a project in a city in South Stockholm, which looks at why a person chooses to travel in a sustainable way. But the project is ongoing. We do not have results just yet.

3. **Would you agree there is a real paradigm shift recently in the way there is an urgency to think about what’s going to happen when cars are no longer here, and if it changes the structure of the city?**

Yes, I’m very curious about to see what happens. I agree there’s a lot of discussions going on about how to switch to share to mobility. I’m working on a project about that also. And that’s, we were appointed from the government to create a roadmap for combined mobility as a service, so mobility service that uses mixes public transport bike sharing car sharing taxi, whatever, to be attractive enough to compete with the private car. We were appointed by the government to set up a roadmap for Sweden, how can Sweden make this happen? There is a lot of talk around this. So, in this roadmap, we identified barriers to mobility as a service as well as suggested actions which are now taking place to speed up this movement. From the present to mobility as a service. It is a public report.

4. **When you were looking into the barriers and actions going into place, was there any discussion on self-organization as part of the research. How much of the framework came from a top level? And how much can from a bottom level, is it a possibility for mixed combined to be self-organized?**

It’s important to both understand that MaaS is not one solution that fits all. It will be different solutions depending on who you are and what priorities are, or where you live. If you live in the city or the suburbs or even a smaller village, so it will be different solutions and. Right now, many talks about in smaller villages, like in more the countryside probably it’s more social development, from the members initiatives for them getting together to organize. While in the bigger cities it might be a more top-down approach. But we don’t know now who will take the lead. That is another project which I think could be interesting for you. We made it last year, workshopped development. We invited 40 different experts from the transpiration industry in Sweden and did workshops to identify possible future scenarios for the development in Sweden.
The two main uncertainties in that report were whether we will buy into the shared economy. Or whether we will continue and maybe even develop even more coco-ning individual approach. Not sharing data, being more aware of who has out data etc. And we want to have our own space, at least in Sweden and I think in many other EU countries as well. Everyone is talking about urbanization, but if you listen to the more entrepreneurial, and the ones who are a bit ahead, they are going away from the urbanization. They predict smaller cities or hubs, within a small travelling distance, well connected and easier to move. It is a totally different planning that the biggest cities. I was also last year, invited to an event where I discussed this together with around 100 others of Europe’s leading thinkers, and I was surprised, I went there with the idea that everyone wanted to live in cities and talk about urbanization. But it was very clear that they didn’t want to, they couldn’t see a future in the city. They saw a figure in a much smaller scale.

5 But people will still be living in apartment type housing, or less dense?

Maybe smaller apartments. I think they predicted sharing within the hubs. But really smaller scale sharing. Where you had a chance to have a personal contact with those around you. Maybe an office hub, so you could work on whatever company you wanted. Office hotels. Workplaces you could go and work for a company but work remotely, but still from an office, to reduce travel.

6 You mentioned if we will be really into the sharing economy or will we cocoon. When you reflect on it though working in an office hotel it can feel very cocooning. So, in one way you’re connected but also cocooned.

Yes, I think, I’m excited to see what’s going to happen here. Everyone is moving into the urban areas… but I think there is an opportunity if we talk about city planning to organize it in hubs because it seems like people would want to have that local feeling anyway. Yes, I live in an apartment in a big house, and yes, we are sharing the house and we are sharing the grass and benches outside, but even though, I don’t know my neighbours.

7 About ongoing behaviour. Looking at the reasons why and how they people move around, Elizabeth Shove was talking about the importance of also ensuring ongoing behaviour, so that if people decide to take combined modes of transport the shifts in policy-making are made to allow those new behaviours to really stick. She called it “continual editing of policy”. I was wondering in your line of work and working with the government if that is the way they see how they write policy and agenda here in Sweden.

There are many different views on policies and the role of the authority or the government. I’ve been, last week, also in a meeting for a research project together with policymakers about how it can be used to get what we want from so-called smart mobility, shared automated mobility. There are some policymakers who see themselves in the placed to let the private sector do what they need to do and make the policy in a more reactive way. We take care making sure there are streets and the streets are clean, and then you can do whatever you like on the streets. While others want to investigate how can we use different policy measures to lead the development in the direction we want it to have. And we have this research project that we started in January this year where we are collaborating with two municipalities in two regions and they are really asking us about how they can use policy measures with mobility as a service, and the automated vehicle coming. So, they are more pro-active. But in general, I would say that authorities seem to be a bit reactive, as opposed to pro-active and taking the lead.
There is space for private companies to make & establish services and new ways of moving around?

Yes, but then they are also hindered by policy. For example, the city of Stockholm is not allowed to let carpools park their cars for free on the streets. In other cities, like in Amsterdam, carpool companies use parking places which are for free, which makes it easier for them to make a margin on their services. That’s why we had a carpool company in Stockholm that was closed because they couldn’t get it working. I heard it was due to the high parking fees. There is space for private companies to create new solutions, but they are also very much hindered by old policies.

Do you see a way forward then? In the city of Stockholm do you think there are ways of changing & moving forward with the way people move around the city with the policies that are in place at the moment which also act as barriers to real change happening?

Yes, indeed there are policies which are bad, but sometimes it feels like the development is unbelievably slow. For example, in one of our projects, we have worked a lot for a long time to get new sales channels for public transport tickets.

So that public transport tickets can be bundled together with ride-sharing with bike pools and other mobility services. And that has been a long struggle. Both from a marketing and a business perspective. And, organizational wise, if someone else sells the ticket who will take responsibility for the service level to the customer?

If some information is wrong, or if you miss the last bus who is then responsible? But also due to technical discussions, is apparently difficult to connect different IT systems. So, there are a lot of barriers that slow down the development.

And perhaps some barriers are easier to cover come than others.

In this project that I mentioned, in the areas that we identified, around 5 or 6 different areas to work with, policies and regulations were the main areas. There are challenges and barriers but also possibilities if we can change some policies. It can have a big effect.

There is the possibility to change the policy, so there are some loopholes that people can take advantages of it, might bring down some of those barriers?

I hope to rewrite them. But changing policy is a slow process. Due to several reasons. It’s a distributed management in the public sector compared to the private sector, there is management, and a goal for the company, which is very direct, and everyone can work to that. While in the public sector it’s a much more networking distributed leadership, we have the elections every 4th year, which changes the direction. It’s more difficult to have a clear idea of which direction is really the goal. It should become more sustainable, but depending on who you ask, people interpret that in a very different way. Different politicians form different parties. Different parts of the authorities or, administrations in the public sector interpret this in different ways. It is getting cleaner vehicle’s, getting rid of private cars? Etc.

Do you find research tends to follow trends due to shifts in politics since it takes s time to implement some of these things?

I think the idea is to formulate goals so that everyone agrees regardless of what political colour you have. And that could be done, and that gave us the transport political goals, which are good, but which are fluffy.
So, I think if we compare with Singapore and China, they have a more direct leadership or management, top-down, which also have led to that they are Singapore really are in the front, but they have a lot of regulations, and they have limits on the numbers of cars which can be on the street. If you buy a car, you have to buy a permit to have the car on the street. And those rules are things that could never, it’s very distant that they could be applied in a country like Sweden. It’s just not possible. Because it’s too top down.

But it doesn’t match with how the public sector or can lead the development. So, I think we need to be open to that fact that there will be several types of solutions and that digitalization and data multisided platforms or digitalization and technology, in general, make it possible for us to make specialized services. So, I think we have an opportunity here, but I would love to have a little bit more top-down management, deciding that it’s not allowed to have private cars anymore. But I don’t think that will happen in Sweden.

13  So, the decision needs to come from the people, in their decision-making process...

Yeh, and I believe in nudging in different ways, putting the most sustainable choice at the top, or making the sustainable choices available. Then that’s the bridge operating in a bottom-up the system but requiring a little top-down direction so that something does happen rather than nothing at all.

8.1.5 Interview Document 5 - Academic Researcher

Interview 5
Academic Institution
In person Interview, University library Stockholm, Sweden
Tuesday 8th May 2018, 13:00

1  What kind of urban mobility are you working with in your line of research currently?

I have done two research projects that are finished and then I’m involved in a third one. We start with that one which I’m working together with the head of the research department. We are building a sustainable mobility service system, or we can call that urban mobility. I would talk about it as a mobility service system. It is the concept of a product service system.

2  This system is like what private companies have been doing with their vehicles, offering services attached, to add value to it?

There is a link between the product and the service, and in the case of a transport manufacturer private company, there are products such as commuter buses to take employees from the city centre out to their factory’ site. There are also shuttle buses that move around their campus that are like a taxi service, that you can book if the bus shuttle bus is not suitable. What we have done is put electric bikes as a new type of product in a shared bike pool. The idea of them as a Mobility service system is to develop this service system to be able to sell such a service to other clients. It is a group in this Private Company called Sustainable City Solutions, at were we have students doing thesis work with. Commuter busses availability also influences young people to decide when thinking about getting a job and how accessible it will be, in terms of mobility.
3 But is it integrated with places outside the Private Company’s Campus?

They are just on the site. As there is a culture of meeting people physically, people tend to move a lot between buildings.

4 Doing this project was a Private Company’s initiative?

This private company is part owner of the academic research lab where I work, that is also owned by another private company. There is a long collaboration process. When I did the project where three families with children stayed without a car for one year, we gave them light electric vehicles to use instead. We took their cars (we paid their cars parking) and offered these electric vehicles for a monthly fee. So, some of the families had electric box bikes, some had electric Twizy (Renault).

5 This project was linked with the idea that this private company is developing and with the Mobility as a Service concept?

While we were doing that project, we realised that in order to people change practises, they need to try it before. We need to encourage people to try sustainable mobility practises before starting to think about getting rid the car, they need to get that experience and actually try something. For example, if you want behavioural change from car transport practises to light electric vehicle, we should get people (society) to try light electric vehicles. One of the ideas that came up for that project was that companies could provide a possibility for people to try out new types of vehicles. So, with that knowledge, through the academic research lab and discussions about the subject, I met people and we talked about if it would be possible to do something like this. I run a course called service design, in the master program industrial engineering design. Every year, we do that together with a private company, and, two years ago, we did it with this transport manufacturer private company. We looked together with 48 students the services that they need, and we developed that in a 6-week project. It was the first test at getting more knowledge. Through that, we got to write an application for this particular project as a parallel initiative of this company with the human resource department, to look into how people could be developed within this company. So, in answer to your question it was within this company, but also academia with the research findings.

6 Could you talk more about the try-before-you-buy idea you described earlier in customer relations?

I would say it’s one aspect. There is no silver bullet for this case, as you can have many points of view. The way I see it is that it's not so easy to say that we're going to change the way people behave. There are people who say that we can affect behaviour change, that would be a psychology school of thinking, about attitudes or motivations. I believe we are more structured in a society, where it’s not so easy to look at the individual attitudes. We are also in the situation where practices are shaped by what is provided in a system. And a system is a whole society. So, if you live somewhere where there is no public transport these difference means a lot. I find more interesting to look at the way we do things and the way our practises are than talking about behaviour change.

7 So, could you say it’s maybe understanding the choice architecture?

Choice architecture is still psychology. I prefer to think of it more in a more pragmatic manner, it's the public transport there? Or not? It doesn't, it will help if you just put the bikes there? We have an app, developed with this private company.
You have information regarding these different types of vehicles available. You need to link these physical materials to the digital services.

8 You did a previous study about ride-sharing?

In a previous study, we analysed a group of people ride-sharing habits. They worked in the same building and lived in the same area, so they had a relation to each other. We provided them an app to ride share. I wouldn't call it the choice architecture, I would call it as a system of provision. But the system needs to include, not only the cars, and not just the skill of driving, but if you want to car-ride together with somebody, you also need to have some kind of social skill for socialization at some point. It is not connected to if people know how to ride a car, its more about the surrounding intangible things. This is why some people resist going on public transport, because they might have to speak to their neighbour, and they don’t want to do that.

9 Are there also other variables you noticed in your study, like coming home, and needing to do shopping and other variables that impact in the choice of sharing transportation with other people?

When people talk about commuting trips, they also talk about flexibility. They still only drive from point A to point B, but they want the feeling of flexibility. And then we come to the practise theory. When we deconstruct them, we talk about the skill, but also what we call the shared meanings. While someone opinion over to be flexible is about being time efficient in going on public transport could be affected because it takes 50 minutes instead of 30, other could say that even tough public transport still taking 50 minutes, they might do other things while in it, like reading. People discussion over ‘time’ is an example, these shared values that we have. And this is connected to how we live our lives, lifestyle and attitudes.

10 In Transportation there is a lot of very complicated reasons that need to match before any kind of sharing is going to happen?

Calling them variables or values, not like basic human values but more like value proposition in a design perspective, is necessary to capture user value. Why people choose a specific transport option over another? Because maybe efficiency for them involves different values. I think that you can look at business modelling to look at how you give these various value propositions to urban Mobility systems. And one value proposition is probably not enough, because we all are all different. So, to be successful you probably need to have more than one. So, you have to look at what you are supplying, and which value propositions are we attending and how do we capture these values in the service.

11 This private company think about themselves like a microcosm?

Yes, but we hopefully will do another project where we will do more integration into the service of the municipality. Its starting at this company’s campus, but we can extend it into other Urban spaces.

12 Do you think that’s a model that can be used by Stockholm Stad?

What do you think?
My feeling is that you will always need to address connectivity between the campus and the city. Perhaps at this private company, they have a company bias that in terms of a is more difficult to attend to?
I’m going to Umeå next week for a conference where they are building a new area of Umeå. The municipality is wanting it to be more sustainable, so they are open to understand Urban Mobility.

There are many parts of the system of provision that could be taught when building a new area. In the project that the families stayed without their cars for one year, to deal with empty packaging becomes a major issue to live in sustainable way in the suburbs. Usually you would need to take the car to drive your garbage. And if you are going to promote sustainability you need to think about transporting and getting all kinds of goods to homes. You can get things delivered to your house, whereas if something breaks down, to transport something away from your home is harder.

13 So, there are a lot of rebound effects, if you take away the car?

And then if you bike to work you need to be able to store them safely. Parking the bike is an issue. If you cycle to work it’s not just about parking, it’s about changing, and change lockers, etc.

14 In this Private Company`s project you’re working on now, are you also looking at this ripple effect of the MaaS?

From the research perspective, we are definitely interested in both the work situation for making the work day more efficient, which is the Company’s primary interest. But we are also interested in the whole life puzzle of how you put your work and everyday life together, people would say that they take your car to the company if they have many things to do, and this is not so good for sustainability obviously. It would be better if they used the shuttle busses, like the first thing is using the system that you have there, but the second thing would be between to take the commuter bus, and then the shuttle bus.

15 Are there timetables linked with the shuttle busses?

The white-collar workers have flexible hours between 7 and 9 or whatever the blue-collar workers they would work in shifts.

16 Is there an integration within Private Company though of the larger mobility network?

Their transport options are not connected to the public transport, but that is the next step. At a furniture manufacturer company, in an older project that I did, you used to share a Twizy, available at every reception of the buildings for around five thousand people, where you had also screens with public transportation information. If we extend the project to the municipality, we could connect it to public transport.

17 People change their habits, time between busses, decreases the intervals- how do you address these issues?

We are trying to investigate that, but then we will see how much we can explore that.

18 What kind of interfaces are you working with?

We are working with an app that shows the vehicles position in real-time and also the electric bikes disposal and nearest bike pool.
Have you found through your research if it’s more valuable for people to see the real time location of vehicles, or to see the time intervals between them in a display?

We launched this last week, so we’re looking into this. Also, what we are doing is to get information from the people who operate these busses, through a control tower.

Do you think that are elements of the urban environment that may be more flexible to be changed over time, so parts of the space of the roads can go for cars to bikes and be continuously changed over time.

City planning is a lot about the ratios, for example in Stockholm the number of meters on Main Streets that should be provided for versus cars and pedestrians are regulated. But the allocation of space is a political thing. Right now, there is a prioritisation of pedestrians as a sign from a political point of view. Then if you take it to building places where people live, there is a discussion around parking allocation, how many parking places do you need to build, so there are several examples of municipalities, specific you take the spaces and provide carpools instead.

Yes, they say 5 spaces equals one carpool space.

From a builder’s perspective, you can use the space for selling apartments. But then there for electric vehicles and bikes, how are you going to charge it? And how do you secure a bike infrastructure like where you keep your bike, how can keep it safe, etc.

8.1.6 Interview Document 6 - Statistician and Investigator

Interview 6

Public Transport Agency, Sweden

In person interview, Company’s office Stockholm, Sweden

Tuesday 14th May 2018, 11:00

What kinds of urban mobility are you working within your line of research currently? Do you deal with data from Stockholm or the whole Sweden? About busses, subways, roads or trains?

We are a national agency, so we deal with statistical data from transportation, for transportation analysis for whole Sweden. We have quite many way data. We had interviewed for 5 years or 6 years around 10,000, mostly travelling in one specific day. And the results are in a database, but we can use them for different kinds of analysis. But we have data for all types of traffic like car, planes, trains, etc.

Are you responsible for gathering the data? Or what is your responsibility in gathering mobility data?

We have different types of data for different transport modes. So, we have for aviation and road transport. And we also had a survey on public transport, the medium of public transport. And we collect data from the responsible authorities. We don’t have any sensors or that kind of equipment ourselves. So, we rely on what the operators have available. And we ask them for specific kinds of data.
So, you don’t do the interviews anymore?

We have put the travel surveys on hold, but we will probably start it up again, from next year. And it will be probably based on a web questionnaire.

We have a development project ongoing for last two years, recording how to collect travel habits data. And we have done some tests with using mobile networks and using mobile telephone apps. However, our conclusion is that those techniques are not mature enough, to put into regular data collection. It’s still in the development stages. Until now we were used to using telephone interviews, however, that is, first, expensive and, secondly, it is being more difficult to identify telephone numbers where the respondents are available. So, we will use a cheaper way to collect data and that is through web service, and we will also use a traditional mail survey or questionnaire.

You are an authority assigned by the government, or are you a private company that takes care of these traffic services for the government?

We are an independent government agency or authority. And we are responsible for the national statistics on transport. Well in this regard, the important thing is that we are responsible for the national statistics. But we also do a lot of other studies for the government so that they get the material they need to make good decisions in transport policy.

Do you participate more actively in policy making for urban planning issues?

Not panning really. For that, there is another public agency.

What do you think are the biggest barriers in Sweden during this transition phase?

We will continue with the cooperation with mobile operators, however, I don’t think we have any thoughts about when it will be possible to use data on a more regular basis. Right now, we can only foresee cooperation in development projects, then implementation. Is it about the quality of the data and the privacy issues, that are the main barriers? It’s privacy issues, but it’s also competition between the operators, they don’t want to give anything away.

About the surveys and the data that you get, do you have the freedom to choose the methods and the ways you develop your survey and gather this information or does the government say what they need, and you work towards that? Do you receive feedback on how you do things now and are you are updated on how to give feedback on behavioural data?

There is a regulation that says that we are responsible for national statics on transport and communication. Within that, there are 8 statistical areas. So, there is one for each of the travel habits: one for public transport, one for road transport, and so on. We should publish relevant statics that is needed in society. So that’s really our task.

We should also have contact with the main users of our statics and have meetings with them to discuss both the present statics we publish and how we develop our different statistical projects in the future, to be able to publish the relevant statics. So, we have the kind of meetings with our main users, on a regular basis. The academia participates as well, and they are considered as main users, in most cases.

And do they share their developments for the future, such as pods, models, MaaS, autonomous vehicles? Do they demonstrate any worries about the future in this transition period? Do they ask for different types of statistical behaviour that could be used for their experiments?
The discussions we have with users are about the statistical information they need in their daily work, so I don’t think we discuss in detail the technical development in transport areas, but more about what information they are interested in.

Sometimes quite small developments do push us. For example, when it comes to travel, it’s a real interest from researchers the use of electric bikes. And we find it rather complicated to collect that data from the respondents. It’s not clear what is the impact of an electric bike, we are perhaps holding back a bit because it is important. Those kinds of discussions we do have. It is important that it’s clearly defined what we are going to ask for the respondents. Either the operators or for the population.

The government or the users ever asked for data on shared modes like shared cars?

Yes, there is interest in that as well. We have had questions on that for quite many years. But, it’s still very small. So, it is complicated to get the data on it. And it’s complicated to ask about it. We had a travel survey were people were asked about the availability of sharing their car, if they already own a passenger car or feel if they would lease it through their employer (that's a quite common way to have accessibility to a passenger car), but we also ask if they are members of a carpool. There are a few positive answers to that question. It's a complicated question, because membership, it's very easy to have an interest in a specific variable like that, but it's complicated to define it, so it's possible to collect information.

For the future, do you think having an open platform within these services` data could be a tool for the government, policy-makers and other actors to understand patterns of behaviour that today are not understood?

There is a project commissioned by the government right now which is about data in the real arena. I am only partly involved in that project, but its proposition is to create a platform with open data. And that platform responsible would not be us, would be the transport administration agency. If road and rail networks should be in the open data hat, I don’t know. The idea is to collect different types of data and put it on a platform, I’m not sure if they plan to use sensors, but perhaps. And then the main purpose of that platform is planning for the transport administration. But also, another idea is that our agency could also use that platform to collect data for statistics on a variety of transport. But it is still just another proposition.

We have been seeing that in articles and talks that we had this these last week's, the industry is taking the lead in a lot of new mobility systems, mobility as a service hypothesis to develop new models. And maybe the way you gather the data for your projections as experts is different to the way private companies would go about collecting data. When you develop how you will gather your data you can kind of shape how the results will be read. If the research is guided by the industry you get a biased result?

Yes, they will be focused on their interests, not including the whole country nor whole transportation system. That is our experience with the cooperation with the mobile network operators. Mainly for their own profits. Of course, our interest is to find data. So, then that’s how we work in those when we do cooperate with the private company. I think it is complicated, we must compromise. But many are interested to cooperate with us that’s for sure. Cities, when want to implement carpooling, could offer free parking or some other benefits in exchange for having the company’s city data. So, the city can use it for urban planning purposes.
There is not something we do, but you could put up some conditions on both sides, so if you get this, we get this in exchange. And then you can get more useful data for this.

I guess because we are in a transition period, solutions like these are being developed. These talks will happen more and more between companies and government, to find a better way to work.

I think it is already possible in development projects in a couple of years, but after that, they need to open. We’re creating services about mobility as a service, creating a different kind of services through that way.
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