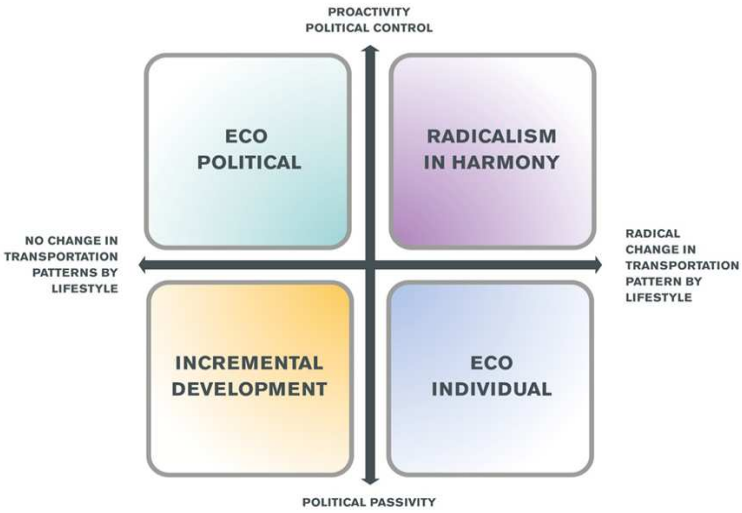
Final report of the Pre-study:

SEVS for Autonomous Drive



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Inhold

1. Executive summary

This pre-study has used a set of tools within the process The SEVS Way to identify potential effects from autonomous drive concepts in relation to the Swedish transport political goals. The SEVS Way, which is a workshop based process, has earlier shown to be a powerful tool for multi-disciplinary teams to work cross- boarders in a structural way, but also a powerful communication tool that facilitates the inclusion of new stakeholders along the journey.

The work within the pre-study has been performed through a number of work packages focusing on:

- A driving force model, which is a very useful tool to find the mechanisms and driving forces which determine how AD influences the society.
- A scenario methodology, with further developed scenarios that consider an AD-environment.
- Use cases that describe the daily agendas and movements of actors and goods. The use cases should identify barriers and opportunities with autonomous vehicles (stage 4 and 5) in order for the actors to carry out the daily activities, and for the goods to be transported, delivered and picked up.
- Methods for measuring and estimating effects related to AD, and how such concepts contribute to the fulfillment of the Swedish transport political goals.

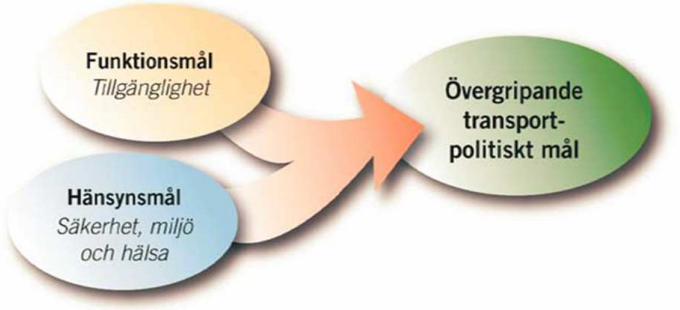
Results from the pre-study include:

- The driving force model used in the pre-study is a good candidate when analyzing effects of AD. The outcome is just preliminary results which can be used as starting point for other investigations, but should be used with care until they have been further verified.
  In addition, it is important that the driving force model is only one of the tools in the SEVS analysis of societal effects of autonomous drive. It can identify important driving forces, likely effects and explain why and when they are likely to happen. However, an analysis of how likely these changes are will always need to be based on deeper analysis of critical mechanisms. One example of that is the *use cases* and *transport selection analysis* which are necessary to analyze a very critical point in the driving force model, namely how the user needs, preferences and possibilities will influence what transport solution will actually be chosen.
- The use cases for goods movement have been prepared in broadly the same style and following a similar methodology to those prepared for personal mobility. This is to help in understanding the interaction between personal mobility and goods movement which is likely to be more significant as AD develops. In addition, it allows the two overlapping systems to be considered in a similar way which is helpful when trying to understand trade-offs and changes that arise from trip substitution (a personal mobility trip is replaced by a goods movement trip). The interaction between mobility and goods movement will be followed up in more depth in the SEVS 3 for AD e-commerce project that started in late December 2016.
- Existing work looking into potential effects of AD-concepts is dominated by studies focusing on user expectations and system simulation studies. This is natural since few (hardly any) autonomous vehicles are on the roads for users to test at the moment.

- Three main factors that impact the transport political goals for the use-cases in the pre-study, were identified:
  - Transport choice. I.e. does the AD-concept induce different choices regarding transport modes? E.g. a more comfortable car solution could increase car use.
  - The amount of transport and impact on congestion.
  - Vehicle functionality and operation. Vehicles can be tailored to fit certain needs better and operation can be optimized, e.g. regarding speed, or regarding usability for disabled drivers.
- Methods evaluating effects of AD-concepts need to be able to handle both technical aspects and performance of vehicles and systems, as well as behaviors and perceptions of users.
- By working according to The SEVS Way methodology the pre-study has followed a structured process and been able to handle the complexity both on a Macro system level as well as on a Micro level. The SEVS components created a model of different societies (scenarios), in which we let a specific actor interact with different mobility solutions in its context (use cases), and analyse in depth if the system solutions fulfil the functional and consideration requirements on a micro level (customer) as well on a macro level (The National Transportation goals).

2. Background

The UN adopted in September 2015 the new global goals for sustainable development in the period up to 2030 the "Sustainable Development Goals". These objectives also include the transport system and its contribution to a sustainable world. For example addressed in Objective 3.6 Road Safety; *"halve the number of global deaths and injuries from road traffic accidents"*. Similarly, there are targets on other aspects of the transport system in sustainable cities and communities, such as target 11 to *"Make cities and human settlements inclusive, safe, resilient and sustainable"*, more specifically, it is stated in 11.2 that *"By 2030, Provide access to safe, affordable, accessible and sustainable transport system for all, Improving Road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situational, women, children, persons with Disabilities and Older persons. "*. Essential to these total 17 overriding objective is that they should be seen and addressed as a whole, a system perspective. The Swedish transport political goals for a sustainable society fit well with this approach.



Great hopes are tied to the potential of automated transport and transport systems and their ability to lead to an efficient transport system, reduced environmental impact and improved

road safety. But society needs to take an active role in stimulating and evaluating which solutions and business models that could benefit many people and lead to a sustainable demand. In order to steer towards this and the overall sustainability objectives, including industrial growth and social development, necessary tools to understand the effects on system level need to be developed. We need to analyze the effects of different societies and understand the driving forces that enable or hinder the effects that occur. It is crucial for the ability to draw conclusions on a societal level that we can manage complex systems issues in a structured manner and to take into account the underlying driving forces. Only then we can take the right decisions that govern the transport policy objectives and other societal goals. To be able to measure effects on the societal system level, driving forces must be identified, understood and described; this is what this pre-study is about.

In recent years almost all major automakers and even many technology companies announced investments in autonomous drive (AD) vehicle fleets; including Scania, AB Volvo, Volvo Cars and Uniti AB. The most common arguments in favor of the introduction are higher road safety and increased transportation efficiency, areas where Swedish actors and parties in this pre-study have high credibility and reputation. In many cities of the world there are several test and demonstration projects with autonomous fleets of goods and / or people planned or ongoing. Sweden and Gothenburg are well advanced with e.g. Drive Me. Most of the demonstration projects have however a technological focus and is seldom about the societal aspects, social impact or effects on the need for transport. (In this pre-study we have included the Drive Me project in our use cases).

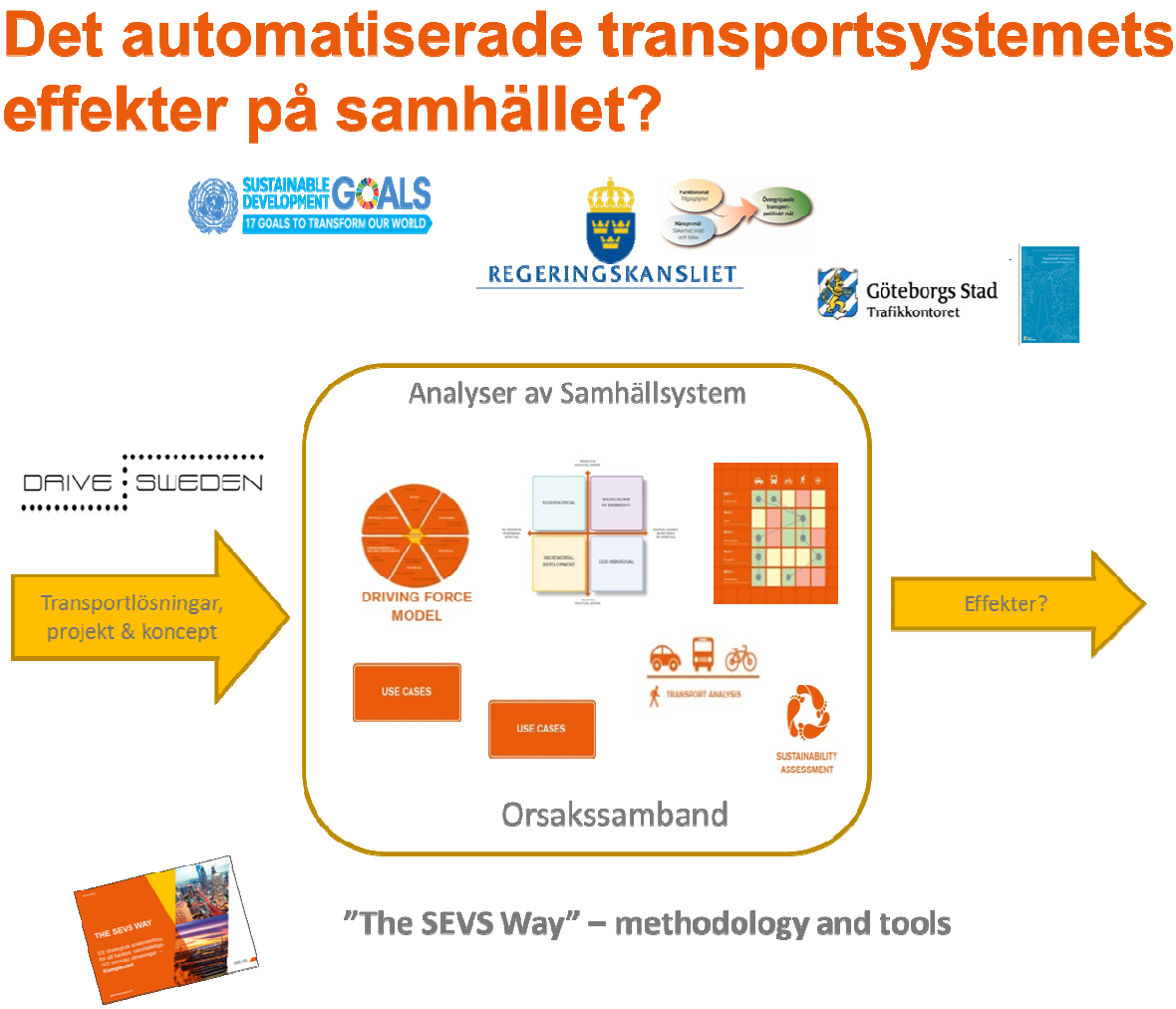
The ADs effects on the societies are an extremely difficult and complex issue where no single part has the answer. As with Electro Mobility solutions, the AD solutions for goods and people must be placed in its context (the societal systems) in order to obtain accurate values of its effects. In SEVS[1] phase 1 (The Electro Mobility Journey", a FFI project with 18 partners from industry, academia and government), we could show that the same EV Solution gave different values on emissions, efficiency, economy and safety depending on the type of societal environment (infrastructure, behavior, policies, etc.) in which the vehicle appeared. It is very likely that this also applies to different types and degrees of automated solutions, and that is why it is important to identify and understand both the direct and the indirect effects and their connection but also the societal context (scenario) in which the solutions will be implemented. That is why we have used the process called The SEVS Way both as a working methodology but also as a powerful communication tool.

3. About the project

The characteristic of a SEVS-project is that no single actor can solve the complex societal or technical challenges by they own. Many actors representing industry, academy and authority need to co-operate in cross-functional and multi- disciplinary teams, to be able to solve the system challenges.

[1] SEVS Safe Efficient Vehicle Solution, www.sevs.se. The SEVS phase 1 (SEVS1) "Green & Safe" was initiated in 2008, SEVS phase 2 (SEVS2) "Electromobility" was initiated in 2012.

The evaluation and measurement of the societal effects of an automated transport system is a complex system challenge. Stakeholders from industry, academy and authority, with different perspectives and challenges, initiated therefore this pre-study project, “SEVS for Autonomous Drive (AD)”, (SEVS3), as a common journey to bring different perspectives together in a holistic system perspective.



SEVS for AD is a SAFER associated project, with the purpose to get a better understanding of the automation direct and indirect drivers and the effects in different types of societies. The main goal of the pre-study was to suggest a methodology how to measure the impact of automated transport solutions and the effects on the Swedish national transport goals. So far, there are very little real life data to collect/measure from, so therefore we have to build models representing different societies, users and possible mobility solutions.

This pre-study has used The SEVS Way as methodology, and also some other results from SEVS phase 1; Green & Safe Journey and phase 2; Electro Mobility Journey. SAFER, as an arena for Open Innovation use The SEVS Way, as a strategic analysis methodology in

explorative projects to handle complex societal and technological challenges. The methodology has been further developed since 2008 by multi-disciplinary teams representing industry, academy and authority. The methodology has also shown to be a powerful communication tool within SAFER as well as externally.

One main result from this pre-study is a suggested methodology how to measure and evaluate the societal impacts of automated transport systems and autonomous vehicles (AV). Other results are a State-of the-Art research, an up-dated Driving Force Model, a Stakeholder Analysis, Scenario descriptions, two new use cases; Mrs Rose and Gotaparcel and one re-used use case; the Kungsbacka family, brief conclusions and preliminary societal effects, a list of new challenges and GO:es, and of course new knowledge and a well-functioning multi-disciplinary team. These results will form the basis for a possible continued project; an implementation project.

The pre-study has already resulted in one spin-off project; “SEVS for AD and e-commerce”. The purpose with this project is to analyse the effects of a combined AD solutions for people as well as goods in a specific use case.

The SEVS for AD pre-study was initiated the 1st of June 2016 and finalized 31st of December 2017. And the spin-off project was initiated in mid of December and will end in April 2017.

The total budget for the pre-study was 1976 350 SEK of which 985 750 SEK (about 50%) was so called in-kind and the other 50% was financed by Vinnova, the Swedish Energy Agency and Formas via Drive Sweden.

3.1. Partners

Project Owner: Anna Nilsson-Ehle, SAFER
Project Manager: Else-Marie Malmek, SAFER/Malmeken AB

Consortium:
- CHALMERS TEKNISKA HÖGSKOLA AKTIEBOLAG SAFER - Fordons- och trafiksäkerhetscentrum
- CHALMERS/SHC, Swedish Electric and Hybrid Vehicle Center
- Göteborg Stad, Trafikkontoret
- Göteborgs Universitet Företagsekonomiska institutionen
- Malmeken AB
- SP SVERIGES TEKNISKA FORSKNINGSINSTITUT AB
- Uniti AB
- VTI, Statens väg- och transportforskningsinstitut
- Volvo Car Group AB

Figur 1; Project partners (SEVS3)

3.1.1. Project organisation

The project was divided into six work packages (WP), and one team leader for each was appointed:
WP1 – Driving Force Model, Anders Grauers, SHC
WP2 – Scenarios, Malin B Andersson, Göteborgs Stad
WP3 – Use Cases, Jessica Berg, VTI
WP4 – Measuring & State of the art, Martin Borgqvist, SP
WP5 – Dissemination, E-M M, SAFER
WP6 – Project Management, E-M M, SAFER

The project was organized around a Core Team (CT) (those partners with most project resources and relevant skills) with weekly working meetings.

A Steering Group (SG) was formed by one representative from each partner. The SG just met once, but several informal actions were handled via WEB-forum or by mail.

The Reference Group (RG) consisted of the project owner at SAFER and one representative from Drive Sweden, which was a prerequisite from Vinnova.

Other stakeholders were invited to three result driven workshops, to gather input from a broader group of individuals from different organizations and different skills.

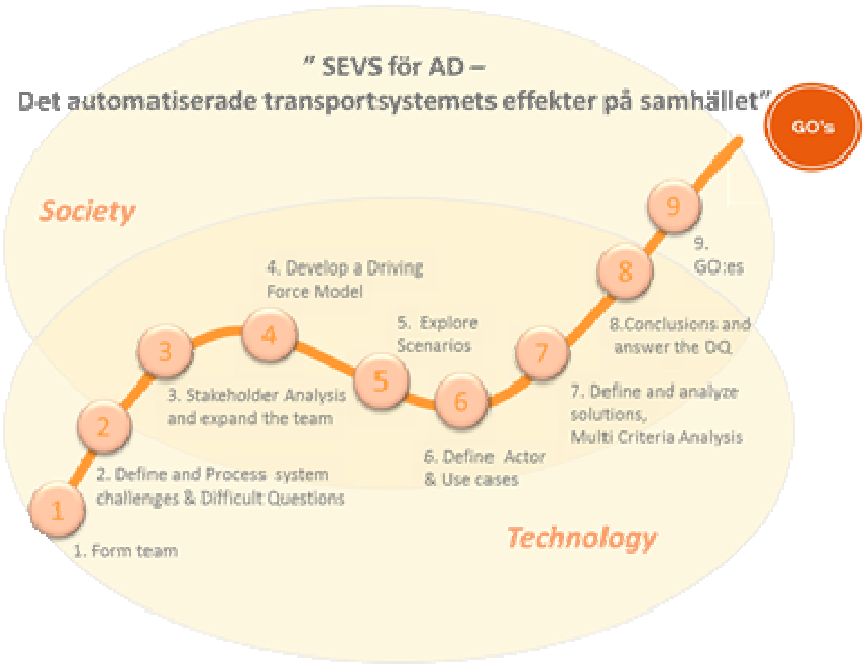
3.2. Methodology

When involving a large number of experts and stakeholders there is a need for a structured method for how to effectively perform the research in multi-disciplinary teams. By involving researchers and using well proven tools and methodologies from SAFER, we can argue that this pre-study has been conducted on a scientific basis. This pre-study was performed

according to The SEVS Way, a strategic analysis methodology applicable to explorative projects to handle complex societal and technological challenges. The methodology originates from Malmeken AB and has been further developed by a multi-disciplinary team in SEVS phase 1 and phase 2. In this pre-study we have adapted and further developed the methodology according to AD and measuring effects.

The SEVS Way has shown to be a powerful tool for multi-disciplinary teams to work cross-boarders in a structural way, but also a powerful communication tool that facilitates the inclusion of new stakeholders along the journey (e.g. Uniti AB). One of the core values of SEVS is to have an inclusive process with the aim of making a real life different. During the "common journey" participants will achieve new knowledge and understanding of the different organisations perspectives.

The SEVS Way methodology starts by formulating of the difficult questions (challenges) and ends by proposing different GO:es, (suggested actions to be taken by different stakeholders). Although SEVS for AD was a pre-study we worked through all nine process steps briefly.



The trigger of the SEVS for AD project was that different stakeholders from authority, industry and academy were interested to know the societal effects of different AD transport solutions. Accordingly, the projects difficult questions were; *How can we measure and evaluate different AD solutions effects on societies, to be able to assess if and in what way they contribute to achieve the Swedish National Transport Goals?*

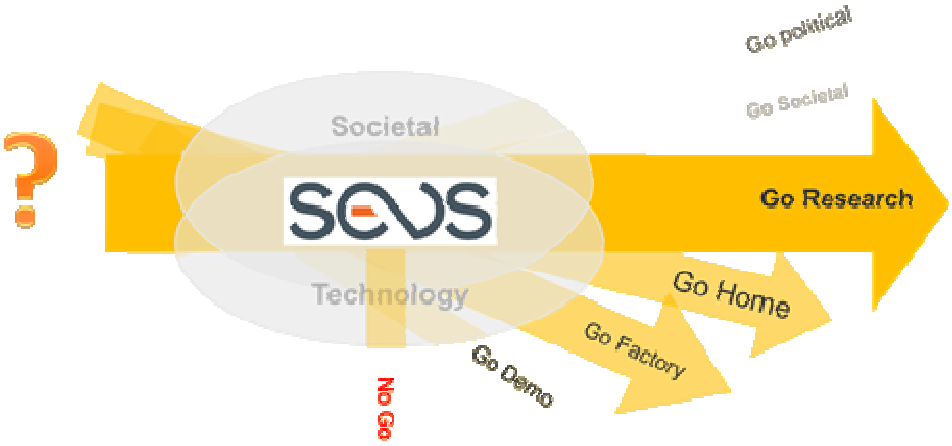


Figure 1: The SEVS holistic system perspective

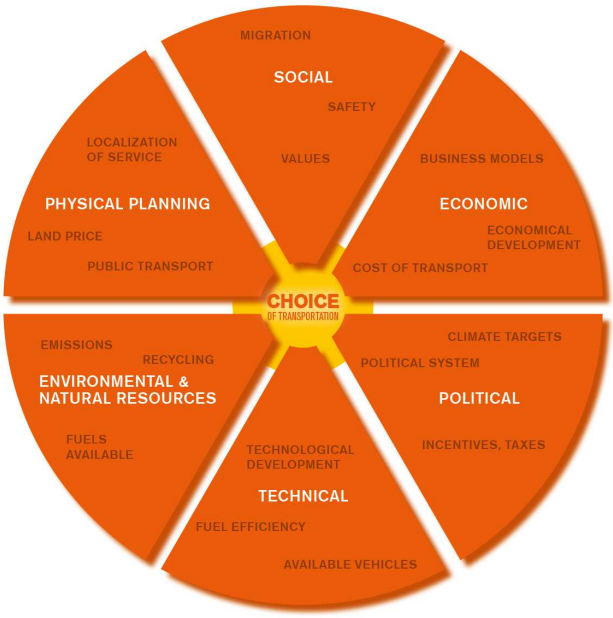
In the end of the SEVS process, we will specify the so called GO:es, the proposals for new activities, new projects etc.

3.2.1. The Driving Force Model (DFM)

The driving force model enables us to think in terms of real causes and effects and to bypass personal feelings, preferences and intuitions that tend to be biased by what we want to find. The model is a visual representation of how the driving forces influence the transport system in both direct and indirect ways and how the driving forces interact with each other. Using the model, each driving force can first be discussed one by one and as a second step be integrated in the final analysis to create a holistic understanding. The DFM is like a map that helps the project team to decide the route for the exploration, indicating what to focus on and what to ignore in each step of the exploration.

As one of several results from SEVS2, a DFM was developed. A large number of direct and indirect driving forces were identified and organized into six groups to make the DFM easier to understand:

- Political/Legal
- Economical
- Spatial: Land use, City structure
- Social: Values, ideas, behaviour
- Technological
- Environmental and Natural resources



Figur 1; The Driving Force Model (from SEVS2)

In this pre-study (SEVS3) we have re-used the DFM from the earlier SEVS2 project and modified and extended it to also cover autonomous drive.

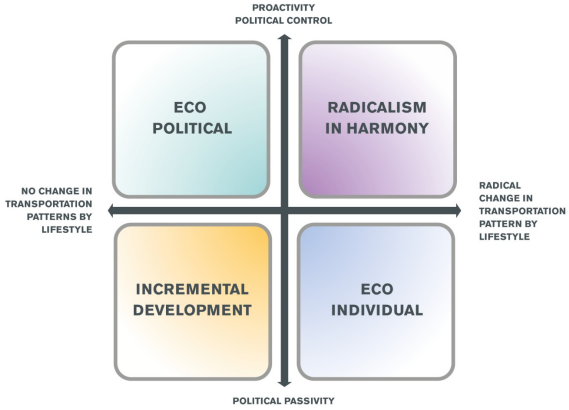
3.2.2. Scenarios

The scenarios are pictures of possible futures, how the society and the physical environment can look like, and how people, companies and organisations behave.

The Driving force model illustrates which driving forces shape the future, but not how they will play out in different societies. In SEVS1 the scenarios were developed by ranking the driving forces according to how strongly they influence the future transport system and how certain/uncertain the development of them was. The created scenarios are not predictions of what will happen, rather tools for exploring possible outcomes. They are selected to be rather extreme, such that the future is likely to fall within the area that they span.

The developments of many of the driving forces are rather certain and will influence all scenarios in the same way, while other important and uncertain driving forces will cause large differences in the scenarios. The two main dimensions used to generate the SEVS scenarios are:

- *Proactive political system vs. Reactive political system*
- *Radical change in transport patterns by lifestyle vs. No change in transport patterns by lifestyle*

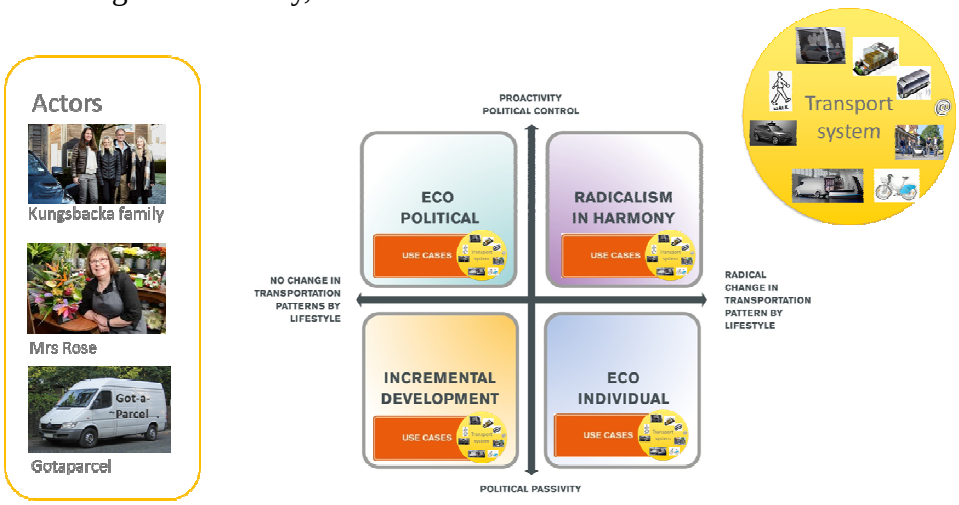


Figur 2; SEVS scenarios

Although the scenarios from SEVS1 are almost generic, they have been further adapted and explored according to AD. See WP2 Scenarios.

3.2.3. Use Cases

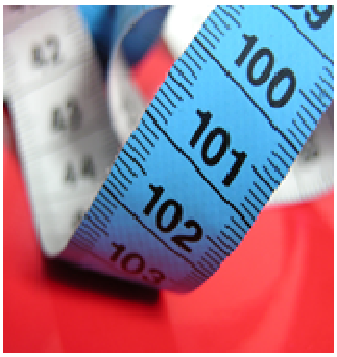
One way to handle complexity is to work with so called Use Cases and Activity based approaches. A use case consists of an actor (a person, a family, a company…) who interacts with the (transport-) system for a specific purpose (fulfillment of needs), in a specific context (scenario). In SEVS2 we developed several use cases based upon the actual challenges for that project (The Electro Mobility Journey). One of the use cases for personal mobility was The Kungsbacka family, and this use-case has been re-used and modified according to AD.



The use cases for goods transportation have been developed almost from scratch, but now integrated with the personal mobility. The reason for this is that the mobility of people and small goods/parcels will be even more integrated in AD based solutions. In this pre-study we have therefore developed two new use cases; Mrs Rose and Gotaparcel. See WP3 Use Cases.

3.2.4. Measurements

Already in SEVS1 we tried to develop a methodology "how to measure sustainability", but we didn't manage to achieve this. In SEVS2 we developed a methodology to evaluate the relative sustainability of different kinds of mobility solutions. The assessment was performed as qualitative multi criteria analysis (MCA), which is suitable when there are criteria with different dimensions that have to be valued compared to each other and when there are different stakeholders involved.



One of the most important results from SEVS1 and SEVS2, was that we could show that the extent to which one solution was more or less sustainable depended on its context, e.g. in which scenario it was applied to.

In this pre-study project the aim was to develop a methodology how to measure different AD initiatives and evaluate in what way they effect the Swedish National transportation goals. Accordingly we have not evaluated different kind of AD solutions in different scenarios just showing some examples how to measure effects. See WP4 Measurement.

4. Project Results

4.1. WP1 Driving Force Model

This part of the report will explain the DFM which this project has developed to analyze autonomous drive (AD), as well as the ideas and theory behind it. Note that the purpose of this project was only to be a pre-study for developing a method to analyze the societal effects of autonomous drive, not to do the full analysis. Therefore, the main purpose of this section is to demonstrate that a driving force model is a very useful tool to find the mechanisms and driving forces which determine how AD influences the society. To do that we also present results from the project regarding possible societal effects and likely leverage points in the system, as well as presenting the preliminary driving force model. Note that these are only based on a very short analysis, and are not thoroughly verified. So, the main takeaway from this section is that a driving force model like this is a good candidate when analyzing effects of AD. The outcome is just preliminary results which can be used as starting point for other investigations, but should be used with care until they have been further verified.

In addition, it is important that the driving force model is only one of the tools in the SEVS analysis of societal effects of autonomous drive. It can identify important driving forces, likely effects and explain why and when they are likely to happen. However, an analysis of how likely these changes are will always need to be based on deeper analysis of critical mechanisms. One example of that is the *use cases* and *transport selection analysis* which are necessary to analyze a very critical point in the driving force model, namely how the user needs, preferences and possibilities will influence what transport solution will actually be chosen.

4.1.1. Theoretical Background

Transition theories provide the intellectual tools to carry out a socio-technical analysis of technological transitions considering social factors and conditions that exist around technologies (Geels, 2002; Geels, 2005). According to Geels (2002) these may be considered as a result of evolutionary processes. As shown in Figure 1, there are three levels with which technological transitions can be analysed, the meso-, micro- and macro-level.
On the **meso-level** socio-technical regimes drive innovative activities towards incremental improvements based on a set of different dimensions including social groups of various backgrounds and interests, besides engineers, that are connected with rather innovative activities as part of technological niches (s. micro-level). On the **micro-level** one can recognise the technological niches. These serve as *'[...] incubation rooms for radical novelties [...]'* (Geels, 2002) which means that niches are responsible for the generation and development of radical innovations (e.g. Autonomous Dive technologies or electric vehicles). The importance about niches is that they *'provide locations for learning processes'* (Geels, 2005), which may occur in different dimensions of the socio-technical regime on the meso-level. On the **macro-level** the landscape developments are external factors (e.g. demographic trends, political changes) that change slowly interacting with the regimes.

In this report, the transportation system is considered the socio-technical regime and is investigated in reference to the development of the socio-technical innovation of Autonomous Drive as technological niche. As the majority of socio-technical innovations often presuppose a change in the relevant socio-technical systems (or regimes) that they are embedded in, this theoretical framework is employed to reduce complexity by breaking down a complex system in smaller parts (SEVS 2 Driving Force Model categories) that can be analysed more easily in a structured and effective way.

The system analysis unfolds in the following sections. Firstly, the technological niche level is presented in the following section where futuristic Autonomous transport solutions are presented with basic technical specifications. Subsequently, the regime analysis, namely the transportation system of a contemporary city in Europe, is presented in two sections. Firstly, a stakeholder analysis provides an overview of the actors from the various social groups that are related to the transportation system and therefore to the AD niche. Secondly, a Driving Force Model is employed to demonstrate a series of incremental improvements, essential steps but also institutional interrelations among actors and actions that take place in the transportation system and its environment (interaction within the regime and between the regime and the landscape).

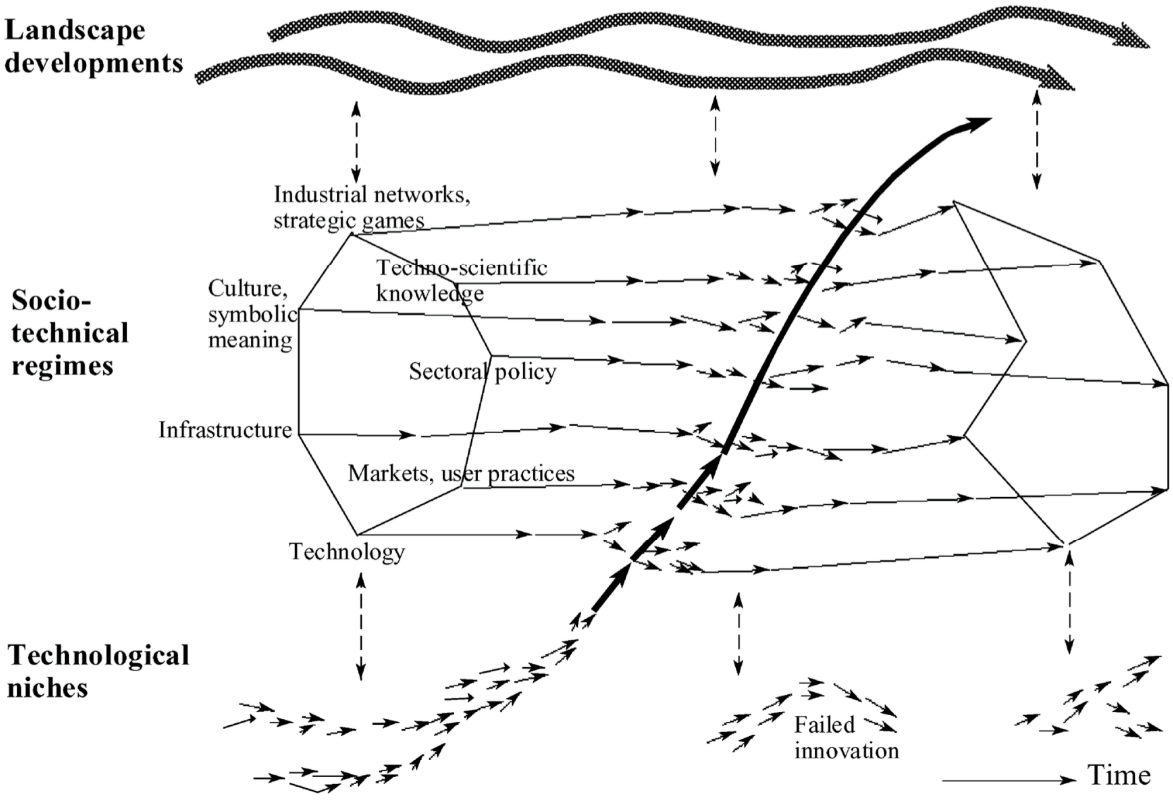


Figure 1 A dynamic Multi-Level Perspective used for analyzing systems innovations including macro- (Landscape development), meso- (Socio-technical regime) and micro-level (Technological niches) (Geels, 2002).

4.1.2. AD Transport solutions – Technological Niche analysis

To analyze possible effects of AD we first need to have an idea of what vehicles and transport services will be offered, once AD is successfully developed. Based on literature search and contributions by the project partners we have made a short list of some of the main vehicles or transport services we think will become available. The list could be much longer, but in this pre-study project we have limited ourselves to only analyze a few main categories of transport solutions, without dividing them into many subcategories. Even though the list is short we believe that it covers many of the vehicle types which can emerge once AD technology is available on the market.

The Autonomous transport solutions presented here are a result of a series of weekly meetings where the core stakeholders of this project took part. During the meetings, open discussions and brainstorming activities were employed to motivate the mobility experts to contribute with their knowledge of characteristics of Autonomous transport solutions. For these solutions, it is considered that technological development will be in place to accommodate for their advent. These solutions focus on goods distribution and passenger transport but they also propose an integrated concept for both goods and passengers, as it is shown in Figure 2. The listed AD transport solutions will in our analysis be offered in parallel with all the existing

vehicle types, such that persons and companies can select if they prefer to use one of the AD transport solutions or one of the conventional transport solutions for their needs, or a mix of them.

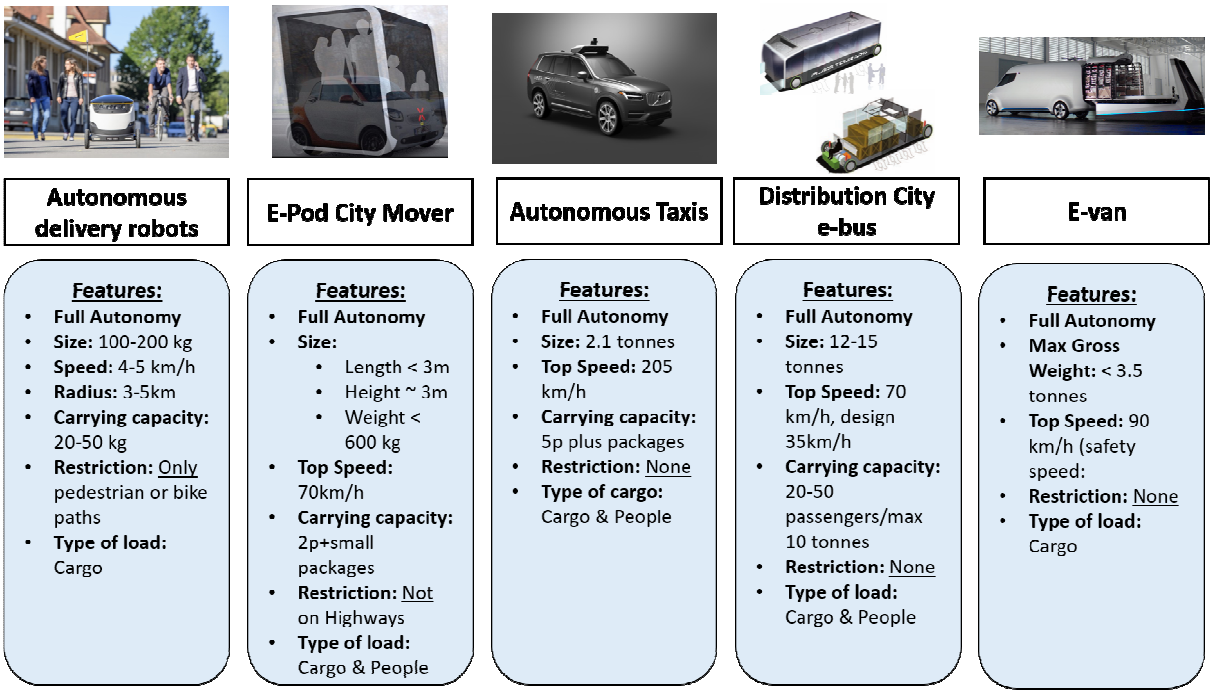


Figure 2 AD transport solutions

4.1.3. Stakeholder Analysis – Regime analysis

In a driving force model, many of the key factors which drive development are in some way involving decisions by one or several persons, companies or organizations. Therefore, it is very important to include all the key stake-holders in the analysis, in order not to miss some important driving force. To do that the SEVS project included a short stakeholder analysis, to identify key players in the system.

The regime configuration consists of 6 categories which are taken from the SEVS 2 project: Social, Economic, Political, Technical, Environmental and Physical Planning. Thus, stakeholders that are presented below, represent groups which are related to the AD innovation. The stakeholders are divided into these categories, to make it easier to get an overview of them. Brainstorming activities were used during the Core team meetings and the Work Package 1 workshop to identify the main stakeholders that interact with AD.
It is important to note here that a stakeholder analysis is context dependent, in reference to the relevant question that is examined. Here, the following table (Table 1) provides an overview of stakeholders that are connected with the transport system and AD. For a more comprehensive and detailed list of stakeholders see Actors: Independent flower shop in Linnégatan the specific actor in this case is the owner of the flower shop is Mrs Rose (her first name is Elisabeth but in the use case she is referred to as Mrs Rose). The shop also employs two assistants who work at the store at different times/days. Mrs Rose has a son (Erik) at university and a daughter (Julia) at school. She lives in Lindome about 20 kms from the shop in a small house near her mother.

Actors needs

a) To be able to deliver flowers and plants when ordered by customers.

Orders could come from:

- Customer who visits the shop
- Customer who telephoned
- Customer who ordered from somewhere else though a network such as 'Interflora'

b) Transport needs to able to take flowers and plants from the company location to the customers home (or in the cases of a business customer to their establishment). Transport needs to be close by or if possible parked at the flower shop (the latter is not possible in Linnégatan). The parking place needs to be available to the van/car used by Mrs Rose.

c) Transport needs to be available all the time as deliveries can be required 7 days/week.

d) Transport needs to be able to accommodate plants and flowers that are not packaged without damage.

e) Transport needs to be low cost because the margin on plants and flowers is rather small.

Functional requirements, transport modes and route start and end

- Small vehicle
- Can be driven by someone with car driving licence
- Powered van or car (could be electric, hybrid or fossil fuel)
- Delivery cycle - electrically assisted?
- Route starts and ends at the home of the shop owner - but the main use of the vehicle is for business

System without AD

One Thursday

Mrs Rose drives to the store every day in a small van that she uses both for the trip to/from work and also for delivering flowers during the week. During the working day the van is parked at a nearby parking space (which has to be paid for). Sometimes the van is parked up to 750 metres from the flower shop which is time-consuming and occasionally problematic for Mrs Rose. When loading the flowers and plants she sometimes has to park outside the shop which can cause an obstruction and even incur a fine.
The van is diesel powered but Mrs Rose is thinking about getting a hybrid or electric vehicle but is concerned about the additional capital cost. The main reason is to be seen to be more environmentally aware and also because running costs could be reduced in the longer run.

Mrs Rose wakes up at 05:30, she has breakfast and makes sure that she is organised for her work - at the end of last week she has placed a big order for flowers and plants; today will be a busy day at the shop.

Her daughter Julia gets ready for school but today Mrs Rose will leave early for work and so she will drive Julia to her mother's house where she will stay until it is time to walk to school.

As it happens her son is at home as well as the university term finished last week. But he has not got up in time for breakfast. He said he would help in the shop in the afternoon and he will have to get there himself by bus.

06:30 drive to her mother's house with Julia in the small van.

06:45 drives to Linnégatan arriving at 07:10; today there was not a lot of traffic. Parks the van 750 metres from the shop in a parking area and walks to the shop arriving at 07:20.

07:20 to 09:00 works in the shop getting everything ready for the day ahead. This includes preparing the orders that need to be delivered. At 08:30 one of the two people that help in the shop arrives (Karin).

09:00 the shop opens - on Thursday and Friday Mrs Rose has decided to open at 09:00 on the other days she opens at 10:00.

09:15 Mrs Rose decides it is time to make some of the deliveries. She normally tries to do the deliveries to offices at this time in the morning and then will deliver flowers to private addresses later in the day. Of course sometimes there is an unexpected order that needs to be delivered urgently.

09:15 to 09:25 Mrs Rose spends some time wondering whether it is better to wait for a loading space outside the shop to be available or whether she will need to find a way to take the flowers to the van. This problem has been getting worse recently with the lack of parking spaces.

09:25 a space is available - Mrs Rose hurries off to the van. She drives back (rather quickly) and parks in the space (it is now 09:35).

09:35 to 09:50 Mrs Rose loads the small van - flowers have to be treated with care and this takes 15 minutes although she tries to do it more quickly - but flowers are difficult - they come in all shapes and sizes as well as being fragile.

09:50 sets out on the delivery trip. Luckily she knows most of the places where she has to deliver rather well although today she has to make a delivery to an address that she is not familiar with. She knows her phone can help with this but today she has forgotten to charge it and she worries that if she uses it to find the address the power will run out.

10:40 just this one delivery to make; now to the unfamiliar address. It is a bit annoying but two people who had ordered flowers were not in so she still has their orders in the van (one was to a private address and so that does happen from time to time but she was a bit surprised to find that the delivery to the office that was planned could not be made because there was a sign on the door saying 'back in 15 minutes' and she could not wait and hope that this would happen. However, things improve - despite her uncertainty about this final address Mrs Rose finds it rather easily and makes the delivery - another happy customer!

11:00 Just as she is about to get into the van her phone rings - it is Karin - the two people who were out when she called earlier to deliver their flowers have both phoned to say how sorry they are and to ask if there is any possibility that she can still deliver. Mrs Rose says yes and the deliveries are only slightly out of the way. Mrs Rose is pleased that her phone still had enough charge to take the call - just as well she did not use it to find the last address.

11:00 to 11:25 Mrs Rose makes the two deliveries and returns to Linnégatan. This time she is able to part a bit closer to her shop and is pleased because in the afternoon she will deliver to five people and one of them has placed a very big order.

11:25 to 14:30 A busy time in the shop and Karin and Mrs Rose have to find time to have coffee and a sandwich. It was a good thing she was back by 11:30 though because a package was delivered and one corner seemed damaged - this was a display stand that she needs to take with an order she will deliver in the afternoon. Luckily Mrs Rose was able to ask the person delivering to wait and they both checked the package and realised that it was just the box that was damaged and the thing inside was fine. The van driver (Mrs Rose thought that her badge said her name was Maria) was pleased as well since it saved another trip and more paperwork.

14:30 Mrs Rose decides that it is time to make the deliveries - her son should have arrived at 14:00 but just as she is thinking that she will have to organise the deliveries herself he arrives - on his bike - he has decided to visit a friend later in the day and the bus was not convenient - since all this was decided at the last minute he forgot that not taking the bus would mean he arrived a bit late. Amazing thought Mrs Rose - he is studying 'logistics'.

Anyway he is here now and they begin to organise the deliveries and get things ready to put in the van. Everything is ready and at 15:00 Mrs Rose is set to leave but the delays mean that she does not have very long before the large order she placed last week will be delivered to the shop. If only Erik (her son) could drive but he is still having lessons and so he cannot deliver the customer orders on his own.

Mrs Rose decides that she will have to explain to Karin about the order that will arrive at the shop and that she will now need to leave Erik in the shop to help when it arrives. Not what she had planned that morning at 05:30.

15:10 Mrs Rose sets off to make the afternoon deliveries - she is late and she worries that her customers will be stressed about this or (perhaps worse) that they will not be in.

But, everything goes quite well and almost all the deliveries are made by 16:30 (including the large order that required the display stand) when Mrs Rose returns to the shop.

During the last deliveries she received a text message from her mother to say that Julia was back from school and that she seemed to have caught a cold but was alright and she would look after her until she could collect her later.

16:30 parks and gets to the shop at 16:40. Where she sees that the large delivery is still taking pace - this is a surprise because it should have been finished by now because at 16:45 the shop starts to get busy again. It seems that Karin and Erik insisted on counting all the boxes and the plants and this has delayed everything. The delivery driver does not seem very pleased.

16:45 Karin leaves at 17:00 and another assistant (Anna) arrives to help until the shop closes at 19:00.

17:15 Erik asks his mother if she needs any more help and Mrs Rose says that it is fine for him to leave and go and visit his friends - what time will he be home she asks and gets a rather vague reply.

17:15 to 19:00 Mrs Rose and Anna work together in the shop. Just before 17:30 a customer who comes to the flower shop to collect a wreath that his wife has ordered. Mrs Rose mentions that she also offers a delivery service and he says that he wished he had thought about that because the traffic is very bad today and he thinks he will be late arriving home. He seemed pleased that Mrs Rose had told him this because he said "well sometimes it makes sense to spend a little bit more in order to save time and to have a more convenient day". On the other hand while he was in the shop he also bought some flowers for his wife and that would not have happened if the wreath had been delivered. Mrs Rose decides that life is quite complicated when you start to really think about things.

Anna and Mrs Rose close the shop soon after 19:00 and Mrs Rose leaves for home at 19:20.

20:00 Mrs Rose collects Julia from her mother and they go home together - her cold seems worse. Mrs Rose hopes she will be fine to go to school tomorrow.

20:10 Mrs Rose makes something to eat (Julia has eaten earlier) and as she is finishing her meal Erik arrives. He eats and they talk for a while about how university is going - and whether he will be able to help in the shop in the vacation.

Mrs Rose decides she has had quite a tiring day and goes to bed at 22:00 after watching television show that she likes. Tomorrow will be a calmer day she hopes.
END OF USE CASE

OPTION 1 FOR AN AUTONOMOUS VEHICLE

In this optionwe have assumed that Mrs Rose has decided to own her own autonomous vehicle.

Activity of the AV

The autonomous vehicle is used to get from home to work just as it was before. However now Mrs Rose can get out of the van at the flower shop and send the AV to park itself (in order to save parking fees Mrs Rose decides to use a parking space further away than the one she used before).

When orders need to be delivered Mrs Rose can ask the vehicle to come to the store or park nearby in order to load it.

After it is loaded the AV can be sent to make the deliveries of flowers and Mrs Rose can remain in the store - this saves some costs because it is now possible to reduce the need for assistance in the flower shop (of course this has employment consequences - these are not directly related to driving the vehicle). Unfortunately not all deliveries can be made using the AV because the customer needs to be there to take the flowers from the vehicle when it arrives. In addition Mrs Rose has had to have a modification made to the original AV because she has to be sure that customers can only access the flowers they have ordered and paid for. Therefore the vehicle now has a system of small 'lockers' which has reduced its carrying capacity.

The need for a customised AV

Because of the limitation at the delivery point which used to be overcome by Mrs Rose getting out of the van and making the delivery herself a new option for delivery has been created. This enables the flowers to be left close to the customer at a nearby shop (or other facility) where

several orders can be received (by the pick up point staff). The flowers/plants can then be collected by the customer later on that day or in the evening.

Some problems of customer service

Of course not all customers are happy with this service as they preferred the personal delivery made by Mrs Rose and for some customers (several office buildings for example) she offered an additional service when she would arrange the flowers in the relevant entrance areas of the office.

This question of customer service has worried Mrs Rose since it was an important part of her business and she has now decided that she will continue to offer a delivery service where someone goes with the AV. This has reduced the cost advantages of the AV but it has enabled Mrs Rose to employ her student son during the long university vacation periods - although he does not have a driving licence he is of course able to travel in the AV and make the delivery. During the university term time Mrs Rose asks one of the shop assistants to make some deliveries in the AV and this has been a success because the job is now more varied. In addition Mrs Rose has been able to spend more time in the shop and has realised that it needs some re-design and could be made more welcoming to customers.

After the AV has made the various delivery trips it does not return to the store but finds a parking space and parks there until it is needed by Mrs Rose.

Use of the AV for the journey to work trip

When it is time to go home Mrs Rose calls the AV and travels home in it. Of course in times when she is not at work she has found the AV useful for other activities. Some of these things she used to do on her way to and from work (sometimes referred to as trip-chaining). Now this is no longer necessary and the AV can be sent to collect her young daughter from after school activities without Mrs Rose needing to go along as well. Naturally the locker boxes that have had to be installed (for the delivery trips) need to be removed and this 'pod' is then left at the flower shop overnight.

Overall view of the change to an AV option

Overall Mrs Rose is pleased about the arrival of the AV option but she is a bit surprised that it has not saved much money as she had been led to believe this was one of the key features of AVs. In addition she has noticed that the AV travels almost 30% further than the van used to travel mainly because of the parking distance and also because she no longer reduces travel by trip-chaining.

She was also a bit surprised about how difficult it was to obtain the locker pods for the delivery service but this was because it appears that flower and plant deliveries are very specialised and few businesses required this option.
Appendix . Moreover, a next step after forming the stakeholder table would be to provide a map of stakeholders according to their interest and power, for a more in depth and complete stakeholder analysis. However, that was outside the scope of this pre-study.

Table 1 Stakeholders related to the transport system and autonomous drive.

Social	Economic	Political	Technical	Environmental & Natural Resources	Physical Planning
Families	Banking sector	Political Authorities	Car mechanics	Energy Providers	Urban planners
Single-users	Car dealers	Urban Administration	Communication systems providers	Fuel providers	Transport Operators
Groups with special mobility	Mobility service providers	Legislators	Vehicle Manufacturers		Transport network owners
Pedestrians	Logistics service		Research Institutions		Land owners
Professional Drivers	Insurance Companies				Real estate agencies
	On the fly service providers				Parking Administration
	Vehicle interior designers				Parking lot owners
	Cloud Stores				
				Actors subject to change	Potential new actors

4.1.4. Driving Force Model analysis

The Driving Force Model describes mechanisms that shape the future and helps a team to analyse a complex system. It is a visual representation of how different driving forces influence a system directly and indirectly and how the driving forces interact with each other. The Driving Force Model is one of the tools which, together with the rest of the SEVS method, allow a team of experts to analyse a complex system in a structured way. The Driving Force Model:

- makes it possible to break down difficult questions into manageable segments and the results can thereafter be combined again, creating a holistic understanding.
- is qualitative and describes the most important mechanisms, not the exact effect of a specific factor. It is a tool that structures discussions within teams of experts, not a simulator that calculates what will happen.
- needs to include a wide spectrum of direct and indirect driving forces in order to explain the long-term development of society or sectors in society.
- can be used, for instance, to identify which driving forces are most likely to influence transport needs and then support the assessment of how the transport system will change and offer the opportunity to control and guide in a desired direction.
- can help us understand emergent system phenomena, such as if there are any tipping points in the system or why the disadvantages of new solutions seem to be greatest at the introduction stage and then reduce after some time, whilst advantages seem to grow over time.

In this project the driving force model developed in SEVS2 has been further developed and extended to include an AD perspective. This work has been done by a workshop where the involved experts worked in teams to generate smaller driving force models focusing on different aspects of AD. Based on the workshop results the understanding of driving forces for AD was improved. The new knowledge was used to make an example of how AD can be introduced and what effects it will lead to. This work also lead to the invention of a new analysis tool; the *driving force story*. The driving force story can be seen as a simulation done with the driving force model. I.e. it has some initial conditions and assumptions as input, and then describes how the driving forces act, as time leads stepwise to more and more changes. This tool is, again, not a way of getting "a correct prediction" but it makes it easy for experts of different disciplines to discuss what the likely development is, and identify where the high uncertainties are. The driving force story is presented later as a result that stems from the workshops.

4.1.4.1. Workshop method and results

To build the Driving Force Model, a one day workshop took place with the participation of local experts in mobility.
The workshop was based on the following theoretical "algorithm" for building the Driving Force Model:

1. Identify stakeholders. (see previous section)
2. Find key factors and how they influence each other.
3. Quantitative analysis of key factors – determine how the sum of different influence adds up to a particular outcome.
4. Find important changes in the system:
    - changes in transport solutions
    - market forces
    - bottle necks
    - trends
5. Actively try to find counter forces or to falsify one's conclusions.

During the workshop, preliminary work done by the respective core team of the Work Package on how factors influence each other in goods distribution and passenger transport was presented to the participants.

For this project and the workshop the following assumptions were made:
Generally:

- Technological challenges are solved in a reasonable pace.
- Autonomous Drive Vehicles have the required performance.

More specifically:

- No driver needed in the vehicle - Automation level 5
- Sensors and advanced monitoring systems enabling full autonomy

Two working group sessions were designed and performed.
In the first session, the participants were asked to create influence diagrams of their own invention for the AD innovation system. More specifically, they were asked to look for potential radical changes in the transport system as we know it today (e.g. changes in the vehicle design), important bottle necks, possible trends, factors that are likely to influence the

direction of development of AD (e.g. changes in cost balance between different solutions) as well as potential counter forces against their strings of reasoning. For that both deductive and inductive reasoning were encouraged.
In the second session, they were asked to come up with first and second order societal effects that are generated with the introduction and development of AD. Throughout the workshop, the guidance provided was limited with a lot of room for subjective interpretation, for fear of confining creativity among participants for such a complex issue.

The following figures (Figure 3 and Figure 4) are indicative of the results from the collective group work during the workshop.
The frames in blue dash outline represent the fields in the transport system where actors, processes, steps or interrelations (pale red colored boxes) take place. The frame in red dash outline represents the first or second order effects on transportation or other sectors. The arrows show mainly the causality or a generic relation between the entities and processes of the transportation system. Both figures are a slightly edited by the authors – for the sake of readability - depiction of the participants' work during the workshop.

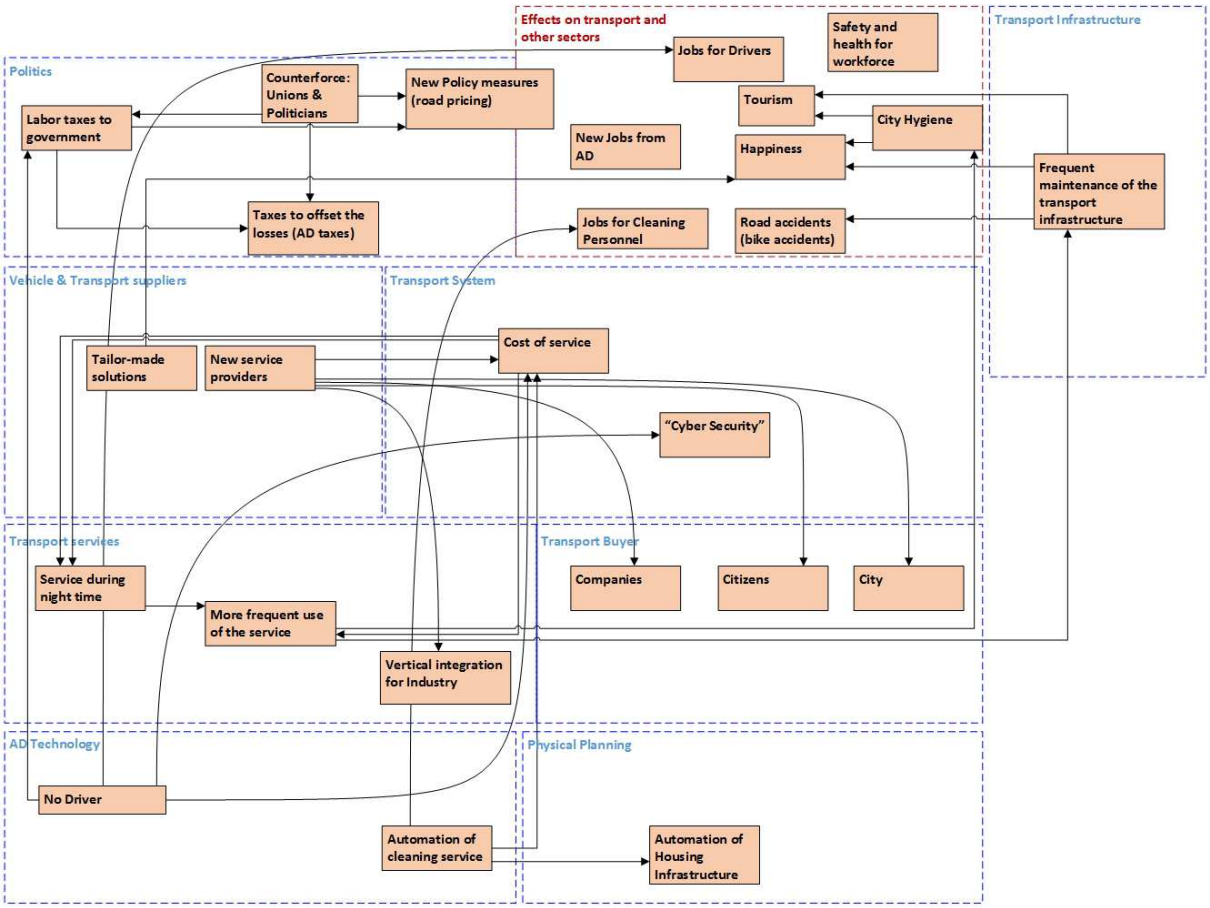


Figure 3 Influence Diagram for an Automated Cleaning service made by a working group during the workshop.

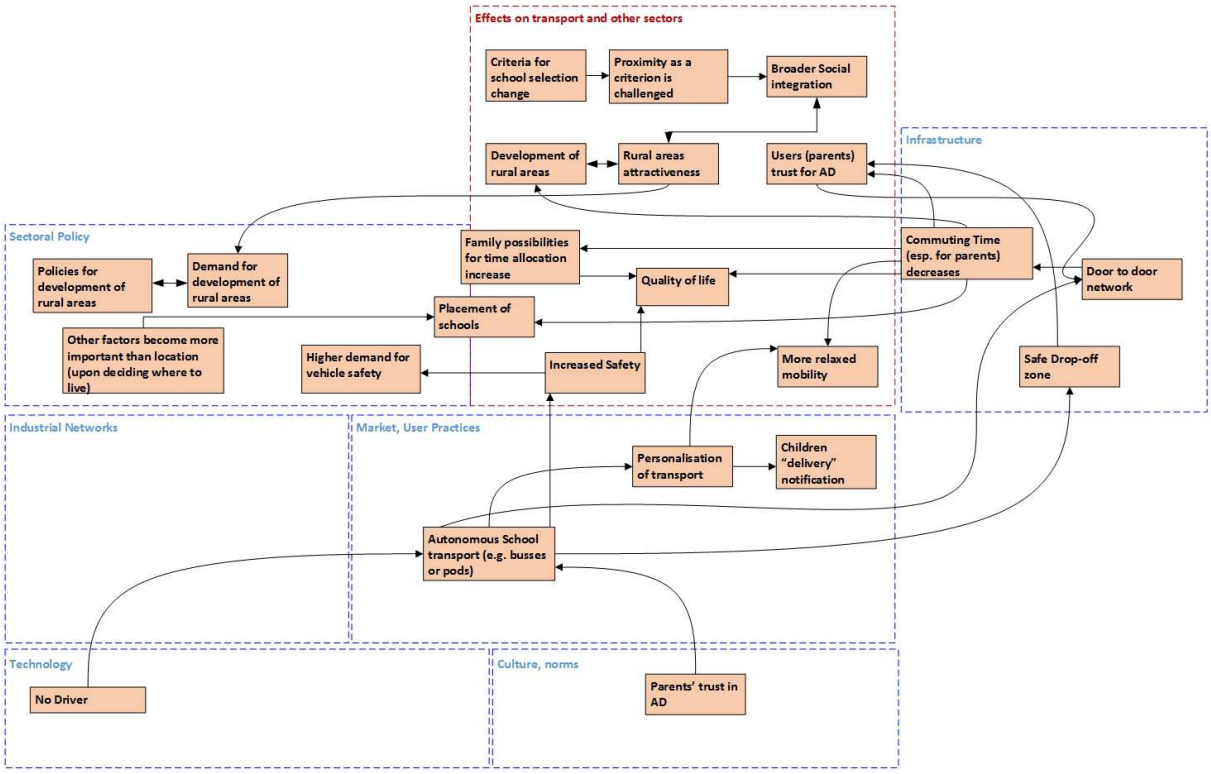


Figure 4 Influence Diagram for Automated School Transport service, made by a working group during the workshop.

As a result of the workshops the concept of driving force stories was developed and a few examples were developed. In Figure 5 a simplified version of the driving force story shows possible development steps in the introduction of AD vehicles into different market segments. Notice, that the fully autonomous private cars are one of the final steps, according to this analysis, while there are many other segments of commercial vehicles which may come much earlier. In Figure 6 a part of the driving force story related to analyzing the effects of more useful commuting time is shown, as an illustration of how to analyse the societal effects.
A more detailed version the developed driving force story is shown in

Appendix C – Driving Force Story. In that figure the driving forces are followed all the way to the transport political goals and it also indicates likely introduction niches as well as likely order for AD to reach different segments of the market.

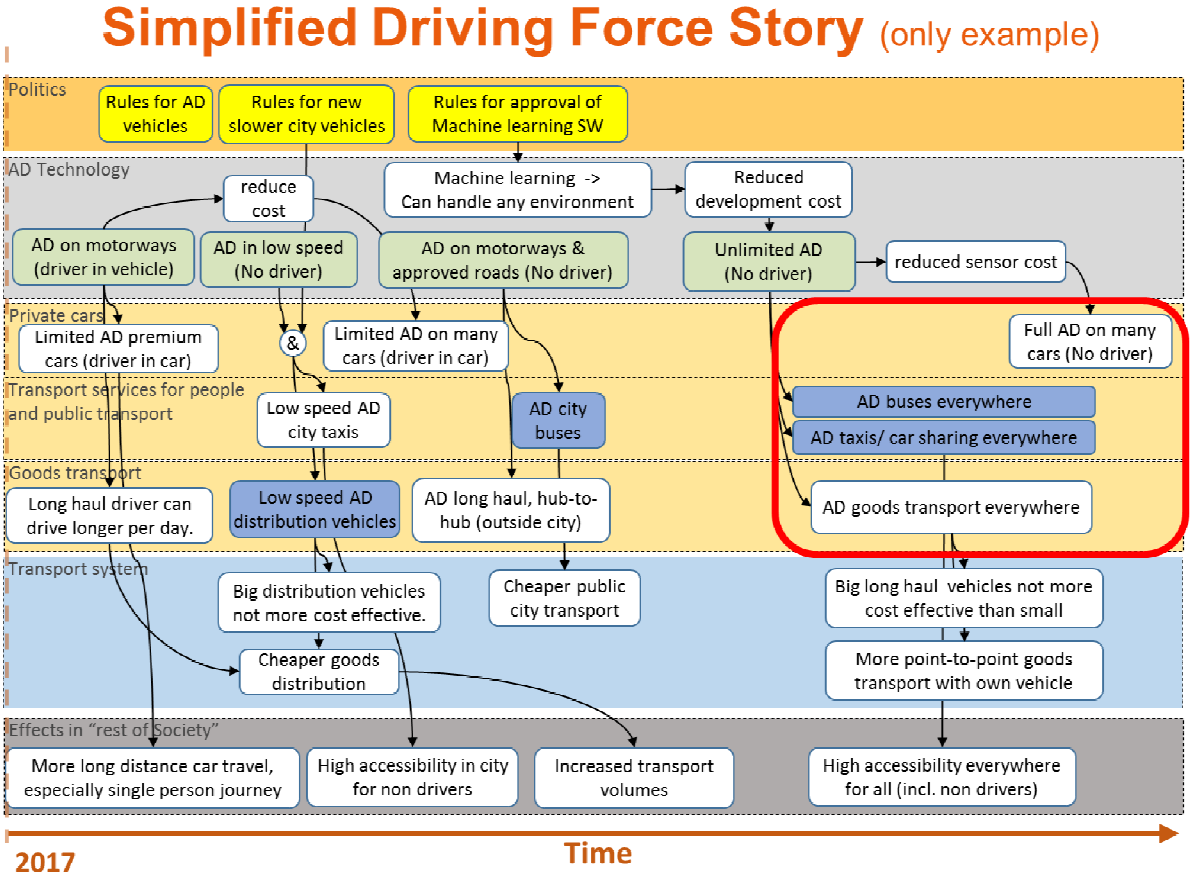


Figure 5 Possible development steps for AD in different market segments

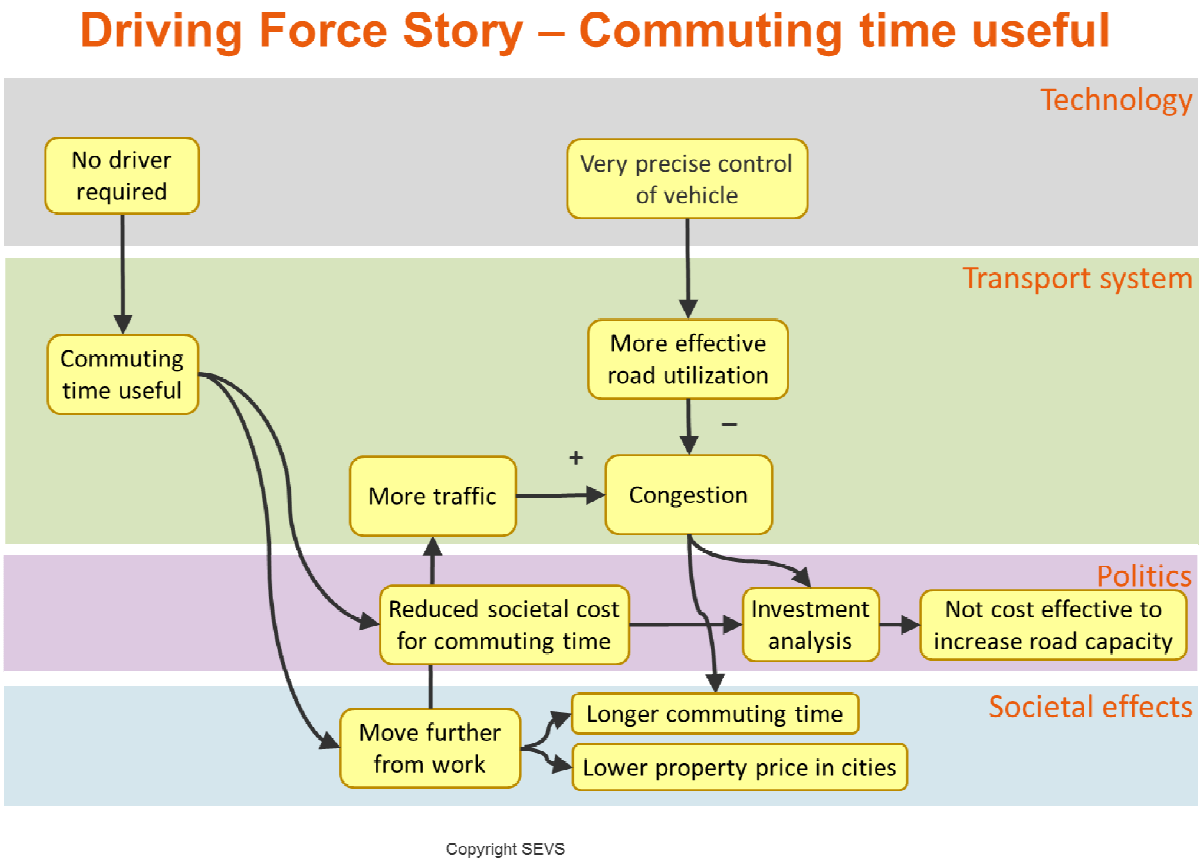


Figure 6 Driving force story and societal effects

4.1.5. Preliminary Societal Effects

Based on the driving force analysis several likely effects in different parts of the society can be identified. By systematic search of the results a long list of possible societal effect was identified. In order to draw more general conclusions and to find patterns in the societal effects they were categorized into the different categories developed in SEVS2, and they were also divided into effects in the regime (the transport system and directly related parts of society), and effects in the landscape (indirect effects on society outside the transport system). The resulting “map” of the effects of AD is shown in Table 2 below.

Table 2 Societal effects of AD on a Multi-level and intersectoral perspective

	Driving Force Categories						
Systemic Level	**Social**		**Physical Planning**	**Politcy and legislation**	**Economic - Market practices**	**Technical**	**Environmental**
	User	**Other effects (collective)**					
Regime (Meso-level)	More free time	Enhanced gender equality	Higher capacity of existing road infrastructure	Need for policies for efficient use of road network (active capacity management)	New business models for Automotive industries (Monetization of the usage of the vehicle, focus: asset efficiency)	Vehicle customization (e g the concept of vehicle is challenged, change of interior designs)	Mitigation of emissions and energy use with smart efficient driving
	Less road fatalities and accident risks	Safer societies	Possible rebound effect: Higher congestion	Gradual divestment from policies on reducing the commuting time	Possible vertical integration of Automotive industries eliminating the brokers	Lighter vehicles with less materials	Better air quality
	Higher accessibility with on demand mobility	More inclusive and accessible societies	More decentralised parking infrastructure; urban spaces gain more functions	New legislations for accident accountability and Insurance	Lower cost for goods distribution	New vehicle sizes	Rebound effect: Higher demand for products/services--> energy & materials
	Mobility for disabled groups	Cyber security risks		New legislation for central or decentralised control of AVs	Lower cost for passenger transport	Development of safe and resilitent IT systems	Circling Fossil-fueled vehicles might increase emissions and energy use
	Change in transport criteria (options of personalisation and customization might make time less important factor)	Need for more advanced car mechanics familiar with electric and software issues		New regulations for new vehicle categorization	Higher cooperative competition (More multi-modal mobility, more entrants more transport providers)	Development of dynamic capacity management technology	Increased demand for Rare Earth Elements (Hardware for automated systems)
	Reduced cost of transport services	Unemployment for professional drivers and car dealers		New Legislation for Ethics and Artificial Intelligence	Actors will have to acquire new technology	Development of machine learning	AD technology provides higher energy efficiency
	Higher comfort for users	AD technology will become more reliable than manned driving		Policy for replacing Car Ownership Taxes	Car dealerships might transform to central showrooms	Development of sensors and sensor fusion	
	More night travels	Rebound effect: Laggards are left behind			Possible need for open data exchange	Development of software for traffic decision making	
	No need for car ownership	Opportunities for new jobs in the transport system			New entrants in Automotive market		
	Longer Commuting				Rebound effect: Higher demand for products/services		
Landscape (Macro-level)	Higher demand for transport	Change in perception of car ownership for the society	Need for automation of housing and market infrastructure	Geopolitical: Need for transnational legislation (esp. for bordering nations)	Further e-Commerce development	Co-development of AD and Robotic technology	Mitigation of emissions with smart efficient driving
	Criteria for accommodation and housing change	Rebound effect: Higher demand for products/services/energy	Cleaner cities (Automated cleaning service with higher frequency)	Geopolitical: Possible inequality between Developed and Developing countries	Increased cost of Natural resources	Digitilization	Cleaner cities
	Sleeping habits change	Elderly people visit more frequently their children than vice-versa	Sprawling	Need for broader collaborations within and across EU borders	New trends of Cloud Stores	Enhanced integrative Conncectivity (V2I, V2V, V2C)	Sprawling (land use change)
	Behavioral change in daily life	People have higher power to buy other products services etc.	Real Estate landscape changes (Land value reallocation)	Stricter Environmental regulations (UN and EU level)	Increased cost of resources and materials	Internet of things	Increasing Sustainability awareness
	Trends of sharing models	Immigration	Urbanization	Emission and congestion zones in Cities	Servitization of business models across sectors		Climate change

Legend				
Positive effect	Negative effect	Neutral effect	Uncertain if the effect occurs	Social trends in landscape

4.1.6. Analysis of the societal effects table

Looking for patterns

First of all, it is important to note here, that this table was made intuitively as an attempt to gather and converge the understanding and opinions from the stakeholder meetings and dialogues while reviewing relevant literature. Especially the reason for the color addition is to ignite a discussion around the qualitative effects of AD development by providing a possible picture of how the effects would appear in a Multi-level systemic perspective.
When one examines the colour "mosaic" of social effects of the AD development as a socio-technical innovation it is possible to find many patterns.

From a macroscopic perspective, when looking at the regime level on Table 2, it is easily observed that the most positive effects are gathered on the user and the collective side while there is high uncertainty on the policy-legislation and industry side. On the environmental side, we consider any potential environmental issues to be detached from the AD development per se, as most of them are thought to be result of rebound effects that can be avoided with the right policies and decision-making actions.

Even though there is high complexity it is already apparent, that policy and legislation are crucial leverage instruments on such a complex issue without underestimating the high leverage from users and their behavior.

On the landscape level one can notice how present and future trends are inextricably connected to the AD and the transportation system. However, it is not an axiom that AD will bring these trends into life or vice versa. Rather trends such as car sharing or internet of things, electrical vehicles etc can occur regardless of the AD disruption even though their potential synergies are obvious.

Zooming in to the Regime level

The beneficiaries

Firstly, as mentioned previously the user and the collective (seen as a set of the social groups in society) are the entities benefiting most (see accumulation of green cells on the corresponding columns). One of the most recurring social effects in our analysis is that AD ultimately will have a positive effect on people's **quality of life**. Most notably, users gain more **free time**, use transport more **safely** (human errors are almost eliminated) at a **lower cost** and **higher comfort** (e.g. more flexible on demand transport with absence of driver) than today. The major factor for that will be the increasing utilization of commuting time that is nowadays considered as largely a waste of time. The use of the phone etc. means that not all commuting time by drivers, (and this waste of time argument only applies to drivers), cannot be considered a total waste of time. In addition, the absence of the need of a physical driver grants **independence for vulnerable groups** of people with limited mobility possibilities (e.g. blind people) as they are empowered to transport on demand by self-driving vehicle solutions and/or door-to-door transport solutions that are enabled by the AD technology. Hence, societies become more **inclusive** ensuring autonomous mobility for all the social groups therefore enhancing the individual and collective quality of life.

These effects might have a second order effect of **higher transport volume** patterns and exert potential pressure for higher congestion affecting the physical planning of societies.
Even though it seems that societies become more inclusive and accessible, enjoying a more reliable AD technology than manned driving, at the same time there is a risk of increased rates of **unemployment** for professional drivers. This will also put pressure on the policymakers and government bodies to create job opportunities either in the transportation system or in other fields or markets. Through the analysis, there are also predictions for **new jobs** and professions in the field of transportation and the automotive industry as with AD the whole concept of the car is challenged and gains multiple functions. However, the expected much lower cost for AD transportation is almost only related to reduced need for drivers, so if there would be as many new jobs created in the transport sector as there are reduced driver jobs, the cost will not be significantly reduced. A possible effect is of course that the per unit cost of transport is greatly reduced, but transport volume increases so much that the total number of employed remains the same, but now this workforce offers double the transport capacity.
Many of the predictions about changing costs for AD transport relate to cars or to the platooning of trucks. In the case of urban deliveries the driver's role is often split between driving and loading and unloading packages. Indeed if walking is taken into account much of the driver’s day in an urban area does not involve any driving

Need for resilient decision-making
The concentration of the yellow colour (Neutral effect – things which requires change but they are not negative or positive, per se) on the policy, industry and technical columns portrays the need for strong decision making and policy making regarding the changes brought on by AD to the relevant actors. Most importantly, there will be high need for policies to **balance the increasing transport demand**, as well as a **robust legislation** update by the state and public administration actors (e.g. legislations on ethics and artificial intelligence, schemes to control AVs, accident accountability etc). On the industry side, there is also a lot of change happening mostly on the **business model design** (e.g. shift to “pay per use service” models with per mileage use) as well as on the capacity from the actors to keep up with the probable technological reform (especially for the automotive industry). The absence of a professional driver with AD will open enormous opportunities especially for actors offering transport services because of the **lower costs** and eventual high mileage use from the users.
Lower costs and the scope for more convenient individual transport may induce a shift to more rural living for those who currently seek to live in the city or at any rate in suburban areas. Such a move could lead to urban sprawl unless planning controls are made stricter. On the technical side, with the AD, the whole concept of the vehicle as it is known today will be challenged and technical features such as size, external or internal design and material intensity will change. Most notably, **machine learning** and dynamic traffic decision making are considered crucial for the AD diffusion and OEM actors must keep up with these technical concepts. Without machine learning it is unlikely that a fully generic AD technology will be viable, as it is very unlikely that it is possible to manually program the AD vision system and controller to handle all possible environments without the use of machine learning.

4.1.7. Leverage Points

This section introduces the concept of leverage points, which is a good way of understanding why certain factors in the driving force model have a much stronger effect than other seemingly similar factors. In this section some general examples of leverage points from the literature are presented, in the following section the specific leverage points of the SEVS AD driving force model is discussed.

Apart from analysing and understanding a system and applying systemic approaches, it is highly relevant to understand how systems change and how one can steer a change. In order to induce sustainability transitions, systemic thinking can also be applied effectively when so-called leverage points are identified in advance. Meadows (2009) has been one of the pioneers in systems thinking. More specifically, she has highlighted 12 leverage points which are *'[...] places in the system where a small change could lead to a large shift in system behavior'* (Meadows, 2009) (s. Figure 7). The leverage points are presented in a list of increasing leverage:

1. Numbers - Constants and parameters such as subsidies, taxes, standards.
2. Buffers - The size of stabilizing stocks relative to their flows.
3. Stock and flow structures — Physical systems and their nodes of intersection.
4. Delays - The lengths of time relative to the rates of system changes.
5. Balancing feedback loops - The strength of the feedbacks relative to the im- pacts they are trying to correct.
6. Reinforcing feedback loops - The strength of the gain of driving loops.
7. Information flows - The structure of who does and does not have access to information.
8. The rules of the system - Incentives, punishment, constraints.
9. Self-organisation - The power to add change, or evolve system structure.
10. The goals of the system - The purpose or function of the system.
11. Paradigms - The mindset out of which the system - its goals, structure, rules, delays and parameters - arise.
12. Transcending paradigms.

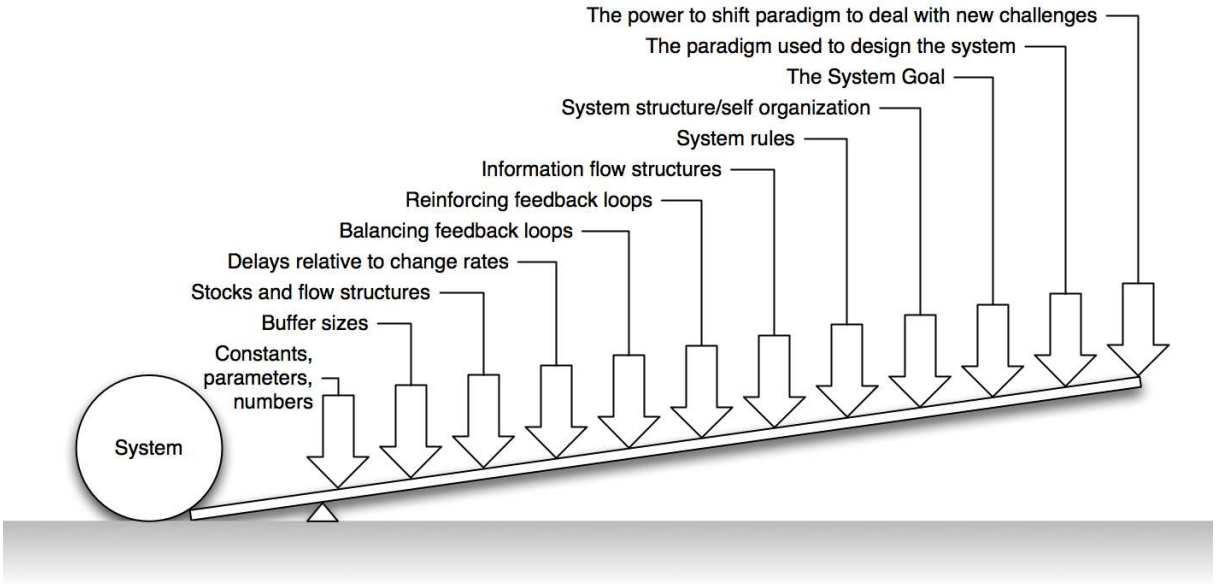


Figure 7 The 12 leverage points on a system as developed by Meadows (2009)

4.1.7.1. SEVS for AD and leverage points

The analysis of the driving forces around the diffusion of the AD innovation and the sociotechnical system that surrounds it has provided us with some key questions. The answers to these questions are highly uncertain; therefore these questions function as “watersheds” in the possible developments of AD in the future depending on “what values they take”. They are the so-called leverage points, a term that is borrowed from the System Sciences (see previous section). They are the determinant factors that can shape drastically the different scenarios of the future depending on their “values”. Hence, their answers should be either assumed or considered as an input for the next step of the SEVS analysis for shaping the four possible futures where AD might be part of and play a role (see following section WP2 Scenarios).
Some examples of leverage points along with their extreme values are presented below:

- Will the volume of transport be higher or lower?
- Will people trust and accept transport disruptions and innovations?
- Will the users transport selection criteria change over time?
- Will Policymakers design policies for AD innovations proactively or reactively?
- Will the legislation change follow and facilitate the AD disruption?
- Will machine learning be enabled to drive the AD development?
- Will the urban cities sprawl or become denser in the future?

More examples of such leverage points can be found in the Actors**:** Independent flower shop in Linnégatan the specific actor in this case is the owner of the flower shop is Mrs Rose (her first name is Elisabeth but in the use case she is referred to as Mrs Rose). The shop also employs two assistants who work at the store at different times/days. Mrs Rose has a son (Erik) at university and a daughter (Julia) at school. She lives in Lindome about 20 kms from the shop in a small house near her mother.

Actors needs
a) To be able to deliver flowers and plants when ordered by customers.

Orders could come from:
- Customer who visits the shop
- Customer who telephoned
- Customer who ordered from somewhere else though a network such as 'Interflora'

b) Transport needs to able to take flowers and plants from the company location to the customers home (or in the cases of a business customer to their establishment). Transport needs to be close by or if possible parked at the flower shop (the latter is not possible in Linnégatan). The parking place needs to be available to the van/car used by Mrs Rose.

c) Transport needs to be available all the time as deliveries can be required 7 days/week.

d) Transport needs to be able to accommodate plants and flowers that are not packaged without damage.

e) Transport needs to be low cost because the margin on plants and flowers is rather small.

Functional requirements, transport modes and route start and end

- Small vehicle
- Can be driven by someone with car driving licence
- Powered van or car (could be electric, hybrid or fossil fuel)
- Delivery cycle - electrically assisted?
- Route starts and ends at the home of the shop owner - but the main use of the vehicle is for business

System without AD

One Thursday

Mrs Rose drives to the store every day in a small van that she uses both for the trip to/from work and also for delivering flowers during the week. During the working day the van is parked at a nearby parking space (which has to be paid for). Sometimes the van is parked up to 750 metres from the flower shop which is time-consuming and occasionally problematic for Mrs Rose. When loading the flowers and plants she sometimes has to park outside the shop which can cause an obstruction and even incur a fine.
The van is diesel powered but Mrs Rose is thinking about getting a hybrid or electric vehicle but is concerned about the additional capital cost. The main reason is to be seen to be more environmentally aware and also because running costs could be reduced in the longer run.

Mrs Rose wakes up at 05:30, she has breakfast and makes sure that she is organised for her work - at the end of last week she has placed a big order for flowers and plants; today will be a busy day at the shop.

Her daughter Julia gets ready for school but today Mrs Rose will leave early for work and so she will drive Julia to her mother's house where she will stay until it is time to walk to school.

As it happens her son is at home as well as the university term finished last week. But he has not got up in time for breakfast. He said he would help in the shop in the afternoon and he will have to get there himself by bus.

06:30 drive to her mother's house with Julia in the small van.

06:45 drives to Linnégatan arriving at 07:10; today there was not a lot of traffic. Parks the van 750 metres from the shop in a parking area and walks to the shop arriving at 07:20.

07:20 to 09:00 works in the shop getting everything ready for the day ahead. This includes preparing the orders that need to be delivered. At 08:30 one of the two people that help in the shop arrives (Karin).

09:00 the shop opens - on Thursday and Friday Mrs Rose has decided to open at 09:00 on the other days she opens at 10:00.

09:15 Mrs Rose decides it is time to make some of the deliveries. She normally tries to do the deliveries to offices at this time in the morning and then will deliver flowers to private addresses later in the day. Of course sometimes there is an unexpected order that needs to be delivered urgently.

09:15 to 09:25 Mrs Rose spends some time wondering whether it is better to wait for a loading space outside the shop to be available or whether she will need to find a way to take the flowers to the van. This problem has been getting worse recently with the lack of parking spaces.

09:25 a space is available - Mrs Rose hurries off to the van. She drives back (rather quickly) and parks in the space (it is now 09:35).

09:35 to 09:50 Mrs Rose loads the small van - flowers have to be treated with care and this takes 15 minutes although she tries to do it more quickly - but flowers are difficult - they come in all shapes and sizes as well as being fragile.

09:50 sets out on the delivery trip. Luckily she knows most of the places where she has to deliver rather well although today she has to make a delivery to an address that she is not familiar with. She knows her phone can help with this but today she has forgotten to charge it and she worries that if she uses it to find the address the power will run out.

10:40 just this one delivery to make; now to the unfamiliar address. It is a bit annoying but two people who had ordered flowers were not in so she still has their orders in the van (one was to a private address and so that does happen from time to time but she was a bit surprised to find that the delivery to the office that was planned could not be made because there was a sign on the door saying 'back in 15 minutes' and she could not wait and hope that this would happen. However, things improve - despite her uncertainty about this final address Mrs Rose finds it rather easily and makes the delivery - another happy customer!

11:00 Just as she is about to get into the van her phone rings - it is Karin - the two people who were out when she called earlier to deliver their flowers have both phoned to say how sorry they are and to ask if there is any possibility that she can still deliver. Mrs Rose says yes and the deliveries are only slightly out of the way. Mrs Rose is pleased that her phone still had enough charge to take the call - just as well she did not use it to find the last address.

11:00 to 11:25 Mrs Rose makes the two deliveries and returns to Linnégatan. This time she is able to part a bit closer to her shop and is pleased because in the afternoon she will deliver to five people and one of them has placed a very big order.

11:25 to 14:30 A busy time in the shop and Karin and Mrs Rose have to find time to have coffee and a sandwich. It was a good thing she was back by 11:30 though because a package was delivered and one corner seemed damaged - this was a display stand that she needs to take with an order she will deliver in the afternoon. Luckily Mrs Rose was able to ask the person delivering to wait and they both checked the package and realised that it was just the box that was damaged and the thing inside was fine. The van driver (Mrs Rose thought that her badge said her name was Maria) was pleased as well since it saved another trip and more paperwork.

14:30 Mrs Rose decides that it is time to make the deliveries - her son should have arrived at 14:00 but just as she is thinking that she will have to organise the deliveries herself he arrives - on his bike - he has decided to visit a friend later in the day and the bus was not convenient - since all this was decided at the last minute he forgot that not taking the bus would mean he arrived a bit late. Amazing thought Mrs Rose - he is studying 'logistics'.

Anyway he is here now and they begin to organise the deliveries and get things ready to put in the van. Everything is ready and at 15:00 Mrs Rose is set to leave but the delays mean that she does not have very long before the large order she placed last week will be delivered to the shop. If

only Erik (her son) could drive but he is still having lessons and so he cannot deliver the customer orders on his own.

Mrs Rose decides that she will have to explain to Karin about the order that will arrive at the shop and that she will now need to leave Erik in the shop to help when it arrives. Not what she had planned that morning at 05:30.

15:10 Mrs Rose sets off to make the afternoon deliveries - she is late and she worries that her customers will be stressed about this or (perhaps worse) that they will not be in.

But, everything goes quite well and almost all the deliveries are made by 16:30 (including the large order that required the display stand) when Mrs Rose returns to the shop.

During the last deliveries she received a text message from her mother to say that Julia was back from school and that she seemed to have caught a cold but was alright and she would look after her until she could collect her later.

16:30 parks and gets to the shop at 16:40. Where she sees that the large delivery is still taking pace - this is a surprise because it should have been finished by now because at 16:45 the shop starts to get busy again. It seems that Karin and Erik insisted on counting all the boxes and the plants and this has delayed everything. The delivery driver does not seem very pleased.

16:45 Karin leaves at 17:00 and another assistant (Anna) arrives to help until the shop closes at 19:00.

17:15 Erik asks his mother if she needs any more help and Mrs Rose says that it is fine for him to leave and go and visit his friends - what time will he be home she asks and gets a rather vague reply.

17:15 to 19:00 Mrs Rose and Anna work together in the shop. Just before 17:30 a customer who comes to the flower shop to collect a wreath that his wife has ordered. Mrs Rose mentions that she also offers a delivery service and he says that he wished he had thought about that because the traffic is very bad today and he thinks he will be late arriving home. He seemed pleased that Mrs Rose had told him this because he said "well sometimes it makes sense to spend a little bit more in order to save time and to have a more convenient day". On the other hand while he was in the shop he also bought some flowers for his wife and that would not have happened if the wreath had been delivered. Mrs Rose decides that life is quite complicated when you start to really think about things.

Anna and Mrs Rose close the shop soon after 19:00 and Mrs Rose leaves for home at 19:20.

20:00 Mrs Rose collects Julia from her mother and they go home together - her cold seems worse. Mrs Rose hopes she will be fine to go to school tomorrow.

20:10 Mrs Rose makes something to eat (Julia has eaten earlier) and as she is finishing her meal Erik arrives. He eats and they talk for a while about how university is going - and whether he will be able to help in the shop in the vacation.

Mrs Rose decides she has had quite a tiring day and goes to bed at 22:00 after watching television show that she likes. Tomorrow will be a calmer day she hopes.
END OF USE CASE

OPTION 1 FOR AN AUTONOMOUS VEHICLE

In this optionwe have assumed that Mrs Rose has decided to own her own autonomous vehicle.

Activity of the AV

The autonomous vehicle is used to get from home to work just as it was before. However now Mrs Rose can get out of the van at the flower shop and send the AV to park itself (in order to save parking fees Mrs Rose decides to use a parking space further away than the one she used before).

When orders need to be delivered Mrs Rose can ask the vehicle to come to the store or park nearby in order to load it.

After it is loaded the AV can be sent to make the deliveries of flowers and Mrs Rose can remain in the store - this saves some costs because it is now possible to reduce the need for assistance in the flower shop (of course this has employment consequences - these are not directly related to driving the vehicle). Unfortunately not all deliveries can be made using the AV because the customer needs to be there to take the flowers from the vehicle when it arrives. In addition Mrs Rose has had to have a modification made to the original AV because she has to be sure that customers can only access the flowers they have ordered and paid for. Therefore the vehicle now has a system of small 'lockers' which has reduced its carrying capacity.

The need for a customised AV

Because of the limitation at the delivery point which used to be overcome by Mrs Rose getting out of the van and making the delivery herself a new option for delivery has been created. This enables the flowers to be left close to the customer at a nearby shop (or other facility) where several orders can be received (by the pick up point staff). The flowers/plants can then be collected by the customer later on that day or in the evening.

Some problems of customer service

Of course not all customers are happy with this service as they preferred the personal delivery made by Mrs Rose and for some customers (several office buildings for example) she offered an additional service when she would arrange the flowers in the relevant entrance areas of the office.

This question of customer service has worried Mrs Rose since it was an important part of her business and she has now decided that she will continue to offer a delivery service where someone goes with the AV. This has reduced the cost advantages of the AV but it has enabled Mrs Rose to employ her student son during the long university vacation periods - although he does not have a driving licence he is of course able to travel in the AV and make the delivery. During the university term time Mrs Rose asks one of the shop assistants to make some deliveries in the AV and this has been a success because the job is now more varied. In addition Mrs Rose has been able to spend more time in the shop and has realised that it needs some re-design and could be made more welcoming to customers.

After the AV has made the various delivery trips it does not return to the store but finds a parking space and parks there until it is needed by Mrs Rose.

Use of the AV for the journey to work trip

When it is time to go home Mrs Rose calls the AV and travels home in it. Of course in times when she is not at work she has found the AV useful for other activities. Some of these things she used to do on her way to and from work (sometimes referred to as trip-chaining). Now this is no longer necessary and the AV can be sent to collect her young daughter from after school activities without Mrs Rose needing to go along as well. Naturally the locker boxes that have had to be installed (for the delivery trips) need to be removed and this 'pod' is then left at the flower shop overnight.

Overall view of the change to an AV option

Overall Mrs Rose is pleased about the arrival of the AV option but she is a bit surprised that it has not saved much money as she had been led to believe this was one of the key features of AVs. In addition she has noticed that the AV travels almost 30% further than the van used to travel mainly because of the parking distance and also because she no longer reduces travel by trip-chaining.

She was also a bit surprised about how difficult it was to obtain the locker pods for the delivery service but this was because it appears that flower and plant deliveries are very specialised and few businesses required this option.
Appendix D.

An important observation while examining the leverage points around AD is that the order of leverage is challenged (see Figure 8 below). In such a complex system as the diffusion of AD, market forces could exert more leverage with the advent of Automation level 5. The absence of a driver will lower the costs radically, putting pressure on all the other system entities to follow that shift, which potentially would play a more impactful role in the acceleration of AD. This can be seen in Figure 8 as the fact that the “market forces and economy” is a weaker leverage point than “policies” for automation level 5, but when reaching automation level 5 the “market forces and economy” becomes a stronger force than “policies”.

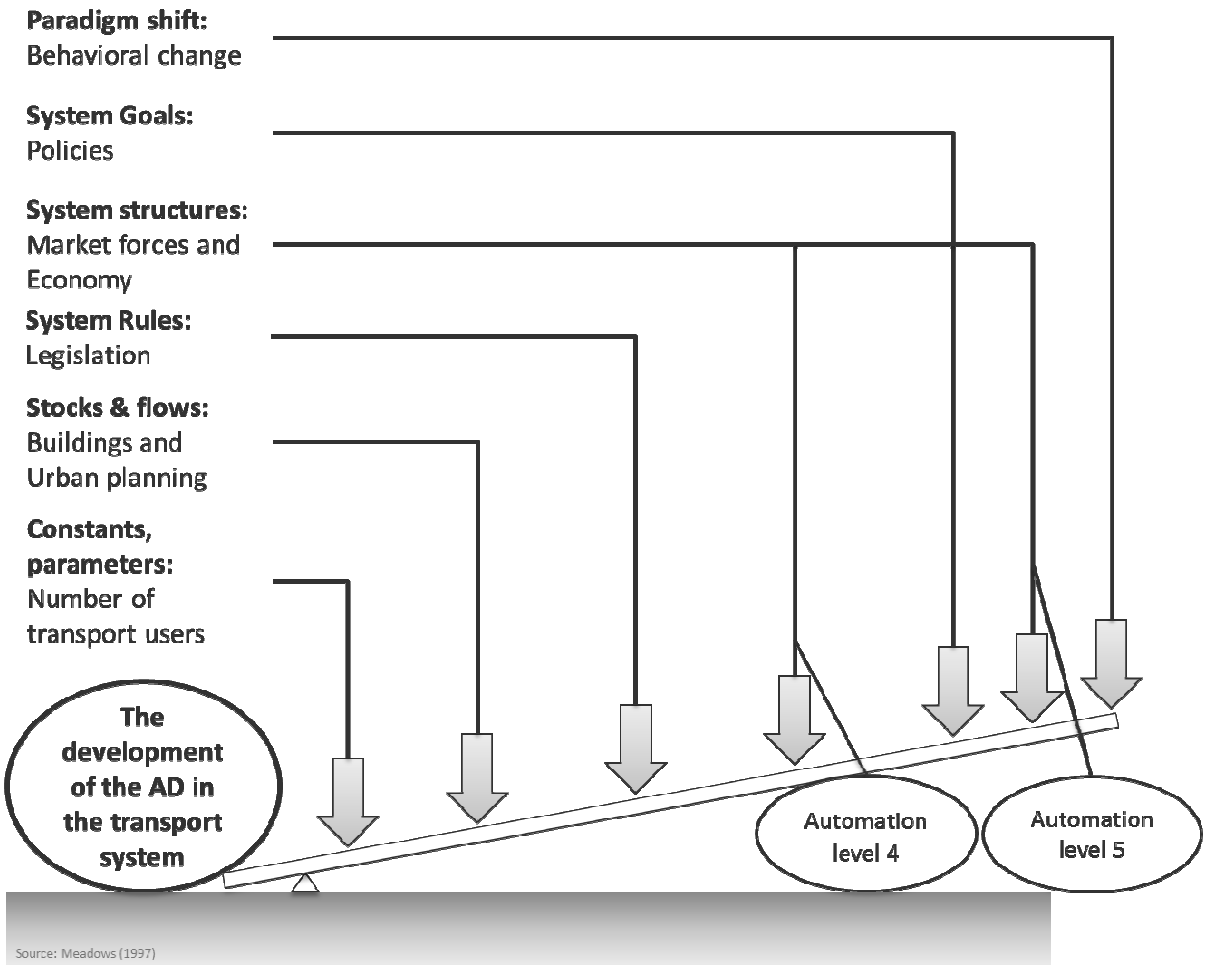


Figure 8 The Leverage Points tool (Meadows, 2009) applied on the AD case. Here one can also witness how the tehcnological advance from Automation Level 4 to Level 5 can influence strongly the market forces.

Using the leverage points tool as presented in Figure 8, the points of highest leverage were selected. Namely, the **radical change of transportation pattern by lifestyle** (equivalent to paradigm shift according to the tool) and the **Policies proactivity** (equivalent to system goals) were chosen as the ones of the highest leverage and importance. However, their high uncertainty calls for further analysis. Hence, in the next sections, scenario design method is employed to investigate these uncertain leverage points. The fact that economic market forces can outweigh the force of policy when presenting the leverage points is not in conflict with having policy as one of the scenario axis. Scenario axes are selected to be the factors which are **both of big influence and uncertain**. The strong economic force for AD is one of the few certain factors and therefore it is not needed as a variable in the generation of the scenarios.

The leverage point of radical change of transportation pattern by lifestyle needs further elaboration as it is a priori very challenging to analyse and predict. Thus, an additional

Transport Analysis follows and Use Cases are developed to reduce uncertainties and to enable a structured analysis of the user's behavior (see WP3 Use Cases section).

4.2. WP2 Scenarios

4.2.1. SEVS and Scenarios

The Scenario methodology is a powerful tool for freeing one's mind from the present and personal presumptions and to actually transport one's mind to possible futures while evaluating different solutions in relation to the needs of key actors.

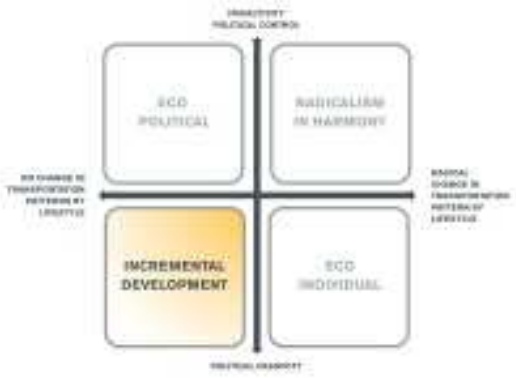
It is important to point out that the scenarios are not predictions, but possible outcomes of uncertain and important driving forces playing out in different directions. A scenario analysis starts with identifying and ranking driving forces, but working in the scenarios is actually the best way to understand how the driving forces work and how they are connected.

The two axes of the scenario cross SEVS 1, referring to the two most important and uncertain driving forces as described in the text above. The vertical axis represents the degree of political initiative (reactive or proactive) and the horizontal the level of change in lifestyle due to shifting values and norms.

This pre-study has now further developed the scenarios that were identified and described in SEVS 1 and SEVS 2. Some new perspectives based upon the reviewed Driving Force Model have already been integrated into the characteristic scenarios below.

4.2.2. Four possible futures by 2030+ adapted to AD

Incremental Development by 2030+



BACKGROUND THE ROAD TO THE INCREMENTAL DEVELOPMENT SCENARIO

Southern Europe's low economic credibility instigated a free fall on the financial markets. EU financial officers tried to regain the markets' confidence, but to no avail. After the "Brexit" in mid-2010's, more EU members followed UK to the isolation. The financial and political downturn made it impossible for the Paris UN Agreement on Climate change of 2015 to be practically implemented and the 17 Sustainable Development Goals to be reached. Combined with the psychological effect of a depression looming on the horizon, the political right and left parties focused on economic growth and welfare. Sustainability movements were marginalized.

When the economy recovered, higher oil price stimulated electric and alternative fuel vehicle sales and some sporadic investments on Autonomous Vehicles were made but the underlying motivation was strictly economical with no political vision. High fuel, battery prices and high costs of Autonomous technology increased demand for public transportation, but not enough for a revolutionary change. The transport behavior has remained roughly the same with the mid 2010's, along with high car ownership and low asset efficiency (vehicle usage). Sharing models and sustainable mobility patterns failed to enter the, financially driven, rigid transport landscape. As a result of the political mistrust but also the lack of political guidance towards sustainable and shared models, mobility users have been characterized by suspicion and lack of trust towards changing their transport patterns.

Traffic fatalities remained stable failing to decline over the years, largely due to increasing traffic but also the failed diffusion of safe Autonomous transport technologies and solutions. Lack of coordinated and collective actions didn't allow for building a reliable infrastructure for diffusing Autonomous vehicles. The latter are privately owned and driven by the elite of the society. Fully Autonomous solutions are only applied to restricted areas that are privately owned with regulated access and circulation of pedestrians. Low average speed rates are the main contributor to keeping casualty figures down.

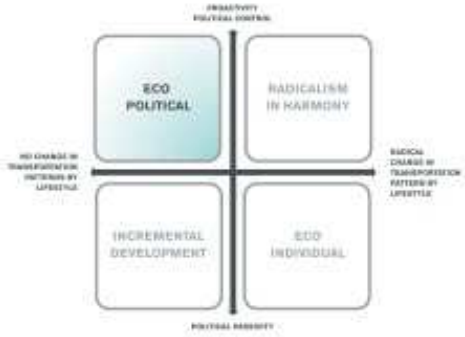
Society:
Mainly individualistic values. Cities are polarised, into high income and low income areas. In general, low awareness of the environmental effect of different diet choices. The majority of the citizens still eat meat. People are informed about the greenhouse effect, but they are too busy with their daily lives to take personal initiatives. Private ownership rules. Those who choose to buy AD is not because of safety or minor congestions, but because it makes life easier (e.g. your car can park by its own)
Politics: Focus is on economic growth, jobs and general welfare. Competitiveness of the Western world is commonly discussed; global warming is not. City officials are passive, taking no actions to stimulate clean and safe mobility accessible to all groups of society. Short-term economic decisions counteract long-term solutions.

Economics: Severe fluctuations in the price of oil due to upswings or downturns in the economy. These variations make the economy more volatile. Very few investments and subsidies in Autonomous transport systems.

Public transportation: Investments have been made in an effort to cope with increasing traffic congestion. Very little has been done to stimulate public transport. No stimuli from cities to order invest in implementing sustainable transport.
Infrastructure: New roads are built all the time, but they look like the roads of today. Private roads for those who can afford them, such as AD vehicles owners. Absence of standardization in marking, mapping, signage and signals especially in rural places prevented AVs from circulating.
Safety: Is taken for granted, but not a priority. Most traffic injuries are caused by frustrated drivers hurting each other, more or less deliberately (road rage).
Engineering: Alternative fuels and electric vehicles are developed from a cost-efficiency perspective only.

Products and services: Smart logistics systems for private and commercial customers. The few fully Autonomous Vehicles are found sporadically in “protected” environments such as Autonomous pods in Airports and private facilities in prototype stage.
Vehicles: Heterogeneous mix; old and new, small and large, and many different fuel alternatives. Primarily Premium Autonomous vehicles with some autonomous functionality is standard k, eg driver involvement is needed; few Autonomous Pods or full Automation for limited use.
Energy supply: Mainly oil-based. Many alternatives (natural gas, bio fuel etc) are available but they are used only when they are cheaper than oil-based fuel.
Communication: Vehicle-to-vehicle, vehicle to consumer and vehicle-to-infrastructure. Lack of standardization will hinder the development of reducing congestion, enhancing safety and comfort for the owner.

Eco-political



BACKGROUND THE ROAD TO THE ECO POLITICAL SCENARIO

In the mid-2010s, a succession of severe rains and scorching summers nearly created an ecological disaster. After the 2015 UN Paris agreement for Climate Change, a coordinated campaign on application of Sustainable Development Goals resulted in politicians with a green agenda coming into power. However, the citizens have heard about climate change for some decades now and are more interested in short term issues of unemployment, education and tax cuts. Conclusive evidence that the drastic climate changes were caused by sunspots compelled people to forget their brush with disaster. Nevertheless, the politicians try to implement policy measures that lead towards the climate targets, but are at the same time cautious not to annoy the citizens too much. The general public largely disregards the steady, less dramatic increase in global temperatures.

Despite public opinion, European politicians introduce an ambitious program aimed at a better environment with innovative and green technologies, mainly Autonomous technology systems and alternative fuels. More specifically, governments financially support upstarts offering promising new green technology. At the same time, they make considerable investments and broad partnerships in introducing such technologies in the public transport.

The program is partly funded by high taxes on fossil fuels and road pricing amid protests and demonstrations. Users enjoy a reliable ubiquitous state-of the art public transportation network with Autonomous transport solutions that have been provided to them in a top-down fashion. However, trends related to shared and efficient mobility and mutual trust are not diffused enough and people keep attached to their 2010’s lifestyle. After some sporadic incidents of privacy and data violation, extra measures have been taken against cyber terrorism connected to Autonomous Transport. The events have caused an increasing skepticism against Autonomous Transport. In 2022, the maximum speed limit is lowered to 70 km/h to decrease carbon dioxide emissions and save lives in traffic.

KEY ISSUES:

Politics: The goal is a cleaner, more inclusive greener society. Taxation, standardization and legislation are used to realize this goal, regardless of whether the general public wants it.
Policies: Policies and measures to increase road capacity for the future rather than investing in new infrastructure. In many cities where AD is part of the public transport system, legislation has already been updated even though not completely internalized by the citizens.
Public transportation: Drastic expansion of the public transportation system, which is subsidized to gain acceptance among the general public. A central control system has been in place to maintain and administrate the network of the Autonomous vehicles and their interaction with the environment. Autonomous systems have been mainly used in connecting rural areas.
Infrastructure:The drastic expansion of the public transportation system will have a big influence on the city center infrastructure in terms of road and energy distribution. Infrastructure for AD solutions has been in place but it is still expensive for the general public, hence most people still choose individualistic conventional transport. City plans for moving parking lots outside the city have been received with resistance from the public.
Safety: Car traffic restricted to driving slowly. Downtown areas are safe for walking, bicycling and driving small electric vehicles with Advanced Driver Assistance Systems and no extensive collision zones. High congestion still causes road rage. There have been threats and some rare incidents for cyber vulnerability but the infrastructure seems robust enough.
Technology: Apart from the vehicle itself, new innovative IT solutions are advocated, making mass transportation solutions more convenient.

Products and services: Focus on co-modality opens up for new IT solutions and business models like smooth ticket services, provided by a third party. A few innovative niche business models exist, based on pay per mileage, use or subscription.
Vehicles: Alternative fuels, electricity and Autonomous Drive transport solutions are heavily subsidized (directly or indirectly), while fossil fuel is heavily taxed.
Partnerships: Energy companies and more transportation providers that collaborate with public authorities. Insurance companies and IT providers; information opens up for lower insurance costs for those who drive carefully. Liability belongs to OEMs.
Economy: Standardization will favor traditional vehicle companies since they have influence over those who set standards.
Roads: More plants and trees. Grid networks will be developed to supply vehicles with energy. Clear separation between pedestrians and different types of vehicles.
Energy supply: Ground and air-located energy distribution systems for public transportation vehicles. Personal electric vehicles can be charged at strategic locations.
Communication: Vehicle-to-vehicle and vehicle-to-infrastructure systems. Traffic guidance systems and route planning tools for proper energy management.

Eco-individual

BACKGROUND THE ROAD TO THE ECO INDIVIDUAL SOCIETY

In the mid-2010s elections, most politicians around the world focused primarily on jobs. After the 2015 UN Paris agreement for Climate Change the World leaders failed to deliver a viable and radical enough scheme to apply the UN Sustainable Development Goals. Consequently, all green and safe incentives were discarded and the drastic measures needed were not taken. However public disappointment in traditional party policies as well as strong self-organization initiated by global and local nongovernmental organizations led to the formation of a robust, green subculture. This new green bottom-up wave lobbied quite hard getting business actors on board as well as consumer organizations and media. People care and show it by modifying their consumption patterns, both in terms of goods and transportation. The former subculture is no longer a subculture and trends such as Sharing economy and alternative sustainable transport models become mainstream.

On the transport market, new actors entrance the market and offer different kind of vehicles as well as a lot of different functionalities and services, which quickly become popular among the public but the infrastructure is not there yet. The legislation, the urban planning and the political readiness and willingness are far behind to accommodate for the diffusion of Innovative Autonomous solutions. There is great inequality observed locally among the regions, cities or even smaller municipalities regarding the adoption of AD as people self-organize and bring novelties in their neighborhoods. Public transport is obsolete and people have started their own initiatives to push forward sustainable solutions such as clean AD solutions with the support from some new innovative market entrants. Traditional Automotive industry actors couldn’t follow all the way the growing green trends amid political passivity and their offer of efficient transport is also quite outdated.

KEY ISSUES

Society: Green and safe has a very high status. There is a willingness to spend more on green and safe transportation, even without incentives or regulation. Trends such as circular economy, dematerialization, sustainable consumption and lifestyle rise. Exit the “0-to-100 generation”.
Technology: No standardization. Green and safe due to consumer requirements. New battery technology and business models support new local and decentralized energy sources and diversified transportation alternatives such as Autonomous technologies.
Sustainable transportation: Extreme diversification, unique solutions for different purposes. Small-medium scale, flexible solutions such as carpooling and ridesharing with friends and neighbours.
Business: Large, established companies suffer due to inertia. Startups with innovative mindset grow offering all-inclusive safe and sustainable Autonomous solutions. Innovative business models on pay per mileage, per use or subscription emerge.
Safety: Caring is a key word, including caring for the environment as well as caring for the safety of all. More and more growing transport solutions are equipped with guaranteed safety by autonomous systems.
Products and services: Carpool service including cars, logistics systems, service and maintenance, ridesharing, package and ride hailing etc. The automotive industry has just started selling not only products, but transportation solutions such as integrated goods distribution with people transport, as well integrated transport solutions with cloud stores.
Infrastructure: Slow change driven by consumer demands, not incentives or regulations. Parking lots are located outside cities and are combined with public transportation.
Roads: Maintained, but not improved with governmental funding.

Energy supply: Local, small entrepreneurs dominate. Green and safe solutions attract venture capital. New battery technology supplies small-scale wind power to the grid.
Communication: Need for faster, more precise navigation with an option for the greenest route as standard. Need for vehicle-to-infrastructure connectivity. Need for a more digitalized infrastructure compatible to new transport solutions.

1.1

Radicalism in Harmony

BACKGROUND THE ROAD TO RADICALISM IN HARMONY

It all started when the European green parties decided on a common agenda. The strategy was to own “The Big Story”. Just like the liberals owned the story of freedom and the left owned the story of justice, the greens would own the story of a clean, safe earth. The best PR and advertising consultants money can buy communicated the new strategy. The Green Wave in Europe was an immediate success, making it clear that one could live a cool, green, efficient and affordable life using the latest technologies. Finally, voters and elected officials understood each other and tried to outdo each other in being, living, voting and governing green. Old, smoggy technologies were banned, and an upgrading program was implemented in all sectors including vehicles, houses, roads, industry, energy production and agricultural production. The scales had shifted to green once and for all.

World leaders have reached an unprecedented consensus with the populace. Individualistic transport solutions have been coexisting in concert with shared mobility models and a state of the art ubiquitous public transport. In this “hybrid”, sustainable model of transport system, Autonomous solutions are close to enjoying the lion’s share. It has just been forbidden to sell new non-Autonomous Vehicles including at least almost fully autonomous technology for years and now some local authorities are considering abandoning the circulation of conventional vehicles of high Automation functionality solutions in city centers. The risks of cyber-attacks have been mitigated after transitioning to a more decentralized system. The transportation market has opened and many new smart and green private actors have been participating actively. Soon Public transport will be running for the first time in history with public subsidy lower than 20%. Local city officials are facing a dilemma between dense and sprawling planning as rural areas have been successfully connected to the city. The “on the fly” market has emerged and is the number one hype in business start-ups.

KEY ISSUES

Transportation market: Radical change to greener alternatives, offering more niche products. The green aspects determine transportation. Smart logistics solutions dominate.

Economy: Willingness to pay more for green, safe products. Strong legal and financial incentives and public opinion that demand faster modifications creates a positive spiral. New business models have emerged as new business actors operate for offering services on the fly.

Technology: Quicker shift towards green and safe. Public opinion and government co-act for greener and safer engineering solutions for transportation. Vehicles and infrastructure is a perfect match – development activities are coordinated. Hardware, software, and logistics solutions are matched.

Sustainable transportation: New drive- lines. Public transportation is dramatically enhanced, and as are goods and passenger freight solutions.

Safety: Low, adaptable speed limits. Separate lanes, and a willingness and acceptance for more expensive infrastructure in general geared toward the ultimate objective of being as green and safe as possible.

Products and services: Diversified products. Co-planning for goods and passenger transportation and services. Incentives for sustainable alternatives. Sustainable `servitization' business models in place. New business actors enter and new services are offered all along the life cycle of a transport service.

Infrastructure: Always building the safest infrastructure. More public transportation solutions. Adaptable speed limits (low). Separate lanes.

Roads: Safety first! Willingness to spend both more money and time in order to realize the Zero Vision Goal.

Energy supply: The safest source of energy is used. The safest batteries possible – rapid advances here! Green electricity. Solar power.

Communication: Adaptable road guidance for safe and smart transportation. Vehicle-to-vehicle and infrastructure- to-vehicle systems are implemented efficiently.
Partnerships: Bigger companies initiate partnerships with smaller companies with emerging technologies at a faster pace, driven by strict legislation.
Environment: Sustainable leadership and lifestyles have achieved net positive impact on the environment.

4.3. WP3 Use Cases

The purpose with use cases in is to describe the daily agendas and movements of actors and goods. Actors can be an individual, a household, a company, or individuals working in the company that is studied. The questions that are asked when studying and analyzing use cases are: Who does what? At what time and at what places are activities carried out? What activities can be moved in time and place? How tied are activities to certain individuals and vice versa? The use cases should identify barriers and opportunities with autonomous vehicles (stage 4 and 5) in order for the actors to carry out the daily activities, and for the goods to be transported, delivered and picked up. People coordinate with others- with family members, with colleagues or with customers, and often travelling involves more than going from A to B. It also includes errands on the way. Therefore, bundles of individuals, as well as trip chains are important units of analysis in order to describe and measure the factors that influence choice of transport mode. The use cases should identify how an autonomous transport system can satisfy the actor's needs as regards accessibility, affordability, mobility, safety, security, health and quality of life.

The use cases for goods movement have been prepared in broadly the same style and following a similar methodology to those prepared for personal mobility. This is to help in understanding the interaction between personal mobility and goods movement which is likely to be more significant as AD develops. In addition, it allows the two overlapping systems to be considered in a similar way which is helpful when trying to understand trade-offs and changes that arise from trip substitution (a personal mobility trip is replaced by a goods movement trip). The interaction between mobility and goods movement will be followed up in more depth in the SEVS 3 for AD e-commerce project that started in late December 2017.

An activity based approach

The use cases have been analysed according to an activity based approach, which is based on the time-geographical approach. Time- geography enables a visualisation of the relationship between activities in time and space and how everyday life is organised and structured (Hägerstrand, 1970; Hägerstrand and Lenntorp, 1974). Individuals use their time carrying out activities that are always taking place somewhere and require different types of resources. Even if time is available as a resource, people face different types of constraints that limit their freedom of action. Three types of constraints surround the individual and limit his or her freedom to implement activities (Hägerstrand, 1970; Hägerstrand et al., 1991). *Capacity*

constraints concern an individual's biological characteristics and his or her access to tools and ability to use them. Some constraints limit the ability to use time or compete for time. Eating and sleeping are limiting because they usually occur at specific places (home) and with certain regularity. Other capacity constraints are the individual's physical and psychological abilities, material resources, as well as being aware of the existence of certain tools and services and knowing how to use them. To be able to use a variety of transport modes demands for example; knowledge of where and how to book a car or a bike, where to get on the bus, how to buy a ticket etc. *Coupling constraints* concerns the fact that individuals, tools, material objects and the physical environment are interdependent, which is vital in order for production, consumption, socialising, and everyday life to work. For example, some activities require coordination between family members or colleagues in a production chain. *Authority constraints* are the laws, rules and norms and expectations in our institutionalized and societal context that make certain places or domains available only for certain persons and activities at certain times. The workplace may require an adaptation to certain working hours, and the public transport system may reschedule its timetables. An individual's daily schedule is thus dependent on a large number of decision-making entities that are beyond his or her own control.
Thus, by using the activity based approach to study how an automated transport system influence transport of people and goods, this study considers travel behaviour as secondary to activity behaviour. Sequences or patterns of activities and linked trips, not individual trips, are the relevant unit of analysis. Further, household composition, life stage and other social structures influence individual activity pattern and thus travel behaviour. In the following paragraphs, the use cases of personal and freight transport are described.

4.3.1. Transport analysis

4.3.1.1. Personal Mobility

The actors are a family with children living in a single attached house in Kungsbacka, 25 km from Gothenburg CBD. The family consists of father Björn 46 years old, mother Lena 43 years old, one son David 10 years old and one daughter Stella 14 years old. The father works as an engineer in Torslanda, 45 kilometer from home. The mother is a teacher at a school in Kungsbacka. There are no direct connections between Kungsbacka and Torslanda by public transport. Both parents work fulltime. The son David goes to a school in Kungsbacka. His main leisure activity, scouting, is located in the countryside 5 kilometers from home. The daughter Stella attends a school located in the central city and has basketball as a leisure activity located in Mölndal, 20 kilometers from home. Björn is disabled and mostly uses a wheelchair but he can walk short distances at home and at work. The family has a dog that stays at home every day. The mother and the son take turns walking the dog during the days. In the original use case, the household has two cars.

One Thursday
Lena and Björn wake up at 06:00. Björn starts to prepare breakfast while Lena walks the dog for 20 min. The children are awake when Lena gets back home and they all have breakfast together. Each and every one get ready for the day.

Lena

Today Lena takes the bike to work at 7:25. It takes her 15 minutes to get these by bike. Classes start at 8:10. She works until 11:15 when it´s time for lunch. Due to an incident at school she needs to stay at work over lunch to discuss the incident with her colleagues and can therefore not go home to walk the dog. She calls her father who is retired and lives in Kungsbacka as well. He drives to Lena's house and walks the dog. Lena's classes are finished at 3 pm but she has a lot of work to do still and stays at work until 5:30. She bikes home and takes the dog out for a walk. When she gets home she is going through the post and calls her mother who lives in Askim. The mother needs home care but Lena helps her with grocery shopping and they make a list together on the phone. Thereafter Lena makes dinner. Lena and David eat together and by the time they are finished, Björn comes home. Lena gives David a ride to scouting at 6:30 and continues after that to the store to grocery shop for her mother. After the store she drives to her mother and stays there until 8:30 p.m. when she drives back home. When she gets home, she talks to the other family members and goes to bed at 10:30 p.m.

Björn

After having breakfast Björn gets ready and steps into the car at 7:15 a.m., together with Stella. He gives her a ride to the bus stop which takes 4 minutes. He then continues to work which usually takes about 45 minutes in rush hour. During the trip to work he calls a colleague so they can plan a client meeting the same day. On his way, he needs to go to Kurt´s bakery on Hisingen to pick up some pastries for the meeting. He can manage to walk in there with a crutch (krycka). However, this morning the parking lot right outside the bakery is occupied by a van and he has to park further away and walk quite far. This makes him very angry and disappointed. It is not the first time that he experience that some places are inaccessible for disabled persons. This detour and stop takes him 15 minutes extra. After parking he shows up at work at 8:30. If Björn should go by public transport to work he would have to make two transfers. First bus, then train, then a 5 minute walk to the last bus. The total travel time would be 1 h and 10 min, excluding errands such as the stop at Kurt´s bakery. Buses and trains are overcrowded during morning rush hours and Björn feels that it is difficult to get on the buses with a wheelchair.

Björn works until noon when he goes to the restaurant in the same building and has lunch. After lunch he works until 5:15 when he walks to the parking lot. At 5:25 he drives from there. On his way home he stops at Mrs Rose´s flower shop to pick up a wreath that Lena will put on her grandparents grave this coming weekend. The journey (including the stp) takes 20 minutes extra in total due to the traffic jams in the city. After that he continues the trip home, comes home at 6:20 but just misses to have dinner with Lena and David because they need to get ready to leave for the scouting activity. After dinner he takes care of the kitchen, answers some e-mails and goes through the post. After that he goes out to the garage and starts loading things in the car that he needs to take to the recycling station the next day. When the rest of the family gets home they spend some time together and watch TV. At 9:30 p.m. he takes a 20 minute walk with the dog. He goes to bed at 10:30.

David

David bikes to school around 7:45 and is thus responsible for locking the house. Sometimes Lena and David bike together. After school he bikes home. After scouting, he gets a ride back home with a friend's parent since Lena visits her mother. Since eight out of ten children in the scout group are being picked up by their parents there is always someone who can give

another child a ride back home. Two of the children are able to walk back home since they live close to the scouting cottage.

Stella

Stella goes by bus and commuter train to school in Gothenburg city. It takes one hour. There is one bus stop close to the house but to get there she has to cross a road with a 90 km speed limit and is very busy with cars, trucks and buses. To wait at this bus stop means that she will be exposed for noise and air pollutions. Sometimes Björn can give her a ride there, otherwise she can walk to another bus that departs from another, safe bus stop but that is located further away from the house. During the winter and when it is dark outside she tries to avoid this bus stop because she needs to walk through a dark park to get there, which makes her feel uncomfortable. Often she bikes there but she is always afraid that the bike will be stolen. School finishes at 4 o´clock and then she goes directly to basketball training in Mölndal. The tram to the training center in Mölndal leaves every fifth minutes and takes 32 minutes. She is there at 4:47, and had time to change and starts training at 5 o´clock. She trains until 6:30 and takes the commuter train and bus back to Kungsbacka. The trip takes 39 minutes. She walks from the bus stop which takes 12 minutes. When she is home she´s having dinner, takes a shower, chat with friends and talks to the rest of the family before she goes to bed.

4.3.1.2. Goods Transportation

The actor is Götaparcel, a company that provides delivery services for packages in the Gothenburg region. The company is sub-contractor to a larger organisation that provides a national service across Sweden. Most of the packages are delivered to business addresses but about 10% of the volume is now delivered to private addresses. Sometimes the items delivered to a business address are to a pick up point such as a small shop where packages are collected. This use case considers the delivery and collection of packages mainly within the municipal area of Gothenburg (but this also includes Kungsbacka and Mölndal).

The vehicle fleet is a variety of vans below 3.5 tonnes. A total of 10 vehicles are kept at the distribution centre. A large truck delivers several hundred packages every night (from a central hub). These arrive at about 03:00 and are then sorted into the rounds for delivery the next day. Packages that have been collected from customers in Gothenburg are sent every evening to the central hub from where they are distributed to other distribution centres very similar to the one in Gothenburg. The location of the distribution centre is in Mölndal.

One Thursday

Here we will follow one vehicle from 00:00 on Thursday to 23:59.

00:00 to 05:00 vehicle is parked waiting to be used.

05:00 the vehicle is driven by a member of the loading team, Berit, to one of the doors where the outbound loads are being assembled.

05:00 to 06:30 the vehicle is loaded with packages. On this Thursday it is a busy period in the year and there are almost 200 packages of various sizes - most of them can easily be picked

up but there are two items that have to be delivered which are very awkward size and shape and difficult to handle. They are also marked 'Fragile'. This has resulted in a small delay in loading the van.

Packages need to be loaded in the order that will be most effective for the delivery round. This task is done manually and is based on the knowledge of the loading team. In this distribution centre the driver (Berit) also performs some parts of this activity as she knows where there are some stops which are complicated in terms of access to the addresses etc.

06:30 the van sets off and the first deliveries are to be made in Kungsbacka.

06:55 the van arrives in the centre of Kungsbacka and makes the first delivery of 10 packages to a small shop. There is a delay while the person in the shop checks whether the packages are correct but everything seems fine and they sign for the delivery.

07:10 The van makes further deliveries without any problems and there are 5 stops each taking 5 minutes.

07:35 The van arrives at Kurt's bakery - Berit is always pleased when there is a delivery to Kurt's bakery because normally she will get a free cup of coffee and a trial piece of the special fika that has been made that day. Kurt is pleased to see Berit who he knows quite well. They chat and Berit then delivers the three packages - all items that are needed in the bakery for packing cakes when customers come to collect them and also products such as paper serviettes etc.

All this takes a few minutes and it is just after 07:50 when a customer comes in the bakery - he seems slightly annoyed and complains to Kurt that a van has decided to park in the place that he understood was reserved for customers. Berit feels she should say something and points out that unfortunately there are so few places to stop that this was the only space available and she had no choice this time. The customer appreciates this explanation but Berit realises it has been a problem and thinks that perhaps in future she will have to park a bit further away and that means this stop will take longer than it should (she will have to tell the person who plans the rounds).

08:00 the van is back on the route and all the rest of the Kungsbacka deliveries are made - most of the packages are to a business address but there are a few to private houses. Although these deliveries are usually small they often take longer than the business ones because it can be hard to confirm the address and also sometimes it is necessary to find someone at home to sign for the package. One package that Berit has to deliver has a clear house and street address but the name of the person is not clear and all Berit can see is 'Lena …'. She finds the house but nobody is at home although when she rings the bell she can hear a dog bark. What to do? Well the package will not quite fit into the mail box but there is a plastic box with a lid that holds some outdoor things - Berit decides to leave the package in the box and place a note in the mailbox. She is almost sure she remembers delivering here once before and this is what she had done then.

Berit hurries back to the van and drives to Mölndal where the large packages need to be delivered at an agreed time (09:30). Traffic is worse than usual and so the van arrives a few minutes late.

09:39 Berit parks and walks to the address about 50 metres away and finds the person who is expecting the large items - unfortunately they have just sent one of their colleagues away to do something else and so there is nobody to help with taking the packages out of the van and bringing them across the road and into the delivery address - a small specialist engineering company. There is no choice but to wait - especially as the customer points out that if the van had arrived at 09:30 then there would have been help available.

09:50 Berit is about to say that she will have to continue on the round when the person who can help reappears. Everything is now fine and the packages are delivered without further problems.

But now the delivery round is about 20 minutes behind the planned schedule.

Berit thinks about the remaining items that need to be delivered. She knows that the order planned for the route will mean that one of the customers will not be there when she arrives and she decides to change the route slightly because she is also aware that one of the deliveries scheduled for 10:45 can in fact be made at 11:15 or 11:30 without any problems from that customer.

10:20 to 11:30 More deliveries are made between Mölndal and Gothenburg and then the last few packages are now left in the van.

11:30 the last package is delivered to a flower shop in Linnégatan and it is quite a big box of what seem to be display stands - one corner is a bit damaged but when the box is taken into the shop Berit and the shop owner (a Mrs Rose) check the item and agree that it is in fact undamaged so there is no need to take any further action.

11:40 the van leaves Linnégaten and returns to Mölndal making two stops to collect packages on the way back.

12:15 arrives back at the distribution centre.

12:15 to 13:15 lunch break - the van is parked and Berit goes home - today she has driven to work because she needs to collect something on her way home. Also when she starts very early she sometimes prefers to drive because the traffic is not busy and she feels certain she will be on time.

13:15 the van is loaded with a small number of packages that need to be delivered in central Gothenburg. Many of the items are clearly for private customers and will be delivered to several pick up points. In some cases there will also be packages that need to be collected from these locations.

Another driver (Johan) is driving on the afternoon shift - in fact he also made a delivery round this morning but he did not start work until 08:00 and so he is well within his driving time allowance.

14:15 to 14:25 the first afternoon delivery is made.

14:25 to 15:30 deliveries continue with some further collections.

15:30 to 17:00 Now most of the work is to make collections. These do not take as long as a delivery but sometimes it can be difficult to find a new address and Johan is not that familiar with this round as he normally deals with the deliveries and collections just outside Gothenburg. Nevertheless everything goes quite well until the final collection needs to be made - it is now 17:15.

17:15 to 17:20 When he arrives there it turns out that the wrong address has been typed into the plan as in fact the company he is collecting from have two offices. Really it is time to go back to the depot but when the person in the office explains to him how important the package collection is and that it must go this evening he decides that he will make the last collection and in fact he knows exactly where the other office address is and it is not far away.

17:20 to 17:30 Johan drives to the other address and makes the collection. The office manager is delighted and says that she will be making sure that they use this company for all their collections if possible.

17:30 to 18:00 return to the distribution centre - the traffic is rather bad this evening and it has started snowing.

18:00 Johan ends his driving shift after parking the van at the unloading door. Today he will go home by bus - this journey is not too bad but he has to change twice and he is a bit fed up that it is snowing.

18:00 to 19:00 the van is unloaded and the packages are transferred to the large vehicle that will then take them to the central 'hub' location.

19:00 to 23:59 the van is parked in the parking place for the companies van fleet.

4.3.1.3. Discussions on ad for goods movement

The following points were identified at the Workshop and following discussions as being relevant to the potential use of AD in goods movement.

1) The significant interactions between goods movements and personal mobility should be noted. These arise for various reasons and in various ways including:

a) Trips that can be combined (for example: personal trip to collect packages; use of AD vehicle to collect packages without the need for a personal trip).

b) Small vehicles (typically vans) that are used by independent businesses for both personal and business trips - e.g. vans that someone uses to go to a place of work and that is then used for delivery and other activities (Service trips: plumbers, carpenters etc; Goods trips: retailers such as flower shops, antique dealers etc)

The interactions are also important in terms of vehicle use (distance travelled, average trip length, utilisation, allocation of trip between private and business - important for data/statistical purposes).

2) Driving time (and cost of the driver) may not be so important in the context of urban goods deliveries. Much more important may be questions concerning the role of the driver in delivering (and collecting) goods during a trip. Without a driver the system will need to evolve in a significant way - probably to a much greater extent than is the case for personal mobility. The use case for GotaParcel makes this point clear in a qualitative way.

3) Parking directly outside the delivery address may not be possible, particularly on key arterial roads where parking may not be permitted. There can, therefore, be a significant element of walking between the vehicle and the delivery address. An example from London - walking comprised a total of 3.4km of the total distance of 9.6km travelled (a ratio of walking to driving of 35% / 65%).

4) Vehicle routing software and planning models tend to significantly over-estimate driving distance as a result of being unable to model ‘final-approach’ walking. Delivery rounds in many multi-drop operations are combined with collections. While most collections are known in advance and can be planned, some are dynamic in nature with collection requests being received from clients during the round and relayed to the driver who then determines if and how they can be incorporated. In some cases, time during which the driver is away from the vehicle making deliveries can account for as much as 87 percent of the total time for the route.

4.4. WP4 Measurement

The purpose of WP4 has been to look into ways off measuring and estimating effects related to AD, with the aim of proposing methods to determine how AD-concepts contributes to the fulfillment of the Swedish transport political goals.

4.4.1. The Swedish transport political goals

The transport political goals were established in 2009 and consist of:

- An overall goal; to ensure a socioeconomic efficient and long-term sustainable transport provision for citizens and business in the whole country.
- A functional goal targeting accessibility, quality and usability.
- A consideration goal targeting safety and environmental impacts.

The two latter goals are built up of a number of more detailed specifications. The goals are detailed in e.g. Transportanalys (2015, 2016). See Figure 9.

Figure 9, The transport political goals

The authority Trafikanalys performs an annual follow-up on the transport political goals, in which the state of the transport system is presented against the specifications for the functional and consideration goals. The change of state since 2009 is also presented, as well as an assessment of the fulfillment of the goals in time.

The transport political goals are evaluated on a high level using macro-statistics from Trafikanalys and other authorities (e.g. The Swedish Energy Agency and the Swedish Environmental Protection Agency).

Even if the goals describe desired attributes of the transport system, they are designed to manage and monitor the state of an existing transport system and they do not say how a new better system should be developed.

4.4.2. Approach

As mentioned, the state of the transport system is evaluated using macro statistics, meaning that the effects of specific solutions, such as AD-vehicles, are not seen until those solutions exist in large numbers in the system. Also, the state of the transport system is not expressed by metrics, but rather by an assessment based on the macro statistics. Nevertheless it is of interest to evaluate if the impacts of a certain solution would be aligned with a desired development, e.g. reduced climate impact or increased safety. In order to do so it is necessary to describe the relations between goals and factors that influence them.

Our aim has been to start with the transport political goals as a framework and use a traditional measurement technology process to identify what is relevant to measure and how to do it. This involves a breakdown of goals into sub-goals and measurable entities from which it is possible to identify measurement methods. This would later on result in metrics and methods that tell how a specific AD-concept in a defined context (scenario and use case) performs against the goals on a local level (e.g. in the context of a smaller scale pilot project).

However, during the project it has become evident that the larger scale effects in society also are of high interest, i.e. what are the effects of a large degree of AVs.

As a consequence, two main approaches have been discussed during the project;

A. Methods for **measuring** effects in real world testing of AD involving users.
B. Methods for **estimating** impacts and effects in society with a larger degree of AD-vehicles in the transport system.

Focus has however been on approach **A** above.

The process has involved a state of the art investigation as well as identifying relations between technology, its use and the transport political goals. The latter has been performed through discussions within the core team and at workshops involving more stakeholders and experts. The results from this are presented in the following sections.

4.4.3. State of the art overview

This section gives a short overview of previous work in the field of potential effects related to autonomous vehicles. The overview is not a comprehensive literature study; however it gives a rough indication on the focus of previous research.

Two main approaches are identified;

- Studies on expectations and attitudes towards autonomous vehicles
- Simulation studies and system analysis of potential effects based on system models

The dominance of work looking into potential effects (B estimating) is natural since few (hardly any) autonomous vehicles are on the roads for users to test at the moment (A measuring).

4.4.3.1. Studies on people's attitudes towards autonomous vehicles and transport systems

Several studies in the field are based on the public's opinion of or attitude towards the use of automated transportation systems and autonomous vehicles (private vehicles and public transport). The following section gives a summary of a number of such studies; a longer description is presented in Appendix E.
Individuals have in most cases not experienced autonomous vehicles, and focus is therefore on individual expectations and beliefs about the use. Primarily surveys are used to examine people's attitudes towards fully autonomous vehicles. Interviews and focus groups also exist, or a combination of methods, such as surveys and interviews. The target audience has usually been "public" and sometimes focused on a specific audience, such as students at a university or visitors to a science museum.

Highlighting the themes of previous research is important in order to identify what researchers have been interested in measuring earlier. The following themes have been identified in previous studies:

- ***People's attitudes to acquire and choose autonomous vehicles***. This theme includes:
  - Intentions to buy and willingness to pay for the related costs (e.g. Kyriakidis, et al 2015, Payre 2014).

  - How individuals may begin to use autonomous vehicles; e.g. by retrofitting an existing vehicle, buying a new one or through the use of public transport, taxi or car sharing (e.g. Howard and Dai 2013, Piao 2016).
  - Public awareness and understanding of autonomous transports (e.g. Schoettle and Sivak 2014b).
- ***People's attitudes towards using autonomous vehicles.*** This theme is focused on different aspects related to the use of autonomous vehicles and transport systems, e.g.:
  - Safety and reliability; *Will there be fewer accidents? Will I feel safe in such a vehicle? Is the technology reliable enough?What does it mean to lose control of such a vehicle?* (e.g. Piao 2016)
  - Comfort; e.g. not needing to search for a parking lot, and being able to do other things (than driving) while riding in a car (e.g. Howard and Dai 2013).
  - The liability issue; Who is responsible if the car is involved in an accident? (Underwood, 2014
  - Environmental reasons; are environmental benefits expected? (Piao 2016)
  - Reduced driving ability requirements– the possibility for disabled persons to move (e.g. Payre 2014 et al.).
  - Infrastructure; e.g. will autonomous cars use the same lanes as conventional cars?
  - Different degrees of automation (Kyriakidis 2015).
  - Autonomous transport within public transport
- ***The feasibility of autonomous transports.*** The theme includes the questions if and when people expect that autonomous transport will be a reality (Begg, 2014) as well as barriers and possibilities (Underwood 2004).
- ***People's background and present situation.*** Socioeconomic background as well as present travel habits and how this affects people's attitudes towards autonomous vehicles. In this theme, perspectives like gender (e.g. KPMG 2013, Casley, 2013), income, house-hold characteristics, education, age and country are included.

Besides studies on people's expectations and attitudes, there are also projects that investigate the interaction between users and AVs. A number of such research projects are conducted in Sweden by RISE Viktoria, e.g. the projects AIMMIT and AVIP (RISE Viktoria, 2017a, 2017b). These projects address, among other things, desires and experiences of drivers, interaction with other road users, as well as reactions to encounters between pedestrians and autonomous vehicles. In some cases, Wizard of Oz tests have been performed, i.e. that the users in the test think they are interacting with a machine, but the machine is actually controlled by a human. This method allows autonomous features to be simulated. Some of the projects have used the test facility AstaZero. Experiences from completed projects suggest that in many cases it will not be noticeable that a vehicle is autonomous.

4.4.3.2. Studies on system analysis of autonomous transports

A number of studies use cities as a use case and apply forecasting methods like ripple effect to predict the future, e.g.:

- Driving Changes: Automated Vehicles in Toronto. (Ticoll, D. 2015)
- The ripple effect of automated driving (Milakis, D., Van Arem, B., & Van Wee, B. 2015)

- Development of automated vehicles in the Netherlands: scenarios for 2030 and 2050 (Milakis, D. et al., 2015)

The studies aims are focusing on long term strategic effects and are used as a tool to guide and influence city planners in terms of the need for change in legislation. All studies are based on assumptions and have a great deal of uncertainties.

Several studies have performed theoretical predictions of reductions of vehicles due to sharing, e.g.:

- Estimated Bounds and Important Factors for Fuel Use and Consumer Costs of Connected and Automated Vehicles (Stephens et al. 2016)
- Urban Mobility System Upgrade. How shared self-driving cars could change city traffic. (OECD, 2015)
- Potential impact of self-driving vehicles on household vehicle demand and usage. (Schoettle, B., & Sivak, M., 2015).

A common problem with the studies is that they lack user's attitude towards sharing and the perceived value of owning and having full control of a vehicle. Simulation models could greatly benefit from "calibration" by using real data to lower the degree of uncertainty. The "calibration" data could be acquired from real pilots and tests.

4.4.4. Break down of goals into measurable entities

In order to measure performance of e.g. an AD-concept against goals, measurable entities need to be identified and there needs to be a consensus on how these entities are measured. Since the transport political goals consist of a larger number of specifications, see Figure 9, the picture becomes complex. E.g. looking at climate impact, which is only one of the specifications that build up the consideration goal, a number of factors of importance can be identified. This is illustrated in Figure 10.

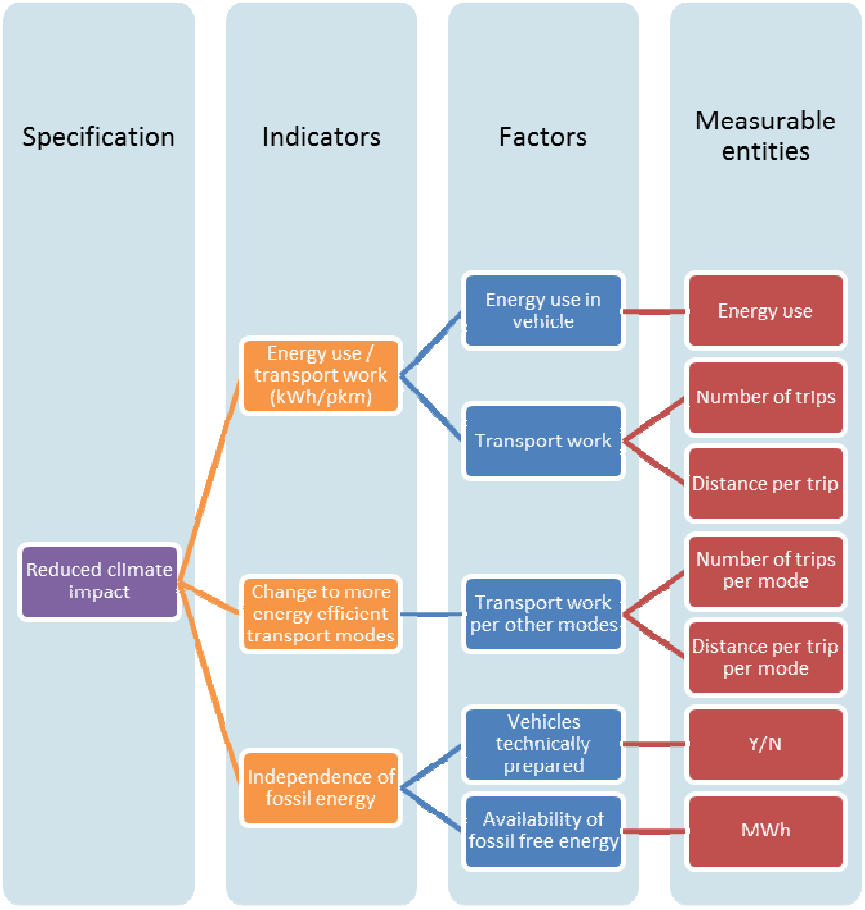
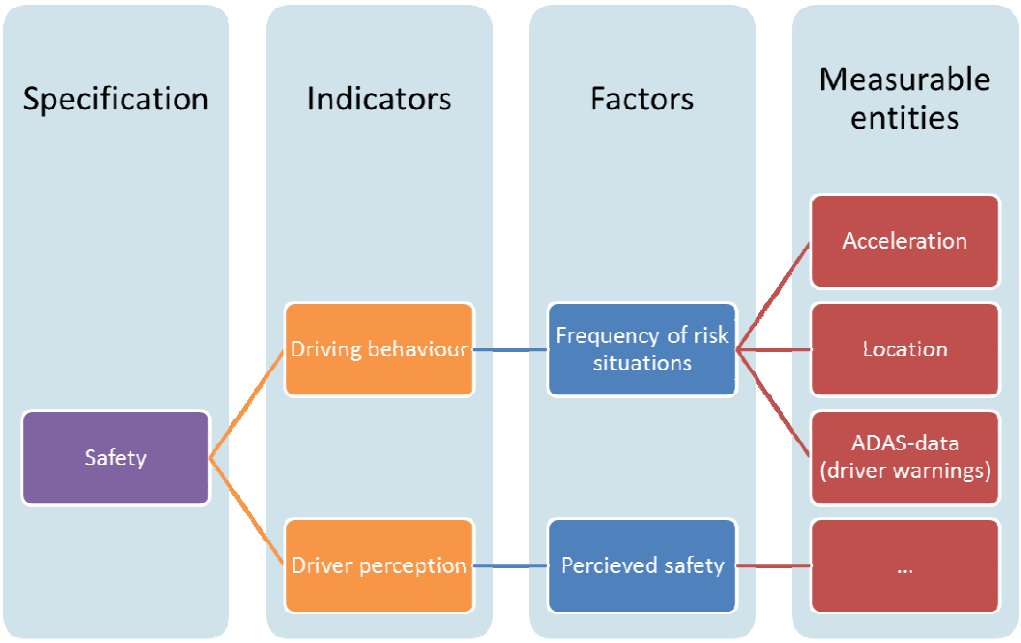


Figure 10, Break down of the climate impact specification

Measurable entities in this case could for example be:

- Distance travelled and energy used over a time period,
- Type of fuel used
- Availability of fuel
- The degree of use of different transport modes for the users involved, i.e. does the AD-solution have impact on the kind of transport modes that are used? This would probably require a method that captures the transport choice of users.

A similar break down of the specification safety is presented below.



It would be possible to construct a model that uses the values of measurable entities in order to create indicators based on the specifications (e.g. climate impact). Such a model can use both measured and estimated values. The challenge is however to integrate and weigh different indicators and specifications together into one indicator, since this means that the importance of different goal specifications needs to be defined. E.g. is safety more important than climate impact?

4.4.5. What to measure

There are a number of potential goal conflicts for AD solutions in relation to the transport political goals. E.g. a more comfortable self-driving car could result in more car travel and thus more emissions, i.e. a goal conflict between comfortable transport for citizens and reduced environmental impact. This is natural; since the transport political goals have a number of conflicts among their specifications, see Trafikanalys (2015, 2016) for examples.

In order to identify the factors that have important impact for the transport political goals, two workshop exercises were performed within WP4. ***The first exercise*** had the purpose of identifying the relationship between different AD-solutions and the goals as well as identifying goal conflicts on a higher level. There are several goal conflicts among the goals, e.g. reduced speed for improved safety has a negative impact on quality and accessibility. Three workshop groups discussed the relations between a specific AD-concept and the goals and indicated if the AD-concept contributed in a positive, negative or neutral way towards the different goal specifications and why. The analysis was performed based on the following use cases:

- DriveMe car and the Kungsbacka family
- Uniti vehicle and the Kungsbacka family
- AD delivery robot and the company Götaparcel

In the current pre-study the use cases were not explored in the context of each of the scenarios. This assessment could and would be extended in an implementation project yielding a richer set of insights.

The second exercise had the purpose of identifying how different types of stakeholders view and value the goals. When measuring new entities, there needs to be a consensus among the stakeholders on the methods to measure. A starting point is to discuss the meaning of the goals that constitute the frame work for measurements.
The workshop attendants were divided into three stakeholder groups based on the organization they represent; OEM, City, Citizen. Each stakeholder group discussed the meaning of the transport political goals based on their different perspectives.

Workshop results
Three main factors that impact the transport political goals for the current use-cases were identified based on the outcomes of the first exercise:

- Transport choice. I.e. does the AD-concept induce different choices regarding transport modes? E.g. a more comfortable car solution could increase car use.
- The amount of transport and impact on congestion.
- Vehicle functionality and operation. Vehicles can be tailored to fit certain needs better and operation can be optimized, e.g. regarding speed, or regarding usability for disabled drivers.

The outcomes are illustrated in Figure 11.

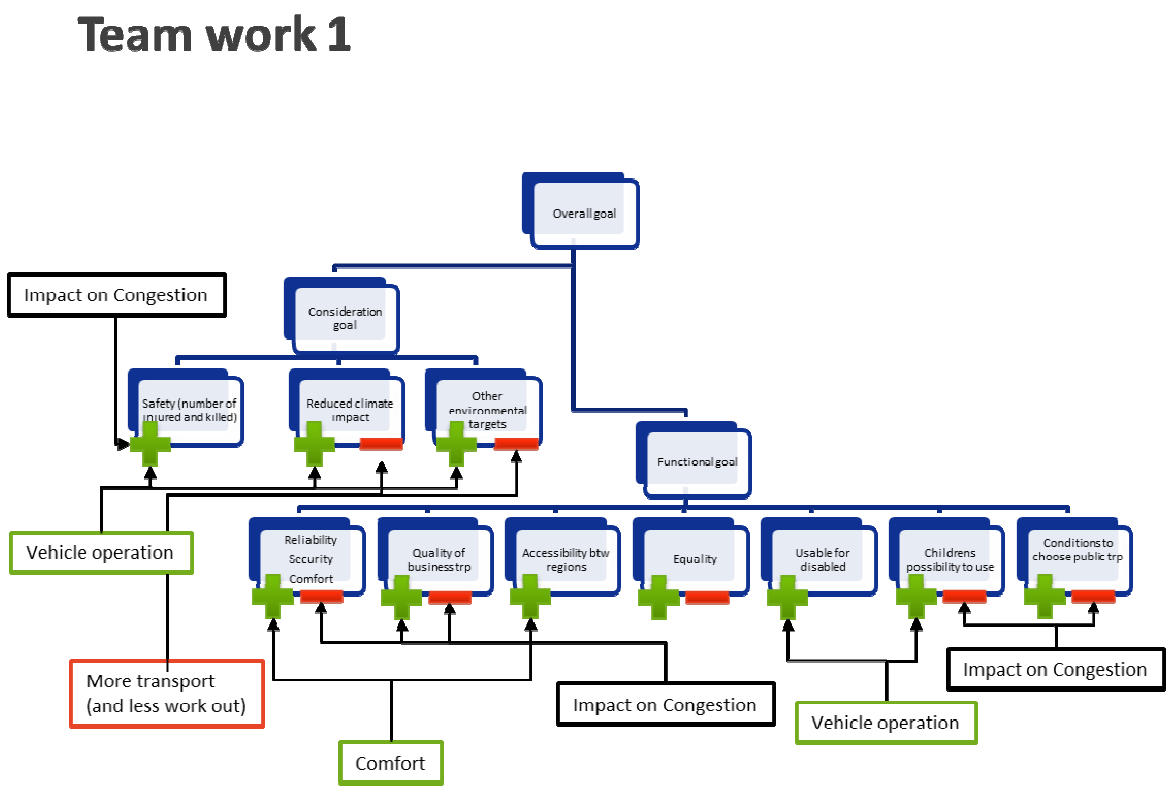


Figure 11, Overview of outcomes from workshop exercise one.

The three identified main factors correlate to the findings from the driving force model in WP1, see sections 4.1.4 and 4.1.7. Collecting empirical data from real AD use regarding transport choice, transport volume and vehicle operation, could give insights into the effects in relation to the transport political goals.

Regarding different stakeholders views, the second exercise indicated that the OEM and city groups in general had a system and strategy perspective, while the citizen group had a more emotional perspective on the transport political goals. This is exemplified in Figure 12 below, which shows the highlighted perspectives from the stakeholders regarding the consideration goals. E.g. the OEM and city groups viewed safety as very important issue that they have strategies for, while the citizen group highlighted that safety has to do with the poor driving ability of others.

To conclude, methods evaluating effects of AD-concepts need to be able to handle both technical aspects and performance of vehicles and systems, as well as behaviors and perceptions of users.

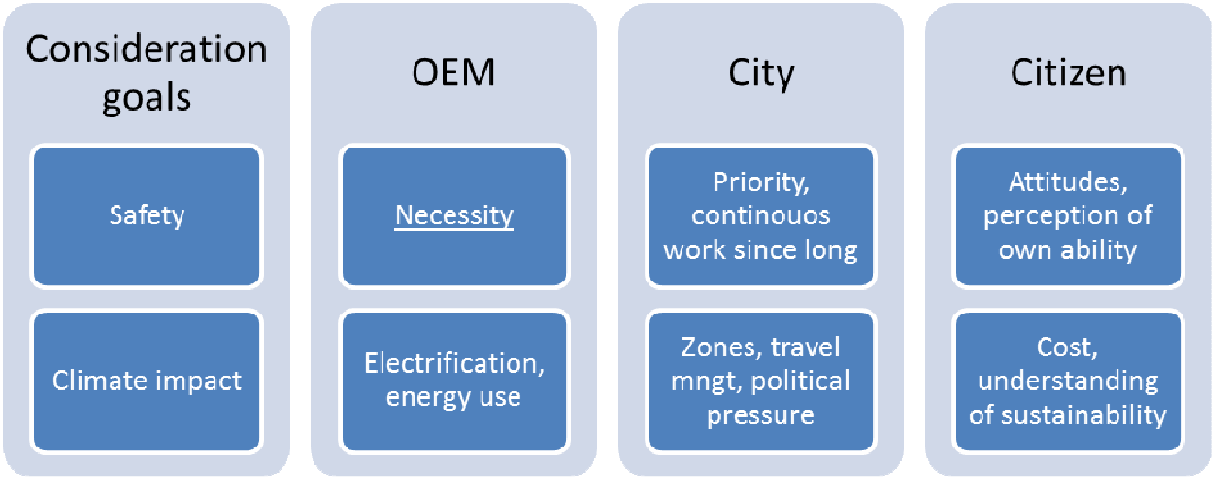


Figure 12, Example of outcome from workshop exercise two.

4.4.6. Development of measurement methods

Effects from AD-concepts depend on the context it is operated in, since there is interplay between the vehicle, its users and the use case (Figure 13, Context for measurements methods). Methods to measure and estimate effects need to take this into account.

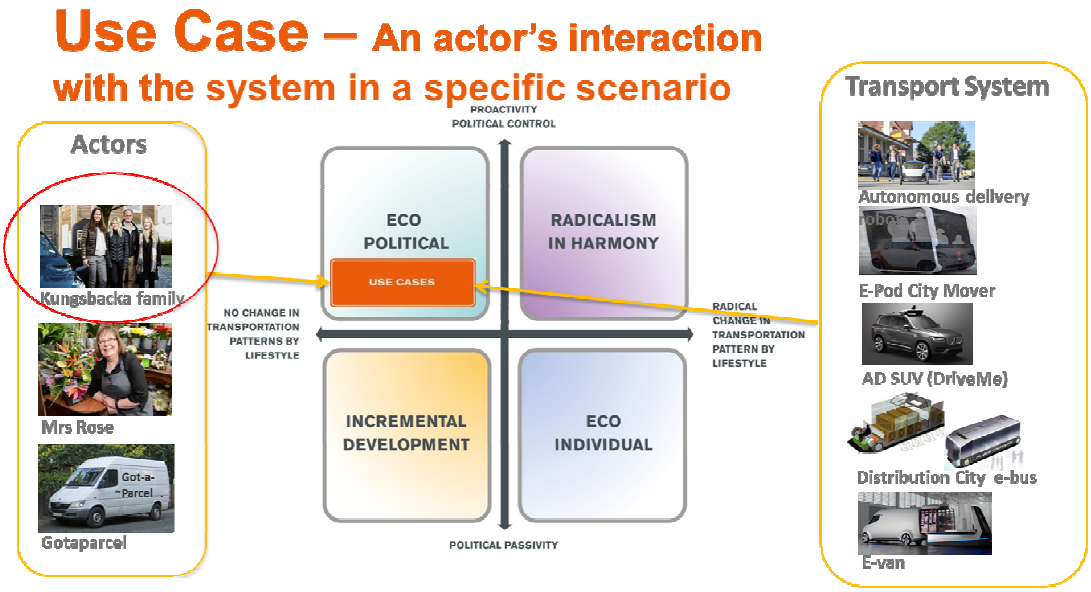


Figure 13, Context for measurements methods

To measure new parameters a number of steps need to be performed according to a method, e.g. the one laid out by Emardson et al. (2012):

- Defining the concept
- Breaking it down into components
- Identifying measuring instruments
- Ensuring validity
- Identifying scales
- Defining a reference to make measurements traceable

If the transport political goals are used as the framework for measurements of effects, many different types of factors needs to be measured. The reason for this is that the specifications of the goals are many and rather complex. However, according to this pre-study it seems that a smaller number of factors have influence on many goal specifications. These factors are important to measure in order to evaluate or estimate effects of AD-concepts and it is suggested that development of methods should start with them. The factors are:

- Vehicle operation – which relates to the design of the vehicle concept.
- Transport choice – which depends on user behavior.
- Amount of transport – which depends on system design, e.g. infrastructure, policy, etc. as well as the two factors above.

Regarding the factor **Vehicle operation,** methods could most likely be based on existing in-vehicle measurements such as e.g. speed, distance, ADAS-data, warnings etc. The factor **Transport choice** requires qualitative methods that involve users. The factor **Amount of transport** is relevant to measure on a system level, e.g. within a certain part of a city where AD is implemented.

Developing methods to measure the identified factors requires more efforts and is a possible next step from this pre-study. Also, when measuring new entities, there needs to be a consensus among stakeholders on how these entities are measured. It is not necessary to agree on the meaning of the metrics, but it is central that the method itself is fully agreed. Therefore, it is suggested that the stakeholders in the program Drive Sweden are involved in the discussion on the set of measurement methods.

4.5. WP5 Dissemination

The characteristic of the SEVS methodology is that it is an inclusive process with several multi-stakeholders workshops and seminars.

The following seminars and workshops have been performed during this pre-study:

- Kick-off
- Workshop1 – Driving Force Model
- Workshop2 – Scenarios & Use Cases
- Workshop3 – Analysis & Measurements
- Result seminar

Other dissemination activities:

- The ongoing pre-study was presented at Chalmers Initiative Seminar the 27th of October.
- The project was also presented to Drive Sweden Program committee in October 2016.
- All working material, background information and reports are available at Webforum.

- A document describing the project and working procedures [About the project and Instructions] was sent to all stakeholders in August 2016.
- A project description was written and published at Drive Sweden's Web page.
- The project results were presented at Drive Sweden's board meeting in February 2017
- The project is planning to write at least one article to the ITS EC Strasbourg conference in June 2017.

Publications:

- A Final public report will be presented to Vinnova and Drive Sweden.
- A report including all results will be available to participating partners.
- Some of the results will be presented to a wider public at www.sevs.se.
- Scientific articles will be presented at applicable conferences.

4.6. WP6 Project Management

This pre-study was performed according to The SEVS Way. The project used Webforum as a project planning tool and as well as a document archive. All participants have access to Webforum on request.

4.6.1. Working procedures

Characteristics of SEVS is to work in an inclusive process, with as much learning and new knowledge as possible to the participants.
A document [About the project and instructions,v1] was written and sent to all stakeholders in august. This document included general information about the project; scope, organization, budget as well as practical things like working procedures with Webforum and how to report time spent etc.

We have tried to work as sustainably as possible, which resulted in a lot of Skype meetings instead of a lot of transportations to physical meetings in Gothenburg, Lund and Linköping. But, co-creation in creativity workshops via Skype is difficult.

The Core Team consisted of about six team members. This group was almost too small to be able to keep the momentum in the project process. If one or two members were not able to participate in the Skype meeting, it ended up with only one or two persons in front of each computer screen, and in those cases it was hard as a project manager to inspire the creativity and create the right atmosphere. Although the team members

4.6.2. Economy

The table 3 below shows the pre-study original project budget.

Table 3

Projektpart	Betald Insats SEK	Inkind (SEK)	Totalinsats i projektet (SEK)
SAFER	140250	46750	187000
SAFER	140250	46750	187000
Chalmers	140250	169150	309400
Göteborgs universitet	100000	79750	179750
Göteborg stad	0	288000	288000
Trafikverket	0	72000	72000
SP	265000	88333	353333
VTI	200000	66667	266667
Volvo Cars	0	72000	72000
Uniti	0	61200	61200
	985750	990600	1976350

5. Conclusions

This project has developed a method to analyse and measure the societal effects of autonomous drive. The overall method has been further developed as well as its main parts: Driving force model, Scenarios, Use-cases and Measurement methods. The method has been demonstrated through a first analysis.

It shall be stressed that the project is only a pre-study, and did not have the resources to develop all details needed for final conclusions on the very complex questions related to how the society will change due to autonomous drive. Despite that, the analysis method is found to be very useful for analysis of these questions. The results also have led to several important insights which can serve as a basis for coming projects.

The strength of the developed method is that it can handle analysis on both an abstract societal level, and connect it with analysis all the way down to the level of individual users. In order to deal with complex questions about societal development it is necessary to be able to include both these perspectives.

5.1. WP1 –Driving Forces

Within WP1 the project has made a driving force model for autonomous drive, and used it to derive effects on the transport system and wider societal effects. This project also introduces what is called *driving force stories* which is a new tool to analyze how AD is introduced over

time. The driving force stories also show which influence mechanisms are the cause of the effects in the transport system and society. From this analysis leverage points and societal effects have been identified and a way of categorizing them is also demonstrated.

The analysis of societal effects demonstrates the immense AD benefits for the individual user but also for the collective (social groups as a whole) mainly in the quality of life and the inclusiveness and accessibility in future societies. For the rest of the dimensions in the driving force model such as policy, legislation and industry and business sector there is higher uncertainty. However, some factors are apparently important. Firstly, the need for robust strategies and policies to proactively offset any rebound effects. Secondly, strong decision making is required from the side of the industry leaders to keep up with and benefit from the technological advance. The technological change to AD will happen eventually, but how quickly depend strongly on the two dimensions of Policy and Industry.

Also, there are indirect effects on society that might occur with the AD development that should be dealt with as separate challenges. Firstly, unemployment for drivers should be dealt with, both trough any possibilities to create new employment opportunities in the transport system or to strengthen the employment in other sectors in the society. That said, the impact of unemployment from machines replacing humans should be tackled proactively, but AD is only one of many reasons for this. In addition, possible environmental deterioration that might happen will not stem from the AD development itself but rather from rebound effects of for example resources misuse or over-use of natural resources. AD technology is primarily (or essentially) a facilitator of transportation and is fundamentally decoupled from environmental pressure itself. Thus, again policy and decision makers will be key players for ensuring sustainable development in general and, of course, also for an automated transport system.

Overall, WP1 has contributed with tools required for analyzing societal effects, and the results demonstrate that these tools are effective. Note that the specific results have not been tested as much as desirable, due to resource limitations of the project, so they should mainly be considered as examples of possible results.

5.2. WP2 – Scenarios

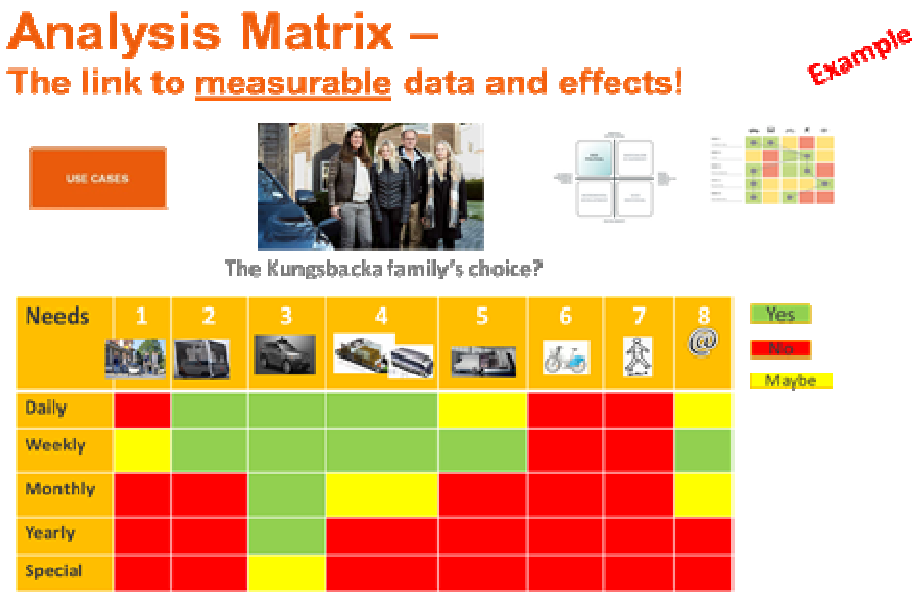
The scenarios are an important part of the analysis method, as they allow the team to handle uncertain factors with a large influence on the development of autonomous drive. In this project the scenarios have been based on scenarios developed in the SEVS2 project but they have been modified to better include factors relevant for the development of AD solutions. However, by considering each question in the context of at least one scenario indicative results have been obtained and are noted in the project report.

5.3. WP3 – Use Cases

By studying sequences of activities among the actors, using the activity-based approach, we can gain an understanding of the actors' travel patterns and their choice of transport modes. Most importantly, the study of activities shows the different types of space-time restrictions that the actors face when implementing various activities during one day, including travel activities. Coupling restrictions among the actors concerned relying on parents for transport to

bus stop and scouting, opening hours at the flower shop, caring for an older parent, dealing with conflicts at work, traffic jam, crowded buses which gets complicated with a wheelchair, and public transport routes and timetables that do not fit to use between home and work (for the father). In the case of goods movement, coupling restrictions can include the need for a vehicle to be present at a specific location in order to be loaded or unloaded, the need to match the shift time of drivers with vehicle availability, and incompatibility between customer demands in terms of delivery slots. Capacity restrictions in the use cases were physical limitations to use public transport and inability to walk far, for example from a parking lot. Again in the case of goods transport such restrictions could include limitations on the distance over which packages could be transferred from a parked vehicle to a customer, lack of space on a vehicle for a specific product, or the need for specialist capacity that is not available. Authority restrictions that were identified concerned bus stops along busy roads, dark parks/walking paths to bus stop, traffic jam, not enough space on buses for wheelchairs, roads unsafe for biking, norms regarding taking care of older parents, public transport not available, and working obligations and norms. In the goods transport use cases then regulations limiting times or places for the delivery of packages can be considered as authority restrictions. In addition, there are many such restrictions on operating practices for goods transport. Restrictions should evidently not necessarily be understood in a negative sense. Coupling restrictions often arise from a desire to care for and spend time with others. Restrictions as a conceptual tool, explains the limitations in the use of time and space since one can only be at one place at the time.

In this pre-study, the relevant questions are to what extent can AD satisfy the actors' needs based on the activities described? And what are the possibilities and potential constraints with AD and driverless vehicles? Such an analysis has been done during the workshops and can identify relevant measure variables (see example in Appendix A). The analysis is based on the Kungsbacka family and the eco-political scenario, assuming a car free city centre. The possibilities with different types of transport modes, e-commerce and work from home are analysed. The analysis shows that there are many possibilities with AD-solutions but in many cases the trip would be too expensive or not available outside the city centre, which is to no use for those living or operating in suburban areas. Further, in many cases AD would not necessarily improve mobility among the actors that are studied.



5.4. WP4 - Measurements

We recommend that studies based on real world testing with users are conducted once vehicles are available, in order to collect experience from actual use. This could e.g. be performed within local pilots, where qualitative methods are used to collect empirical data. Empirical data could complement system analysis and perhaps help to calibrate simulation models and in that way give a better understanding on potential effects in society from the use of autonomous vehicles.

Methods for evaluating effects of AD-solutions should be developed based on the following important factors:

- Vehicle operation – which relates to the design of the vehicle concept.
- Transport choice – which depends on user behavior.
- Amount of transport – which depends on system design, e.g. infrastructure, policy, etc. as well as the two factors above.

When measuring new entities, there needs to be a consensus among stakeholders on how these entities are measured. It is not necessary to agree on the meaning of the metrics, but it is central that the method itself is fully agreed. In the case of this pre-study it is suggested that the stakeholders in the program Drive Sweden establish and agree on a set of methods for measuring effects of AV-concepts and efforts should be made to establish a national consensus to be able to compare results on a wider level.

5.5. GO:es – Proposal Next Steps

According to The SEVS Way methodology, the last step in the process is to propose new actions or initiate new projects, the so called GO:es. They are often a result of new research questions that have been identified during the project, (or might to be outside the scope of the existing project, e.g. from a Pre-study to an Implementation project). Some input to the GO:es

from this pre-study can be found from Appendix B – Leverage points and from Appendix J – Input to GO:es.

GO - Methodology:

- Develop an electronic simulation system based upon the SEVS Way and from different user perspective (OEMs, politicians, city planners, researchers etc). Describe different scenarios (worlds of context), define actors, AD mobility solutions (private and public), define Use Cases, define parameters to measure and how to measure etc.
- Go out and measure in real life e.g. the Drive Me project.
- Set up a living-lab and apply the SEVS uses cases in different functionality tests etc.
- Calibrate the system model based on real life measurements. Verify the quality and consistency etc.
- Refine the model and include more use cases.

GO- Societal System perspective of AD solutions:

- Societal perspective – Benefits and drawbacks on a system level for e.g. Gothenburg region. Public and/or private AD-solutions. Consequences of lower speed regarding congestions, emissions, safety, noise, accessibility and economy? Density vs sprawl (Urban vs rural)? Requirements on a Traffic management system? The interaction between different AD pods/vehicles, humans in a dens city environment?
- User's perspective – Benefits and drawbacks for different customer categories, acceptance for sharing business models, AD technology acceptance, willingness to pay, customers' choice and behavior? etc.
- Industry's/OEMs perspective [limited to e.g. Gothenburg region scope by 2030]– Business opportunities and risks for different industrial stakeholders, new demands on vehicles/pods, new business models, new technology/service for moving on/off goods, synergies between industries e.g. Open-sourced software for autonomous driving and cloud data, standardization regarding communication protocol (ITS stations)?
- Politician's perspective – What policy instruments are needed to provide maximum benefit to society, based on AD technologies? When should the policy instruments be introduced? Legal aspects on physical environment as well as data? Legal aspects on open source software for AD solutions (e.g. in case of accidents).

GO-Implementation of this pre-study:

- Implement the use cases in all four scenarios (Mrs Rose, GotaParcel and the Kungsbacka family)
- Define what to measure and how to measure according to this pre-study methodlogy
- Measure in real life what is possible to measure (e.g. Drive Me), and use The SEVS Way methodology as a complement.
- The Autolog project "SEVS for AD e-commerce" has already been initiated. This use case is about measuring and analyzing the effects of the increase of internet shopping, and when a personal transport becomes goods transportation. We compare different mobility alternatives and then evaluate the effects by different measurement methods.

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Appendix A – Stakeholder analysis

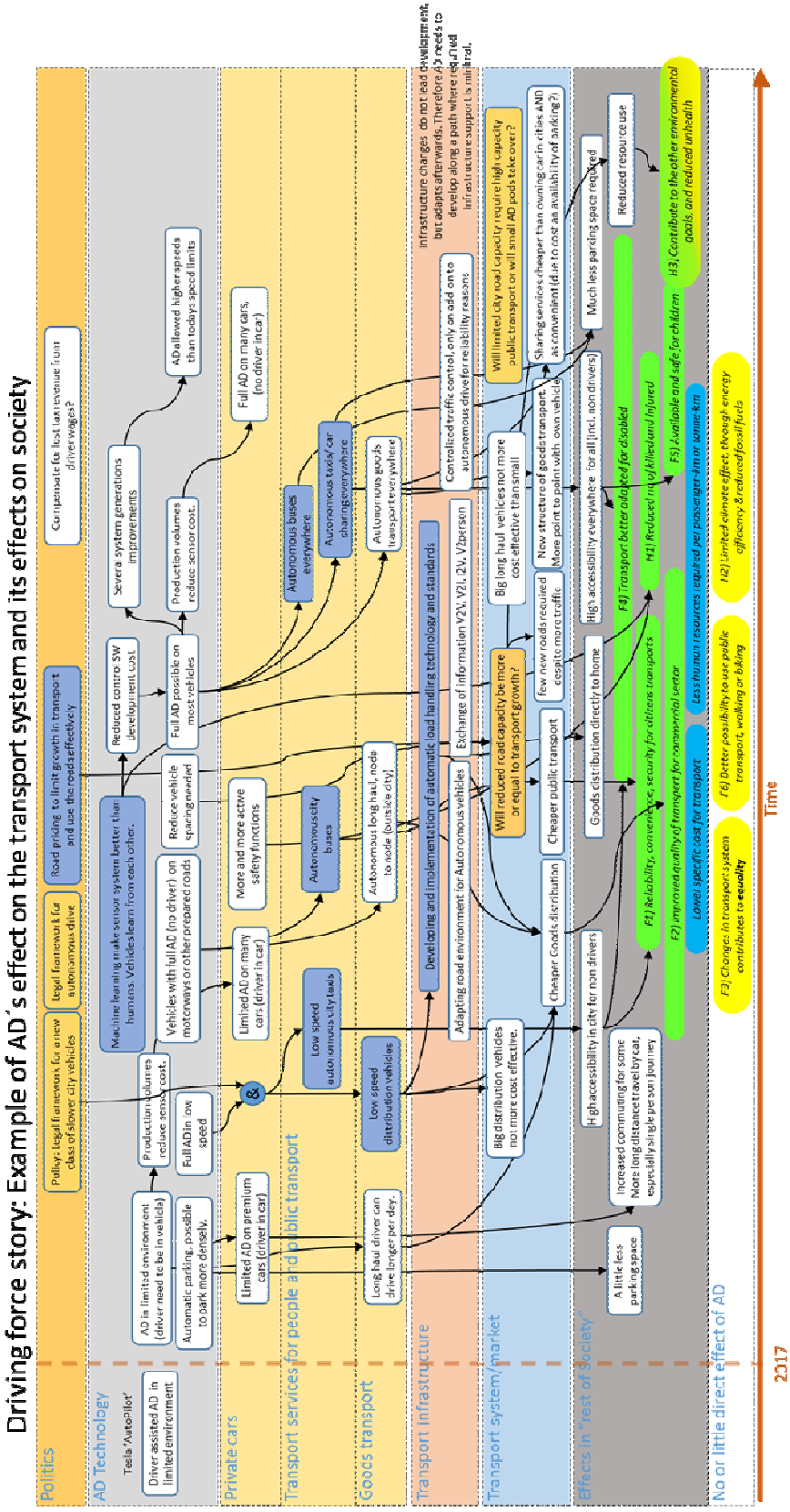
Stakeholders:		
Authorities	**Organizations / groups**	**Private companies**
Blåljusmyndigheter /räddningstjänsten	Organisations for disabled	Eldistributörer
Lawmakers (safety rules and standardization)	drivers (Taxi, truck ,…) and their unions	Transport service companies (Uber, etc.)
City planners	Fraktmottagare (kontor, affärer, privatpersoner, …)	Ägare till lastnings och lossningsplatser
Transport authorities	citizens	Laywers
Politicians (trafiknämnden, …)	Entrepreneurs	Sensor suppliers
Regional authorities	Philosphers	Suppliers of Autonomous drive technology (f.ex. Apple, Google, Volvo, …)
Citiy authorities		Oil industry and its owners
national authorities		Infastructure builders
Parkförvaltningen	**Users:**	Freight companies (Post service, distributers, contruction freight,…)
Parkeringsförvatling/bolag	Children	Architects
City fleetowners/operators (Gatubolaget)	Teenagers	Realestate owners and managers
Länstrafikbolag / region kollektivtrafik myndigheter	Young single	property developers
Tax authority	Couples	Vehicle OEMs
Service developers for mobility services	Families	transport equipment OEMs
Valet(Wallet?) parking - parkeringstjänster	Elders	manufacturing companies
Package delivery service	City inhabitants	trading companies
Hospitals	Country inhabitants	Maintenance companies
	drivers	Data security
	richer and poorer,…	insurance companies / re-insurance companies
		Telecom suppliers
		Telecom operators
		Private fleet owners
		Bicycle sharing systems (styr&Ställ)
		Car dealers
		Car sharing companies
		car rental
		Operatörer av kollektivtrafik

Appendix B – Leverage points

Leverage points questions related to AD:

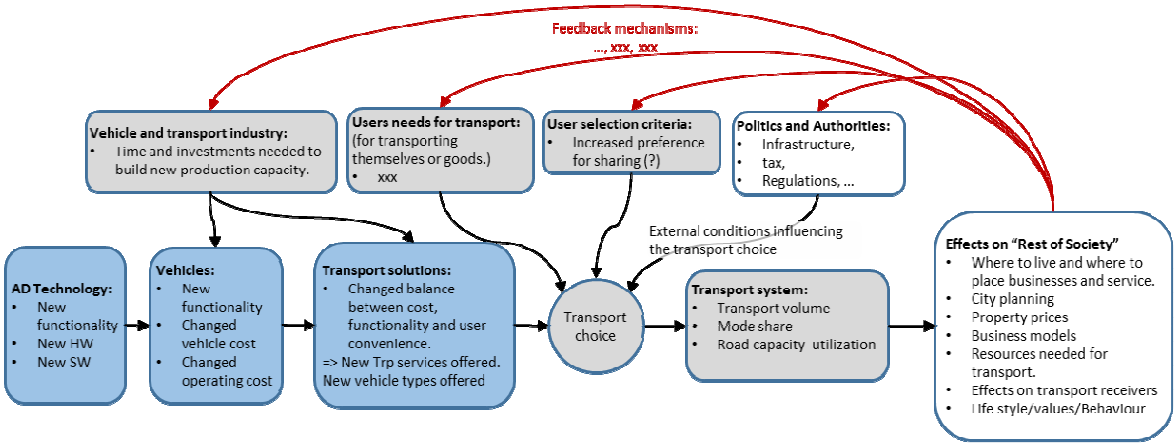
- What will be the cost of transport service for the user in the future?
- Will the volume of transport be higher or lower?
- Will people trust and accept transport disruptions and innovations?
- Will transport criteria change over time?
- Will Policymakers design policies for innovations proactively or reactively?
- What will the mix of public and private transport be?
- What sizes of vehicles will emerge in the future?
- What types of vehicles will emerge in the future?
- Will we have robust security systems?
- Will be Privacy ensured?
- Will Technology development be in place?
- Will business actors be willing to change?
- Will transport users be willing to change?
- How will the Human – machine relationship develop?
- How will the Vehicle ownership develop?
- Will the infrastructure be in place?
- Will we have more or less collaborative models among actors in the future?

Appendix C – Driving Force Story



Appendix D – Influence Diagram

Influence diagram: AD´s effect on the transport system and its effects on society



Appendix E – Studies on people's attitudes

Studier om människors inställning till autonoma fordon och transportsystem

Flera studier inom området baserar sig på allmänhetens uppskattning om/inställning till att använda automatiserade transportsystem och autonoma fordon, (privata fordon samt inom kollektivtrafiken). Individerna har i de flesta fall själva inte kört ett sådant fordon, och det handlar alltså om individers förväntningar och föreställningar om användning. Primärt har enkäter används för att undersöka människors inställning till helautomatiska fordon. Intervjuer, och fokusgrupper förekommer också, eller en kombination av metoder, t ex enkäter och intervjuer. Målgruppen har vanligtvis varit ”allmänheten” som ibland kan vara fokuserade på en viss målgrupp såsom studenter vid ett universitet eller besökare på ett science museum.

Nedan ges en inblick i olika studier och val av metod, därefter ges en bild av *vad* studierna undersöker.

Enkätstudier
En del av studierna är av tvärkulturell karaktär. I en studie av Kyriakidis, Happee och Winter (2015) studeras människors acceptans och angelägenheter relaterat till automatiserade transporter, liksom deras benägenhet att införskaffa ett fordon som antingen är delvis, i hög grad eller helt automatiserad. Studien baseras på en internetenkät insamlad från 109 länder (40 länder med åtminstone 25 respondenter). 5000 besvarade enkäten.

Schoettle and Sivak (2014) har genomfört två tvärkulturella enkätstudier: I den första studerades allmänhetens åsikter om autonoma och självkörande fordon I USA, Storbritannien och Australien.
I den andra studien studeras allmänhetens åsikter om autonoma och självkörande fordon i Kina Indien och Japan. 610 respondenter i Kina, 527 respondenter i Indien och 585 respondenter i Japan medverkade i enkätstudien.

Tvärkulturella studier som särskilt är fokuserade på kollektivtrafiken förekommer också. Alessandrini mfl (2014) presenterar erfarenheter från projektet ”Citymobil2” som handlar om automatiserade vägtransportsystem för kollektivtrafiken (ARTS), vilket involverade pilotprojekt från 12 olika länder. Alessandrinis mfl studie handlar om att undersöka användarnas attityder gentemot ARTS och konventionella bussar: vilka är att föredra? Enkätundersökningen har genomförts genom kortare intervjuer där frågorna har ställts direkt till respondenterna och i en del fall genom en onlineenkät i tolv olika europeiska städer. Antalet respondenter i varje land varierar mellan 167-482.

Exempel på enkätstudier som är genomförda i enskilda länder är Payre mfl (2014) som har genomfört en enkätundersökning för att studera allmänhetens föreställningar/förväntade acceptans, attityd, personliga värderingar och intention att använda helautomatiserade transporter. Studien genomfördes i Frankrike och 421 personer deltog, 153 män, och resten kvinnor. Enkäten distribuerades online och föregicks av två pilotstudier (semistrukturerade intervjuer med fem personer och en mindre enkätundersökning (n= 45).

Howard och Dai (2013) har genomfört en enkätundersökning för att undersöka allmänhetens attityd till självkörande bilar. Studien genomfördes i Kalifornien, USA. Deras intention var att vända sig till en population som troligtvis var intresserade av att använda sig av självkörande bilar. De påtalar det metodologiska problemet att många personer inte är tillräckligt informerade om automatiserade bilar för att tillfullo besvara frågorna. Därför kompletterade de enkäterna med en filmvisning om helautomatiserade bilar som respondenterna fick titta på efter att de hade besvarat en del av frågorna. I enkäten får respondenterna förhålla sig till tre olika scenarier kring hur självkörande bilar kan användas.

Casley (2013) har studerat i vilken utsträckning studenter vid Worcester Polytechnic institute tilltalas av autonoma bilar. 450 respondenter besvarade en enkät om deras uppfattningar, förväntningar och förutsägelser om tekniken. Enkäten utgick från tre primära faktorer som förväntas påverka allmänhetens inställning till autonoma bilar: hur ”säker bilen är”, vad den kostar, och hur bekväma människor är med det rådande juridiska upplägget beträffande utveckling, försäljning och användning av autonoma bilar. De sekundära påverkansfaktorerna var den nytta som autonoma bilar skulle kunna utgöra under en dag; samt faktorer kring köp såsom huruvida dessa ”nyttor skulle påverka köpbeslutet och om miljöfaktorer spelade in.

Studierna ovan vänder sig primärt till lekmän, men även enkätstudier riktat till experter har genomförts. Underwood (2014 a och b) har genomfört tre olika enkäter med experter från olika discipliner och yrkesområden inom transportområdet för att undersöka tekniska och sociala trender relaterat till automatiserade fordon, samt hinder och möjligheter för introduktion av automatiserade fordon.

Övriga metoder
Några studier har kombinerat flera olika metoder såsom Begg (2014) som också vänder sig till experter inom området. Begg har studerat tänkbara konsekvenser av automatiserade transporter, liksom om och i så fall hur snart automatiserade transporter blir en verklighet i London. Beggs har genomfört såväl intervjuer, gruppdiskussioner såsom enkäter (3500) riktat till Londons transport experter.

Piao mfl (2016) har studerat allmänhetens åsikter om automatiserade fordon (bussar och bilar) med stöd av en online-enkät (148 respondenter) och telefonintervjuer (500 respondenter) i La Rochelle, Frankrike. Studien belyser, allmänhetens medvetenhet och förståelse av automatiska fordon, samt deras inställning till automatiska bussar, taxi, bilpooler samt privat ägande.

Om självkörande fordon vore säkra och tillgängliga, skulle du använda dem? Denna fråga var temat för fokusgruppsintervjuer genomförda med fordonsägare på tre platser i USA; Los Angeles, California, Chicago Illinois och Iselin, New Jersey. Studierna genomfördes av konsultföretaget KPMG, med syfte att undersöka när, varför och hur konsumenter kan komma att använda självkörande bilar. (KPMG, 2013).

Metodologiskt dilemma
Studierna behandlar i stor utsträckning individers förväntningar och föreställningar om användning. Ett dilemma är att individerna inte är tillräckligt informerade om automatiserade bilar för att tillfullo besvara frågorna. Då krävs att forskarna först informerar användarna, vilket också har gjorts i en del av enkätstudierna via text, bilder eller film.

Teman

Att lyfta fram vilka områden/teman som har behandlats i tidigare forskning är av vikt för att tydliggöra de frågor som har uppfattats som väsentliga att studera, m.a.o. vad är det som forskningen har varit intresserad av att mäta: Följande stycke ger en översikt av detta med utgångspunkt i teman

Människors inställning till att införskaffa och välja autonoma transportfordon
Inom detta tema undersöks individers *intention/önskan* om att köpa ett helautomatiskt fordon, samt individers benägenhet att betala för dess *kostnader*. (se t ex Kyriakidis, mfl 2015, Payre 2014).
Det handlar också om att undersöka *hur individer kan tänkas börja använda automatiska fordon*, t ex skulle det ske genom ombyggnad av befintlig bil till självkörande teknologi, eller genom att köpa en ny bil eller genom att använda självkörande fordon via kollektivtrafiken, taxi eller bilpool. (se t ex Howard and Dai 2013, Piao 2016) *Medvetenhet och förståelse*: Har allmänheten hört talas om autonoma transporter? (T ex Schoettle och Sivak 2014b).

Människors inställning till användning av autonoma fordon
Merparten av frågorna i enkäterna kretsar kring olika aspekter av den konkreta användningen av automatiserade transportsystem och fordon. Övergripande frågor om positiv respektive negativ inställning, vad som är mest respektive minst attraktivt liksom olika för- och nackdelar med att använda fordonen är av intresse. Det är ofta relaterat till följande aspekter som var för sig kan delas in i underteman:
Säkerhet/pålitlighet: Förväntas olyckorna t ex minska? Känner jag mig säker i ett sådant fordon. Är tekniken tillräckligt pålitlig? Kör det automatiserade fordonet lika bra som en mänsklig förare? Vad innebär det att förlora kontrollen över fordonet (”att ge upp kontrollen till en maskin”)? (t ex Piao 2016) *Bekvämlighet:* att t ex slippa leta efter en parkeringsplats, att kunna göra annat samtidigt som man åker bil, (t ex Howard och Dai 2013).
Ansvarsfrågan/juridisk reglering: Vem har ansvar för om bilen råkar ut för en olycka? Hur ska ansvarsfrågan regleras? (t ex försäkring där ingen tydlig part är ansvarig, ägaren, tillverkare, leverantör, staten. (Underwood, 2014)

Miljöskäl : Förväntas det bli några miljövinster? tex minskade avgaser, minskad energianvändning *(Piao). Nedsatt körförmåga*: möjlighet att förflytta sig för personer med nedsatt körförmåga; grad av intresse för detta. (te x Payre 2014 mfl) *Infrastruktur:* Aspekter relaterat till transportnätverket t ex, ska självkörande bilar köra i samma körfält som normal trafik? Skulle allmänheten stödja en ny infrastruktur för självkörande bilar? *Sammanhang:* Under vilka omständigheter är individer benägna att använda automatiserade transporter?
Olika grad av automatisering: Denna aspekt behandlar människors inställning till olika grader av automatisering från manuellt (som referens) till delvis, i hög grad och hel-automatiserad transporter. Relaterat till aspekter såsom underhållning, enkelhet att köra. (Kyriakidis 2015).
Autonoma transporter inom kollektivtrafiken: Belyser aspekter såsom kostnader (t ex lägre taxa för att kostnader för förare saknas), samt passagerarsäkerhet.

Automatiserade transporters genomförbarhet
Behandlar frågan, om och hur snart människor förväntar sig att automatiserade transporter ska vara en verklighet (Begg, 2014) liksom hinder och möjligheter relaterade till det, såsom juridisk pålitlighet, reglering, infrastruktur, kostnader, konsument acceptans, social acceptans och teknisk utveckling. (Underwood 2014).

Människors bakgrund och nuvarande situation
Individers socioekonomiska bakgrund liksom nuvarande resevanor och hur det inverkar på deras inställning till automatiska fordon är ofta av intresse i enkäterna. Det handlar också om att synliggöra hur autonoma fordon kan tänkas påverka olika samhällsgrupper.
Könsperspektiv: Finns det t ex skillnader mellan mäns och kvinnors syn på automatiserade transporter? (t ex, KPMG 2013, Casley, 2013). *Inkomst :* Finns det skillnader i syn mellan hög och låginkomsttagare? T ex benägenhet att betala för helautomatiserade fordon eller angelägenhet om säkerhet, kontroll och ansvarsfrågan. *Hushållskaraktäristika, Utbildning, ålder och land .* Finns det någon skillnad i syn mellan olika åldersgrupper, utbildningsnivå och mellan länder? *Nuvarande resevanor och innehav av fordon* : T ex Hur pendlar man vanligtvis till arbete och fritidsaktiviteter?

Kvalitativa undersökningar
Nedan ges en kort inblick i studier som bygger på kvalitativt orienterad data, dvs som inte utgörs av statistiskt material och siffror. Kvalitativa data ger en djupare och mångfacetterad förståelse av ett fenomen, samt bidrar med konkreta beskrivningar av hur olika företeelser och effekter kan ta sig uttryck.

I texten nedan ges en kort bakgrundsbeskrivning med exempel på kvalitativa metoder/analyser som har används för att studera hushållens förutsättningar, erfarenheter och angelägenheter relaterat transport.

Intervjuer:
Intervjuer är en vanligt använd metod för att undersöka användningen av transporter utifrån hushållens perspektiv. Intervjuerna är vanligtvis semistrukturerade, dvs forskare förbereder och utvecklar en intervjuguide med teman och frågor som ligger till grund för intervjun, men som inte är helt styrande. Ett exempel är Pierre m.fl (2011) som genomförde 1-2h långa semistrukturerade intervjuer med personer som har införskaffat elbilar (Frankrike). Fokus med studien var att undersöka olika stadier/moment, vid bruket av elbilar såsom förväntningar och medvetenhet, inköp, den tidiga användningen, den rutinmässiga användningen, underhåll och ev haveri. Om Pierre m.fl (2011) vände sig till sk early adopters, dvs pionärer när det gäller användningen av elbilar vänder sig Graham-Growe m.fl. (2012) intervjustudie i Storbritannien till icke kommersiella bilister (20 kvinnor och 20 män) som prövar på att använda en elbil under en veckas tid. Respondenterna intervjuades direkt efter försöksperioden, beträffande deras kunskap och medvetenhet om elbilar, fördelar och nackdelar erfarenheter av att köra osv.
Caperello och Kurani (2012) genomförde ett liknande försök i USA som dock varade i fyra till sex veckor och genomfördes med stöd av såväl kvalitativa och kvantitativa metoder för att undersöka resenärernas erfarenheter och angelägenheter när det gäller användningen av elbilar. Intervjuer genomfördes med 36 hushåll i början, mitten och i slutet av testperioden

Studierna ovan berör användningen av elbilar. Exempel på intervjustudier kan givetvis hämtas från andra områden såsom Carreira mfl (2013) som genomförde semistrukturerade intervjuer med 49 bussresenärer (för vardagliga resor och turistresor) för att undersöka deras erfarenheter av bussresan. Eller Lowe mfl (2016) som med stöd av intervjuer undersökte låg-inkomsttagares dagliga erfarenheter av transporter.

Observationer

Med intervjuer och fokusgrupper är det möjligt att undersöka företeelser som kan beskrivas i ord. Observationsstudier innebär en möjlighet att studera mer dolda beteenden och behov som respondenterna ifråga inte själva vill eller är medvetna om. I Carreira m.fl (2013) studie genomfördes, förutom intervjuer även initiala observationer av bussresenärer för att bättre förstå resenärernas beteende och behov, en studie som också låg till grund för utvecklingen av intervjuguiden.

Tidsdagböcker och resedagböcker

Tidsdagböcker har används för att undersöka hushållens resmönster. Berg och Karresand (2015) utgick exempelvis från tidsdagböcker för att studera hushållens förutsättningar att utföra vardagliga aktiviteter med stöd av minskad bilresande och ökad användning av kollektivtrafik, cykel och gång. X och Y

En tidsdagbok skrivs av en enskild individ (ofta samtliga över 10 år i ett hushåll) under ett eller flera dygn. Personen skriver ned de aktiviteter han eller hon gör under en dag, vilket beroende på syftet kan vara mer eller mindre detaljerat och med fokus på vissa aktiviteter (exempelvis transport). Vilka som medverkar i aktiviteten anges också.

Tidsdagböcker kan användas vid interventionsstudier med autonoma fordon för att synliggöra resmönster. Det är också tänkbart att studera eventuella förändringar i resmönster, före och efter interventionen. Tidsdagböcker kompletteras med fördel med kvalitativa intervjuer. (Se Berg & Karresand 2015)

Scheiner mfl. (2013) använder sig istället av sk resedagböcker, där alla som fyllt 10 år i hushållet får notera sina resor (vilket färdsätt, tidsåtgång, tidpunkt osv) under en veckas tid. Avsikten med metodvalet var att samla information om de resor hushållen genomför. Resedagböcker genomfördes under tre års tid (en vecka varje år) för att undersöka förändringar i hushållens resande.

Kombination av metoder

Det är inte ovanligt att olika typer av kvalitativa metoder används för att undersöka en företeelse, såsom intervjuer och observationer (t ex Carreira m.fl. 2013), eller intervjuer och dagböcker.

Kommentar

Mätning och kvantifiering av effekter av automatiserade transportsystem och autonoma fordon på samhällsnivå, kan med fördel kompletteras med pilotstudier på lokal nivå där olika grupper av användare prövar att köra automatiska fordon under en viss tidsperiod . Sådana studier kan med fördel undersökas med stöd av kvalitativa metoder. Merparten av tidigare studier när det gäller automatiska fordon består av människors förväntningar, och i nästa steg handlar då om att undersöka faktiska erfarenheter, såsom exempelvis gjorts i tidigare skede när det gäller elbilar.

Appendix F – Workshop Results WP4-1

WP4 Workshop results, team work exercise 1

FUNKTIONSMÅL	Grupp: DriveMe Car		Grupp: Uniti vehicle		Grupp: Starship delivery robot	
Citizens travel improved through increased reliability, security and convenience.	+ Comfort	The driver can do something else when the vehicle is in AD mode. Could also be negative - forced to work	+	Comfort	+	Night service, no heave vehicles on the street
	+/- Security	Security can be divided; in the vehicle/outside the vehicle	+/-	Security and reliability	-	Create congestion
The quality of the business transport is improved and the international competitiveness is strengthened	+	If it leeds to lees disturbances in the traffic system in general -> more availability	n/a		+ & -	Closed system and limited mobility -> efficiency Open system -> rush hours problems
Accesibility is improved within and between regions, as well as between Sweden and other countries	+	"Rounder Sweden", place of residence of less importance...?	n/a		n/a	
The working arrangements, implementation and the results of the transport policy contributes to an equal society.	Neutral				+ & -	For very short distances, for the final delivery But negativ for disabled poeple
The transport system be designed so that it is useful for people with disabilities.	Neutral	The driver must control the vehicle on roads where it cannot operate in AD mode	+	No driver needed	+	Distances to the delivery point is short
Children's opportunities to safely use the transport system, and be part of the traffic environment increases.	Neutral	The vehicle demands a driver with licence	+	More secure traffic, children get access to transports	+ & -	Replaces heavy vehicle But negative if used during peak hours when children go to and from school
The conditions for choosing public transport, walking and cycling are improved.	Neutral		+	Last mile solution, becomes part of public transport	+ & -	Less bulky vehicles But negatice is used at the "wrong" time of day
HÄNSYNSMÅL						
The number of fatalities in road transport is halved and the number of seriously injured reduced by a quarter between 2007 and 2020.	+	But small impact due to low number of accidents on the type of roads where the vehicle can operate in AD mode	+	AD is more secure for the ones in the vehicle as well as them outside	+	Less heacy vehicles on the streets
The transport sector contributes to that the environmental quality goal "Reduced Climate Impact" is reached by a stepwise increased energy efficiency in the transport system and a broken dependency on fossil fuels. In 2030, Sweden should have a vehicle fleet independent of fossil fuels.	+ & -	Vehicles could be forced to keep speed limits - > better efficiency But possibly more transport work due to increased comfort	+ & -	Not AD per se, but the technology/system enables elctrification at low cost. Creates more travel and higher energy use	+	Small electric vehicles
The transport sector contributes to that the overall generation goal for the Environment and other environmental quality goals are reached, and to improve health. Priority is given to the environmental policy objectives where transport development is of great importance for the prospects of achieving the set goals.	+ & -	Vehicles could be forced to keep speed limits - > better efficiency But possibly more transport work due to increased comfort	+ & -	More effective use of vehicles gives less resource usage. Cleaner air on a local level. Negative impact on health due to less work out	+ & -	Clean mobility But higher deamnd for material resources
Övriga kommentarer		*The transportpolitical goals are designed to manage the current transportsystem, not adopted to building a new better system*				
		We should study furhter how to steer toward a future system that utilizes the technology in a sustinable way				

Appendix G – Workshop Results WP4-2

WP4 Workshop results, team work exercise2

FUNCTIONAL GOALS	Citizen: the group took a individualistic perspective		OEM		City	
Citizens travel improved through increased:						
Reliability:	• It is complex. • It depends on what kind of transport user you are • Trade off; car vs public transport • It's a function of **time**: some service providers increase the trip time-length in the time table --> gives them better reliability • "Reliable enough when going from A --> B" • **Trust** the transport • AD can reduce slack and improve reliability • **Expectations, predictability, robustness** • You can't easily sum up the effects	• Time • Trust • Expectations • Predictability • Robustness	AD makes the whole city more accessible - city center is not as important -the whole city is utilized more	• Avilability	City: Overall perspective Citizen: Individual perspective	
Security:	• We use the car to take kids to school because we don't **trust** other drivers • Security when sharing a car with strangers is a challenge • **Perception**; different individuals have different fears	• Trust • Perception	Important sales argument	• Trust • Perception		
Reliability:	Better use of **time** (than driving) while in the car/vehicle	• Use of time	Dont have to wash, service and park. Time for other things i	• Use of time		
The quality of the business transport is improved and the international competitiveness is strengthened	--		Lower cost (to own?) AD-knowledge -> profit Cheaper transports increase global competition. Automatisation can help bring manufactoring back to Sweden	• Cost of ownership • Competitiveness	Göteborg should be the centre for logistics in the Nordic region	• Competitiveness
Accesibility is improved within and between regions, as well as between Sweden and other countries	• We as citizens like to have accessibility • Does AD encourage multi-modal travel? • Accessibility in rural areas • AD can be local but not intercity, the cities determines what is allowed in some cases • Legislation can vary between countries (* This is a regional political goal)	• Transport choice • Rules in different locations	Accessability for cheaper and realiable transports. Makes regional and contry cross boarder operations easier	• Cost effective • Reliability	Göteborg shall be a strong regional center. 30 min between hubs with public transports	• Predictability • Reliability
The working arrangements, implementation and the results of the transport policy contributes to an equal society.	• More equal access to a car from a physical point of view (you don't have to know how to drive) • But is it equal from a economical point of view? AD may not be available to everyone due to economic reasons • AD can be a new transport offering • Does the long term effects reduce possibilities?	• Access • Cost	AD increase number of qulified jobs and decrease number of "simple" jobs	• Jobs • Education	Work in progress with "jämlikt Göteborg" Tentative and important questions are not defined, lacking methodology	
The transport system be designed so that it is useful for people with disabilities.	• Improved access to the transportation system • Better accessibility is introduced in new vehicles • "It's designed for the common good"	• Access	Different adoptations of vehicles/services will be needed to fit different disabilites and needs	• Variety	Easy to redress obstacles in public areasm both traffic and buildings. Systematic work. On the political agenda.	• Tool
Children's opportunities to safely use the transport system, and be part of the traffic environment increases.	• Do we trust the system? • AD can bring about a more safe trafiic environment for kids in the streets • Safety is a perception in this case • The feeling of safety (biking can be dangerous) • "Fear of putting the kid in the wrong pod"	• Trust • Perception	Vehicles that will drive kids on their own will require extra functions	• Functionality	Political focus. Childrens safe roads to school, methodology to bring in the childrens perspective in city planning	• Safety
The conditions for choosing public transport, walking and cycling are improved.	• "I am a driver, I don't care" • "I am a driver, more other drivers should choose public transport" • AD could bring benefits if steered in the right direction • AD --> deregulated bus system • Choice based on: - Convenieince - depends on the context: family, where you live, house pricing, parking space - Accessibility to/with public transport	• Attitudes • Convenience • Accessibility	AD will probably increase quality and eanble lower price for public transport. Travel services will make it easier to walk one way and be driven the other.	• Realiability • Cost • Accessibility	Political goals exists. Sustainable travel shall increase. Trafic strategy to implement bicykel program. On going wotk with public transport hubs for Gothenburg, Mölndal och Partille.	• Attitudes • Accessibility

CONSIDERATION GOALS						
The number of fatalities in road transport is halved and the number of seriously injured reduced by a quarter between 2007 and 2020.	• "A very good thing, we hope it happens" • We don't think we have control over this; "others have accidents - we don't" • Perception of own driving ability • "It is other drivers fault" • The amount of AD in the system matters a lot	• Attitudes • Perception of own ability	AD will not be introduced if it dosent lead to increased safety	•Necessity	Trafik safety program, goal and succesful work since many years	• Priority
The transport sector contributes to that the environmental quality goal "Reduced Climate Impact" is reached by a stepwise increased energy efficiency in the transport system and a broken dependency on fossil fuels. In 2030, Sweden should have a vehicle fleet independent of fossil fuels.	•"It is fine with me as long as it does not cost any more" • What is sustainable? Not even experts can always tell or agree • The solutions available might not be enough for addressing climate change	• Cost • Understanding of sustainability	Transport as a service makes introduction of electrification easier. Energy use / km is lower . Total energy use can increase energiförbrukning kan öka, ok if its renwable energy.	• Electrification • Energy use	Climat strategy program. Environmental requirements on the itys vehicles. Environmentla zon in the city. Travel policies - support to work places with travel policies.	• Zoned city • Travel management • Political pressure
The transport sector contributes to that the overall generation goal for the Environment and other environmental quality goals are reached, and to improve health. Priority is given to the environmental policy objectives where transport development is of great importance for the prospects of achieving the set goals.	Same as above with the following addition reagrding HEALTH: Some things we can understand e.g. if we can see it, feel it, smell it etc. E.g. noise, smog etc.	• Cost • Definition of sustainability • Understanding of impacts	Samller and resource efficient vehicles is more important than AD to reach the environemental goals. Scalable transport solutions increase fill ratio, vehicles can be used by both goods and people.	• Cost • Mixed transports • Scalability		
Other comments	Heterogenicity of the group We as citizens do not take cost/benefits into					

Appendix H – Mrs Rose

Actors: Independent flower shop in Linnégatan the specific actor in this case is the owner of the flower shop is Mrs Rose (her first name is Elisabeth but in the use case she is referred to as Mrs Rose). The shop also employs two assistants who work at the store at different times/days. Mrs Rose has a son (Erik) at university and a daughter (Julia) at school. She lives in Lindome about 20 kms from the shop in a small house near her mother.

Actors needs
a) To be able to deliver flowers and plants when ordered by customers.

Orders could come from:
- Customer who visits the shop
- Customer who telephoned
- Customer who ordered from somewhere else though a network such as 'Interflora'

b) Transport needs to able to take flowers and plants from the company location to the customers home (or in the cases of a business customer to their establishment). Transport needs to be close by or if possible parked at the flower shop (the latter is not possible in Linnégatan). The parking place needs to be available to the van/car used by Mrs Rose.

c) Transport needs to be available all the time as deliveries can be required 7 days/week.

d) Transport needs to be able to accommodate plants and flowers that are not packaged without damage.

e) Transport needs to be low cost because the margin on plants and flowers is rather small.

Functional requirements, transport modes and route start and end
- Small vehicle
- Can be driven by someone with car driving licence
- Powered van or car (could be electric, hybrid or fossil fuel)
- Delivery cycle - electrically assisted?
- Route starts and ends at the home of the shop owner - but the main use of the vehicle is for business

System without AD

One Thursday

Mrs Rose drives to the store every day in a small van that she uses both for the trip to/from work and also for delivering flowers during the week. During the working day the van is parked at a nearby parking space (which has to be paid for). Sometimes the van is parked up to 750 metres from the flower shop which is time-consuming and occasionally problematic for Mrs Rose. When loading the flowers and plants she sometimes has to park outside the shop which can cause an obstruction and even incur a fine.
The van is diesel powered but Mrs Rose is thinking about getting a hybrid or electric vehicle but is concerned about the additional capital cost. The main reason is to be seen to be more environmentally aware and also because running costs could be reduced in the longer run.

Mrs Rose wakes up at 05:30, she has breakfast and makes sure that she is organised for her work - at the end of last week she has placed a big order for flowers and plants; today will be a busy day at the shop.

Her daughter Julia gets ready for school but today Mrs Rose will leave early for work and so she will drive Julia to her mother's house where she will stay until it is time to walk to school.

As it happens her son is at home as well as the university term finished last week. But he has not got up in time for breakfast. He said he would help in the shop in the afternoon and he will have to get there himself by bus.

06:30 drive to her mother's house with Julia in the small van.

06:45 drives to Linnégatan arriving at 07:10; today there was not a lot of traffic. Parks the van 750 metres from the shop in a parking area and walks to the shop arriving at 07:20.

07:20 to 09:00 works in the shop getting everything ready for the day ahead. This includes preparing the orders that need to be delivered. At 08:30 one of the two people that help in the shop arrives (Karin).

09:00 the shop opens - on Thursday and Friday Mrs Rose has decided to open at 09:00 on the other days she opens at 10:00.

09:15 Mrs Rose decides it is time to make some of the deliveries. She normally tries to do the deliveries to offices at this time in the morning and then will deliver flowers to private addresses later in the day. Of course sometimes there is an unexpected order that needs to be delivered urgently.

09:15 to 09:25 Mrs Rose spends some time wondering whether it is better to wait for a loading space outside the shop to be available or whether she will need to find a way to take the flowers to the van. This problem has been getting worse recently with the lack of parking spaces.

09:25 a space is available - Mrs Rose hurries off to the van. She drives back (rather quickly) and parks in the space (it is now 09:35).

09:35 to 09:50 Mrs Rose loads the small van - flowers have to be treated with care and this takes 15 minutes although she tries to do it more quickly - but flowers are difficult - they come in all shapes and sizes as well as being fragile.

09:50 sets out on the delivery trip. Luckily she knows most of the places where she has to deliver rather well although today she has to make a delivery to an address that she is not familiar with. She knows her phone can help with this but today she has forgotten to charge it and she worries that if she uses it to find the address the power will run out.

10:40 just this one delivery to make; now to the unfamiliar address. It is a bit annoying but two people who had ordered flowers were not in so she still has their orders in the van (one was to a private address and so that does happen from time to time but she was a bit surprised to find that the delivery to the office that was planned could not be made because there was a sign on the door saying 'back in 15 minutes' and she could not wait and hope that this would happen. However,

things improve - despite her uncertainty about this final address Mrs Rose finds it rather easily and makes the delivery - another happy customer!

11:00 Just as she is about to get into the van her phone rings - it is Karin - the two people who were out when she called earlier to deliver their flowers have both phoned to say how sorry they are and to ask if there is any possibility that she can still deliver. Mrs Rose says yes and the deliveries are only slightly out of the way. Mrs Rose is pleased that her phone still had enough charge to take the call - just as well she did not use it to find the last address.

11:00 to 11:25 Mrs Rose makes the two deliveries and returns to Linnégatan. This time she is able to part a bit closer to her shop and is pleased because in the afternoon she will deliver to five people and one of them has placed a very big order.

11:25 to 14:30 A busy time in the shop and Karin and Mrs Rose have to find time to have coffee and a sandwich. It was a good thing she was back by 11:30 though because a package was delivered and one corner seemed damaged - this was a display stand that she needs to take with an order she will deliver in the afternoon. Luckily Mrs Rose was able to ask the person delivering to wait and they both checked the package and realised that it was just the box that was damaged and the thing inside was fine. The van driver (Mrs Rose thought that her badge said her name was Maria) was pleased as well since it saved another trip and more paperwork.

14:30 Mrs Rose decides that it is time to make the deliveries - her son should have arrived at 14:00 but just as she is thinking that she will have to organise the deliveries herself he arrives - on his bike - he has decided to visit a friend later in the day and the bus was not convenient - since all this was decided at the last minute he forgot that not taking the bus would mean he arrived a bit late. Amazing thought Mrs Rose - he is studying 'logistics'.

Anyway he is here now and they begin to organise the deliveries and get things ready to put in the van. Everything is ready and at 15:00 Mrs Rose is set to leave but the delays mean that she does not have very long before the large order she placed last week will be delivered to the shop. If only Erik (her son) could drive but he is still having lessons and so he cannot deliver the customer orders on his own.

Mrs Rose decides that she will have to explain to Karin about the order that will arrive at the shop and that she will now need to leave Erik in the shop to help when it arrives. Not what she had planned that morning at 05:30.

15:10 Mrs Rose sets off to make the afternoon deliveries - she is late and she worries that her customers will be stressed about this or (perhaps worse) that they will not be in.

But, everything goes quite well and almost all the deliveries are made by 16:30 (including the large order that required the display stand) when Mrs Rose returns to the shop.

During the last deliveries she received a text message from her mother to say that Julia was back from school and that she seemed to have caught a cold but was alright and she would look after her until she could collect her later.

16:30 parks and gets to the shop at 16:40. Where she sees that the large delivery is still taking pace - this is a surprise because it should have been finished by now because at 16:45 the shop starts to get busy again. It seems that Karin and Erik insisted on counting all the boxes and the plants and this has delayed everything. The delivery driver does not seem very pleased.

16:45 Karin leaves at 17:00 and another assistant (Anna) arrives to help until the shop closes at 19:00.

17:15 Erik asks his mother if she needs any more help and Mrs Rose says that it is fine for him to leave and go and visit his friends - what time will he be home she asks and gets a rather vague reply.

17:15 to 19:00 Mrs Rose and Anna work together in the shop. Just before 17:30 a customer who comes to the flower shop to collect a wreath that his wife has ordered. Mrs Rose mentions that she also offers a delivery service and he says that he wished he had thought about that because the traffic is very bad today and he thinks he will be late arriving home. He seemed pleased that Mrs Rose had told him this because he said "well sometimes it makes sense to spend a little bit more in order to save time and to have a more convenient day". On the other hand while he was in the shop he also bought some flowers for his wife and that would not have happened if the wreath had been delivered. Mrs Rose decides that life is quite complicated when you start to really think about things.

Anna and Mrs Rose close the shop soon after 19:00 and Mrs Rose leaves for home at 19:20.

20:00 Mrs Rose collects Julia from her mother and they go home together - her cold seems worse. Mrs Rose hopes she will be fine to go to school tomorrow.

20:10 Mrs Rose makes something to eat (Julia has eaten earlier) and as she is finishing her meal Erik arrives. He eats and they talk for a while about how university is going - and whether he will be able to help in the shop in the vacation.

Mrs Rose decides she has had quite a tiring day and goes to bed at 22:00 after watching television show that she likes. Tomorrow will be a calmer day she hopes.
END OF USE CASE

OPTION 1 FOR AN AUTONOMOUS VEHICLE

In this optionwe have assumed that Mrs Rose has decided to own her own autonomous vehicle.

Activity of the AV

The autonomous vehicle is used to get from home to work just as it was before. However now Mrs Rose can get out of the van at the flower shop and send the AV to park itself (in order to save parking fees Mrs Rose decides to use a parking space further away than the one she used before).

When orders need to be delivered Mrs Rose can ask the vehicle to come to the store or park nearby in order to load it.

After it is loaded the AV can be sent to make the deliveries of flowers and Mrs Rose can remain in the store - this saves some costs because it is now possible to reduce the need for assistance in the flower shop (of course this has employment consequences - these are not directly related to driving the vehicle). Unfortunately not all deliveries can be made using the AV because the customer needs to be there to take the flowers from the vehicle when it arrives. In addition Mrs Rose has had to have a modification made to the original AV because she has to be sure that

customers can only access the flowers they have ordered and paid for. Therefore the vehicle now has a system of small 'lockers' which has reduced its carrying capacity.

The need for a customised AV

Because of the limitation at the delivery point which used to be overcome by Mrs Rose getting out of the van and making the delivery herself a new option for delivery has been created. This enables the flowers to be left close to the customer at a nearby shop (or other facility) where several orders can be received (by the pick up point staff). The flowers/plants can then be collected by the customer later on that day or in the evening.

Some problems of customer service

Of course not all customers are happy with this service as they preferred the personal delivery made by Mrs Rose and for some customers (several office buildings for example) she offered an additional service when she would arrange the flowers in the relevant entrance areas of the office.

This question of customer service has worried Mrs Rose since it was an important part of her business and she has now decided that she will continue to offer a delivery service where someone goes with the AV. This has reduced the cost advantages of the AV but it has enabled Mrs Rose to employ her student son during the long university vacation periods - although he does not have a driving licence he is of course able to travel in the AV and make the delivery. During the university term time Mrs Rose asks one of the shop assistants to make some deliveries in the AV and this has been a success because the job is now more varied. In addition Mrs Rose has been able to spend more time in the shop and has realised that it needs some re-design and could be made more welcoming to customers.

After the AV has made the various delivery trips it does not return to the store but finds a parking space and parks there until it is needed by Mrs Rose.

Use of the AV for the journey to work trip

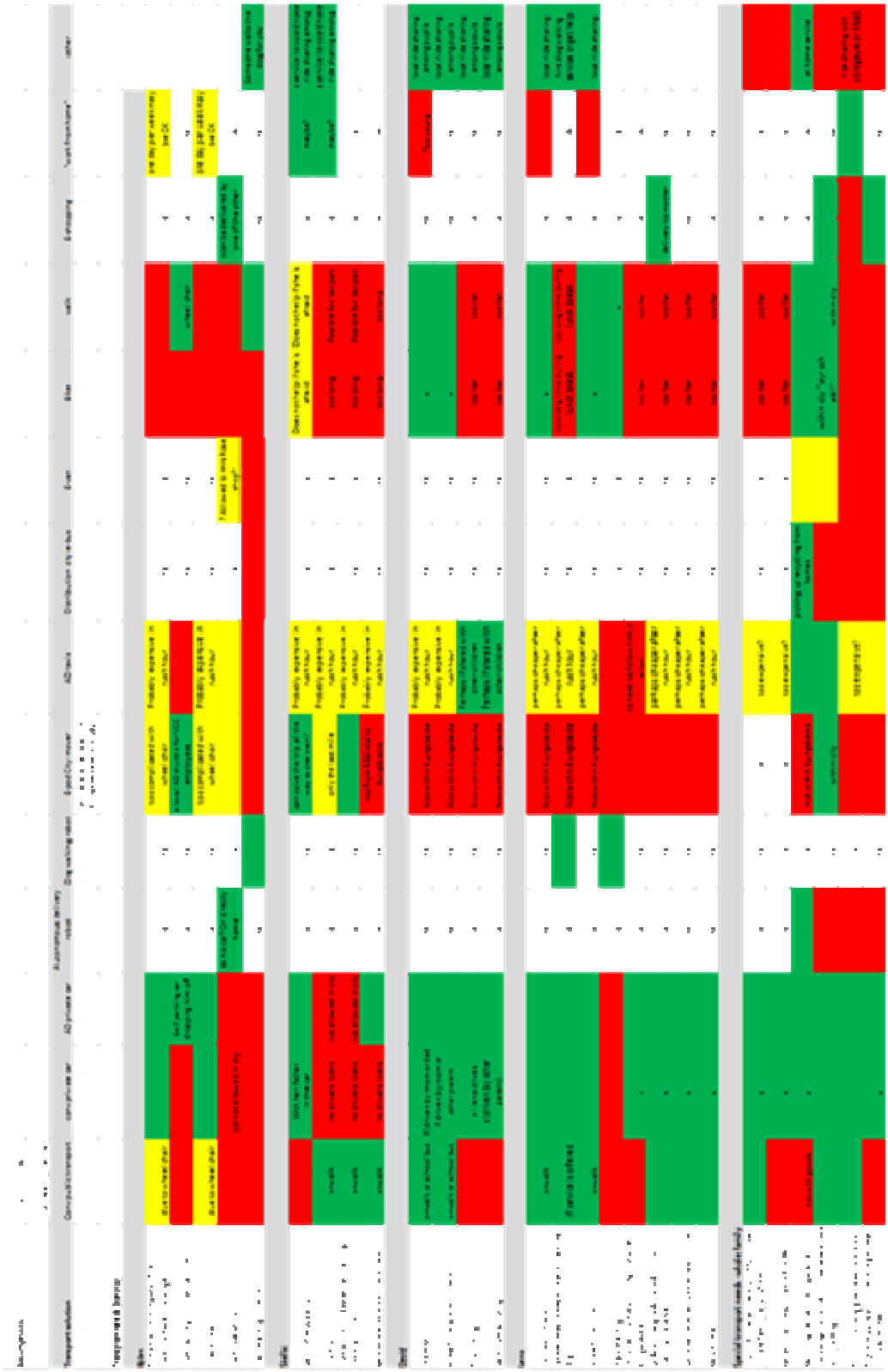
When it is time to go home Mrs Rose calls the AV and travels home in it. Of course in times when she is not at work she has found the AV useful for other activities. Some of these things she used to do on her way to and from work (sometimes referred to as trip-chaining). Now this is no longer necessary and the AV can be sent to collect her young daughter from after school activities without Mrs Rose needing to go along as well. Naturally the locker boxes that have had to be installed (for the delivery trips) need to be removed and this 'pod' is then left at the flower shop overnight.

Overall view of the change to an AV option

Overall Mrs Rose is pleased about the arrival of the AV option but she is a bit surprised that it has not saved much money as she had been led to believe this was one of the key features of AVs. In addition she has noticed that the AV travels almost 30% further than the van used to travel mainly because of the parking distance and also because she no longer reduces travel by trip-chaining.

She was also a bit surprised about how difficult it was to obtain the locker pods for the delivery service but this was because it appears that flower and plant deliveries are very specialised and few businesses required this option.

Appendix I – Transport Analysis Use case; "Kungsbacka Family & Eco Political"



Appendix J – Input to GO:es

Lite input på GO:es som jag kommer på:

Först några nyckelfrågor som är viktiga för att bedöma utvecklingens riktning och samhällseffekter:

- Undersöka vägkapacitetesutnyttjande för små autonoma jämfört med stora autonoma fordon (och samtidigt jämföra deras påverkan på hur direkt man kan resa och hur bekvämligheten är för användarna). Se om svaret på vad som är effektivast beror på storlek på en stad, eller var i staden transporten sker.

- Jämföra ägande mot delade transporttjänster ur användarperspektivet med utgångspunkt från use-casen. Vad är billigast, hur mycket smidigare/krångligare blir delade tjänster? Hur fungerar det i rusningstrafik med eget fordon eller med transporttjänst?

Några andra saker som jag tycker är viktiga att analysera djupare, för de påverkar AD-utvecklingen påtagligt:

- Machine learning/ hur tränas och certifieras mjukvaran? Vad bör man ställa för krav på en ”tränad mjukvara” och hur kan OEM:erna veta att de har en godkänd och säker lösning? Måste en OEM dela data från sina olyckor med konkurrenterna så att deras bilar kan tränas på samma situation?

- utveckla automatisk lasthantering som är tillräckligt generella för 99,9% av allt gods för olika typer av maskiner från små hushållsrobotar till långtradare och sjöfart/flyg.

- Leta synergier med robotutveckling för att undvika att det sker parallell utveckling där båda systemen borde ha delade lösningar. Kanske titta på hur mötet robot/AD fordon fungerar.

Hej!
Förslag på GO:es från min sida:

GO Research/GO Home:

- Utveckla metoder för att mäta och utvärdera
- Användarstudier med personer som använder tekniken på riktigt
- Ta fram metod som kalibrerar systemmodeller med hjälp av data från användarstudier (t.ex. uppmätt tilltro och willingness to share)

Hej,

I ett projekt som inte är större än detta är/har varit är det ju förstås alltid nåt som saknas, som vi inte kan täcka. Här kommer några punkter efter mina reflektioner från den sista workshopen.

- Det individualpsykologiska perspektivet. Hur hanterar förare/passagerare ett system som kör själv? Hur bra är vi på att övervaka ett system? Vad händer om föraren griper in, vad gör fordonet då? Och vad får detta för effekter på säkerheten? Dessa frågor kan vi ju inte besvara i SEVS som det är nu men det kan vara bra att föra en diskussion om detta i slutrapporten om det finns utrymme (och om vi tycker att det är relevant). Kanske behöver vi i fortsättningen någon person som har individualpsykologisk bakgrund? Detta kan vi ta med oss till ”Go research” och ”Go demo”

- Än så länge är det svårt att sia om hur ett AD system kommer att fungera och fylla för funktion för människor och företag eftersom det inte finns något befintligt system att utvärdera. På den nivå vi är nu har det diskuterats att det inte handlar så mycket om fordonen i sig, utan vad vi kommer att göra med den sparade tiden. Vad är det för behov transporterna ska fylla? Här skulle det vara intressant att dra paralleller till andra innovationer som har integrerats i vår vardag, t.ex. internet, e-post och smartphones. Enligt tidsanvändningsstudier som SCB har genomfört har vi ju inte nämnvärt ändrat våra vanor vad gäller de grundläggande behoven som sömn och mat under de senaste 30 åren. Kan vi anta att AD kommer att göra det? Detta är också en fråga vi kan ta med till ”go research”

Vi hörs imorgon. Jag kommer som sagt att behöva avvika för ett annat möte kl 14 som efterföljs med avtackning av vår generaldirektör som slutar på VTI vid årsskiftet.

Hej Else-Marie,
här kommer några spontana reflektioner:

Punkt 1. Du nämnde svårigheten för deltagare att ta med sig deras insikter hem. Det är en pedagogisk utmaning förstås, men kan man stötta detta i arbetssättet? Hur ger man perspektiven vidare till någon annan? Jag tänker mig påverkansdiagrammen som ett möjligt verktyg för att skapa narrativ som kan vara enkla och bli meningsfulla att berätta vidare. Nu spånar jag lite, men jag tror att pilarna emellan respektive ruta är det som skapar “berättelsen” och mening för andra.
Men påverkansdigarmmen är ju bara en del av SEVs, liknande kan säkert finnas i de andra delarna också. Hur paketerar man resultaten på bästa sätt för någon som inte varit med i resonemangen? Kanske borde detta göras i slutet av varje workshop för att skapa en tydlig bild av vad dagens resultat blev.

Punkt 2.
Go Political: det vore intressant att se SEVS tillämpas hos beslutsfattare som ett verktyg för beslutsunderlag och förståelse om effekter. Har politiker som användare av SEVS några särskilda behov?

Go Home: Gäller nog systemtänk i allmänhet inte bara SEVS, att vi i våra projekt i m in grupp på Viktoria med stort användbarhetsfokus alltid borde budgetera för en systemanalys. Finns också personer på Viktoria som gör intressanta analyser inom hållbarhet (miljö, ekonomisk, social), och att tänka vidare vad som händer med en ny teknik i nästa, och nästa, och nästa steg (dvs en representation från olika perspektiv :) är viktigt. Ibland blir det för mycket fokus på utvärdering av prylen/tekniken med en grupp av användare.
Go Demo: är det möjligt att validera SEVS, och är det meningsfullt? Om vi gör en SEVS-process med tex P-shuttle, sedan tittar hur det blev. Stämmer analysen och fångade metodiken upp relevanta saker? Eller är omvärlden så föränderlig att vi har svårt att visionera om de stora disruptiva förändringarna? (Säkert både och, man fångar upp en hel del och missar vissa saker - frågan är vad..)

Små godspoddar eller underhållsmaskiner. Fungerar de? I vilka relationer? Hur upplevs de av människor? Vad händer när de hamnar i gaturummet avseende säkerhet för gående och cyklister, trängsel, upplevelse, skador på fastigheter, möbler i gaturummet?

Kollektivtrafiken. Vilken betydelse skulle AD-teknik få för kollektivtrafiksystem? Finns det kommersiella nyttor? Finns tekniken? För vilka fordonstyper och trafikupplägg är det relevant? Vad händer med passagerarsäkerhet? Arbetstillfällen?
Robotifieringen av samhället, vad innebär den? Förlorade arbetstillfällen, viljan och förmågan till kroppsarbete, social exkludering, inkomster och välfärd?
Restidsnyttor? Betalningsviljan för restidsvinster har en stor betydelse i samhällsekonomiska kalkyler. När restiden är dyrbar, dvs inte kan användas till något annat än förflyttning av person eller vara, skattas den också högre av användarna. När restiden kan dubbelutnyttjas för andra ändamål, tenderas betalningsviljan att minska för snabbare framkomlighet. Vad händer med betalningsviljan för framkomlighet på väg om chaufförer kan göra annat, medan fordonet transporterar sig?
Samhällets kollektiva upplevelse av självstyrande teknik och individens upplevelse av dito. Hur tas tekniken emot? Som ett hot eller som en självklar företeelse? Hur reagerar individer i mötet med autonoma fordon? Hur reagerar förare? Intressant både på objektnivå (möte fordon-människa) och systemnivå (automation i trafiksystemet, i samhället).
Vad händer avseende hastigheter och emissioner på systemnivå? Mer än 50% av körda kilometrar i Sverige sker över lagstadgade hastighetsgränser. Hastigheterna påverkar flera parametrar, bland annat trafiksäkerhet, bullerspridning, spridning av luftföroreningar, energiförbrukning och framkomlighet. Om alla fordon följde hastighetsbegränsningarna skulle detta ha stor effekt inte bara på trafiksäkerhet utan också för energiförbrukning, koldioxid- och andra luftutsläpp samt antalet buller och vibrationsstörda i Sverige.
Cloud och samhällets roll. Ska olika fordonstillverkare erbjuda olika kvalitet på trafikinformation? Hur organiseras ett gemensamt cloud?
Behöver befintlig trafikinformation i gaturummet förändras? I så fall hur? Behöver trafikinformation i kartor och annan open-data förändras? Hur?
Vilka juridiska förutsättningar fungerar som drivkrafter?
Vilka styrmedel behövs för att autonom teknik ska ge största möjliga samhällsnytta? När behöver de införas?

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1. The regulatory feasibility of open-sourced autonomy software

Open-source software is an established paradigm, in which software development is undertaken by usually large groups of people (development communities, which typically

interact only through the internet), and who are motivated solely by the prospect of using the resulting software to simplify or enhance their own activities, or to provide these features to the community. Due to the amount of people working on the same project, open-sourced software has properties that differentiate it from commercially developed software, such as fewer bugs, an increased rate of updates and patches and features that address better the needs of the users. These advantages, along with no development costs, have been harnessed for the development of commercial software by using open-sourced software as a base. Salient examples of this approach include Google's Chrome browser (based on Chromium) and the Red Hat Linux distributions (based on Fedora distributions).

The social significance of open-source software stems from co-creation, where the final users (or a subset of them) develop the software while being supported by a commercial vendor, who supplies software development tools. In autonomy, this introduces the democratization of self-driving vehicles, potentially making this technology accessible to more people and at the same time introducing features that may be overlooked by the companies currently developing autonomy software. However, this approach presents some challenges, of which the greatest one is perhaps the regulatory barriers regarding safety. This is an especially important concern, since open-source software does not usually undergo a formal, centralized quality control/assurance procedure.

The legal feasibility of open source software warrants exploration, where a solution might be government-funded quality assurance of open-source software, along with updated regulations regarding the testing and operation of autonomous vehicles. In fact, the subject of a centralized control framework for autonomous driving (or the lack of said framework) arose from one of the scenarios that we studied in the previous SEVS project. I think following this line of inquiry is natural.

2. The enforcement of V2V (Vehicle-to-Vehicle) communications

There is a number of studies suggesting that vehicle-to-vehicle communication has a great potential to increase safety by having vehicles coordinate their actions in complex situations, such as crossing intersections, minimizing the impact of human error (I can provide you a reference to one such study, if you need it). This would require car software manufacturers to agree on a protocol, which is unlikely to happen spontaneously. Given that the governments of some countries are already planning to ban cars with outdated technologies (such as fossil-fueled motors) in the future, it is conceivable that they may ban cars without communication technologies that can be demonstrated to make transportation safer - especially when this technology can be retrofitted to current cars.

The participation of regulatory agencies in this matter can affect the way software companies develop their V2V software and can also guide the design and manufacture of the hardware the supports it. Needless to say, it would have a great impact on when this technology is made accessible to the public, which in turn will likely change the way people drive their cars (such as how much attention they will pay to the streets while driving). This issue also arose from one of the scenarios studied in SEVS, and I think it may be of interest to pursue the idea further.

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