MASTER

Self-driving for the elderly and chronically ill?!

exploring how the dynamics underlying the autonomous driving approach of California and the cooperative driving approach of the Netherlands affect the elderly and chronically ill

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Self-driving for the elderly and chronically ill?!

"Why cooperate if you can do it on your own?" ~ ***Autonomous vehicle***

"Why bother, if you can cooperate?" ***~ Cooperative vehicle***

"What about us?" ***~ The elderly and chronically ill***

Colophon

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I would like to express my gratitude to those who supported and supervised me during the process that eventually led to this document. In addition I want to thank the Consulate General of the Kingdom of the Netherlands and the Coast to Coast E-Mobility Connection for providing me the opportunity to conduct my research in California. I also want to take this opportunity to thank my girlfriend, friends and family for their support on the other side of the ocean.

Jeroen Aerts
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Management summary

Breakthroughs in information and communication technologies keep on empowering visions towards a future with self-driving vehicles. Self-driving vehicles are highly debated implying that there are a lot of actors which might all hold different perceptions towards what self-driving in the future would look like. These visions are not innocent, implying that they make actors 'do' something. Whereas most of these expectations refer to the benefits in terms of safety, reachability and livability, the real game-changing aspect of self-driving vehicles is that it could give people, who due to certain circumstances cannot and/or are not allowed to drive from A to B independently, the ability to drive independently! Given the increasing population of elderly and chronically ill, their rising incomes, and their desire to stay mobile as long as possible, this user group seems to provide an interesting niche-market for self-driving vehicles.

Within the realm of self-driving vehicles two technological trajectories can be observed. First, the cooperative driving approach is based on the belief that self-driving should be achieved via the gradual implementation of communication technologies which enable the real-time information exchange between vehicles (V2V) and/or between vehicles and road-side systems (V2I). The autonomous driving approach on the other hand is based on the belief that self-driving should be achieved via the implementation of autonomous technologies that do not rely on communication between vehicles (V2V) and/or and road-side systems (V2I). Whereas the Netherlands is particularly known for the efforts undertaken towards cooperative driving, California is particularly known for the efforts undertaken towards autonomous driving. These two technological trajectories are carried by a multitude of actors which might differ in the way they are organized and the context in which they operate, implying that they might hold different perceptions towards what self-driving in the future would look like. This research therefore focusses on the actor dynamics underlying both technological trajectories.

Research aim

This study aims to understand how innovation works via explicitly focusing on the complex interrelationship between technology (self-driving vehicles) and society (the elderly and chronically ill). Via looking at actor expectations and the contexts in which these expectations are expressed this research aims to gain a deeper understanding of how the different actors underlying both technological trajectories shape their own realities. How do they shape technological development? How do they create stability? How do they deal with tensions? In order to understand to what extend these expectations lead towards a solution for the elderly and chronically ill the following research question is formulated:

How do the actor expectations underlying the autonomous driving (California) and cooperative driving (The Netherlands) innovation pathways lead towards a self-driving solution for the elderly and chronically ill?

Research approach

Given the two different technological trajectories which originated in two geographically separated regions characterized by contextual differences, the comparative method was chosen. In order to understand where technological development is going the study combined the theoretical lens of Strategic Niche Management (SNM) with insights from the sociology of expectations. Whereas the 'three forces of expectations framework' was used to understand how local actors 1) legitimize, 2) coordinate, and 3)

guide technological development (independent variables), the ‘SNM perspective’ was used to understand how these expectations (local level) were translated into the technological trajectories (dependent variables). Via comparing the translation processes within the two technological trajectories it was determined to what extend these trajectories lead towards a self-driving solution for the elderly and chronically ill (dependent variable).

The empirical analysis follows a holistic process in which multiple data sources were used in order to gain a deeper and deeper understanding of the topic. Besides 37 semi-structured interviews, a focus-group and two expert interviews, the data collection procedure entailed a multitude of company reports, video conferences and policy papers. Via coding these different data sources on the three forces of expectations as well as on the predetermined socio-technical structures, and via triangulating between these sources, gradually a deeper understanding was acquired of how the stakeholders shape technological development.

Research findings

Taking in account the contextual differences between California and the Netherlands in terms of OEM prominence, intelligence of the infrastructure and the available pool of knowledge and innovations, it becomes clear that the actors underlying both technological trajectories 1) legitimize, 2) guide and 3) coordinate the technological trajectories in different manners. First, whereas the cooperative driving trajectory is mainly legitimized via referring to the expected public benefits in terms of safety, reachability and livability, the autonomous driving trajectory is mainly legitimized via referring to the expected benefits in terms of safety and comfort. Second, whereas the cooperative driving trajectory is coordinated via public-private collaborations on multiple levels, the autonomous driving trajectory is mainly coordinated in-house implying that there is a lot of secrecy. Third, whereas the cooperative driving trajectory is directed towards a gradual (market-driven) implementation in which more and more cooperative systems will be connected, the autonomous driving trajectory is directed towards a gradual implementation in which the number of occasions in which the vehicle can drive autonomously is increased (technological-push).

Via combining the SNM perspective with insights from the sociology of expectations, three major tensions among the different entities were observed. These tensions influence the stability, speed and direction of the respective technological trajectories. First there is uncertainty between road-authorities and market parties about the degree in which cooperative driving (as well as the associated information provision) should be enabled via V2V and/or V2I communications. Second, there is a tension between the OEMs and Google regarding whether the driver should remain the final decision maker (strategy OEMs) or should be taken out of the loop entirely (strategy Google). Third, there is a tension between the automotive industry in California and the regulators (DMV) when it comes to autonomous driving. Whereas the automotive industry prefers to neglect the cooperative driving trajectory, the DMV prefers to embed the autonomous driving trajectory within the cooperative driving trajectory.

Conclusions

Looking at how the expectations of the different actors are translated into the technological trajectories it becomes clear that the autonomous driving trajectory seems to evolve towards a solution for the elderly and chronically ill in a faster and better manner than the cooperative driving trajectory. Especially the approach undertaken by Google, in which the complexity of the driving task is reduced via extending the amount of miles that the vehicle can drive itself, seems to align with the elderly and chronically ill. Google seems to focus explicitly on the elderly and chronically ill as a future niche market (moonshot). The observation that the vehicle will be built from the ground up, the business model will be determined by user experiences, mobility will be provided as a service, and that efforts are dedicated towards a door-to-door solution, are all indicators that the strategy undertaken by Google seems to align with the elderly and chronically ill in a better and faster way than the cooperative driving trajectory and/or the gradual strategy of the OEMs.

However, the strategy undertaken by Google is also the approach which will likely face more resistance from the actors underlying the socio-technical regime of person-driven vehicles, the cooperative driving trajectory and even within the autonomous driving trajectory. Whereas all the actors underlying the cooperative driving trajectory seem to consider autonomous driving as disruptive, the actors underlying the autonomous driving seem to prefer a more gradual approach in which the driver remains attentive. Thus even though the efforts undertaken by Google are often criticized, it seems to be the approach which would lead towards the real innovation behind self-driving vehicles; enabling people who due to certain circumstances cannot and/or are not allowed to drive from A to B independently, to drive independently!

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AV	Autonomous Vehicle
C-ITS	Cooperative Intelligent Transportation Systems
DAVI	Dutch Automated Vehicle Initiative
DITCM	Dutch Integrated Test-site for Cooperative Mobility
DMV	Department of Motor Vehicles
DSRC	Dedicated Short Range Communications
ITS	Intelligent Transportation Services
NHTSA	National Highway Traffic Safety Administration
OEMs	Original Equipment Manufacturers
PATH	Partners for Advanced Transportation Technology
PIB	Partners in International Business
RDW	Rijksdienst voor het Wegverkeer
SAE	Society of Automotive Engineers
SNM	Strategic Niche Management
SWOV	Stichting Wetenschappelijk Onderzoek Verkeersveiligheid
TRIP	Transportation Research Institute Program
V2V	Vehicle to Vehicle
V2I	Vehicle to Infrastructure
VMT	Vehicle Miles Travelled

1.

INTRODUCTION

1. Introduction

This part of the paper introduces the research question and provides the structure required for the rest of the research paper.

1.1 Self-driving for the elderly and chronically ill

Breakthroughs in information and communication technologies keep on empowering visions towards a future with self-driving vehicles (KPMG & CAR, 2013; Morgan Stanley, 2013; STT, 2013; RAND, 2014; Beiker, 2014). As indicated by Van Lente (2012, p. 772), these expectations are not passive, implying that they make actors 'do' something. The vision of a future with self-driving vehicles therefore triggered a lot of research aimed to explore the potential of self-driving vehicles in society (KPMG & CAR, 2012). These visions are often supported by statistics which refer to the potential that self-driving vehicles could have in terms of 1) increasing safety, 2) reducing congestion, and 3) reducing environmental impact. Some of the most mentioned statistics include;

- *"Car crashes are worldwide responsible for 1.27 million deaths annually."* ***~ ENO (2013)***
- *"90% of all car accidents are caused by human error."* ***~ DITCM (2014)***
- *"In 2012 it was estimated that vehicle accidents made up 450 billion dollar in the U.S. alone." ~* ***Morgan Stanley (2013)***

- *"People spent on average 52 minutes per day commuting." ~****Morgan Stanley (2013)***
- *"83% of the time people drive alone in the Netherlands."* ***~ Rijkswaterstaat (2014)***
- *"Annually 46.1 million hours of time loss is attributed to traffic delays in the Netherlands." ~* ***Rijkswaterstaat (2014)***

- *"22% of all carbon dioxide emissions come from trucks and cars."* ***~ ENO (2013)***
- *"40% of energy consumption in cars is due to unnecessary acceleration and deceleration." ~* ***KPMG & CAR (2013)***
- *"40% of total gasoline use in urban areas in the U.S. is caused by cars looking for parking space." ~* ***ENO (2013)***

The above mentioned statistics exemplify some of the expected benefits that self-driving vehicles could have over person-driven vehicles. Research on behalf of the Dutch Ministry of Infrastructure and the Environment (Ministry I&E) estimated that the costs associated with traffic accidents, traffic delays, and environmental damages range between 19.9 and 20.9 billion dollars in the Netherlands (KiM, 2013, p. 13). A study undertaken by Morgan Stanley (2013, p. 10) claims that the implementation of self-driving vehicles has the potential to save the United States 1.3 trillion dollar. Whether or not these numbers are accurate, many envision the self-driving vehicle as a 'game-changer', capable of transforming the way in which transportation is currently fulfilled (ENO, 2013; KPMG and CAR, 2012; KPMG & CAR, 2013; Morgan Stanley, 2013; STT, 2013; Timmer & Kool, 2014; Rijkswaterstaat, 2014; Connekt, 2013; AutomotiveNL, 2010; Beiker, 2014; Walker, 2014). However, the real 'game-changing aspect' underlying self-driving vehicles is that it could give people, who due to certain circumstances cannot and/or are not allowed to drive from A to B independently, the ability to drive independently! Though this argument is mentioned in literature (RAND, 2014, p. 16; Rijkswaterstaat, 2014; Schultz van Haegen, 2015), it is less prominently present than the arguments related to safety, congestion and emissions. Despite that this is imaginable, given the technological, regulatory, and societal challenges that need to be overcome to make this possible (Shladover, 2014; KPMG & CAR, 2013; RAND, 2014; Timmer & Kool, 2014), it is also remarkable, as self-driving vehicles could significantly improve the quality of life for these people. Whereas the desire 'to go wherever and whenever people want to' has been a powerful market force for centuries (Geels et al., 2012), for this user group this desire seems far away. As expressed by Hank (CEO manufacturing firm) who retired due to medical circumstances (KPMG & CAR, 2013, p. 22);

"*Self-driving vehicles could finally give me my beloved freedom back. No longer do I have to appropriate time from others to fulfill my desire to move from A to B whenever I want to." **~ KPMG & CAR (2013, p. 22)***

To express this desire in monetary values Hank was asked whether or not he is willing to pay 15.000 dollar more for a car with self-driving capabilities. Hank provided the following answer:

*"Whereas most people will likely choose for a cheaper vehicle, the ability to move independently is well worth spending 15.000 dollars extra." **~ KPMG & CAR (2013, p. 23)***

Though Hank does not represent the entire population of the elderly and chronically ill, Hank does provide a good example of why self-driving vehicles could provide a solution for people who are seriously constrained in their ability to move from A to B. Whereas most people can make a decision based on type of car, costs, distance, comfort et cetera, the choice of people who cannot drive themselves is limited by their dependency on others to fulfill this need (KPMG & CAR, 2013, p. 22). Given the increasing population of elderly, and with it the chronically ill (Nationaal Kompas 1, n.d.; Nationaal Kompas 2, n.d.), their rising incomes (PBL Notitie, 2013) and their desire to stay mobile (KiM, 2013, pp. 63-69; TRIP, 2012; SWOV, 2012); this user group might provide an interesting niche-market for self-driving vehicles. As indicated by Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (SWOV, 2012) and the Transportation Research Institute Program (TRIP, 2012), giving the elderly and chronically ill more time to perceive, decide and act upon complex traffic situations could significantly enhance their driving capabilities. Thus even vehicles with a low level of self-driving capabilities can already have an impact on society;

*"Everyone knows the impact of losing a driving license has on people. A driving license symbolizes the thin line between freedom and isolation." **~Anthony Levandowski (Project Lead Google self-driving car)***

Based on the desire to find a mobility solution for those who are seriously constrained in their ability to move from A to B, this study aims to explore to what extend the self-driving developments are directed towards a solution for the elderly and chronically ill. In order to do fulfill this ambition, this research compares the efforts undertaken in California and the Netherlands. This decision is primarily based on the findings of Pel et al. (2014, p. 6) and Timmer & Kool (2014, p. 11), who claim that there are two different innovation pathways towards self-driving vehicles visible; 1) Cooperative driving and 2) Autonomous driving.

- *Cooperative driving is the belief that self-driving should be achieved via the gradual implementation of communication technologies which enable real-time information exchange between vehicles (V2V) and/or between vehicles and road-side systems (V2I).*
- *Autonomous driving is the belief that self-driving can be achieved via the implementation of autonomous technologies that do not rely on communication between vehicles (V2V) and between vehicles and road-side systems (V2I).*

Whereas the cooperative driving efforts are visible in multiple regions across the world (TrafficQuest, 2014; Timmer & Kool, 2014; KPMG & CAR, 2012), the autonomous driving efforts are especially concentrated in California (Beiker, 2014, pp. 65-68; Peters, 2014, pp. 25-26). Whereas California is particularly known for its autonomous driving efforts, the Netherlands is particularly known for its cooperative driving efforts (Pel et al., 2014, p. 2; DITCM, 2014; Ministry I&E, 2013).

Given that there are two different approaches towards self-driving visible within two different regions (California and the Netherlands) it is likely that there will be different dynamics underlying these approaches. Comparing both approaches towards self-driving vehicles could therefore provide valuable insights in how the actors in both regions shape technological development, and how their decisions might influence to what extend the technological trajectories tend to lead towards a self-driving solution for the elderly and chronically ill.

1.2 Expectations in technological development

Given the ambition to identify where technological development is going and how this might influence the elderly and chronically ill, this research elaborates on insights from the sociology of expectations. To explain the power of expectations in technological development researchers often refer to the story of Moore's Law, in which Gordon Moore predicted in 1965 that the capacity of computers would more or less double every two years (Van Lente, 2012, p. 773). This expectation became a so-called 'self-fulfilling prophecy' as companies used Moore's prediction as the right strategy to follow, adjusting their R&D investments to reach this goal. Based on this principle Van Lente (2012, p. 773) argues that the accuracy of the prediction was more the result of a strategic game between chip manufacturers than an accurate prediction. According to Van Lente (2012, p. 774) this implies that there is always a message behind the expressed expectations. Expectations therefore contain valuable information about how the different actors shape technological developments. However, as indicated by Bakker et al. (2011), Van Lente (2012), Gartner Consulting (2003), McDowall (2012) and Pel et al. (2014), in order to make sense of these expectations one needs to take in account 1) the context in which these expectations are formulated, 2) the purpose behind these expectations, 3) how these expectations are protected, and 4) how these expectations are perceived by other actors.

Given that emerging technologies are highly complex and systemic in nature, there are a multitude of actors involved in technological development, which might all have different expectations about where technological development is going (Bakker et al., 2011, p. 154). To understand how these actors shape technological development one needs to understand the purpose behind these expectations. Based on this premise Van Lente (2012, p. 774) developed the 'three forces of expectations framework', arguing that expectations can fulfill three different roles; 1) legitimize investments, 2) heuristic guidance, and 3) coordinating efforts. To explain these concepts textbox 1 provides an example of how the early vision of

Norman Bel Geddes triggered research and development activities towards self-driving vehicles. Despite that the example of the vision of an 'automated highway' narrows down a lot of the actual developments that took place over the years, it does provide some valuable insights in the role of expectations in technological development.

Textbox 1: Envisioning a future of self-driving vehicles

The first vision of self-driving vehicles was already expressed in 1939 at the General Motors "Futurama" exhibit at the New York World's Fair (RAND, 2014, p. 1). Here industrial engineer Norman Bel Geddes provided his view on what transportation would look like in 1960 (Shladover et al., 2014, p. 7). Norman Bel Geddes envisioned an 'Automated Highway' where 'automatic radio control' would enable cars to navigate roads while maintaining a safe distance (Beiker, 2014, p. 62). As expressed by Beiker (2014, p. 62) and Shladover et al. (2014, p. 7) this vision triggered a lot of research and investments in radio communication technologies for longitudinal and lateral vehicle control. Given the focus on radio technologies and the importance of technological investments at the infrastructural side of the equation General Motors closely collaborated with the Radio Corporation of America (RCA), Ohio State University and the Federal Highway Administration (FHA). Significant funding of the FHA eventually led to a demonstration of 'platooning' on Interstate 5 in San Diego (Beiker, 2014, p. 63). However, due to budget constraints the U.S. Department of Transportation decided to stop investments slowing down research in the field of V2V and V2I communication technologies. Instead in 1995 Carnegie Mellon University demonstrated in a 4500 km drive from Pittsburg to Los Angeles that it was possible to drive without using communication systems. This demonstration which led to public competitions launched by the U.S. Defense Advanced Research Project Agency (DARPA) triggered a new vision towards self-driving vehicles, this time based on the belief that self-driving is possible without communication technologies. Whereas the DARPA challenges triggered technological developments towards autonomous driving, it was mainly after the launch of Google's 'Self-driving-car project' in 2010 which led to testing on public roads, that society started to get more and more familiar with self-driving vehicles (Beiker, 2014, p. 63).

First, expectations legitimize investments via justifying project efforts by referring to a promising future. Thus even though the current performance of a technology might be insufficient, future possibilities could still justify the costs (Van Lente, 2012, p. 774).

- *For instance, the vision of an 'Automated Highway' legitimized investments in radio communication technologies for longitudinal and lateral vehicle control, eventually enabling so-called platooning.*

However, as indicated by Van Lente (2012, p. 774), whereas expectations are needed to start a project in terms of attracting capital and personnel, they can also make a project more vulnerable, as project outcomes turn out to be different than expected. The claim of Van Lente (2012, p. 774) is therefore in line with the work of Gartner Consulting (2003, p. 9) who developed the 'Hype cycle for emerging technologies framework'. As can be derived from figure 1, after the technology (e.g. automated highway) is introduced via a public demonstration (e.g. Futurama of General Motors), a press release or another event, this triggers more and more interest in the emerging technology leading all the way up towards a so-called 'peak of inflated expectations'. If the technology cannot live up to these expectations this creates a downward spiral pushing the emerging technology in a so-called 'Trough of Disillusionment'.

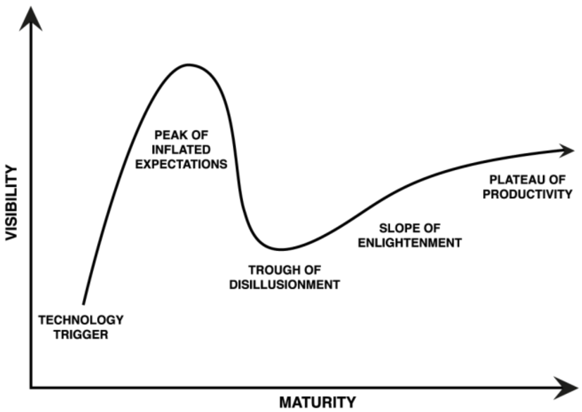

Figure 1: Hype cycle for emerging technologies (Gartner Consulting, 2003)

Despite these low expectations there are still some early adopters who tend to see the benefits of the emerging technology, triggering experimental efforts to gain a deeper understanding of the technological applications, risks and benefits. During this so called 'climbing the scope of enlightenment phase' the technology starts to attract interest again, eventually reaching the 'Plateau of Productivity'. At this stage the general public starts to accept the benefits of the technology, leading to mainstream adoption. The 'Hype cycle framework' therefore provides valuable lessons for the role of expectations in technological development. First, one should not just invest in technologies just because these are hyped. Second, firms should not ignore technologies that currently cannot live up to the exaggerated expectations that were formed at an earlier stage. Third, via formulating realistic expectations it is possible to avoid exaggerated expectations.

- *For instance, whereas the vision of an 'Automated Highway' triggered a lot of research in the field of V2V and V2I communications, the eventual results did not live up to the expectations, eventually leading to the decision of the U.S. Department of Transportation to stop investing. However, despite that the vision of Norman Bel Geddes still has not become a reality, efforts within the realm of V2V and V2I continue. Thus even though the autonomous driving approach of California is now generating a lot of public attention, this does not mean that the vision of an 'automated highway' should be ignored.*

Second, expectations can provide direction, as the prospect of a certain future guides search efforts in science and technology (Van Lente, 2012, p. 774). Expectations therefore reduce uncertainty.

- *For instance, the vision of an 'automated highway' on which vehicles use radio controls to maintain a safe distance, guided research in two ways. Not only did the vision guide researchers to focus on the development of radio communication technologies, it also defined the highway as the context in which these technologies should be deployed first.*

However, expectations can also be used to guide other actors in a different direction. To understand the meaning behind expectations it is therefore important to look at the context in which these expectations are expressed (Van Lente, 2012, p. 772). Whereas a statement made at a public event (e.g. New York World Fair) could be used to get the public excited for the new technology (e.g. automated highway), a statement made at a conference with other competitors could be used to steer competitors in a different direction.

Third, expectations can provide coordination in technological development. Not only do expectations allocate roles, expectations also indicate the type of work that needs to be undertaken (Van Lente, 2012, p. 774). Especially in technological development when there is a lot of uncertainty among actors, expectations provide a valuable role in coordinating these efforts.

- *For instance, the vision of an Automated Highway coordinated the Radio Corporation of America to develop radio communication technologies and the Federal Highway Administration to invest in the required roadside systems.*

Despite that it is difficult to predict where technological developments are going; expectations provide a valuable means for understanding how different entities shape their own realities. This research therefore aims to understand the differences between the cooperative driving approach of the Netherlands and the autonomous driving approach of California via looking at the role of actor expectations and to what extend these expectations lead towards a solution for the elderly and chronically ill.

1.3 Research objectives and questions

This study aims to investigate how innovation works via explicitly focusing on the complex interrelationship between technology (self-driving vehicles) and society (the elderly and chronically ill). In order to understand how technologies make it into society one needs to look beyond the engineered artifacts themselves (Hughes, 1987, p. 53). As indicated by Geels (2002, p. 1258) the world can be seen as a collection of socio-technical configurations, which are made up of people and the perceptions they hold towards society. The self-driving vehicle, which in turn consists of multiple components, is only one of the many components that are part the socio-technical configuration (Geels, 2002, p. 1258). Behind every embedded element there are different actors which might hold different interests towards technological development (Rip & Kemp, 1998, p. 330). As indicated in paragraph 1.2, analyzing expectations therefore provides a valuable means to understand the role of agency in emerging technologies.

The aim of this research is therefore twofold. Above all, this research aims to explore to what extend the cooperative driving trajectory of the Netherlands and the autonomous driving trajectory of California could potentially lead towards a solution for the elderly and chronically ill. Second, this research aims to make sense of the debates currently going on about self-driving vehicles, via explicitly focusing on the dynamics underlying the autonomous driving and cooperative driving approach undertaken in respectively California and the Netherlands.

In order to fulfill these research ambitions a couple of guidelines have to be specified. First, the cooperative driving approach of the Netherlands and the autonomous driving approach of California should be seen as two separate technological trajectories, active within the same technological niche (self-driving vehicles) and competing with the same dominant regime (person-driven vehicles). Second, both technological trajectories are carried by different actors active which are active within different contexts (California and the Netherlands), implying that these actors do not compete for the same funding, attention and legitimacy. Third, this study assumes that the different trajectories towards self-driving are caused by the expectations of the actors underlying these trajectories and the context in which these expectations were expressed. Fourth, this study assumes that these different expectations as well as the context in which these expectations were expressed have different implications for the elderly and chronically ill. Thus in order to understand how the actor expectations underlying the two technological trajectories influence the elderly and chronically ill, the following research question is formulated;

- ***RQ:*** *How do the actor expectations underlying the autonomous driving (California) and cooperative driving (The Netherlands) innovation pathways lead towards a self-driving solution for the elderly and chronically ill?*

The study takes a rather technocratic approach as it aims to explore how the stakeholders (mostly experts) shape technological development. This does not mean that the elderly and chronically ill are seen as unimportant for technological development, it means that this study assumes that this user group is currently not taken in account by the stakeholders underlying both technological trajectories. Despite that it is recognized that users play an important role in innovation (Schot & Geels, 2008), it was chosen to focus specifically on how the different actors shape technological development and what the consequences of these decisions could be for the elderly and chronically ill. Focusing specifically on the elderly and chronically ill would mean sacrificing some of the dynamics which might influence the implementation of a self-driving solution for the elderly and chronically ill. After all, the stability, speed and direction of the two technological trajectories all influence to what extend the two trajectories could potentially lead towards a solution for the elderly and chronically ill. In line with this ambition, and to answer the main research question the following sub-questions were defined:

- ***Q1:*** *How do actor expectations shape the cooperative driving trajectory undertaken in the Netherlands?*
- ***Q2:*** *How do actor expectations shape the autonomous driving trajectory undertaken in California?*
- ***Q3:*** *How do the cooperative driving approach of the Netherlands and the autonomous driving approach of California lead towards a self-driving solution for the elderly and chronically ill?*
- ***Q4:*** *How and under what circumstances can both pathways benefit from each other in order to enable a self-driving vehicles for the elderly and chronically ill?*

1.4 Research justification

This research contributes to Innovation Sciences, society, and the Consulate General of the Kingdom of the Netherlands in multiple ways.

1.4.1 Societal relevance

Currently there is a lot of discussion regarding the development and implementation of self-driving vehicles (Alessandrini et al., 2014; Amsterdam Group, 2013; Beiker, 2014; KPMG & CAR, 2012; RAND, 2014; ENO, 2013; Timmer & Kool, 2014). The demonstration of Google's self-driving car project in combination with a multitude of studies undertaken by marketing and consultancy agencies, have generated a lot of public attention (Morgan Stanley, 2013; Fung, 2014; KPMG & CAR, 2013; Beiker, 2014). As indicated by a data analysis undertaken by KPMG & CAR (2013, p. 6), online discussions about self-driving vehicles keep on increasing exponentialy. Given the multitude of people which might hold different perceptions towards self-driving vehicles, there is also a lot of noise. Comparing how the different actors underlying the technological trajectories undertaken in California and the Netherlands shape technological development therefore contributes to the actual understanding about what is going on. This is especially important as this research domain is still relatively unexplored (Timmer & Kool, 2014; Morgan Stanley, 2013; TrafficQuest, 2014).

The main contribution to society is that this research specifically elaborates on the elderly and chronically ill. As indicated by the SWOV (2012) and TRIP (2012) this user group continuous to increase, putting more and more pressure on the transportation system. However, despite their increasing numbers the elderly and chronically ill remain relatively unserved by transportation (KiM, 2013, p. 65; TRIP, 2012; SWOV, 2012). Given the impact that losing the ability to drive from A to B independently can have on these people (SWOV, 2012), it would be more than wonderfull to find a mobility solution for them. Given the assumption that self-driving vehicles might provide a solution for the elderly and chronically ill, the comparison between the dynamics underlying the autonomous driving and cooperative driving approach might therefore provide valuable insights in how this user group could be served by transportation.

1.4.2 Scientific relevance

This study contributes to Innovation Sciences in multiple ways. First of all, the thesis focusses on the complex interrelationship between technology (self-driving vehicles) and society (the elderly and chronically ill) and the role of agency in these processes. Second, this research contributes to the literature on Strategic Niche Management (SNM) via exploring the role of agency in shaping the two different technological trajectories (autonomous driving and cooperative driving) within the same niche (self-driving vehicles). As indicated by Raven et al. (2014) and Bakker et al. (2012), SNM scholars have only recently started to explore the role of plural niches and regimes active in different regions. Third, via focusing on how actor expectations shape technological development this research aims to show that SNM is not just a reflective approach (Geels & Schot, 2007, p. 400), but can also be used for foresight purposes. Fourth, except from the work of Pel et al. (2014) and Timmer & Kool (2014) the self-driving approaches undertaken in the Netherlands and California have hardly been explored in scientific literature. Given the tendency of SNM scholars to focus on sustainable developments associated with transportation and/or transportation in a Dutch context (Pel et al., 2014), the concepts of cooperative driving and especially autonomous driving are relatively unexplored. When it comes to the potential of self-driving vehicles for vulnerable groups, such as the elderly and chronically ill, there is hardly any scientific literature available. Finally, this research contributes to the literature on the sociology of expectations via conducting an empirical analysis on how the three forces of expectations (Van Lente, 2012) shape the cooperative driving trajectory of the Netherlands and the autonomous driving trajectory of California. The SNM perspective and the three forces of expectations framework therefore strengthen each other. Whereas the insights of the 'three forces of expectations framework' contribute in understanding the purpose behind expectations, the SNM perspective makes it possible to translate these expectations in the respective technological trajectories.

1.4.3 Relevance for the Consulate General in San Francisco

The study was undertaken on behalf of the Coast to Coast E-Mobility Connection located at the Consulate General of the Kingdom of Netherlands in San Francisco. The Coast to Coast E-Mobility Connection is one of the so-called Partners in International Business (PIB) programs, which enables the Dutch government to use economic diplomacy as a means to remove international trade and investments impediments (Agentschap NL, 2012). These PIB-programs are part of the 'Top Sector Policy' of the Netherlands, in which the government specified nine sectors in which the Netherlands wants to excel (Rijksoverheid, n.d.). The goal of this policy is to leverage Dutch public and private parties in these promising markets and via that way improve the competitive power of the Netherlands. The main goal of these PIB programs is therefore to stimulate knowledge and innovation exchange between, governments, universities via creating strong international consortiums (Agentschap NL, 2012, p. 3).

This research contributes to the Consulate General of the Netherlands in San Francisco via providing insight in the different dynamics underlying the self-driving approaches undertaken in the Netherlands and California. Via comparing these efforts it is possible to identify the barriers and opportunities for Dutch public and private parties. Not only will this thesis be used for upcoming trade-missions to California, this report also provides the handles that the Rijksdienst voor Ondernemend Nederland (RVO) will use to decide whether or not a new PIB Program will be launched.

1.5 Comparative method

This study aims to understand how innovation works via explicitly focusing on the complex interrelationship between technology and society. The study therefore follows the interpretivism philosophy, assuming that reality is only accessible through social construction (Creswell, 2009, p. 175). Or as rightfully mentioned by Geels (2002, p. 1259) technologies only fulfill societal functions in association with human agency.

Given the ambition to understand how the actors underlying the autonomous driving approach and the cooperative driving approach shape technological development, this research follows a qualitative research procedure in which both regions will be compared. As indicated by Lor ((2011, p. 7) and Creswell (2009, p. 175), this implies that the researcher is strongly engaged in the studied objects.

Via conducting a comparative study this study assumes to find some interesting dynamics which could cause the differences between California and the Netherlands in their respective approaches towards self-driving vehicles. Instead of quantifying the variables, this research aims to follow a holistic approach in which multiple sources of data will be used to gain a deeper and deeper understanding of the many factors influencing the depending variables (Creswell, 2009, p. 176). Given the ambition to compare two geographically separated regions, this study could best be described as a case-oriented Few-N comparison in which N represents the two investigated populations. As indicated by Lor (2011, p. 9) the smaller N, the higher the level of detail that can be achieved. Given the complex nature of the social phenomenon the smaller N gives the researcher the ability to provide 'thicker descriptions' (Creswell, 2009, p. 173). This still makes a comparison a daunting process as qualitative research involves lots of interconnected independent variables which can all lead to different outcomes (Lor, 2011, p. 9).

In order to establish causality this study assumes that there are different layers of differences and similarities underlying the two technological trajectories. Not only do the two technological trajectories (dependent variables) differ, there are also differences between the contexts in which these trajectories emerge. Focusing solely on a Most Different Systems Design (MDSD) or Most Similar Systems Design (MSSD) is therefore less suitable to establish causality (Lor, 2011, p. 9). Causality is therefore mainly established via a continuous process in which the different actor expectations are compared to each other as well as to the context in which these were expressed. The two trajectories are therefore analyzed separately via a similar methodology. This implies that causality is established via applying similar methodologies, rather than controlling for established concepts.

Despite that the comparative method provides a valuable means for exploring how agents shape technological development (Grin et al., 2010), as indicated by Azarian (2011), Lor (2011) and Creswell (2009) the methodology has some limitations with which the researcher has to deal carefully. First, there is the autonomy problem, which refers to the tendency of researchers to consider the compared entities as autonomous, ignoring the complex interplay among the different entities. Second, the way in which the units of analysis are chosen needs to be explained thoroughly. As indicated by Azarian (2011, p. 121) and Lor (2011, p. 3) the decision on the units for analysis should be based on the added knowledge these specific units can provide above other units, not just because these were the only units available. The latter could lead to an inherent bias in the entire research study, with serious implications for the validity of the findings. Third, the researcher has to deal carefully with asymmetries in the comparison. As mentioned by Azarian (2011, p. 122) one of the major problems with comparisons is that the researcher does not have an equally adequate knowledge about the units studied. The strength of the comparison is therefore determined by the capability of the researcher to penetrate into a different context and get acquainted with the context-specific meanings attached to the phenomena under observation. Fourth, as indicated by Azarian, (2011, p.123), whereas comparative studies are very suitable explorative research, establishing general causing explanations turns out to be problematic. Azarian (2011, p. 123) and Lor (2011, p. 5) argue that this is mainly caused by the multitude of interacting variables within different contexts, making it difficult to compare on equal terms. Finally, there is the problem of obscured differences within countries. As indicated by Lor (2011, p. 2) obscured differences within countries occur when the differences within the units are bigger than the differences between the units.

All in all, the comparative method provides a valuable means to explore how agents located within two different regions shape technological development. However, as indicated by Azarian (2011), Creswell, (2009) and Lor (2011) the strength of the comparative methodology depends on the capability of the researcher to control the differences between both units, enabling a comparison as equal as possible.

1.6 Research approach

As can be derived in figure 2 this research paper consists of three main parts; 1) theoretical framework, 2) empirical analysis, 3) synthesis. Despite that figure 2 shows a linear process, this does not reflect the actual research process. Given the exploratory nature and the amount of complexity involved, the process could best be described as a ‘continues feedback loop’ in which every step whether back or forward results in a in a deeper understanding of the linkages between theory and empirics.

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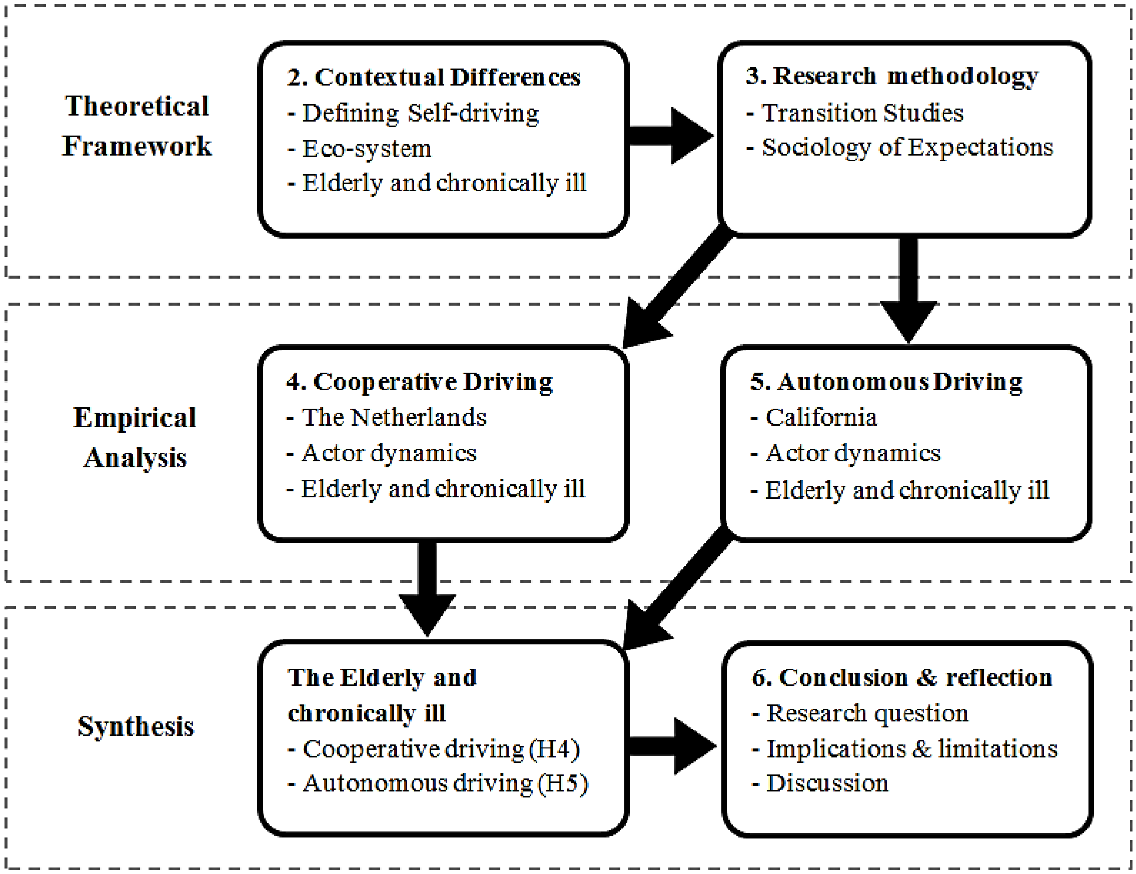

Figure 2: Overview of the research approach

In order to explain how the actor expectations underlying the autonomous driving (California) and cooperative driving (The Netherlands) trajectories lead towards a solution for the elderly and chronically ill, this thesis is divided into six chapters. Whereas the first chapter introduces the research question and provides the structure required for the rest of the paper, the second chapter mainly elaborates on the contextual differences between the two regions. As indicated in paragraph 1.5 controlling the contextual differences leads to a stronger comparison, further enhancing the credibility of this study. The third chapter introduces the theoretical lens which was used to examine the role of agency (actor expectations) in technological development (self-driving vehicles). This theoretical framework is established via combining literature on Strategic Niche Management (SNM) with the sociology of expectations. Whereas the fourth chapter elaborates on the actor dynamics underlying the cooperative driving approach undertaken in the Netherlands, the fifth chapter elaborates on the actor dynamics underlying the autonomous driving approach undertaken in California. Finally, in chapter six conclusions are drawn. Via comparing the different implications that the two technological trajectories have on the elderly and chronically ill the main research question is answered. Furthermore this chapter also reflects on the chosen research methodology and elaborates on the limitations and recommendations.

2.

CONTEXTUAL DIFFERENCES

2. Contextual differences

As indicated in paragraph 1.5 the strength of a comparison depends on the capability of the researcher to control for contextual variation. To explore to what extend both regions are similar and/or different this chapter compares 1) the two approaches undertaken towards self-driving, 2) the population of elderly and chronically ill and 3) the eco-systems in which the self-driving vehicles are developed. Besides controlling for contextual differences this chapter also elaborates on the why questions surrounding the research question. Why the comparison between the cooperative driving and autonomous driving approach? Why the comparison between California and the Netherlands? Why the specific focus on the elderly and chronically ill? The answers of these questions not only validate the research question, they also place the research question in the right perspective.

2.1 Two approaches towards self-driving vehicles

This paragraph introduces the concepts of autonomous driving and cooperative driving and places both concepts in perspective.

2.1.1 Conceptualization

The concept 'self-driving vehicle', sometimes referred to as 'driverless vehicle' or 'automated vehicle' already defines the main principle underlying the concept; namely the ability of a vehicle to drive itself. Despite this relatively straightforward principle, there is no universal terminology for self-driving vehicles (TrafficQuest, 2014, p. 5). As indicated by Pel et al. (2014, p. 6) and Walker (2014, pp. 90-91) there is a lot of uncertainty about what self-driving vehicles would look like in the future. Derived from the papers of Pel et al (2014), Timmer & Kool (2014), RAND (2014), Traffic Quest (2014), KPMG & CAR (2013), and Walker (2014) it becomes clear that this uncertainty seems to be caused by two dynamics. First, there are multiple ways in which the vision of self-driving vehicles can be achieved. As indicated by Pel et al. (2014, p. 6) and Timmer & Kool (2014, p. 11) self-driving can be achieved via 1) communication between vehicles (V2V), 2) communication between vehicles and the infrastructure (V2I) or 3) without communication systems. Second, vehicles can possess different self-driving capabilities. As indicated by the Centre for Autonomous Research (KPMG & CAR, 2013) these differences are caused by the technological decisions made by the car manufacturers. These decisions in turn depend on a variety of internal and external factors, such as availability of resources, regulations, and economics. Pel et al (2014), Timmer & Kool (2014), RAND (2014), Traffic Quest (2014) and Walker (2014, p. 91) therefore argue that due to these two dynamics it is difficult to provide a coherent conceptualization for self-driving vehicles.

The purpose of this research is not to provide a universal definition for self-driving vehicles. Instead this study aims to gain a deeper understanding about the dynamics surrounding the concept of self-driving vehicles. This research therefore elaborates on the different approaches undertaken within the realm of self-driving vehicles. For the purpose of this research it is therefore chosen to focus specifically on the autonomous driving approach undertaken in California and the cooperative driving approach undertaken in the Netherlands. This decision was based on insights from Pel et al. (2014, p. 6) and Timmer & Kool (2014, p. 13), who argue that there are three ways in which the vision of self-driving vehicles can be achieved. The main premise underlying these pathways is that self-driving can be achieved via making the infrastructure and/or the vehicle more intelligent. As can be derived from figure 3 these decisions, which in turn depend on the context in which these decisions were made, can lead towards three different technological trajectories.

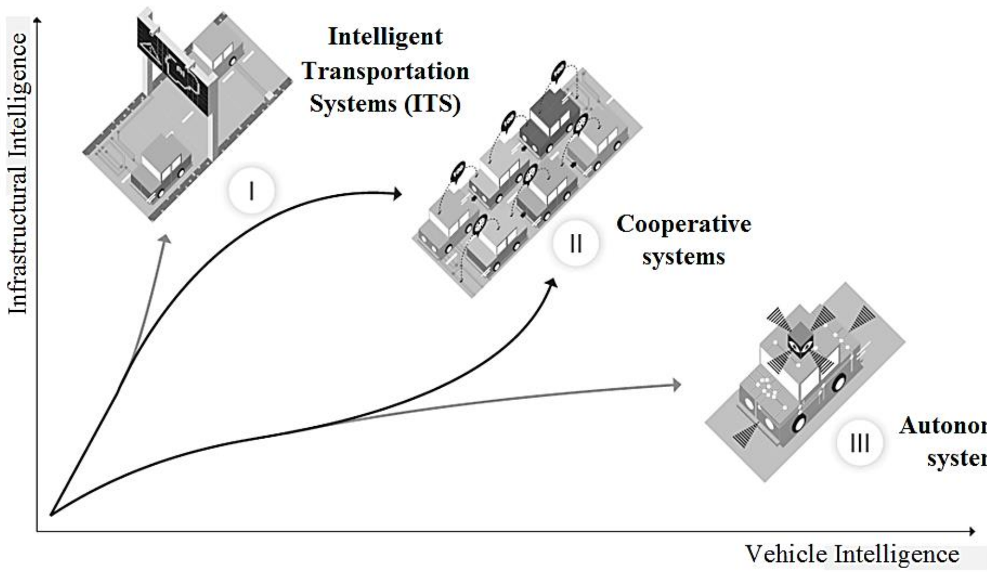

Figure 3: Three approaches towards self-driving vehicles (Timmer & Kool, 2014)

The Intelligent Transportation Systems (ITS) approach is based on the premise that self-driving should be achieved without making the vehicles more intelligent (Timmer & Kool, 2014, p. 13). The autonomous driving approach on the other hand is based on the premise that self-driving should be achieved without an intelligent infrastructure (Pel et al., 2014, p. 7). The main premise underlying the cooperative driving approach on the other hand is that self-driving should be the result of a combination of vehicle intelligence and infrastructural intelligence (Timmer & Kool, 2014, p. 13).

Whereas cooperative driving is on the agenda of many governments, the autonomous driving approach is especially visible in California (Walker, 2014). To understand why this is the case it is important to differentiate between cooperative driving and autonomous driving. In line with TrafficQuest (2014, p. 7) and the Amsterdam Group (2013, p. 3) the ITS approach is therefore considered part of the cooperative driving approach. It is important to note that this does not imply that there is no autonomous driving in the Netherlands and that there is no cooperative driving in California. As indicated by Pel et al. (2014, p. 9) and Timmer & Kool (2014) it simply means that the majority of efforts are directed towards autonomous driving in California, and cooperative driving in the Netherlands.

2.1.2 The cooperative driving approach of the Netherlands

The Dutch approach towards cooperative driving is embedded in in the regulatory frameworks and visions of the European Commission (Timmer & Kool, 2014, p. 13). To coordinate these visions at a European level the Amsterdam Group (2013, p. 3) was founded. The Amsterdam Group (2013, p. 3) defines cooperative driving as an approach in which Intelligent Transport Systems (ITS) make use of wireless communication technologies to exchange real-time information between vehicles (V2V), between vehicles and infrastructure (V2I), and between infrastructures (I2I).

In order to make communication between vehicles (V2V) and the infrastructure (V2I) possible cooperative systems make use of short-range and long-range communications (TrafficQuest, 2014, p. 17). These short-range communications are mostly used for time-critical applications. These applications are phrased under the header of Dedicated Short Range Communications (DSRC), which makes use of the IEEE 802.11p standard (TrafficQuest, 2014, p. 7). DSRC enables the real-time data exchange between moving vehicles and road-side systems via the 5.9 GHz (5.85-5.925) band, which is a spectrum of radio frequencies specifically dedicated for automotive purposes (Amsterdam Group, 2013, p. 5). DSRC allows vehicles to communicate their position, direction and speed to other vehicles (V2V) and/or road-side systems (V2I). Whereas short-range communications are used for-time critical applications, for non-time critical applications cellular networks such as 3G and 4G are used (Amsterdam Group, 2013, p. 5). These long-range communications between vehicles and/or road-side systems are mostly provided via servers connected to a back-office (TrafficQuest, 2014, p. 17). As indicated by TrafficQuest (2014, p. 17), Timmer & Kool (2014, p. 79) and RAND (2014, p. 75) communication via smartphones and navigation-systems is already common.

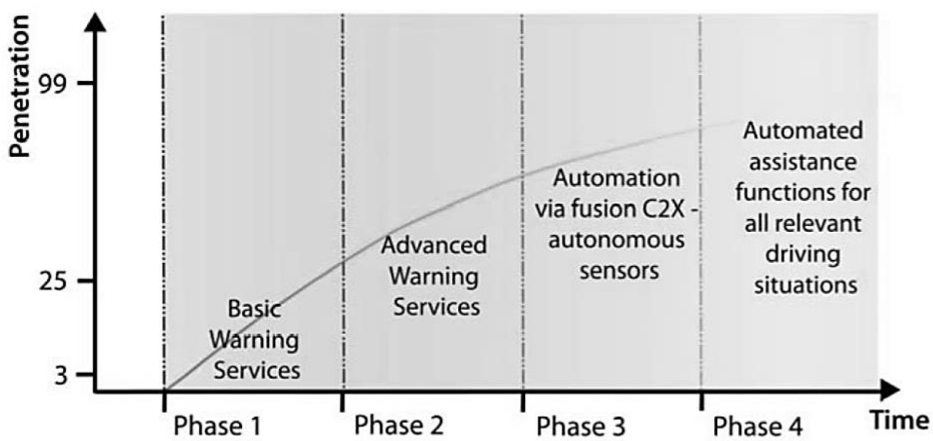

Figure 3: Different stages of cooperative driving (Amsterdam Group, 2013)

Given the importance of cooperation between different communication systems the Amsterdam Group (2013, p. 3) defines cooperative driving under the header of Cooperative ITS (C-ITS). According to the Amsterdam Group (2013, p. 4) the initial deployment will consist of simple 'Day One Services' in which users even with a low level of ITS penetration can benefit. As can be derived from figure 4, the Amsterdam Group (2013, p. 4) believes that cooperative driving should follow a gradual approach in which more and more cooperative systems will be connected to each other. Whereas the Amsterdam Group coordinates efforts at a European level, network organizations as DITCM (2014), AutomotiveNL (2015), Connecting Mobility (n.d.), DAVI (2013) and Connekt (2013) and the Ministry of Infrastructure and the Environment (Ministry I&E) coordinate efforts at a national level. In line with the Amsterdam Group there is a consensus among the represented public and private parties that the Netherlands should focus on the gradual deployment of cooperative driving solutions (DITCM, 2014; AutomotiveNL, 2015; Connekt, 2013; DAVI, 2013). In line with the definitions provided in the roadmaps of the different stakeholders underlying the cooperative driving trajectory of the Netherlands, cooperative driving is defined as follows;

- *Cooperative driving is the belief that self-driving should be achieved via the gradual implementation of communication technologies which enable real-time information exchange between vehicles (V2V) and/or between vehicles and road-side systems (V2I).*

For the purpose of this research it is important to mention that this concept should not be confused with the concept of ‘connected vehicles’. Whereas a ‘connected vehicle’ can refer to a vehicle equipped with cooperative systems, it could also refer to a vehicle which possesses an internet connection (e.g. smartphones, navigation systems) (TrafficQuest, 2014, p. 5). As a connected vehicle does not necessarily possess self-driving capabilities, the term cooperative driving is used.

2.1.3 The autonomous driving approach of California

As indicated by Timmer & Kool (2014), Pel et al. (2014) Walker (2014), Beiker (2014) and Soriano et al. (2014), in California there is a different pathway visible. According to Timmer & Kool (2014, p. 67) and Pel et al. (2014, p. 9) this more radical approach towards self-driving is based on the belief that self-driving can be achieved without relying on communication technologies. As this approach focuses solely on vehicle intelligence without communicating with other vehicles (V2V) and/or road systems (V2I), Pel et al. (2014, p. 6) and Timmer & Kool (2014, p. 21) refer to this approach as the ‘autonomous driving’ approach.

As indicated by research undertaken by RAND (2014, pp. 58-65) and Morgan Stanley (2013, p. 24) the core principle underlying an autonomous vehicle (AV) is a ‘sense-plan-act’ design, which is the foundation of many robotic systems. First the autonomous vehicle uses a multitude of sensors to gain raw data about the world (Morgan Stanley, 2013, p. 25). The second part is the data-mining procedure in which computing power is used to make sense of the raw data and translate this information into software algorithms. These software algorithms are then used to determine the actions the vehicle needs to fulfill in the real world. Third, these plans are converted into actionable commands for the vehicle’s control system (Morgan Stanley, 2013, p. 24). These commands enable the vehicle to perform actions such as steering, accelerating and braking (RAND, 2014, p. 59). An autonomous vehicle could therefore be described as a ‘library on wheels’ which needs to run through its database (library) every time it needs to make a decision, gradually learning and recognizing more and more of the real world.

To make autonomous driving possible the vehicle therefore relies on both hardware and software components. Table 1 provides an overview of the core components that enable autonomous driving (Morgan Stanley, 2013, pp. 25-28).

Table 1: Purpose of the Hardware components underlying autonomous driving

Technology:	Purpose:
Camera’s	Providing the visual confirmation of the surroundings of the car.
Short-range and long-range Radar	Uses radio waves to identify objects.
LIDAR	Uses a combination of reflected laser/light (LI) and radar (DAR) to create a 3D profile (360 degree) of the surroundings of the car.
Sensors	Used to understand what is going on with the car itself.
Global Positioning System (GPS)	Uses satellite communication to determine where the vehicle is positioned
Human Machine Interface (HMI)	Refers to all the systems in the vehicle that interact with the user via

	providing driving information and other infotainment and entertainment features.
Domain Controller	Functions as the ‘brain’ of the vehicle via converting the perceived information of the car itself and its surroundings into actions.
Actuators	Control the steering and other mechanical components in the drivetrain.

Despite that hardware components will continue to play an important role, the value proposition of future vehicles seems to shift more and more towards software (Morgan Stanley, 2013, p. 24; KPMG & CAR, 2013, p. 11; RAND, 2014, p. 59). As indicated by RAND (2014, p. 59) this is in line with the development of computers which continue to grow in computing power. Estimates of Morgan Stanley (2013, p. 69) already indicate that in 2014 an average car contained around 5 – 10 million lines of code.

Given the technological efforts required to enable a vehicle to drive autonomously, it becomes clear that an autonomous vehicle requires a higher upfront investment than a cooperative vehicle. Timmer & Kool (2014, p. 15), Pel et al. (2014, p. 11) and Traffic Quest (2014, p. 15) even argue that autonomous driving leads to lower outcomes in terms of public benefits. As an autonomous vehicles does not communicate with other vehicles (V2V) and/or road-side systems (V2I) the benefits in terms of reducing congestion, reducing emissions and safety are harder to achieve. However, as indicated by RAND (2014, p. 59), Timmer & Kool (2014, p. 16), Pel et al. (2014, pp. 9-10) an autonomous vehicle does not rely on investments on the road-side to enable self-driving. This implies that autonomous vehicles can be developed ‘autonomously’ by the automotive industry. As indicated by Beiker (2014, pp. 65-68) and Timmer & Kool (2014, p. 16) this approach is especially visible in California where Governor Jerry Brown authorized the Department of Motor Vehicles (DMV) on September 25, 2012 to develop regulations for allowing autonomous vehicle developers to test and operate autonomous vehicles on California’s public roadways. Whereas the Amsterdam Group and the Ministry of Infrastructure and the Environment coordinate the cooperative driving efforts in the Netherlands, the DMV is authorized to coordinate the autonomous driving efforts undertaken in Californian. In the California Vehicle Code, Division 16.6, the DMV uses the concepts of ‘autonomous vehicle’ and ‘autonomous technology’ to define the principle of autonomous driving (Soriano et al., 2014, p. 17). An autonomous vehicle is therefore defined as a vehicle that is equipped with autonomous technology that has been integrated into that vehicle. With autonomous technology the DMV refers to technology that has the capability to drive a vehicle without the active physical control or monitoring by a human operator.

For the purpose of this research it is important to place the autonomous driving approach and the cooperative driving approach in the right perspective without neglecting the beliefs that the main stakeholders hold towards these approaches. In line with Timmer & Kool (2014) and Pel et al. (2014) self-driving is therefore considered to be a more radical approach in which the decision is made to neglect communication with other vehicles (V2V) and road-side systems (V2I). Via combining this premise with the definition provided by the DMV autonomous driving is defined as follows;

- *Autonomous driving is the belief that self-driving should be achieved via the implementation of autonomous technologies that do not rely on communication between vehicles (V2V) and between vehicles and road-side systems (V2I).*

Given that both the autonomous driving approach and the cooperative driving approach are aimed to reach the same goal, it is assumed that both approaches will converge at one point in time. As can be derived from the research undertaken by Traffic Quest (2014, p. 13) and KPMG & CAR (2013, p. 15), both in the Netherlands and in California there is a consensus that at one point in time both approaches will converge. However, when this will happen and how these pathways will develop is still uncertain (Timmer & Kool, 2014, pp. 23-24). For the purpose of this research it is therefore important to realize that the two approaches take a different starting position. Whereas autonomous driving starts without the usage of cooperative systems, it could be that at one point in time these systems will be used to connect the autonomous vehicles together (V2V) and/or with the road-side systems (V2I). The cooperative driving approach on the other hand starts with the premise that V2V and V2I communications are required to enable self-driving. As indicated by Timmer & Kool (2014, p. 24) these different approaches create different dynamics as well within as between the two technological trajectories.

2.1.4 Levels of automation

In order to understand how the two different approaches towards self-driving interact with the elderly and chronically ill it is important to investigate the dynamics within and between the two approaches. This paper therefore does not aim to exclude one of the approaches as a solution for the elderly and the chronically ill. After all, for the elderly and chronically ill it does not matter whether their freedom to move independently from A to B will be reached via autonomous driving and/or cooperative driving. For them, the only thing that matters is that there will be a mobility solution for them (SWOV, 2012). To understand to what extend self-driving vehicles can meet the needs of the elderly and chronically ill it is therefore important to distinguish between the different levels of automation.

In order to determine the levels of automation it is possible to use the NHTSA-standard and/or SAE-International standard for self-driving (Kim et al., 2014). For the purpose of this research it was chosen to use the SAE-International Standard J3016 (SAE International, 2013). As can be derived from figure 5 these levels deal better with the functional aspects of the technology than the NHTSA levels (indicated in the right column). However, as indicated by Alessandrini et al. (2014, p. 171) it is important to realize that both the SAE levels and the NHTSA levels fail to include the automation levels for cooperative driving. To get a coherent comparison it is therefore chosen to reflect the cooperative driving efforts on the SAE levels of automation.

The SAE-International (2013, p. 2) levels distinguish between self-driving in which either the 1) human driver and/or 2) the automated driving system monitors the driving environment. Within the first research strand, the SAE-International distinguishes between no automation (level 0), driver assistance (level 1) and partial automation (level 2). Within the second research strand, the SAE-International distinguishes between conditional automation (level 3), high automation (level 4) and full automation (level 5).

Summary of Levels of Driving Automation for On-Road Vehicles

This table summarizes SAE International's levels of *driving* automation for on-road vehicles. Information Report J3016 provides full definitions for these levels and for the italicized terms used therein. The levels are descriptive rather than normative and technical rather than legal. Elements indicate minimum rather than maximum capabilities for each level. "System" refers to the driver assistance system, combination of driver assistance systems, or *automated driving system*, as appropriate.

The table also shows how SAE's levels definitively correspond to those developed by the Germany Federal Highway Research Institute (BASt) and approximately correspond to those described by the US National Highway Traffic Safety Administration (NHTSA) in its "Preliminary Statement of Policy Concerning Automated Vehicles" of May 30, 2013.

Level	Name	Narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)	BASt level	NHTSA level
***Human driver* monitors the driving environment**								
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	Driver only	0
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes	Partially automated	2
***Automated driving system* ("system") monitors the driving environment**								
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes	Highly automated	3
4	High Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes	Fully automated	3/4
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**	-	

Figure 4: SAE-International Levels of Driving Automation (Traffic Quest, 2014)

For cooperative driving this implies that the levels range from no automation via communication (level 0) to full automation via communication (level 5). The SAE-levels of self-driving therefore make it possible to differentiate the efforts within the realm of cooperative driving and autonomous driving on the degree of constraint the elderly and chronically ill are experiencing in their ability to move from A to B independently. People who due to certain circumstances are not able and/or allowed to drive would for instance rely on a vehicle with full automation (SAE-level 5) in order to drive from A to B independently.

2.2 Contextual differences between California and the Netherlands

This paragraph describes some of the relevant contextual differences between California and the Netherlands and how the actors behind the two different trajectories towards self-driving vehicles have organized themselves.

2.2.1 Differences between automotive eco-systems

As indicated by Pel et al. (2014, p. 2) and Peters (2014, pp. 25-26) both California and the Netherlands face similar challenges associated with their dense infrastructures. Estimations undertaken by KiM (2013, p. 13) and TRIP (2012, p. 2) indicate that the costs associated with traffic delays, traffic accidents and environmental damage, represent respectively 21 billion dollar in the Netherlands and 44 billion dollar in

California. Given that the population of California doubles the population of the Netherlands, this might imply that both regions face similar challenges.

Within both regions there seems to be a consensus that self-driving vehicles could provide a powerful means to solve these transportation challenges (Timmer & Kool, 2014, p. 5). Whereas the cooperative driving approach aims to solve these problems via investing in communication technologies between vehicles (V2V) and/or road-side systems (V2I), the autonomous driving approach focusses solely on the vehicle itself. Research undertaken by Timmer & Kool (2014), Pel et al. (2014), RAND (2014), KPMG & CAR (2013), Beiker (2014), Peters (2014) and Walker (2014) indicates that these dynamics are mainly caused by differences in the respective automotive eco-systems of both regions. As presented in table 2, California and the Netherlands mainly differ in terms of 1) presence of Original Equipment Manufacturers (OEMs) and 2) the level of intelligence of the infrastructural system.

Table 2: Differences between automotive sector and infrastructural system

The Netherlands (cooperative driving)	California (autonomous driving)
Advanced infrastructure system	Less advanced infrastructure system.
Low prominence in OEMs	High prominence in OEMs
Small knowledge and innovation pool	Large knowledge and innovation pool
'Sober' capital	Venture capital

As indicated by AutomotiveNL (2010, p. 7) the Netherlands is less prominent in terms of Automotive Companies compared to countries like Germany, France, Japan and the United States. AutomotiveNL (2010, p. 7) therefore describes the Dutch automotive industry as a supplier-based industry in which 95% of the automotive companies supply to either national or international OEMs. Despite the presence of some noticeable automotive companies in the field of self-driving vehicles, such as NXP and TomTom, the Netherlands is not considered to become a hotspot for the development of self-driving vehicles (AutomotiveNL, 2010, p. 24; Schultz van Haegen, 2014, p.2). As can be derived from figure 6 California shows an entirely different image.

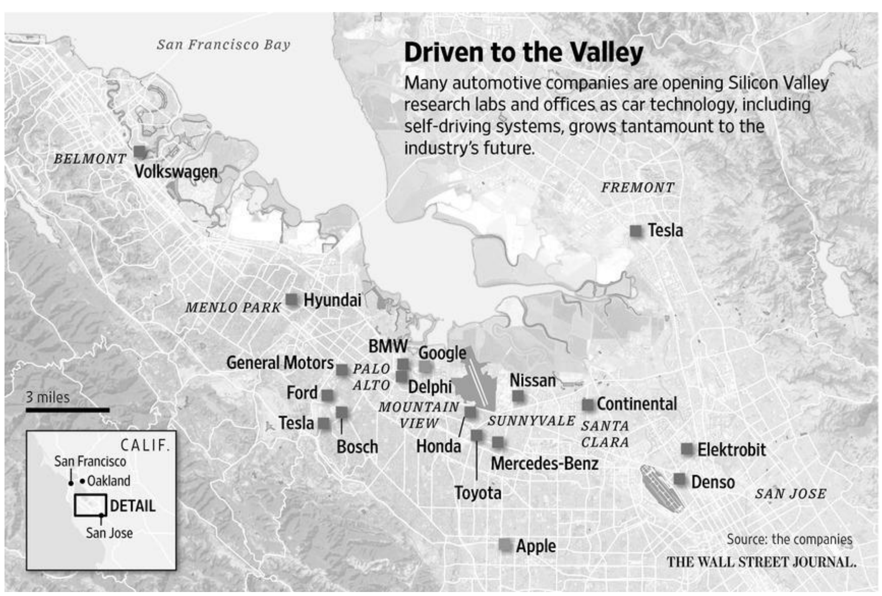

Figure 5: Presence of automotive companies in Silicon Valley (The Wall street Journal, 2015).

As indicated by Morgan Stanley (2013, p. 32) and Beiker (2014, p. 65) California is a hotspot for the development of self-driving vehicles. Manufacturers and suppliers from all over the world have allocated R&D laboratories in California. Morgan Stanley (2013, p. 32) and Beiker (2014, p. 65) argue that this is mainly caused by the presence of Silicon Valley. The high-tech companies, knowledge institutions and engineers provide an important pool of knowledge and innovations for the development of autonomous vehicles. Besides this pool of knowledge and innovations, there is also a lot of capital behind the developments in Silicon Valley. As indicated by Beiker (2014, p. 65) and Morgan Stanley (2013, p. 72) this is mainly due to the presence of some wealthy multinationals and venture capitalists.

Despite that the Netherlands claims to have an extensive automotive eco-system in terms of internationally ranked knowledge institutions, universities and testing-sites (AutomotiveNL, 2010, pp. 8-10; TrafficQuest, 2014, pp. 32-34), these numbers fall short compared to Silicon Valley (Beiker, 2014).

Compared to California, the Netherlands possesses a relatively advanced infrastructural system. Pel et al (2014, pp. 1-3), and the Ministry I&E (Nederland ITS, 2013, p. 7) accredit this difference to the continuous deployment of Intelligent Transportation Systems (ITS) by the road authorities on behalf of the government since 1970. Due to these investments the Netherlands is known to possess one of the most intelligent infrastructures in the world (Pel & Boons, 2010, p. 1251). California on the other hand has a relatively low-tech infrastructure. As indicated by Peters (2014, pp. 27-31) and the Californian Road-authorities represented by Caltrans (2010), ITS investments in California are lagging behind. According to Timmer & Kool (2014, p. 22) this is one of the reasons why the automotive industry has decided to focus on autonomous systems instead of cooperative systems.

2.2.2 Consensus versus competition

As indicated in paragraph 2.1 the difference between the cooperative driving approach of the Netherlands and the autonomous driving approach of California is that the autonomous driving approach is based on the belief that self-driving is possible without communicating with other vehicles and/or road-side systems. Given that there is no need to communicate with other vehicles (V2V) and or road-side systems (V2I) the self-driving vehicles can be developed more independently (Alessandrini et al. 2014, p. 171). Whereas the self-driving capabilities of autonomous vehicles can be optimized by the OEMs and their affiliated suppliers independently, the capability of cooperative driving vehicles depends on the degree to which the vehicle is capable to communicate to other vehicles and/or road-side systems. The cooperative driving capabilities of the vehicles therefore depends on collaborations between a multitude of public and private parties. As indicated Timmer & Kool (2014, p. 19) and Pel et al. (2014, p. 6) this implies that whereas the cooperative driving approach of the Netherlands is based on consensus among public and private parties, the autonomous approach of California is more based on competition between private parties.

As can be derived from figure 7, the differences between the two approaches also influence the way in which the main stakeholders are organized. In line with Timmer & Kool (2014) and Pel et al. (2014) these figures indicate that the cooperative driving approach is mainly driven by the government, whereas the autonomous approach is mainly driven by the industry. As indicated in paragraph 2.2.1 this is for a large part accredited to differences in terms of OEM presence and already made investments in ITS.

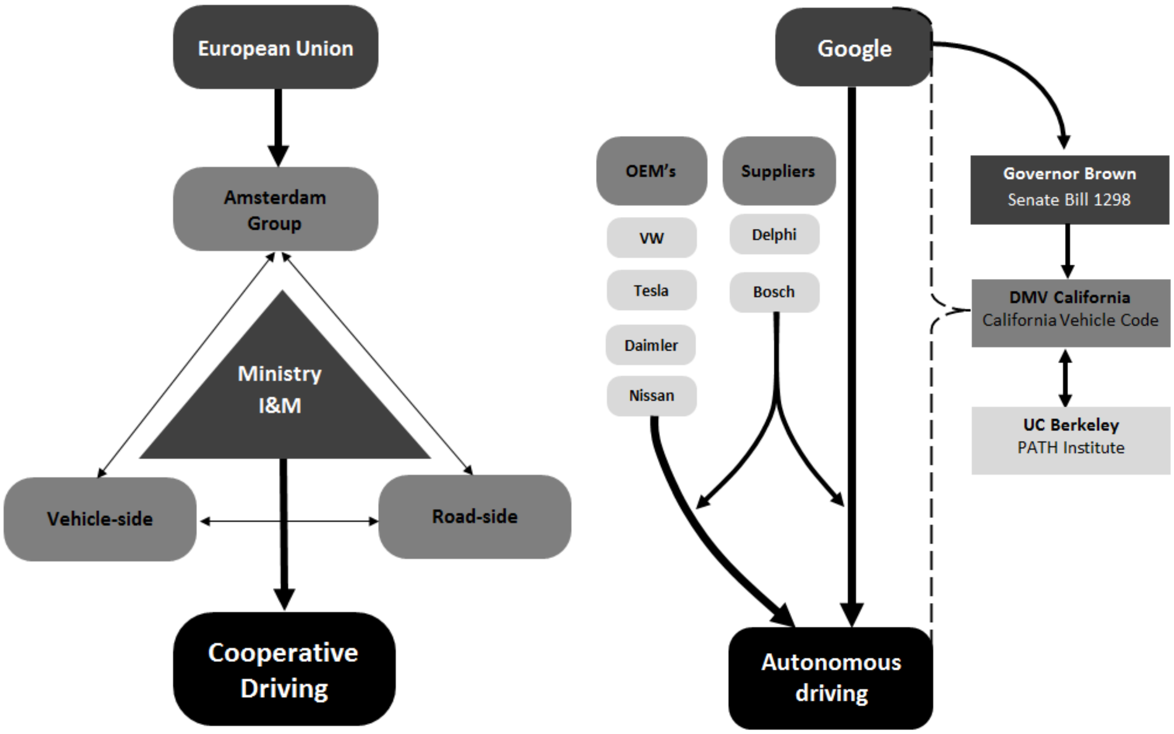

Figure 6: Consensus model of the Netherlands (left) and the competition model of California (right)

2.2.3 The consensus model of the Netherlands

The cooperative driving approach undertaken in the Netherlands is the result of a consensus between public and private parties in which the Ministry of Infrastructure and the Environment plays a central role (Timmer & Kool, 2014, p. 30). Whereas the vehicle-side is mainly driven by private parties, the road-side is mainly driven by the road authorities which in turn can be divided into three entities; Rijkswaterstaat, the provinces and the municipalities. These three entities are responsible for respectively the highways, the provincial roads and the local roads. To reduce the chicken-and-egg dilemma's between the vehicle and road-side of the self-driving vehicle equation a number of network organizations were founded (Pel, et al., 2014, p. 11). The most noticeable network organizations within the realm of cooperative driving are DITCM, Connekt, AutomotiveNL, Connecting Mobility, DAVI, and the Amsterdam Group. These network organizations play an important role in guiding technological development via creating a consensus among its members (Pel et al., 2014, p. 5).

As indicated by Timmer & Kool (2014, pp. 18-20) and Pel et al. (2014, p. 12) the developments in the Netherlands are for a large extend guided by legislations, visions and coordination platforms at a European level. In order to coordinate these efforts at a European level the 'Amsterdam Group' was founded. The Amsterdam Group (2013, p. 22) is a public-private partnership addressed to facilitate the joint-deployment of 'Cooperative Intelligent Transport Systems (C-ITS)' in Europe. The Amsterdam Group (2013, p. 22) consists of four umbrella organizations; 1) the European Association of Operators of Toll Road Infrastructures (ASECAP), 2) the European Organization for National Road Administrators (CEDR), 3) a Network that coordinates innovative transport solutions at a regional- and city level (POLIS), and 4) the Car 2 Car Communication Consortium (C2C-CC) which represents the European automotive industry.

The interests of the Dutch Automotive Industry when it comes to cooperative driving are mainly coordinated by DITCM, DAVI, and AutomotiveNL. Whereas AutomotiveNL (2010, p. 10) aims to coordinate the Dutch automotive industry as a whole, DITCM (2014, p. 2) specifically focusses on the successful introduction of cooperative systems in the Netherlands. Similar to DITCM, DAVI (n.d.) is a public-private platform where market parties and knowledge institutions work together to investigate and demonstrate cooperative driving solutions on public roads. DAVI (2013) was initiated by TU Delft, RDW, Connekt and TNO out of a need to take a more proactive role towards actually testing cooperative driving technologies. AutomotiveNL, DITCM and DAVI represent respectively 161, 30 and 19 member organizations.

Whereas DITCM and AutomotiveNL mainly represent the interests of the Automotive Industry, Connekt (2013) and Connecting Mobility (n.d.) represents the interest of the travel information providers and traffic managers. Connekt (2013) aims to facilitate its members via creating platforms on which its 125 members can exchange knowledge and collaborate. As stated in the roadmap 'Beter Geïnformeerd op Weg', Connekt (2013, p. 12) aims to coordinate the transition from road-side information provision towards in-car information provision. Connecting Mobility (n.d.) on the other hand monitors the ITS developments in the Netherlands and guides these efforts on behalf of the Ministry of Infrastructure and the Environment.

2.2.4 The competition model of California

Whereas the cooperative driving approach of the Netherlands seems to be driven by the government, the autonomous approach undertaken in California seems to be driven by the industry (Timmer & Kool, 2014, p. 77; Pel et al., 2014, pp. 9-12). The autonomous approach is therefore mainly driven by competition instead of consensus. Beiker (2014, p. 65) accredits this difference to the Silicon Valley mindset which is based on 'no guts, no glory'. This different approach also leads to a different role for the government. Whereas the Dutch government takes a pro-active role in coordinating the cooperative driving trajectory, the Californian government takes more of a facilitating role in the autonomous driving trajectory.

As explained by Soriano et al. (2014, p. 15) Governor Jerry Brown signed Senate Bill 1298 on September 25, 2012, authorizing the Department of Motor Vehicles (DMV) to develop regulations that enable the testing of autonomous vehicles on Californian public roads. As can be derived from the official website of the DMV (2014) as of October 31, 2014 the DMV has provided seven participants the required permits for testing autonomous vehicles on public roads. The companies, the number of permits and the types of vehicles are listed in table 3.

Table 3: Testing permits per automotive company

Automotive company	Type and number of vehicles
Google Inc.	Lexus RX450h (18), Toyota Prius (6), Audi TT (1)
Volkswagen Group of America	Audi A7 (2)
Mercedes-Benz	Mercedes S500 Intelligent Drive (2)
Tesla	Tesla Model S (1)
Nissan	Nissan Leaf (2)
Delphi Automotive	Audi SQ5 (2)
Bosch	BMW 325D (1), Tesla Model S (1)

Table 3 already provides some interesting dynamics between the different automotive companies. First, Google is significantly testing more on public roads than the OEMs. Second, Tier 1 suppliers such as Delphi Automotive and Bosch are testing their self-driving products on the vehicles of the OEMs. Finally, a lot of OEMs that are present in California are not testing on public roads.

Whereas the DMV plays an important role in determining the boundaries for autonomous driving, Google is one of the entities that aim to explore these boundaries (Poczter & Jankovic, 2014, p. 8). After the Grand Urban Challenges launched by the Defense Advanced Research Projects Agency (DARPA) Google was the first major private party to launch its own full autonomous vehicle program (Beiker, 2014, p. 65). The Google 'self-driving car project' is by many considered as the commercial frontrunner in terms of autonomous driving (Beiker, 2014, p. 65; Morgan Stanley, 2013, p. 82; KPMG & CAR, 2013, p. 8; RAND, 2014, p. 4; Pel et al., 2014, p. 9). Not only is Google the most active company in terms of testing on public roads, Google is also testing a lot at their headquarters in Mountain View (RAND, 2014, p. 4). Many research institutions even argue that it was actually a lobby of Google that resulted in the revised regulations in California that enabled the testing of self-driving vehicles on public roads (Timmer & Kool, 2014, p. 66; Poczter & Jankovic, 2014, p. 10; Soriano et al., 2014, p. 17). The main argument behind this claim is that Governor Brown signed Senate Bill 1298 at the Google headquarters in Mountain View after been driven around in one of their prototypes.

Many authors argue that the OEMs responded to Google by launching their own autonomous driving programs (Beiker, 2014, p. 67; Morgan Stanley, 2013, p. 82; KPMG & CAR, 2013, p. 8; RAND, 2014, p. 4; Pel et al., 2014, p. 9). Whether or not this is true, as can be derived from figure 6, almost all the OEMs have a presence in Silicon Valley. Whereas some of these OEMs are there for monitoring technological developments and scouting for new talent, others are intensively developing their own autonomous vehicles (Morgan Stanley, 2013, p. 83; Beiker, 2014, p. 67; Poczter & Jankovic, 2014, p. 9). As can be derived from table 3, the OEMs most active in terms of testing on public roads in California are Volkswagen, Mercedes-Benz, Nissan, Tesla and BMW.

As visualized in figure 6 there are also a lot of suppliers present in Silicon Valley. These suppliers can be divided by tiers (Beiker, 2014, p. 67). Whereas a Tier 1 supplies directly to the OEM, the Tier 2 supplies directly to the Tier 1, and so forth. As can be derived from table 3, Delphi Automotive and Bosch are the two most active Tier 1 suppliers in terms of testing autonomous vehicles on public roads. These two suppliers therefore provide a valuable source of information in order to understand the role of Tier 1 suppliers when it comes to autonomous driving.

Next to the DMV and automotive companies, Beiker (2014, p. 67) argues that universities play an important role in terms of research, advice and the supply of skilled labor. The most noticeable knowledge institutions are the Institute of Transportation Studies (ITS) of UC Berkeley and the Centre of Automotive Research (CARS) program of Stanford (Beiker, 2014, p. 68). For the purpose of this research it is important to mention that UC Berkeley is a public institution compared to Stanford which is a private institution (Beiker, 2014, p. 68). Whereas UC Berkeley focusses primarily on research on behalf of governmental agencies, Stanford focusses primarily on research for industrial purposes (Beiker, 2014, p. 68). As indicated in figure 7 the DMV gains most of its knowledge and expertise via collaborations with the PATH program of UC Berkeley.

2.3 The elderly and chronically ill

This paragraph describes why this paper focuses specifically on the elderly and the chronically ill as a potential user group for self-driving vehicles.

2.3.1 Defining the niche-market

As indicated in the introduction the real game-changing aspect underlying self-driving vehicles is that these vehicles could enable vulnerable user groups, who are somehow constrained in their ability to drive, to drive from A to B independently! Given the increasing population of elderly, and with it the chronically ill (Nationaal Kompas 1, n.d.; Nationaal Kompas 2, n.d.), their rising incomes (PBL Notitie, 2013) and their desire to stay mobile as long as possible (KiM, 2013, pp. 63-69); this user group might provide an interesting niche-market for self-driving vehicles. Whereas the elderly refers to all people aged over 65 years (Nationaal Kompas 1, n.d.), the chronically ill refers to those people who suffer from prolonged illness with no prospect of full recovery (Nationaal Kompas 4, n.d.).

This research focuses specifically on the people who are seriously constrained in their ability to drive, making their participation in traffic too dangerous for themselves and others. Next to blind, deaf and disabled people this often also includes elderly (SWOV, 2012, p. 5). Given that 80% of the chronically ill are older than 65 (Nationaal Kompas 3, n.d.), it was chosen not to distinguish between the elderly and chronically ill too often. The only time this research differentiates between the elderly and the chronically ill, is when technological developments are reflected on the respective user groups. After all, the elderly might face different constraints in their ability to move from A to B than the chronically ill.

Even though this study is particularly aimed at understanding how the actor expectations underlying both technological trajectories might eventually lead towards a solution for the elderly and chronically ill, does not mean that one needs to consider whether this is something the elderly and chronically ill want. However, before elaborating on the elderly and chronically ill, it is important to mention that there is only very little information available about how the elderly and chronically ill look at self-driving vehicles. Most of the literature that is out there is written from a manufacturers point of view, implying that the studies answer why the elderly and chronically ill are a potential niche-market for self-driving vehicles rather than actually taken in account what this user group actually wants. Except from some marketing studies (KPMG and CAR, 2012) and demonstration videos of Google (Google Car, 2012; Google Car02, 2014) the opinions of the elderly and chronically ill are hardly taken in account. As indicated in the introduction this is partly because of the technological and societal hurdles that need to be overcome before those who are seriously constraint in their ability to drive to operate these vehicles. Except from Google (n.d.), the elderly and chronically ill therefore seem not to be considered as an interesting niche market for the first implementation of self-driving vehicles.

To investigate to what extend the elderly and chronically ill provide an interesting niche-market for self-driving vehicles it is therefore important to look at the demographics of this population in the Netherlands and California and how this population is currently served by transportation. After consulting a multitude of sources the main arguments in favor and against self-driving for the elderly and chronically ill were identified. These arguments are listed in table 4.

Table 4: Arguments in favor and against self-driving for the elderly and chronically ill

Arguments in favor	Arguments against
- Continue to increase in numbers	- Alternative modes of transportation
- Want to stay mobile	- Increase in Vehicle Miles Travelled (VMT)
- More familiar with information technologies than their predecessors	- Less capable to exploit the benefits of information technologies
- Not well served by transportation (T=0)	- More expensive
- Strong financial position	
- Constrained in their freedom to move	
- Fear of isolation	

2.3.2 Arguments in favor

First, both California and the Netherlands are experiencing a continuous increase in the population of elderly and the chronically ill. As indicated by the Dutch Ministry of Health, Welfare and Sport on January 1, 2012 there are 2.7 million people over 65 living in the Netherlands, who represent 16% of the total population of the Netherlands (Nationaal Kompas 1, n.d.). Estimates of the United States Census Bureau (USCB, n.d.), indicate that there are currently 4.8 million elderly living in California, which equals 12% of the total population of California. Due to declining mortality rates and declining birth rates the group of elderly is expected to continue to increase in relative numbers. Statistical predictions in both the Netherlands (Nationaal Kompas 2, n.d.) and California (CDA, 2012) indicate that in 2040 the population of elderly is estimated to represent around 20% of the total population. With almost 1/3 of the population, the number of chronically ill has an even greater impact on the total populations of both California and the Netherlands. Whereas the population of chronically ill was estimated to represent almost 5.3 million (2011) people in the Netherlands (Nationaal Kompas 3, n.d.), the number of chronically ill in California (CHCF, 2015, p. 3) is estimated around 11 million (2014). Given that there is a strong correlation between chronic diseases and age it is difficult to determine how big the actual population of elderly and chronically ill is. Even though it is hard to determine how many of the elderly and chronically ill actually experience impediments in their ability to drive from A to B, one can assume that this number is already quite large and will likely continue to increase.

Second, indicators in both California and the Netherlands show that the elderly, and with it the chronically ill, are more vital, active and mobile than their predecessors (KiM, 2013, p. 64; TRIP, 2012, p. 3). That the elderly want to stay mobile becomes clear from increases in driving license, car ownership and kilometers travelled (KiM, 2013, p. 64). In 2012 more than 16 percent of the elderly in California (TRIP, 2012, p. 2) and 48% of the elderly in the Netherlands (PBL Notitie, 2013, p. 3) possessed a driving license. Estimations show that in the upcoming 15 years this number will increase to 20% in California (TRIP, 2012, p. 2) and 60% in the Netherlands (PBL-notitie, 2013, p. 7). The elderly, and with it the chronically ill, will therefore have an increasing effect on the mobility system. Despite that the travel distance decreases as people get older, due to more frequent trips and an increasing population, the vehicle miles travelled (VMT) might continue to increase. As indicated by Kennisinsituut voor de Mobiliteit (KiM, 2013, p. 65) and the Transportation Research Group (TRIP, 2012, p. 3) this trend is visible in both the Netherlands and California.

Third, the desire of the elderly and the chronically ill to stay mobile is in line with the impact that losing their ability to move from A to B independently can have on their lives. As indicated by research undertaken by SWOV (2012, p. 4), Rijkswaterstaat (2014, p. 4) and TRIP (2012, p. 3) losing the ability to drive can cause serious isolation. As indicated by KPMG & CAR (2013, p. 22) this leads to significant changes in the lifestyle of the elderly and chronically ill. No longer do the elderly and chronically ill have the freedom to make trips, go shopping and visit their friends and family whenever and wherever they want to (KPMG & CAR, 2013, p. 22). From this point onwards the elderly and chronically ill rely on others to fulfill these needs. In other words, either they arrange someone else to move them from A to B or they remain at A. As indicated by research undertaken by TRIP (2012, p. 3) these people are less satisfied with their lives than people who do not experience these mobility impediments.

Fourth, research undertaken in both the Netherlands and California indicates that the elderly become more and more constrained in their ability to drive over the years (SWOV, 2012; TRIP, 2012). Both SWOV (2010, p. 1) and TRIP (2012, pp. 4-9) attribute these impediments to the greater physical vulnerability these people have due to mental impairments. The most common mental impairments are listed in table 5.

Table 5: Mental impairments that constrain the elderly and with it the chronically ill in their capabilities to drive.

Mental impairments caused by aging
- Deterioration of visual capabilities
- Reduced capability to separate relevant information from irrelevant information
- Increasing difficulty in dividing attention between different tasks
- Delays between perception and reaction-time
- Reduced flexibility in neck and torso
- Reduced muscle power
- Delay in motion
- Decreasing fine motor skills
- Decreasing capability to adapt to sudden changes in posture

Both SWOV (2010, p. 3) and TRIP (2012, pp. 6-7) indicate that due to these mental impairments the elderly, and with it chronically ill, are often involved in driving accidents. In 2010, with a total of 390 crashes, around 21% of the fatal driving accidents in California involved at least one driver over 65 years old (2012, pp. 6-7). SWOV (2010, p. 3) even estimated that the chance of an accident per travelled kilometer by car is eight times higher for people above 65 in the Netherlands. Most of these driving accidents involve complex traffic situation in which the elderly have to divide attention between different tasks under a time pressure (SWOV, 2012, p. 2). As presented in table 6, Davidse & Hoekstra (2010, p. 30) identified the most complex driving tasks for the elderly.

Table 6: Most difficult driving tasks for the elderly and chronically ill

Most complex driving tasks
- Turning left at intersection (especially with no traffic lights)
- Finding the right traffic lane for turning left
- Crossing an intersection (especially with no traffic lights)
- Driving roundabouts with multiple traffic lanes
- Join traffic at highways
- Reading traffic signs
- Censoring road signs in order to keep track of the road.
- Responding to traffic lights.

As indicated by SWOV (2010, p. 3) and TRIP (2012, p. 9) vehicles with self-driving capabilities could provide the elderly more time to perceive, decide and act upon complex traffic situations and via that way enhance their driving capabilities. As indicated by SWOV (2012, pp. 3-4) and CROW (2011, pp. 34-40) this can be achieved via infrastructural adjustments (e.g. phased crossing, better lighting, clearer markers etc.) and/or adjustments at the vehicle-side (e.g. advanced driver assistance systems, automated gearbox, etc.). As indicated by SWOV (2012, pp. 3-4) it is important that these adjustments connect with the experience and existing automatisms of the elderly.

Whereas self-driving vehicles could enhance the ability to drive for people who are a little bit constrained in their ability to drive, there are also people (e.g. blind, disabled) for which enhancing their driving capabilities is not enough. These people can only be served by fully automated vehicles (SAE-level 4-5). The strategy chosen by the different stakeholders therefore influences the size and type of elderly and chronically ill that could benefit from the self-driving solution.

Fifth, as indicated by the Planbureau voor de Leefomgeving (PBL-notitie, 2013, p. 3) and TRIP (2012, p. 3) the upcoming generation of elderly, and with it the chronically ill, is higher educated, have a higher income and a better financial position than their predecessors. Given that a vehicle with self-driving capabilities is more expensive than a vehicle without self-driving capabilities these people might have the financial position to afford these capabilities. Given their desire to stay mobile as long as possible (SWOV, 2012, p. 4; Rijkswaterstaat, 2014, p. 4; TRIP, 2012, p. 3), the elderly and chronically ill might also be willing to invest in these capabilities. Given that the elderly and with it chronically ill are more familiar with computer systems than their predecessors (2014, p. 6) they are also more capable to absorb the benefits of self-driving vehicles than their predecessors. As indicated by KPMG & CAR (2013, p. 22) and RAND (2014, p. 37) these are all arguments that might lower some of the thresholds for the elderly and chronically ill to start using self-driving vehicles at one point in time.

2.3.3 Arguments against

Besides arguments in favor of a self-driving solution for the elderly and chronically ill, there are also arguments that question the potential of self-driving vehicles for the elderly and chronically ill. First of all, as indicated by SWOV (2012, pp. 3-4) and TRIP (2012, p. 5) there are other means to serve the elderly and chronically ill. As indicated by research undertaken by CROW (2011, pp. 34-40) it is possible to improve the driving capabilities of the elderly and chronically ill via minor adjustments at the infrastructural-side (e.g. phased crossing, better lighting, clearer markers) and vehicle-side (e.g. automated gearbox, obvious car interface). These adjustments do not necessarily require advanced levels of vehicle and/or infrastructural intelligence. As indicated by research undertaken by SWOV (2012, pp. 3-4) and TRIP (2012, p. 5), the driving capabilities can also be enhanced without making use of technology. As explained by Davidse & Hoekstra (2010, p. 12) education plays an important role in enabling the elderly and chronically ill to stay mobile as long as possible. Not only does education provide a valuable means to make the elderly and chronically ill more aware of the mental impairments that come with aging and/or chronic constraints, it also provides a valuable means to let them know what kind of appliances are available to them.

Second, if the elderly and chronically ill are too constrained in their ability to move from A to B independently, does not necessarily mean that they need to rely on vehicles with self-driving capabilities.

As indicated by SWOV (2012, pp. 4-5) and TRIP (2012, p. 5) these groups can also be served by public transit services (e.g. trains, busses, people movers). However as indicated by SWOV (2012, pp. 4-5) and TRIP (2012, p. 5) these modes of transportation are often considered to be too expensive and inflexible. The reason for this is mostly twofold. The mental impairments that constrain the elderly and chronically ill from driving might also limit them from using public transit services (TRIP, 2012, p. 5). Also, public transit services often do not cover the last mile, implying that the elderly and chronically ill still have to switch between different modes of transportation, increasing the complexity of travelling (PBL-notitie, 2013, p. 5). Given that a private vehicle provides an A to B solution whenever and wherever a driver wants to, it might not be surprising that both in the Netherlands (KiM, 2013, p. 66; PBL-notitie, 2013, p. 5) and in California (TRIP, 2012, p. 5) the majority of trips by the elderly and chronically ill takes place in private vehicles. Ride and/or car-sharing initiatives might therefore also provide an interesting option for the elderly and chronically ill as these services enable the passengers to go whenever and wherever they want to go without worrying about all the difficulties that come with driving and or car-ownership (e.g. maintenance). However, this might imply that these organizations might need to be convinced to add vehicles to their fleet that better meet the needs of the elderly and chronically ill.

Third, despite that vehicles with self-driving capabilities might provide a valuable solution for the elderly and chronically ill, there are also claims against this proposition. First of all, as indicated by research undertaken by ENO (2013, p. 10) and KPMG & CAR (2013, p. 12) a vehicle with self-driving capabilities is more expensive than a vehicle without these capabilities. Despite economies of scale, technological advances and mandatory requirements, this is expected to remain for the upcoming years (ENO, 2013, p. 10). Second, some papers argue that despite that the elderly are more familiar with computers than their predecessors they are less capable to exploit the actual benefits of information technologies than generations that grew up with these technologies (Digivaardig & Digibewust, 2010, p. 16). Finally there are also papers that argue that self-driving would lead to an increase in 'Vehicle Miles Travelled' (VMT). As indicated by research undertaken by RAND (2014, p. 37), and CPB & ICF (2014, pp. 7-16) the actual impact of the self-driving vehicles depends on how many people switch to this mode of transportation and to what extend the self-driving business model is based on car-ownership, ride-sharing, and/or car-sharing. Looking at the elderly and chronically ill one could argue that this will lead to an increase in VMT both in absolute (people who now have the ability to move from A to B independently) and relative numbers (amount of people who switch from public transit services).

2.3.4 Levels of impediments

All in all it becomes clear that the arguments in favor of self-driving for the elderly and with it the chronically ill outweigh the arguments against this proposition. However, as indicated in table 6 it is important to realize that the extent to which the elderly and the chronically ill rely on vehicles with self-driving capabilities depends on the extend in which these people are constrained in their ability to move from A to B independently. The level of constrained therefore determines the required level of self-driving capabilities the vehicle has to possess in order to meet the mobility needs of the elderly and chronically ill.

Looking at the SAE-levels, as represented in figure 5, these capabilities range from no automation (level 0) to full automation (level 5), in which the vehicle takes over more and more tasks of the driver. For the purpose of this research it is important to realize that at level 0 (no automation) level 1 (driver assistance) and level 2 (partial automation) the human driver monitors the environment and has to be able to take over when required. At these levels the elderly and chronically ill are assisted with steering or accelerating/decelerating (level 1) or both (level 2). These Advanced Driver Assistance Systems (ADAS) provide the elderly and the chronically ill more time to perceive, decide and act upon traffic situation, enhancing their driving capabilities (SWOV, 2010, p. 1). Some of these features such as park assist, traffic-jam assist, adaptive cruise control, lane keeping support, blind spot detection and emergency braking are already on the market. As indicated by KPMG & CAR (2013, p. 11) and RAND (2014, p. 16) these driver assistance systems will continue to improve and via that way enhance the self-driving capabilities of vehicles. The popularity of vehicles with an automated gearbox and power steering among elderly is already a strong indicator of the potential that driver assistance systems can have in enhancing the driving abilities of the elderly and with it the chronically ill (SWOV, 2012, p. 4).

Whereas between level 0 and level 2 the driver remains in control of the vehicle, at level 3 (conditional automation), level 4 (high automation) and level 5 (full automation) the ‘automated driving system’ monitors the environment. Whereas at level 3 the human driver still acts as a back-up, at level 4 and level 5 the ‘automated driving system’ acts as a back-up. At this stage the human driver does no longer have to act as a back-up, enabling people who due to certain circumstances are not capable and/or allowed to drive, to drive from A to B independently. The transition from a vehicle with low automation to a vehicle with full automation is visualized in figure 8. Whereas at low levels of automation the advanced driver systems operate independently, at higher levels of automation these systems are controlled by a central controller (Morgan Stanley, 2013, p. 70).

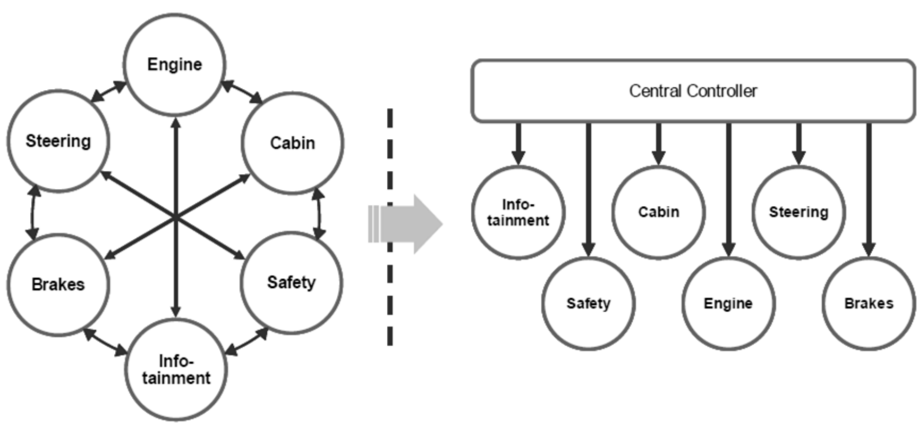

Figure 7: Current system architecture versus self-driving system architecture (Morgan Stanley, 2011)

As vehicle automation is not necessarily based on the level of impediments of people, the different decisions made by the stakeholders in terms of vehicle automation will therefore influence how the elderly and chronically ill will be served by self-driving vehicles.

As explained in paragraph 2.1 and 2.2 this study focuses on the dynamics between and within the cooperative driving approach of the Netherlands and the autonomous driving approach of California.
For the purpose of this research it is therefore important to understand that both approaches serve the elderly and chronically ill in a different way. As indicated in paragraph 2.1 both approaches aim for full automation at one point in time. However, whereas autonomous driving is based on the belief that this can be achieved via advanced censoring technologies and smart algorithms, the cooperative driving approach aims to achieve this goal via communicating with other vehicles (V2V) and/or road-side systems (V2I) .

These cooperative systems provide real-time information on which the human driver and/or advanced driver system can make decisions. Research by Traffic Quest (2014, p. 56) indicates that whereas autonomous systems have more benefits in terms of taking over the driving tasks of human drivers, cooperative systems have more advantages in terms of providing information. As indicated in table 7 the main advantages of cooperative systems is that these can provide more accurate information than autonomous systems.

Table 7: Advantages cooperative systems compared to the advantages of autonomous systems

Cooperative systems versus autonomous systems
Cooperative systems provide more information about the state of the road network
- The availability of more information from a large area of roadways (e.g. floating car data)
- The availability of information about the traffic situation beyond the horizon of the driver
- The availability of information beyond traffic (e.g. weather conditions)
Cooperative systems enable a better match between the generated data and the needs of the driver.
- The 24/7 availability of information and advice, which can be made-to-measure certain users and/or user-groups in certain situations.
Cooperative systems have a greater impact on the entire traffic- and transport systems
- Cooperative systems can reach to higher public benefits in terms of reducing congestion, improving safety, reducing emissions.
- Via V2I communication it is possible for the traffic managers to provide in-car traffic information.

This real-time information provides the elderly and chronically ill more time to perceive, decide and act upon complex traffic situations and via that way enhance their driving capabilities (SWOV, 2010, p. 3; TRIP, 2012, p. 9). Though the elderly and chronically ill could also attain this information via in-car systems which make use of floating-car-data (e.g. navigation systems, smartphones) it is important to mention that this information is 'less accurate' than the information which is directly received via V2V and/or V2I communications (TrafficQuest, 2014, p. 56; Connekt, 2013, p. 17). The Amsterdam Group (2013) which coordinates the cooperative driving efforts at a European level provides a number of so-called 'day one applications' which are expected to be implemented on a short term base.

Table 8: Day one applications identified by Amsterdam Group (2013)

Vehicle to vehicle (V2V) communications	**Vehicle to infrastructure (V2I) communications**
- Hazardous location warning	- Road works warning
- Slow vehicle warning	- In-vehicle signage
- Traffic jam ahead warning	- Signal phase and time
- Stationary vehicle warning	- Probe vehicle data
- Emergency brake light	
- Emergency vehicle warning	
- Motorcycle approaching indication	

As can be derived from table 8 these communications create better informed drivers, enhancing the human driver and/or system to make better driving decisions. Thus whereas both cooperative driving and autonomous driving follow a similar pattern in terms of automation, there is a difference in the data generation and processing procedures, which in turn affect how the self-driving vehicle interacts with the elderly and chronically ill.

2.4 Conclusion

As explained in paragraph 1.5, in order to conduct a reliable comparison the study has to control for the contextual differences between both units of analysis. In an ideal comparison California and the Netherlands would only differ in their respective approaches towards self-driving, implying that the contextual factors surrounding both approaches are equal. However, as can be derived from paragraph 2.2 and 2.3 this is not entirely the case. Even though it is possible to isolate the cooperative driving approach of the Netherlands and the autonomous driving approach of California, there are some contextual differences between California and the Netherlands which influence these approaches in different ways. For the purpose of this research it is therefore important to specify some of these differences upfront. First of all, as indicated in paragraph 2.2 the Netherlands and California differ in terms of 1) OEM prominence, 2) the intelligence of the infrastructure, 3) the size of the knowledge and innovation pool, 4) and the amount and type of capital available. As indicated in paragraph 2.2 the Californian and Dutch actors influence this context just as well as the context influences the actors.

Second, it is important to mention that given the different approaches towards self-driving and the earlier mentioned contextual differences, there are different actors underlying both technological trajectories. As indicated in paragraph 2.2 these actors do not only hold different perceptions towards self-driving, these actors are also organized in different ways. This implies that in order to compare how the Californian and Dutch actors shape technological development, one has to take in account the complex interplay among the different entities. This research therefore assumes that the way in which the actors underlying both technological trajectories shape technological development is affected by the context in which these actors operate as well as the way in which these actors have organized themselves.

Despite that there are some contextual differences that might influence the two technological trajectories, both California are the Netherlands provide some interesting similarities in relation to the research question. First, as indicated in paragraph 2.1 both the Netherlands and California face similar mobility problems in terms of congestion, environmental damages, safety and land-use. Second, even though California is larger than the Netherlands in terms of land-surface and population, the populations of elderly and chronically ill are relatively similar. Despite some minor differences in the way the population of the elderly and chronically ill are served in terms of transportation, both regions face similar challenges when it comes to proving mobility for this user group (paragraph 2.2).

Given that both regions face similar challenges when it comes to self-driving for the elderly and chronically ill, comparing both approaches might unveil some interesting dynamics underlying the two approaches. Despite that the two approaches do not interact directly (two different geographical regions) this does not mean that both approaches cannot learn from each other. To make this possible, this research deals carefully with how the different actors interact with each other, and how these interaction processes are affected by the context in which these actors operate.

3.

THEORY & METHOD

3. Theory and methodology

As indicated in paragraph 1.4, except from the work of Pel et al. (2014) and Timmer & Kool (2014) the self-driving approaches undertaken in the Netherlands and California have hardly been explored within scientific literature. Pel et al. (2014) argue that this is for a large extent due to the tendency of transition scholars to focus specifically on sustainability challenges and/or the Netherlands as unit of analysis. Even when scientific literature elaborates on self-driving vehicles, most of these transition studies are geared towards sustainability (Pel, Van Est, & Raven, 2014; Geels, Kemp, Dudley, & Lyons, 2012, pp. 205-249) and/or the implications these developments can have for the Netherlands (Pel, Teisman, & Boons, 2012; Pel, Est, & Raven, 2014). Even though empirical research sometimes refers to the self-driving efforts undertaken in California (Pel et al., 2014; Timmer & Kool, 2014), the dynamics underlying these efforts are relatively unexplored. Instead, the little research that is out there solely focuses on understanding how the efforts undertaken in California might affect the Dutch efforts towards self-driving (Pel et al., 2014; Timmer & Kool, 2014). The interaction between self-driving vehicles and the elderly and chronically ill is therefore relatively unexplored in scientific literature.

This study contributes to this empirical gap via exploring the complex interrelationship between technology (self-driving vehicles) and society (the elderly and chronically ill). Given that there is a lot of noise surrounding the discussions on self-driving vehicles (Alessandrini et al., 2014; Amsterdam Group, 2013; Beiker, 2014; KPMG & CAR, 2012; RAND, 2014; ENO, 2013; Timmer & Kool, 2014), this research elaborated on insights from Strategic Niche Management (SNM) and the sociology of expectations. Whereas insights from the sociology of expectations were used to understand how the different actor shape technological development, the SNM perspective was used to understand how these expectations were translated into the technological trajectory.

3.1 Strategic Niche Management

The SNM perspective was first introduced by Geels (2002) in his paper 'Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study'. Geels (2002, p. 1257) developed this framework to understand how radical innovations (e.g. self-driving vehicles) make it into society. Geels (2002, p. 1257) emphasizes that radical innovations emergence in niches (e.g. self-driving vehicle experiments) which need to be shielded from the selection mechanisms of the dominant regime (e.g. person-driven vehicles). In order to understand these processes, Geels (2002, p. 1258) takes technology as a constant, arguing that that technologies only fulfill societal functions in association with human agency (Schot & Geels, 2008, p. 540). This implies that in order to understand the role of agency in technological development one should investigate the different perceptions that actors in a population (e.g. California and the Netherlands) hold towards technological developments (Geels, 2010, p.497). In order to understand how the different actor expectations are translated into the respective technological trajectories, the concepts autonomous driving and cooperative driving were carefully positioned in the theoretical lens of SNM.

First, the autonomous driving approach of California and the cooperative driving approach of the Netherlands were considered as two separate socio-technical configurations. As can be derived from figure 9 these socio-technical configurations consist of different entities which hold different perceptions towards society (Geels, 2002, p. 1258). As can be derived from paragraph 2.1 and 2.2 the cooperative driving approach and the autonomous driving approach are based on different beliefs implying that there are not only differences in type of entities that make up the two socio-technical configurations, but also how these entities interact with each other. For instance, whereas within the cooperative driving approach the traffic managers play a significant role, within the autonomous driving approach traffic managers hardly play a role at all. As indicated by Hughes (1987, p. 53) the degree in which the heterogeneous sets of elements are linked together determine the strength of the socio-technical configuration. The degree in which the expectations of the different actors behind the different elements align therefore determines the strength and stability of the socio-technical configuration.

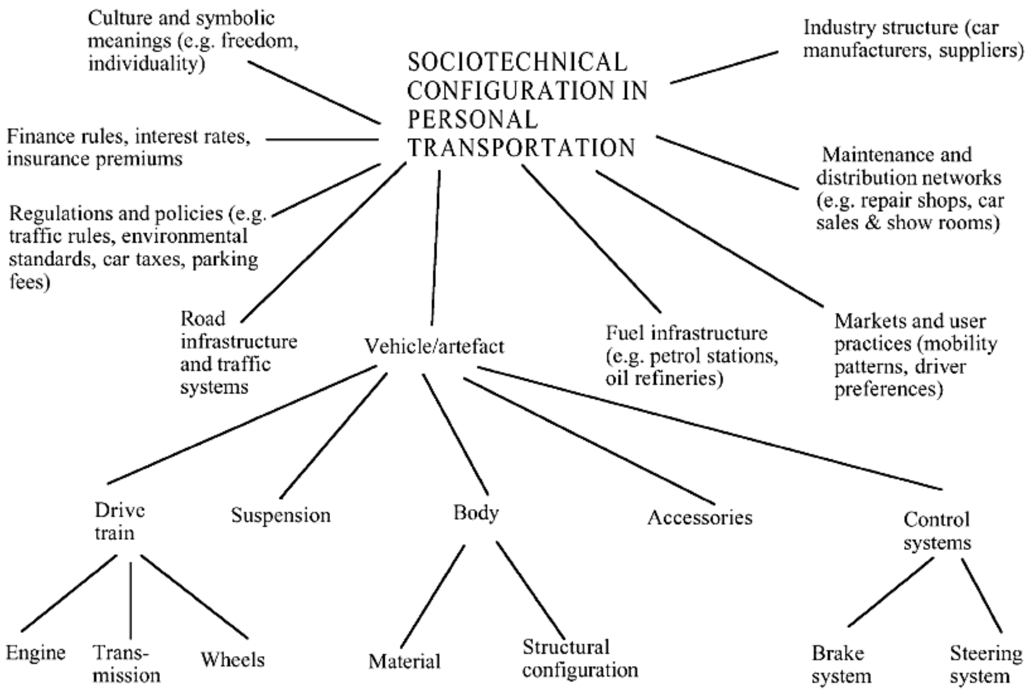

Figure 8: Socio-technical configuration in transportation (Geels, 2002)

Second, in order to understand the interaction between self-driving vehicles (emerging technology) and person-driven vehicles (dominant technology) the Dynamic Multi-Level Perspective (MLP) on technological trajectories of Geels (2002, p. 1262) was used. The core principle underlying the multi-level perspective is that novelties (e.g. self-driving vehicles) emerge in niches which are geared towards the problems of existing regimes (Rip & Kemp, 1998, p. 368). To explain how these novelties emerge Geels (2002, p. 1262) elaborates on the work of Nelson and Winter (1982) and Rip and Kemp (1998) who defined three concepts to explain how technological transitions occur; 1) socio-technical regime, 2) socio-technical landscape, and 3) niches.

As indicated by Geels (2002, p. 1259) the 'socio-technological regime', is defined as the dominant scale of prevailing practices, rules and interests. These socio-technical regimes arise via alignment and co-ordination processes between entities that share similar rules and routines (Grin et al., 2010, p. 39). These shared rules and routines provide stability as all entities are searching in a similar direction. Rip and Kemp (1998, pp. 340-341) therefore argue that socio-technical regimes only generate incremental innovations.

For the purpose of this research the socio-technical configuration (figure 9) surrounding person-driven vehicles was considered as the dominant socio-technical regime.

The 'socio-technical landscape' in turn refers to deep structural trends in wider economy and society (Geels, 2002, p. 1260). These landscape factors form the external context for the actors, making them even harder to change than a socio-technical regime (Geels, 2002, p. 1260). For this research the most relevant macro trends include the aging population and digitalization.

Finally, the concept of niches refers to protective spaces which nurture and incubate radical innovations (Geels, 2002, p.1260). These radical innovations emerge in protective spaces containing different selection criteria than those of the dominant socio-technical regime (Geels, 2002, p.1261). The main principle behind the concept of niches is that radically 'new' technologies need a protective space to gain the strength required to compete with the dominant 'old' socio-technical regime (Geels & Raven, 2006, p. 277; Schot & Geels, 2008, p. 540). For the purpose of this research self-driving vehicles are considered as niche technologies which need to be protected from the selection criteria of the actors underlying the dominant regime of person-driven vehicles.

To understand how self-driving vehicles can emerge in the context of existing socio-technical regimes and socio-technical landscapes, Geels (2002, p.1261) considers the three concepts as a nested hierarchy in which regimes are embedded in landscapes and niches embedded within socio-technical regimes. The core principle underlying this nested hierarchy is that changes take place through processes of co-evolution and mutual adaption between and within multiple levels (Geels, 2002, p.1262). As can be derived from figure 10 these processes can enable radical innovations to break out of the niche.

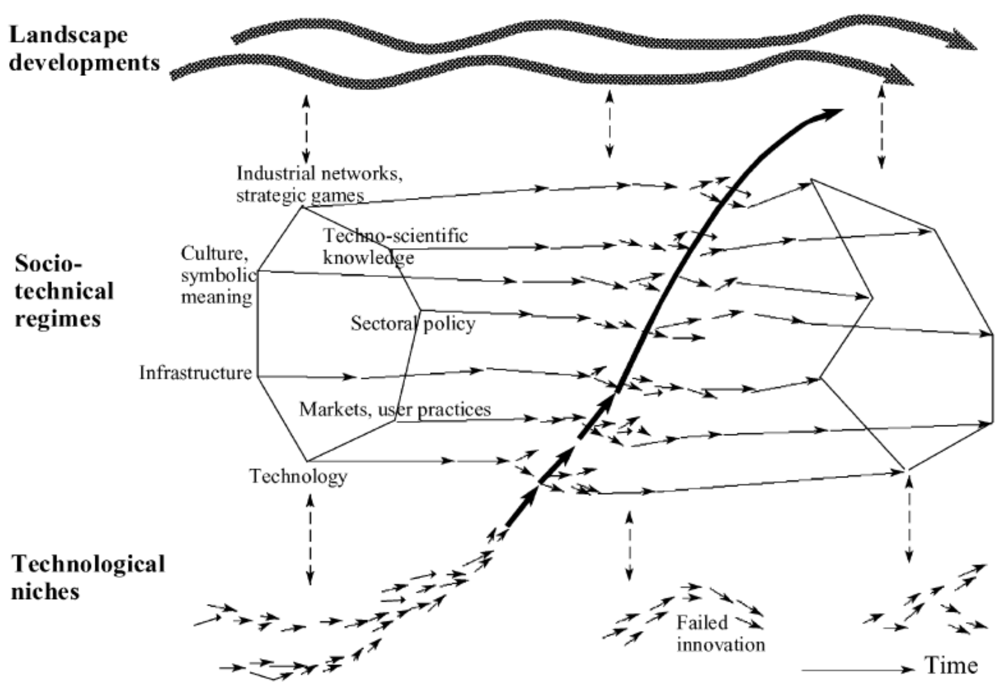

Figure 9: A dynamic multi-level perspective on Technological Transitions (Geels, 2012)

Geels (2002, p. 1262) argues that this only occurs if three conditions are fulfilled. First, there needs to be sufficient pressure from the landscape (e.g. aging population) on the socio-technical regime (e.g. person-driven vehicles). Second, due to this pressure the socio-technical regime has to become instable and open for change, creating a 'window of opportunity' for niches (e.g. self-driving vehicles) to break through. Finally, these niche technologies have to be sufficiently developed and available to break through into the dominant technical system.

Third, the cooperative driving approach of the Netherlands and the autonomous driving approach of California were considered as two different technological trajectories active within the same niche (self-driving vehicles), both aimed to replace the current dominant regime (person-driven vehicles) with a regime of self-driving vehicles. This emphasis is primarily based on the work of Geels & Raven (2006) who argued that technological trajectories are carried by local actors. In order to understand these dynamics Geels & Raven (2006, pp. 377-379) distinguish between two levels; 1) local projects, and the 2) global niche level. The main premise underlying this distinction is that global niches (technological trajectories) are carried by local experiments (Geels & Raven, 2006, p. 377).

Geels & Raven (2006, p. 379) indicated that the development of niches can be explained by looking at the perceptions and expectation that local actors hold towards a particular technology. If these perceptions and expectations are shared this leads to alignment processes between the different actors at the local level. As indicate in figure 11 these alignments lead towards so-called technological trajectories (Geels & Raven, 2006, p. 379). These technological trajectories provide stability via providing for instance, technological standards, codification, model building, formulation of best practices, and attracting political support (Geels & Raven, 2006, p. 378). This leads to an interesting dynamic in which technological trajectories are carried by local projects, and where technological trajectories in turn create the space for local actors to work in. As indicated by Geels & Raven (2006, p. 378) this implies that whereas a technological trajectory does provide the guiding frames for local actors, these frames also leave enough room for actors to shape their own interpretations and adjustments.

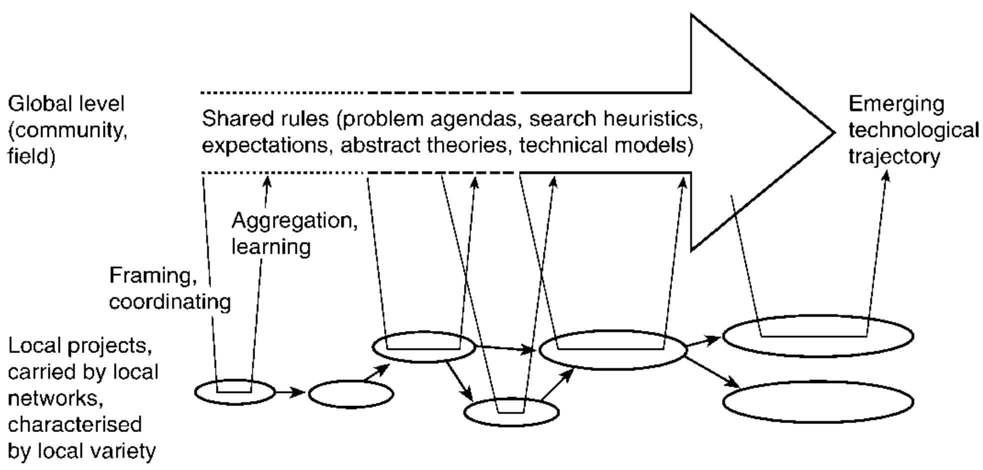

Figure 10: Technical trajectory carried by local projects (Geels & Raven, 2006)

For the purpose of this research it is important to mention that whereas the framework of Geels & Raven (2006) only exemplifies one technological trajectory, this study entails two technological trajectories (autonomous driving and cooperative driving). Both technological trajectories are carried by local actors (e.g. legislators, car manufacturers, suppliers, knowledge institutions) which hold different perceptions towards how self-driving should be fulfilled. Whereas shared rules provide the guiding frames for the local actors to work in, the experiences of the local actors provide new insights on how self-driving should be fulfilled (Geels & Raven, 2006, p. 379). The distinction between local projects (e.g. Google self-driving car project) and the global niche (e.g. autonomous driving) therefore made it possible to explore how the different perceptions of the local actors were translated into the two technological trajectories.

Finally, for the purpose of this research it is important to realize that due to the geographical separation of the two units of analysis (California and the Netherlands) the two technological trajectories do not necessarily compete with each other in terms of attention, infrastructural build-up, supportive regulation, and R&D funding. Instead as indicated in paragraph 2.2 the contextual differences between both regions are an indicator of why these pathways originated in these regions.

3.2 Sociology of Expectations

As indicated in paragraph 1.4 there is currently a lot of discussion regarding the development and implementation of self-driving vehicles (Alessandrini et al., 2014; Amsterdam Group, 2013; Beiker, 2014; KPMG & CAR, 2012; RAND, 2014; ENO, 2013; Timmer & Kool, 2014). The demonstration of Google's self-driving car project in combination with a multitude of studies undertaken by marketing and consultancy agencies has generated a lot of public attention (Morgan Stanley, 2013; Fung, 2014; KPMG & CAR, 2013; Beiker, 2014). Self-driving is a highly debated topic, implying that there is a lot of noise surrounding self-driving vehicles. As the SNM perspective focuses more on the interactions between socio-technical structures instead of the interactions between the agents themselves, it was chosen to strengthen the SNM perspective with insights from the sociology of expectations.

Given that emerging technologies (e.g. self-driving vehicles) are highly complex and systemic in nature, there are a multitude of actors involved in technological development, which all might hold different expectations towards a technological development (Bakker, Van Lente, & Meeus, 2011, p. 154). As indicated by Bakker et al. (2011, p.154) and Pel et al. (2014, p.16) understanding these perceptions implies taking in account 1) the context in which these expectations are formulated, 2) the purpose behind these expectations, 3) how these expectations are protected, and 4) how these expectations are perceived by other actors. In order to make sense of the multitude of expectations surrounding the autonomous driving approach of California and the cooperative driving approach of the Netherlands this research elaborated on the 'three forces of expectations framework' of Van Lente (2012). After a meta-analysis within the literature on the sociology of expectations, Van Lente (2012, p. 773) identified three forces underlying technological expectations; 1) Legitimization, 2) heuristic guidance and 3) coordinating efforts. For the purpose of this research it was chosen to use the following statements derived from the paper of Van Lente (2012, p. 773):

- *First, Expectations **legitimize investments** via justifying project efforts by referring to a promising future. Thus even though the current performance of a technology might be insufficient, future possibilities could still justify the costs (Van Lente, 2012, p. 774).*

- *Second, expectations can **provide direction**, as the prospect of a certain future guides search efforts in science and technology, reducing the uncertainty surrounding the technological trajectories (Van Lente, 2012, p. 774)*

- *Third, expectations **provide coordination** in technological development via allocating roles and indicating what kind of work needs to be undertaken (Van Lente, 2012, p. 774).*

This research therefore agrees with Van Lente (2012, p. 770) that expectations make actors 'do' something, implying that expectations contain valuable information (legitimization, heuristic guidance, coordination) about where technological development is going. Insights from the sociology of expectation therefore make it possible to filter through the amount of noise that is surrounding the self-driving vehicle discourse, while at the same time strengthening the explanatory power of the SNM perspective in terms of the role of agency in technological development.

3.3 General criticism

Despite that since the introduction of the SNM perspective by Geels (2011, p. 24)) a lot of empirical and conceptual work has been undertaken by the scientific community to strengthen the framework, some fundamental criticism remains. This criticism is best summarized by Geels (2011, p. 24) in his paper 'the multi-level perspective on sustainable transitions: Responses to seven criticisms' and Smith et al. (2010) in their paper; 'Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges.

The first critique mentioned in the papers of both Geels (2011, p. 29) and Smith et al. (2010, p. 443) is the so-called lack-of agency. As indicated by Smith et al. (2010, p. 446) the SNM perspective has been criticized on focusing too much on the interactions between socio-technical structures rather than the interactions between the agents themselves. For the purpose of this research, primarily making use of the SNM perspective would imply losing some explanatory power on the role of agency within these socio-technical structures. To deal with this 'lack of agency' this study made use of insights from the sociology of expectations (see paragraph 3.2). This made it possible to gain a deeper understanding of how the different actors shape their own realities, rather than just understanding how the different socio-technical structures interact.

The second criticism which can be derived from the paper of both Geels (2011, p. 29) and Smith et al. (2010, p. 443) is that it is difficult to distinguish between the niche, regime and landscape levels. As indicated by Smith et al. (2010, p. 443) the mechanisms underlying the interactions between the different levels tend to be extremely complex, making it very difficult to distinguish between the different levels. Given that the different levels depend on the perspective of the researcher (Geels & Raven, 2006), the different concepts were carefully positioned within the SNM perspective (see paragraph 3.1). Insights from the sociology of expectations in turn made it easier to distinguish between the different levels. Nevertheless it is important to highlight that the way in which the concepts were positioned in the SNM perspective as well as the way in which the 'three forces of expectations' were identified strongly influence the outcome of the study.

The third major criticism is that among SNM practitioners there is a tendency to focus on bottom-up change (Geels, 2011, p. 32). Berkhout et al. (2004, p. 62) even claimed that transition scholars focused solely on the developments at the niche-level, failing to recognizes the broader context which might affect these niches. This so-called ‘bottom-up niche-bias’ cannot be denied as the core principle underlying the SNM perspective is that novelties emerge in niches which need to be protected from the selection mechanisms of the dominant socio-technical regime (see paragraph 3.1). The latter is strengthened by the fact that this research takes a rather technocratic approach via focusing on how experts shape technological development. The study therefore elaborates deeper on how the niche technologies evolve than how the different contexts surrounding the two technological trajectories evolve. Nevertheless this bias was lowered via controlling for some of the relevant contextual differences between California and the Netherlands upfront (see chapter 2). This made it possible to position the different observations which were made with the help of the SNM perspective as well as the ‘three forces of expectations framework’ in their respective contexts.

The fourth criticism identified by Geels (2011, p. 36) and Smith et al. (2010, p. 444) is the ‘flawed use of secondary data sources’ by SNM scholars. According to the criticizers this bias is especially visible in the historical case studies which characterize SNM (Geels, 2011, p. 36). Given the exploratory nature of this thesis and the novelty of the technology this dilemma also applies for this study. There is a lot of secrecy and competition within the realm of self-driving vehicles, implying that there is a lot of noise. To make this even more complicated, due to contextual differences between the Netherlands and California (see chapter 2), the actors underlying the two technological trajectories are organized differently, implying that it was difficult to gain an equally strong amount of data on both units of analysis. For the purpose of this research it is important to highlight that the ‘three forces of expectations framework’ was used to assess the credibility of the different data sources. Rather than taking expectations for granted the three forces of expectations framework made it possible to understand the message underlying the different expectations.

Fifth, despite that this argument is not often mentioned as a criticism on the SNM perspective, there is no doubt that there is a tendency among SNM scholars to understand transitions via looking at historical patterns. Though this provides a valuable means to understand how transitions came about (Geels, 2011, p. 24), it does not provide insight in where technological development seems to be going. The latter might especially be important with novel technologies, such as self-driving vehicles. This study therefore used the ‘three forces of expectations framework’ as a foresight mechanism rather than a hindsight mechanism. The insights from the sociology of expectations therefore contribute to the explanatory power of the SNM perspective.

The final major criticism on the SNM perspective is related to the value of the empirical work undertaken by SNM practitioners as a tool via which politicians can govern transitions (Smith et al., 2010, p. 444). Given the tendency of SNM scholars to focus on historical case studies to explain how transitions come about, there is less attention for the actual implications this information has for politicians (Geels, 2011, p. 32). This statement seems to be exaggerated as the primarily aim of SNM practitioners is to provide an overview on overview on which politicians, or even enterprises, can make their decisions / investments, rather than a concrete advice. As indicated by Geels (2011, p. 29) the SNM perspective is there to show that technological transitions are not just the result of a single ‘cause’. Instead, technological transitions are the result of complex processes on multiple levels, which align and reinforce each other. The aim of

SNM research is therefore to establish a 'circular causality' instead of a linear causality. This study therefore aims to provide an overview of how the different actors underlying both technological trajectories shape these trajectories, and how these decisions might lead to a solution for the elderly and chronically ill.

Looking at the different criticism on the SNM perspective, it became clear that adding insights from the sociology of expectations (three forces of expectations framework) could significantly strengthen the explanatory power of the SNM perspective as it lowered some of the fundamental critisims surrounding the SNM perspective.

3.4 A combined perspective

The 'technological trajectory framework' of Geels & Raven (2006) makes it possible to gain a deeper understanding about how local variety is translated into the technological trajectory (see paragraph 3.1). These shared rules in turn shape the playing field of the actors to operate in, creating stability. However as indicated by Smith et al. (2010, p. 439) the strength of the SNM perspective to explain how technological transitions come about, implies that the SNM perspective sacrifices some of its strength at the local level (see paragraph 3.3). Thus in order to gain a deeper understanding of how actors shape their own realities it was chosen to combine the framework of Geels & Raven (2006) with literature from the sociology of expectations. Thus whereas the literature on the sociology of expectations makes it possible to understand how the different entities shape their own possible futures (local level), the literature on SNM makes it possible to position these expectations in the context of technological transitions (global level).

To understand the dynamics within the two technological trajectories it was chosen to modify the original framework of Geels & Raven (2006) to contain two technological trajectories. As can be derived from figure 12 these technological trajectories do not interact with each other.

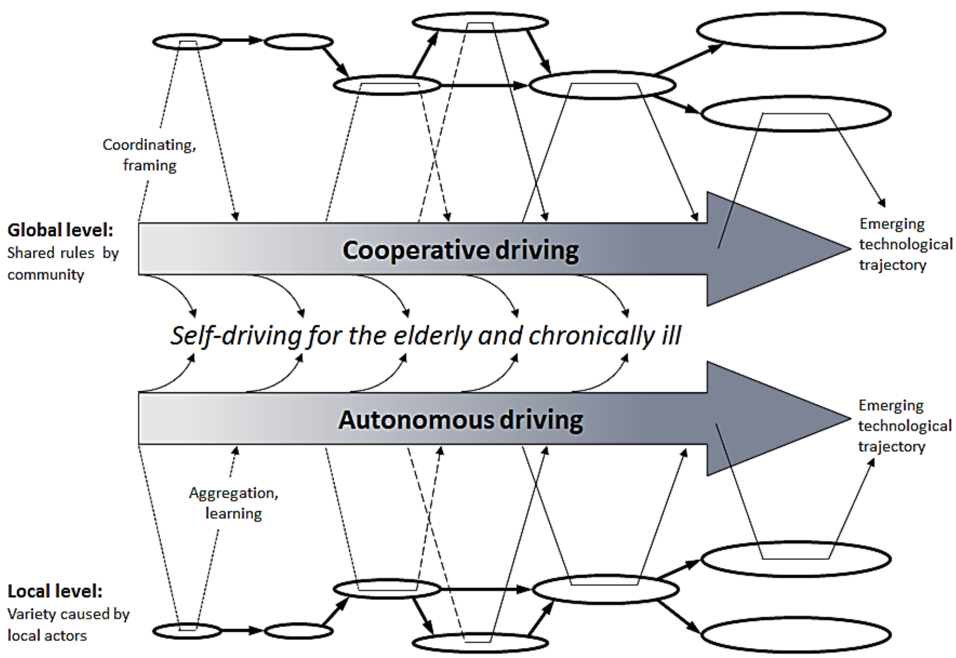

Figure 11: Technological trajectories in relation with the elderly and chronically ill.

However, as indicated in paragraph 2.2 there are different actors underlying both trajectories, which might hold different perspectives towards the respective technological trajectories. This implies that both at the local level (actor expectations) as at the global level (shared expectations) differences could be observed. These differences in turn had different implications for the elderly and chronically ill. As indicated in paragraph 2.3 the decision to examine the consequences for the elderly and chronically ill was primarily based on the assumption that this user group is, except from Google, not yet taken into account. Via keeping the theoretical framework broader it is therefore possible to understand why this group is currently not taken into account by the actors (local level), as well as how the different socio-technical structures might hinder and/or enable a self-driving solution for the elderly and chronically ill (global level).

Based on the work of Geels & Raven (2006, p. 379) it was chosen to investigate how the actor expectations on a local level lead to shared expectations on the global level (technological trajectory) and how these shared rules in turn influence the interaction processes among the actors on the local level. As indicated in paragraph 2.2 the entities underlying both pathways do not only differ in type, but also in how they are organized. Whereas the Dutch approach is mainly coordinated by networkorganizations and governmental agencies, the Californian approach is mainly coordinated by the industry.

For the purpose of this research it was chosen to focus on the entities that are most active in both regions in terms of cooperative (the Netherlands) or autonomous driving (California). For the Netherlands these entities include the Ministry of Infrastructure and the Environment, DITCM, Connekt, AutomotiveNL, Connecting Mobility and the Amsterdam Group. For California these entities include the DMV, PATH, Google, Tesla, Volkswagen, Nissan, Mercedes-Benz, Bosch, and Delphi Automotive. In order to understand how these entities shape their own realities the 'three forces of expectations' framework of Van Lente (2012) was used. Via investigating the objectives behind the expectations (legitimization, heuristic guidance and/or coordination) and the settings in which these expectations were expressed, the dynamics within the two technological trajectories were identified.

Via comparing both technological trajectories on equal terms, while carefully controlling for the contextual differences between California and the Netherlands, the main dynamics on a local level as well as global level were identified. The degree of translation from local variety (actor expectations) into the technological trajectory (shared expectations) therefore determines the stability, speed and direction of the respective trajectories, which in turn determines the degree of experienced resistance of the dominant socio-technical regime of person-driven vehicles. This study therefore provides insight in how local variety might lead towards different self-driving solutions for the elderly and chronically ill, and how stable these solutions are compared to other (potentially competing) socio-technical configurations. Thus what the study sacrifices in understanding the specific needs of the elderly and chronically ill, the study gains in understanding where technological development is going. As indicated in paragraph 1.3 this decision was based on the ambition to provide an overview of how current technological developments might affect the elderly and chronically ill, so that those who are in the position to make a change, can make the required decisions.

3.5 Data collection

Just as enabling vehicles to drive itself starts with collecting data (paragraph 2.1.3), scientific research starts with collecting data. As indicated by Creswell (2009, p. 178) a qualitative data collection procedure must contain a number of steps, in which the procedure of data collection contributes in the reliability, validity and generalizability of the research study. These steps include; 1) the selection of the units for analysis, 2) specifying the types of data that will be collected, 3) the strength and weaknesses of these data collection procedures, 4) and how the data is collected.

Given the ambition to explore how the actors underlying both technological trajectories shape these trajectories, first the main stakeholders were identified. These actors were identified via consulting some relevant scientific papers (Timmer & Kool, 2014; Pel et al, 2014) and consultancy papers (Morgan Stanley, 2013, TrafficQuest, 2014; RAND, 2014). As can be derived from paragraph 2.2 the stakeholders in California and the Netherlands not only differ in type, but also in the way in which these actors are organized. As indicated in paragraph 1.5 these differences are mainly caused by the context these actors are in, implying that certain actors are more relevant for this study than others. Based on the research question the main units of analysis in the Netherlands and California were identified. For the Netherlands these entities include the Ministry of Infrastructure and the Environment, DITCM, Connekt, AutomotiveNL, Connecting Mobility and the Amsterdam Group. This sample includes all the prominent entities behind the cooperative driving approach of the Netherlands. For California the entities include the DMV, PATH, Google, Tesla, Volkswagen, Nissan, Mercedes-Benz, Bosch, and Delphi Automotive. As can be derived from figure 6 this is only a small sample of all the companies and institutions that are active in California. The sample size is therefore based on the entities that have the biggest influence on whether or not there will be a self-driving vehicle solution for the elderly and chronically ill in California. These include the regulators (DMV, PATH), universities (UC Berkeley, Stanford) and the companies (Google, Tesla, Volkswagen, Nissan, Mercedes-Benz, Bosch, Delphi Automotive) that obtained testing permits from the DMV to test their prototypes on Californian public roads.

In order to extract the required data from the identified stakeholders underlying both technological trajectories multiple data collection procedures were applied. First, a lot of documents and audio-visual materials were collected via desk research. For the Netherlands the data was mainly derived from the published technological roadmaps of the network organizations and the governmental agencies. As indicated by Van Lente (2012, p. 771) and McDowall (2012, p. 531) technological roadmaps are used by actors to express their expectations, visions, and sometimes even targets, towards a technological development. The technological roadmaps are therefore the result of a consensus among the actors within the governmental agencies and network organizations about where technological development should be going. The main advantage of these technological roadmaps is that they represent the languages and words of the stakeholders which are the result of a thoughtful process among these actors (Creswell, 2009, p. 180). The main disadvantage of this data collection procedure is that the actors underlying these technological roadmaps might not be equally represented within and between the network organizations, causing skewness in the data (Creswell, 2009, p. 180). In order to counter this skewness the roadmaps were compared in terms of 1) type of entities represented, 2) number of entities represented, 3) purpose behind the roadmap, and the 4) structure of the technological roadmaps.

Whereas the entities behind the cooperative driving approach in the Netherlands are mainly organized in network organizations, in California the entities underlying the autonomous driving approach operate more independently. In order to control for this contextual difference the information of the stakeholders was collected via audio-visual materials, company blogs and company reports. Given the publicity (KPMG & CAR, 2012, p. 12) surrounding the autonomous driving efforts undertaken in California the stakeholders are often interviewed and/or asked to speak at conferences, implying that there is a lot of audio-visual information available. As indicated by Creswell (2009, p. 180) these videos provide a valuable means for observing directly how the stakeholder envisions where technological development should be going. The main disadvantage however is that this information is difficult to interpret, as the context in which these visions are expressed might affect the stakeholder (Creswell, 2009, p. 180). To counter this disadvantage the context in which the stakeholder presented its vision was carefully examined. The advantage behind the company blogs and reports is that these represent the visions as the entities want to express these visions to the outside world. The disadvantage is that these could therefore contain intentionally flawed data, implying that the researcher has to carefully examine the intentions behind the data (Creswell, 2009, p. 180). In cases where there was not sufficiently detailed information available from the main entities in the Netherlands and California secondary data from consultancy bureaus and governmental agencies was collected.

Second, a focus group was conducted at the Consulate General of the Netherlands in San Francisco. As indicated by Creswell (2009, p. 180) the strength of the focus group is that it enables the researcher to quickly validate some of its findings and identify paths that require further investigation. The main weaknesses of the focus group are that the moderator can have a great impact on the outcome of the focus group and that the focus group does not cover sufficient in-depth discussion (Creswell, 2009, p. 180). For the purpose of this research the focus group was therefore solely used to validate findings and to identify the paths that require some further exploration. As can be derived from appendix A, table C, it was chosen to entail participants which were assumed to hold different perceptions towards self-driving for the elderly and chronically ill, while remaining objective. Whereas the members of the Consulate (Innovation Attaché, Coast to Coast E-Mobility Connection) were mainly interested in the implications of self-driving for the Netherlands, the representatives from the universities (UC Berkeley, Stanford) and the healthcare agencies (Healthcare Innovation Transfer, Transport Research Institute), where mainly interested in respectively the implications for the government, the industry and the elderly and chronically ill. The focus group members were approached via email and invited to participate at the conference room at the Consulate General of the Netherlands in San Francisco (appendix B). Beforehand the participants received some statements which were based on the findings in relation with the research question (appendix B). The data gathered during this focus group session was recorded and transcribed. The findings were represented in a report which was sent to the participants afterwards. All participants agreed with the findings as well as the interview questions which were derived from these findings.

Third, semi-structured interviews were conducted in order to gain in-depth understanding of how the main entities underlying both technological trajectories shape these trajectories. As can be derived from appendix A, the semi-structured interviews were conducted in California (January – April) and the Netherlands (May – June). The interviewees were cordially invited (via email and/or orally) to participate in an approximately one hour in depth-interview. As can be derived from appendix A, the majority of stakeholders behind the cooperative driving approach of the Netherlands and the autonomous driving approach of California participated in the interviews. The list also includes relevant stakeholders which were selected on advice of the main stakeholders during the interview and/or proved to be interesting during some of the relevant meetings in which the researcher participated (snowball effect).

For the purpose of this research it is important to mention that some of the actors in the Netherlands fulfilled multiple roles. As explained in paragraph 2.2 this is because a lot of the stakeholders in the Netherlands participate in multiple network organizations.

An interview guide was set up beforehand to structure the interviews. As can be derived from appendix C these questions leave room for interpretation enabling the researcher to control the line of questioning. This also made it possible to use a snowball method in which the information gained at one interviewee could be used to structure the next interview, implying that despite that the interview guide represented in Appendix C represents the core structure for each interview session, this interview guide was made-to-measure per interviewee. As indicated by Creswell (2009, p. 179) despite that this is a time consuming process it does provide the researcher the ability to gain a lot of in-depth information. In order to avoid some bias in response it was chosen to conduct the interviews in the natural setting as much as possible.

Where it was not possible to conduct the interview at the offices of the stakeholders (26x) these were conducted at the Consulate General of the Netherlands (2x), Eindhoven University of Technology (3x) or via Skype (6x). The data gathered during the interview sessions were all recorded and transcribed. Given that there is a lot of secrecy among the different companies especially in California (hence, there is a lot of competition) most of the interviewees preferred specific information regarding their person or the company they work for, to be left out of the actual paper. To set things straight it was therefore chosen to keep all the information of all the participants confidential.

3.6 Data analysis and validation

Just as making sense of data is the biggest challenge to enable vehicles to drive themselves, making sense of the collected data is also the biggest challenge of this research paper. As indicated in paragraph 1.4 there is a lot of noise surrounding the implementation and development of self-driving vehicles, implying that there are a lot of different expectations about where this technological development should be going. In order to make sense of all this information the data analysis procedure is an ongoing process involving continuously reflection on the gathered data, gaining deeper and deeper understanding of the data (Creswell, 2009, p. 184).

The first step was to organize the data in relation to the research question, implying that the different materials were organized in different folders (e.g. California, the Netherlands, the elderly and chronically ill) and subfolders (e.g. autonomous driving, cooperative driving). After this procedure the different data was read through in order to obtain a general sense of the data. As indicated by Creswell (2009, p. 185) this step enables to determine the credibility and value of the data in relation to the research question.

After this the ‘Strategic Niche Management (SNM)’ perspective (paragraph 3.1) and the ‘three forces of expectations’ framework (paragraph 3.2) were used to code the data. The coding was done via ‘Nitro Reader’ which provided the software to add markings and notes to the original digital documents. These coded documents were in turn divided into different folders and subfolders. As indicated by Cresswell

(2009, p. 185) coding is a continuous process in which segments of text and/or images are organized along predetermined concepts. First, the data was scanned on expectations which were considered relevant to answer the research question while carefully taken in account the context in which these expectations were expressed. Second this data was coded on the three forces of expectations framework of Van Lente (2012): 1) legitimization, 2) heuristic guidance and 3) coordinate efforts. Third, the theoretical lens of SNM was used to position the expectations in the right perspective. Via the modified 'technological trajectory' framework (figure 12) the expectations at the local level were carefully positioned in relation to the technological trajectory (global level). Finally these coded documents were analyzed in relation with the elderly and chronically ill.

The above characterized process characterizes qualitative research in which processes, contexts and the researcher are all part of the investigation (Creswell, 2009, p. 188). As indicated by Creswell (2009, p. 190) this process influences the reliability and validity of the findings. In order to make sure that the research approach remains consistent from start to finish the different procedures were often reflected on the original theoretical framework. As indicated by Creswell (2009, p. 190) this avoids shifts in the meaning of codes, which in turn might cause inconsistency in the data. Whereas reliability is relatively hard to achieve due to the complex interrelationships between the different actors and their surroundings, validity is one of the major strengths of qualitative research (Creswell, 2009, p. 191). In order to determine whether the findings were accurate from the researchers, readers, or participants point of view, a couple of validity strategies were applied. First, via triangulating between different data sources it was possible to build a coherent story line. Second, to make this storyline realistic, thick descriptions were provided, giving insight in the settings in which the data was gathered as well as insight in the gathered information which seemed to be contrary to the interpreted findings. Third, the transcribed information from the interviews and focus groups were send back to the participants in order to check if their answers were interpreted in the right way (member checking). Fourth, two external experts (appendix A: Table C) provided feedback on the research process as well as the conclusions (peer debriefing). Finally, the information was gathered and interpreted in California and the Netherlands implying that a lot of time was spend in the field. These validity strategies all contribute to the validity of the findings. As indicated by Creswell (2009, p. 191) this is important as qualitative research relies on the interpretations of the researcher (researchers bias).

4.

COOPERATIVE DRIVING

4. Cooperative driving

As indicated in paragraph 2.1 cooperative driving is the belief that self-driving should be achieved via the gradual implementation of communication technologies which enable real-time information exchange between vehicles (V2V) and/or between vehicles and road-side systems (V2I). To understand how the actors shape the cooperative driving trajectory, this paragraph elaborates on how the expectations of the stakeholders (local level) are translated into the cooperative driving trajectory (global level). As indicated by Geels & Raven (2006, p.379) when expectations align between the different entities on a local level, these shared expectations will be translated into a technological trajectory. These technological trajectories in turn provide stability among actors regarding where technological development should be going (Geels & Raven, 2006, p. 378). Via investigating how local variety is translated into the cooperative driving trajectory some indirect and direct effects of the trajectory on the elderly and chronically ill were identified.

4.1 The cooperative driving trajectory

As can be derived from paragraph 2.2 there is a consensus among the network organizations (AutomotiveNL, Amsterdam Group, DITCM, DAVI, Connekt) and the government (Ministry Infrastructure and the Environment) that the Netherlands should dedicate the majority of efforts towards cooperative driving. Via comparing the roadmaps of the Ministry of Infrastructure and the Environment (Schultz van Haegen, 2013; 2014; 2015), the roadmaps of the network organizations (Automotive NL, 2014; Amsterdam Group, 2013; DAVI, 2013; DITCM 2014; Connekt, 2014) and the interviews with some of the stakeholders underlying the cooperative driving trajectory (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38) the main patterns underlying the cooperative driving trajectory were identified. Table 9 represents an overview of 1) how the cooperative driving trajectory is legitimized, 2) how search efforts are guided towards cooperative driving, and 3) how the cooperative driving trajectory is coordinated.

Table 9: How actor expectations shape the cooperative driving trajectory (global level)

Three forces of expectations:	
1)	**Legitimize investments**
-	Cooperative driving leads to higher public benefits (safety, reachability, livability).
-	Cooperative driving leads to higher economic benefits (e.g. time-savings, cost-savings, supply industry)
-	Long term benefits (e.g. elderly and chronically ill)
-	Autonomous driving shifts attention away from cooperative driving.
2)	**Provide direction:**
-	Investigate the benefits of self-driving in terms of safety, reachability and livability (e.g. magnitude).
-	Cooperative driving will be implemented gradually (mixed traffic)
-	The first implementation of cooperative driving will be in the logistic sector (e.g. truck platooning)
-	Position the Netherlands as an international test-bed for self-driving vehicles
-	Investigate what efforts should be undertaken by market parties and/or road authorities
-	Investigate the technological challenges to enable safe testing)
-	Investigate the challenges to human factors
-	Investigate the impact and effects on society
-	Investigate the required legislation and international policies
-	Identify a community of early adopters (e.g. business)

3)	**Coordinate efforts:**
-	Ministry I&E → Protect public interest
-	Ministry I&E → Convince manufacturers to test in the Netherlands
-	Ministry I&E → Push for international legislation, rules and standards
-	Network organizations → Reach consensus among road authorities, industry and government
-	Network organizations → Provide platform for knowledge and innovation exchange
-	RDW → Develop regulation for testing on public roads
-	Amsterdam Group → Push for legislation, rules and standards on a European level
-	Automotive Industry → Provide knowledge and innovations
-	Road authorities → Collaborate with market parties to divide tasks

From these dynamics, six patterns were identified which might have a direct (how the elderly and chronically ill will be served by cooperative driving) and/or indirect (e.g. speed of implementation, stability of the technological trajectory) effect on the elderly and chronically ill.

1) The elderly and chronically ill are not yet taken in account.
2) The Netherlands is not a producing state, implying that the cooperative driving solution for the elderly and chronically ill has to come from somewhere else.
3) Chicken and egg dilemmas between road authorities (road-side systems) and market parties (in-car systems) could potentially slow down the cooperative driving trajectory.
4) Stability in the cooperative driving trajectory is created via consensus among different entities on multiple levels.
5) The potential benefits of cooperative driving vehicles are determined by the degree of penetration.
6) Regulators have to deal with vehicles with different self-driving capabilities which in turn effect the elderly and chronically ill depending on their degree of impediments.

The following six paragraphs are dedicated to explain the different patterns as well as the consequences these patterns can have on the elderly and chronically ill.

4.2 Safety first

As indicated in paragraph 2.3 the elderly and chronically ill could provide an interesting niche market for self-driving vehicle manufacturers. However, as can be derived from the roadmaps of AutomotiveNL (2014, p. 12), DITCM (2014, p. 7), DAVI, (2013, p. 3), Connekt (2013, p. 7) and the policy paper of Minister of Infrastructure and the Environment Schultz van Haegen (2014, p.1) self-driving for the elderly and chronically ill is mainly considered a long term objective;

"In the far future self-driving vehicles will have an even greater impact on society. Think for instance of the ability to work while driving, more and better mobility for the elderly and chronically ill, and/or different land space usages" ***~ Schultz van Haegen***

All stakeholders seem to agree with this statement as the cooperative systems have to be extremely safe and robust before one should even consider letting these people into the self-driving vehicles (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38). More specific, Minister Schultz van Haegen (2015, p. 4) expressed the expectation hat that the community of early adopters will likely be formed by business people, as even vehicles with a low degree of automation can already lead towards significant cost- and time savings for employee as well as employer. Thus even though self-driving for the elderly and chronically ill is mentioned to legitimize the potential of cooperative driving vehicles, this user group is currently not specifically taken in account. As indicated by all stakeholders (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38), even though vehicles with minor self-driving capabilities could already provide an outcome for the elderly and chronically ill, it would still require significant technological and regulatory advances to allow this to happen. Thus in order to understand to what extend cooperative driving can lead towards a solution for the elderly and chronically ill one needs to look at the stability of the socio-technical configuration, how the actors guide the cooperative driving trajectory and the speed of implementation.

What becomes clear from the roadmaps of AutomotiveNL (2014), DITCM (2014), DAVI, (2013), Connekt (2013) and Minister Schultz van Haegen (2013; 2014; 2015) is that the cooperative driving pathway of the Netherlands is mainly driven by the expected benefits in terms of safety, reachability and livability;

"As vehicles can communicate their position and speed to each other and to the infrastructure it is possible to reduce traffic jams and harmful emissions while increasing road capacity and safety." ~ ***DITCM (2014, p.2)***

Whereas safety features can be calculated into the purchasing price of the cooperative systems, collective benefits such as reducing traffic jams and emissions are more difficult to calculate into the purchasing price of cooperative systems. As can be derived from statements from Minister Schultz van Haegen (2013; 2014) this is one of the reasons why the government, as already indicated in paragraph 2.2, aims to coordinate the cooperative driving trajectory of the Netherlands;

"Because there are a lot of public benefits, I see it as my responsibility to take the initiative and develop a common course for technological development and innovation." ~ ***Schultz van Haegen (2013, p. 1)***

"Whereas technological advances are crucial for the further development of self-driving vehicles, the governmental efforts are determined by the public interests." ***~ Schultz van Haegen (2013, p. 2)***

However as rightfully indicated by a representative of Rijkswaterstaat (Interviewee 38) the extent to which the government can steer these developments depends on the magnitude of the effect that cooperative driving vehicles can have on society. Only based on this information the Ministry I&E can determine in which technologies to invest and which technologies need to be phased-out (Interviewee 38).

After comparing the roadmaps of AutomotiveNL (2014, p. 7), DAVI (2013, p. 3), DITCM (2014, p. 11) and Connekt (2013, p. 36) it becomes clear that the autonomous driving efforts undertaken in California are considered disruptive by the stakeholders underlying the cooperative driving approach. This expectation is primarily legitimized via referring to the fact that cooperative driving leads to higher public benefits than autonomous driving. This expectation is mainly legitimized via referring to the potential of shockwave damping and platooning, which can only be achieved if vehicles communicate to each other and/or road-side systems (DAVI, 2013, p. 3). All stakeholders (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38) therefore agree that the autonomous driving shift attention away from the cooperative driving trajectory;

"An autonomous vehicle is very clever at interpreting the world around it and responding to it. However, this is not enough for the self-regulation of busy traffic. To achieve this, vehicles must be able to communicate with each other." ~ ***Interviewee 20***

"That the Google car performs in the deserts of Silicon Valley does not mean that it can perform in the complex jungle of city traffic." ~ ***Interviewee 25***

"Autonomous cars occupy more space on the road as these need 1 to 2 seconds more headway than a human driver normally allocates in busy rush hour traffic." ~ ***Interviewee 28***

The fact that the stakeholders consider the autonomous driving trajectory as disruptive for the cooperative driving trajectory undertaken in the Netherlands is already an indicator that autonomous driving solutions will likely face some resistance from the actors underlying the cooperative driving approach of the Netherlands.

Besides referring to the higher public benefits the cooperative driving trajectory can achieve compared to the autonomous driving trajectory, the cooperative driving trajectory is also legitimized via referring to the potential benefits cooperative driving can bring to the Dutch economy;

Cooperative driving vehicles will benefit the Dutch economy as the logistics industry and consumers can save time and fuel." ***~ Schultz van Haegen (2014, p. 3)***

Despite that this argument mainly elaborates on the benefits of using cooperative driving vehicles, which is imaginable given that the Netherlands has a low prominence in OEMs, representatives of the automotive industry also mentioned the potential benefits for the Dutch automotive industry (Interviewee 20; 24; 25; 27; 28; 29; 30; 35). Despite that the Netherlands has a low prominence in OEMs; the Netherlands does have a lot of suppliers that are either active in and/or related to the field of vehicle automation (paragraph 2.2).

In sum, the cooperative driving approach of the Netherlands is legitimized via referring to public (safety, reachability, livability) and economic (e.g. time-savings, cost-savings, supply industry) benefits. Self-driving for the elderly and chronically ill is considered as a long-term objective, implying that this user group is currently not taken in account.

4.3 Using instead of producing

The second pattern that was derived from the different expectations expressed by the stakeholders underlying the cooperative driving trajectory, is that the Netherlands will probably not become a self-driving vehicle producer, implying that the self-driving solution for the elderly and chronically has to come from foreign self-driving vehicle manufacturers. As explained in paragraph 2.2, this can be explained by the lower prominence in OEMs and the smaller knowledge and innovation pool the Netherlands has compared to for instance California. Compared to California the Netherlands is therefore not considered a hotspot for the production of self-driving vehicles. However, as confirmed by representatives of AutomotiveNL (Interviewee 20) and the RDW (Interviewee 23) this could also provide opportunities for the Netherlands. First, the added value of self-driving vehicles is expected to come from suppliers (Interviewee 20). Second, the low prominence in OEMs enables the Netherlands to develop legislations without being biased towards the OEMs (Interviewee 21).

As self-driving vehicles will likely not be produced in the Netherlands, the stakeholders need to find other ways to harness the potential public (e.g. safety, reachability and livability) and economic benefits (e.g. profit, employment) associated with self-driving vehicles. As can be derived from the roadmaps of DITCM (2014, p. 2) and the policy papers of Minister Schultz van Haegen (2014, p. 2), the actors aim to do this via positioning the Netherlands as an international test-bed for self-driving vehicles;

I do not just want to be ready for self-driving vehicles; I want to use these developments as an opportunity to position the Netherlands as a country where these innovations can take place!' ~ ***Schultz van Haegen (2014, p.1)***

"In the Netherlands, we believe in "learning by doing" and we are willing to make our country available as a living lab." ***~ DITCM (2014, p.2)***

However, to do this the Netherlands has to convince foreign OEMs to test their self-driving vehicles in the Netherlands (Interviewee 20; 24; 25; 28; 29; 30; 31; 35). As can be derived from the policy paper of Schultz van Haegen (2014, p. 2) and the roadmap of DITCM (2014, p. 2) the Netherlands aims to do this via allowing the OEMs to test their self-driving prototypes on public roads, and via establishing international collaborations. Whereas the Ministry I&E aims to take a pro-active role in establishing international collaborations, the Ministry I&E has authorized the RDW to develop legislation that enables manufacturers to test their vehicle with self-driving capabilities on public roads.

"To position the Netherlands as a test-bed for self-driving vehicles, the RDW has to revise the current exemption permits." ***~ Schultz van Haegen (2014, p. 4)***

"Together with knowledge institutions and market parties I search for opportunities to promote the Netherlands as a test-bed for self-driving vehicles and establish international collaborations." ***~ Schultz van Haegen (2014, p. 4)***

Given the low prominence in OEMs (AutomotiveNL, 2010, p. 2) and the ambition of Minister Schultz van Haegen (2014, p. 1; 2015, p. 1) to position the Netherlands as a test-bed, the cooperative driving trajectory is more directed towards 'using' instead of 'producing'. The focus on 'using' can be derived from the roadmaps of DITCM (2014, p. 4-10), DAVI (2013, p. 3) and the policy papers of Schultz van Haegen (2014; 2015) in which most search efforts are guided towards the societal implications of self-driving vehicles rather than the technological challenges. Though not specified in a similar way, all papers guide search and development efforts in similar directions;

1) *Technological challenges (to allow the vehicles on public roads)*
2) *Challenges related to human factors*
3) *Impact and effect on society*
4) *Legislation and international policies*

As can be derived from the above stated focus areas, most of the search and development activities are directed towards understanding the effects that self-driving vehicles (in particular cooperative driving vehicles) will have on society. This can also be derived from some of the societal questions that are expressed in the roadmaps of DAVI (2013) and DITCM (2014);

"Are drivers actually willing to give up direct control over their vehicle and under what conditions?" ~ ***DAVI (2013, p.3)***

"What will be the impact of the transition from person-driven vehicles towards cooperative (or even automated) vehicles?" ***~DITCM (2014, p.8)***

"What kind of policies and regulations need to be in place to stimulate a safe and successful implementation of self-driving vehicles?" ***~ DITCM (2014, p.9)***

The technological research undertaken in the Netherlands is therefore primarily aimed to understand where technological development is going and to demonstrate the potential of the Netherlands as a test-bed for self-driving vehicles (Interviewee 20; 24; 28; 31). For the actual self-driving vehicles the Netherlands relies on foreign OEMs (Interviewee 20; 24; 25; 28; 29; 30; 31; 35). The efforts undertaken by DAVI (2013, p.3) should therefore not be seen as an example that the Netherlands is capable to produce self-driving vehicles, but as a demonstration of the 'willingness' of the Netherlands to collaborate with car manufacturers (in this case Toyota) towards the successful market introduction of self-driving vehicles. Via these demonstrations on public roads, the Netherlands can draw international attention while at the same time learning how self-driving vehicles interact with society (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38). As can be derived from a statement made by a representative of TNO (Interviewee 28) this can lead towards a win-win situation for both developers as potential users;

"Via gaining experience with self-driving systems in practice, the systems cannot only be adjusted to its surroundings; it also enables fellow road-users to get used to this new phenomenon." ***~ Interviewee 28***

In order to promote the Netherlands as a test-bed for self-driving vehicles, Minister Schultz van Haegen (2014, p. 4; 2015, p. 4) has expressed her ambition to find a community of early adopters.

"A community of early adopters needs to be identified in order to harness the actual user experiences" ~ ***Schultz van Haegen***

The benefits of a community of early adopters for the self-driving vehicle manufacturers are twofold. On the one hand it creates a potential niche market (e.g. the elderly and chronically ill) to sell their systems. On the other hand, testing on the elderly and chronically ill, generates a lot of information on how the autonomous systems interact with potential users. Whereas the elderly and chronically ill were identified as a potential group of early adopters (paragraph 2.3), as indicated in paragraph 4.2 all stakeholders expect that the elderly and chronically ill will not become the first adopters of cooperative driving systems. This expectations therefore has two specific implications for the elderly and chronically ill. On the one hand the elderly and chronically ill will only be taken in account at a later stage of technological development. On the other hand, even if another self-driving solution emerges for the elderly and chronically ill, this solution has to deal with the vested interests of the actors underlying the cooperative driving trajectory.

4.4 Chicken & egg dilemmas

In line with the observations made in paragraph 2.1 and 2.2 it becomes clear that the cooperative driving trajectory is characterized by chicken and egg dilemmas between road authorities and market parties. These chicken and egg dilemmas have two major implications for the elderly and chronically ill. On the one hand the tension between the road authorities and the market parties influence to what extend cooperative driving will be achieved via communication between vehicles (V2V) and/or road-side systems (V2I), and to what extend information will be provided via in-car systems (market parties) and/or road-side systems (road authorities). On the other hand the tensions between the road authorities and market parties could slow down technological development, implying that a self-driving solution for the elderly and chronically ill, which is already considered a long term objective (paragraph 4.1), remains far away.

As indicated in paragraph 2.1 the cooperative driving approach is based on the belief that self-driving can be achieved via enabling vehicles to communicate to other vehicles (V2V) and/or road side systems (V2I). Whereas the cooperative driving approach relies on short range communications (DSRC) for time-critical applications (e.g. speed, position), for non-critical applications (e.g. traffic information) cooperative driving systems rely on cellular networks (e.g. 3G, 4G). Looking from the perspective of car manufacturers this implies that compared to the autonomous approach the cooperative driving approach requires more cooperation with entities that are not traditionally affiliated with the car manufacturers (Timmer & Kool, 2014, p. 18). To enable V2V communications, the car manufacturers, for instance, needs to collaborate with service providers and potentially other car manufacturers. To enable V2I communications the car manufacturers, for instance, need to collaborate with service providers, other car manufacturers and road authorities. Given the vested interests between the different entities (e.g. investments, competition), and the uncertainty surrounding self-driving vehicles, all stakeholders agree that these collaborations could lead towards deadlocks, which slow down technological development (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38).

Whereas there seems to be a general consensus about the potential of V2V communications (Interviewee 20; 24; 25; 28; 29; 30; 31; 35) there is a lot of uncertainty about the potential of V2I communications (Interviewee 20; 25; 27; 31; 38). This dilemma can be described via looking at four statements that were made by proponents and opponents of V2I communications during the interviews;

"Road-side systems (and thus traffic managers) will continue to play an important role in the future due to the importance of emergency warnings." ***~ Interviewee 27***

"Despite that no longer investments are required in expensive conventional technologies, such as matrix signs and DRIP's the traffic managers will continue to play an important role in the event of major unplanned traffic disruptions and the opening and closing of roadways." ***~ Interviewee 32***

"The government should solely invest in bare asphalt, as future information exchange will be provided within the vehicle implying that a lot of road-side systems become redundant." ***~ Interviewee 25***

"Why depend on collective information provision via road-side systems if the same information can be delivered via in-car systems?" ~ ***Interviewee 29***

As can be derived from the statements above, there is a lot of uncertainty about the added value of road-side systems in the future. Should vehicles solely communicate with other vehicles (V2V) or also with road-side systems (V2I)? Should information mainly be provided from inside the vehicle (e.g. smartphones, navigation systems, wearables, Google glass) or from outside the vehicle (e.g. matrix signs, Dynamic Route Information Panels)? To make it even more complicated this uncertainty is not only visible on a national level, but also at the European level. The latter can be derived from the policy paper of Minister Schultz van Haegen (2013, p. 6) and the roadmap of the Amsterdam (Group, 2013);

"Instead of waiting for the other party to make a step, the road authorities and market parties should strengthen their actions via collaborating towards their shared goals; better road utilization!" ***~ Minister Schultz van Haegen (2013, p. 6)***

"For many years several actors have been undertaken by automotive companies and infrastructure operators to launch cooperative systems and services in the market. However, mainly due to a lack of coordination (the chicken and egg) these ambitions are not yet taken up in practical terms." ***~ Amsterdam Group (2013, p. 2)***

Thus in order for cooperative driving vehicles to emerge there has to be a consensus at the national level as well as at the European level. This is the reason why the different entities have organized themselves in network organizations on a national (Automotive NL, DITCM, DAVI, Connekt) and international level (Amsterdam Group). These network organizations aim to guide technological direction via reaching consensus among its partners about where technological development is going (DITCM, 2014; AutomotiveNL, 2014; DAVI, 2013; Connekt, 2013; Amsterdam Group, 2013). The tensions among the different entities on both national as European levels, are one of the reasons why many of the stakeholders (Interviewee 20; 23; 25; 26; 27; 28; 29; 36; 37) expect that the large scale implementation of vehicles with autonomous capabilities will emerge before vehicles with cooperative systems. This also implies that the first self-driving solutions for the elderly and chronically ill will probably be provided via autonomous systems instead of cooperative systems. However, as the different actors consider the autonomous driving trajectory disruptive to the cooperative driving trajectory (paragraph 4.2), one could question to what extend these autonomous solutions will be accepted by the actors underlying the cooperative driving trajectory of the Netherlands.

The tensions between the road authorities and the market parties also have a more direct implication for the elderly and chronically ill as it determines the degree to which the elderly and chronically ill will be served via V2V services and/or V2I services and whether this information will be provided via in-car systems and/or road-side systems. As indicated in paragraph 2.3.4 the more cooperative systems that are connected to the vehicle in which the person is located, the more services can be provided to the person. For instance, whereas sufficient V2V communication systems could enable a vehicle (in case of an emergency) to speed through traffic flows, sufficient V2I communication systems (e.g. traffic lights) could enable the vehicle to speed through traffic lights. As indicated in paragraph 2.1 the main added value of connected vehicles over autonomous vehicles is the degree to which time-critical services are available. For non-time critical applications these differences are less prominently available as this information can be provided via back-offices. For example, if a system detects that there is a health issue with the driver, the system could for instance communicate its position to the nearest emergency vehicle, communicate that there is something wrong to friends and family, et cetera. Though this is just one of the many advantages of connectivity, one can understand that the more objects that are connected the higher the amount of possibilities to serve the elderly and chronically ill.

Despite that the benefits of cooperative driving increase as more and more objects become connected it is important to mention that the way in which this information is provided has different implications for the elderly and chronically ill. As people age, dividing attention between different tasks under time pressure becomes more and more challenging (paragraph 2.3), implying that the higher the level of automation, the less complicated the driving task for the elderly becomes. The same counts for the amount of information that is provided. The higher the amount of information that is provided while driving, the more complex the driving task becomes (SWOV, 2012). Whereas information via road-side systems could provide the elderly and chronically ill more time to perceive the information, it could also imply that due to deterioration of visual capabilities this time benefit reduces. Whereas information provision inside the vehicle (e.g. navigation system) could increase the ability of the driver to perceive the information, it could also increase complexity as the elderly and chronically ill experience problems in separating relevant information from irrelevant information.

For the population of people, who due to certain circumstances (e.g. blindness) are not capable to drive independently, it does not even matter how information is provided. For these people the only thing that matters is that the vehicle drives itself the entire trip, and that information is provided in a way that these people can benefit from it. The way in which information is provided therefore influence the way in which the elderly and the chronically ill are served.

As can be derived from the roadmaps of the Ministry I&E (2013, p. 3) and Connekt (2014, p. 17) there is a consensus among the road authorities that the role of traffic management will gradually shift away from the road authorities (road-side) towards market parties (in-car). As can be derived from the papers of the Ministry I&E (2013, p. 13) and Connekt (2013, p. 16) both market parties and road authorities expect that more and more of the roles of the road-authorities will shift towards market parties;

1) *From collective information to individual information*
2) *From information via road-side systems to systems in vehicles, and a combination of the two.*
3) *From local networks to wider-traffic management*
4) *From traffic management as public domain tasks to public-private partnerships*

This shift is mainly driven by the expectation that the amount of private information services (e.g. smartphone applications) will continue to increase (Interviewee 20; 23 24; 25; 29; 30; 31; 32). However, as can be derived from a statement of Schultz van Haegen (2013, p. 1) these developments also create a lot of uncertainties between the road authorities and market parties;

"The increasing amount of private data available raises difficult question for traffic managers on the required investments as well as on how to safeguard the public interests in the future. Market parties also

have to reconsider the amount of investments they want to invest in new public services." ***~ Schultz van Haegen***

Market parties therefore have to deal with the vested interests of the road authorities, which have invested billions of euros to bring the Netherlands to the current state of infrastructural intelligence (Schultz van Haegen, 2014, p. 3; Ministry I&E, 2013, p. 16). As the tasks of the road authorities will gradually be transferred to market parties, this tension will remain for quite some time (Amsterdam Group, 2013, p. 2; Connekt, 2013, p. 17; Ministry I&M, 2013, p. 10; Interviewee 20; 23 24; 25; 29; 30; 31; 32). As can be derived from a statement of one of the representatives of Connekt (Interviewee 23), this implies that road authorities and market parties will continue to rely on each other to avoid investment failures.

"Whereas waiting for the other party to invest could lead towards under-investments, an early initiative could lead to double investments." ***Interviewee 23***

Thus whereas the chicken and egg dilemmas between road authorities and market parties slow down the cooperative driving trajectory, the gradual shift of traffic management from road authorities to market parties implies that the elderly and chronically ill will be more and more served via in-car systems instead of road-side systems. As indicated this could potentially make the driving task more complicated as more and more information will be available inside the vehicle. Given that the elderly and chronically ill are currently not taken in account (paragraph 4.2) and that the added value of cooperative driving depends on the amount of connected objects this could imply that it will likely take quite some time before the cooperative driving trajectory will lead towards a solution for the elderly and chronically ill. Especially as people who are seriously constraint in their ability to drive (e.g. blind people) would have to rely on a high penetration of cooperative driving vehicles as well as a high level of automation (SAE level 4-5).

4.5 Stability via consensus

Given that the cooperative driving trajectory tends to move relatively slowly towards a solution for the elderly and chronically ill (paragraph 4.4) it is important to investigate to what extend the actors underlying the cooperative driving trajectory are open for a solution (e.g. autonomous vehicles) coming from another country. The latter is especially important as the Netherlands will, as indicated in paragraph 4.3, likely not become a self-driving vehicle producing state. To understand how the actors underlying the dominant cooperative driving trajectory are willing to adopt other solutions, one needs to look at how these actors create stability. The latter is especially important as all actors agreed that the autonomous driving trajectory is considered disruptive (paragraph 4.2).

As indicated in paragraph 2.2 the cooperative driving approach of the Netherlands is characterized by a consensus on multiple levels. On the one hand this implies that the socio-technical configuration surrounding the cooperative driving trajectory can be considered stable, implying that in this case the market parties, the government and the road authorities all agree that the Netherlands should focus on cooperative driving. On the other hand this could also imply that the stability of the socio-technical configuration might hinder the implementation of other solutions (e.g. autonomous driving) that might be more beneficial for the elderly and chronically ill. This could provide a policy dilemma as it is often difficult to predict which technological trajectory might be the best option;

"That a technological trajectory might be considered the best option at a certain point in time, does not imply that this trajectory will remain the best option." ***~ Expert (01; 02)***

Despite the potential chicken-and egg dilemmas (paragraph 4.5), the cooperative driving trajectory can be considered stable. This stability is mainly achieved via collaborations between road authorities, governmental agencies, and market parties on multiple levels. As can be derived from the roadmaps of the network organizations (DITCM, 2014; Connekt, 2013; AutomotiveNL, 2014; DAVI 2013; Amsterdam Group, 2013) and the policy paper of Minister Schultz van Haegen (2013) all parties express the need for public-private collaborations on multiple levels;

"Given the public interests associated with cooperative driving and the potential deadlock between public and private parties it is now time to take the initiative towards a common course for the successful implementation of cooperative driving vehicles." ***~ Schultz van Haegen (2013, p. 2)***

"Public and private parties need each other to make the right investment decisions and via that way strengthen the competitive position of the Netherlands." ***~ Connekt (2013, p. 7)***

"An open flow of cooperation, communication and knowledge between governments and industries, together with a solid transition strategy, is crucial." ***~ DITCM (2014, p. 2)***

"The co-operation between the automotive industry and the road authorities is required to develop a joint strategy on the initial deployment of Cooperative ITS." ***~ Amsterdam Group (2013, p. 2)***

From these statements as well as the interviews with the stakeholders (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38) it becomes clear that there is a consensus among the stakeholders in the Netherlands that in order to harness the public and economic benefits of cooperative driving vehicles public and private parties need to collaborate on multiple levels. As can be derived from the roadmaps of the network organizations (DITCM, 2014; Connekt, 2013; AutomotiveNL, 2014; DAVI 2013; Amsterdam Group, 2013) and the policy paper of Minister Schultz van Haegen (2013) there are four main ways in which the actors underlying the cooperative driving trajectory create stability.

First of all, the different entities have organized themselves in network organizations which represent the interests of their members in a particular field. As can be derived from the statements of the representatives of the different network organizations (Interviewee 20; 22; 24; 28; 31) these network organizations provide multiple benefits. First, network organizations create a platform for members to meet, stimulating the diffusion of knowledge and innovations (Interviewee 20, 22, 24, 28, 31). Second, the knowledge of the network goes beyond the knowledge of a single organization (Interviewee 31). Third, a network organization is more resilient to disruptions as it can quickly adjust to stimuli (Interviewee 24).

As can be derived from the roadmaps of DITCM (2014, p. 12), AutomotiveNL (2014, p. 8), Amsterdam Group (2013, p. 2) and the policy paper of Schultz van Haegen (2015, p. 4) there is not only collaboration within the network organizations but also between the network organizations on a national and an international level.

"I will closely collaborate with both public as private parties such as AutomotiveNL, DITCM, Connekt, ANWB, TLN and 3TU." ***~ Schultz van Haegen (2015, p. 4)***

"DITCM is working closely with Connecting Mobility, Automotive NL, Connekt and the BeterBenutten Programme of the Ministry I&E." ***~ DITCM (2014, p. 12)***

"AutomotiveNL collaborates closely with DITCM and the Ministry I&E to enable the deployment of smart mobility solutions." ***~ AutomotiveNL (2014, p. 8)***

The Dutch approach towards cooperative driving can therefore be seen as a consensus (between public and private parties) within a consensus (between network organizations) within a consensus (on a national level) within a consensus (on a European level). The potential chicken and egg dilemmas (paragraph 2.2; 4.4) between market parties and road authorities on multiple levels therefore explain why all the actors underlying the cooperative driving trajectory agree that network organizations play an important role to keep momentum going.

Second, stability is created via connecting cooperative driving projects on a national as well as European level. As can be derived from the roadmaps of DITCM (2014, p. 04) and the Amsterdam Group (2013, p. 8) the stakeholders seem to agree that this convergence is required to stimulate the wide-spread deployment of cooperative driving solutions;

"DITCM will facilitate the move from the current separate cooperative driving projects, towards a connected whole. Via this way DITCM aims to shift from conducting pilot projects to a wide-spread deployment." ***~ DITCM (2014, p. 4)***

"Due to similar projects in the Netherlands (DITCM), Austria (Testfeld Telematic), and Germany (Drive C2X, SIM TD) it is more than obvious to initiate a first step in the implementation of cooperative services together in a European corridor." ***~ Amsterdam Group (2013, p. 8)***

On a national level DITCM (2014, p. 4) aims to achieve the up-scaling via collaborations in initiatives such as 'SPITSLive' (Cooperative-ITS corridor which connects Rotterdam, Breda, Tilburg and Eindhoven) and the 'Beter Benutten' (Better Utilization) program (60 million euro grant by the government to achieve a 10% shorter journey time in the busiest regions in the Netherlands by 2017). On a European level DITCM (2014, p. 4) collaborates in the 'Horizon 2020' program of the European Union (80 billion research and innovation program aimed to secure Europe's long term competitiveness) and the 'Cooperative ITS Corridor' (Cooperative-ITS corridor which connects Austra, Germany and the Netherlands). Via these public-private collaborations on multiple levels, the network organizations play an important role in establishing guidelines, methods, standards and knowledge for the further deployment of cooperative driving solutions;

"Front runners are proactive and give direction to the developments and deployment of Cooperative ITS by applying and testing early standards and settings for the future." ***~ Amsterdam Group (2013, p. 8)***

Third, these best practices for future development are, as indicated in paragraph 2.2, often expressed in roadmaps. The roadmaps of DITCM (2014), DAVI (2013), AutomotiveNL (2014), Amsterdam Group (2013), Ministry I&E (2013) therefore contain valuable information about;

- *Where technological development should be going;*
- *The benefits of the chosen technological trajectory;*
- *The status of a particular technology;*
- *The possibilities for development and deployment;*
- *The priorities in terms of legislation;*
- *The actors involved;*
- *The roles the actors need to fulfill;*
- *And the activities that need to be undertaken at which time-span.*

These roadmaps therefore create stability via taking away the uncertainty and confusion surrounding technological developments (Expert 01; 02). Hence, these roadmaps 1) legitimize, 2) guide and 3) coordinate the cooperative driving trajectory. Roadmaps are therefore not only aimed to create stability among the members of the different network organizations, but also to guide and inform 'outsiders' where technological development should be going (Expert 01; 02).

Finally, the government plays an important role in establishing stability within the cooperative driving trajectory. As indicated in paragraph 4.2 this pro-active role can be attributed to the public and economic benefits the government expects to harness via the implementation of cooperative driving solutions. This stability is mainly created in two ways. First, the Ministry I&E sets out guidelines on a national level via programs such as 'Better Utilization' and the participation in network organizations such as DITCM, Connekt, AutomotiveNL and the Amsterdam Group. Via participating in these network organizations the government can gain the required knowledge to make the policy decisions required to keep the technological trajectory going (Interviewee 23). As can be derived from the following statements, the chosen technological trajectory is then mainly stabilized via providing a continuous (long-term) flow of financial support;

"The long-term investment-agenda (2013-2018) has to make sure that changes in traffic management become a structural and stable part of the governmental programs" **~ Schultz van Haegen (2013, p. 4)**

"Over the coming years (2013 – 2018) the 'Better Utilization Program" will be investing around €170 million in ITS applications". **Ministry I&E (2013, p. 16)**

"For the upcoming four years, the Ministry I&E will realize a multitude of cooperative driving projects together with market parties." **~ Schultz van Haegen (2015, p. 2)**

Second, the Ministry I&E provides stability via taking away hurdles on both national and international levels (Interviewee 21; 22; 23; 24; 32; 38). On a national level Minister Schultz van Haegen (2015, p. 2) for instance, authorized the RDW to develop legislation which allows manufacturers to apply for a permit to test their self-driving solutions on public roads. On an international level Minister Schultz van Haegen

(2015) for instance, aims to take some hurdles away via the active participation in the Amsterdam Group and the European Presidency of the Netherlands in 2016.

All in all it becomes clear that the cooperative driving trajectory of the Netherlands is the result of a consensus (between members of the network organizations) within a consensus (between network organizations) within a consensus (on a national level) within a consensus (on a European level). Via connecting the different initiatives on multiple levels and providing continuous financial and structural support the cooperative driving trajectory of the Netherlands has gained a lot of momentum, making it stable. However, this also implies that if autonomous vehicles turn out to be more beneficial for the elderly and chronically ill, this would imply that it would be more difficult for these autonomous solutions to break through the stable socio-technical configuration surrounding the cooperative driving trajectory. The latter can especially be challenging as all actors expect that the autonomous driving trajectory would disrupt the cooperative driving trajectory (paragraph 4.2).

4.6 Dealing with mixed traffic

As indicated by Timmer & Kool (2014, p. 55) and Pel et al. (2014, p. 4) the successful implementation of cooperative systems depends on the degree of penetration. As recognized by the stakeholders (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38) the more vehicles that communicate with each other and/or road-side systems, the higher the public benefits in terms of safety, reduced congestion and reduced emissions. The added value of cooperative systems for the elderly and the chronically ill is therefore determined by the degree of penetration. As stated by the stakeholders (Interviewee 20; 22; 24; 25; 26; 28; 29; 30; 31; 32; 33; 35), the more vehicles (V2V) and road-side systems (V2I) to communicate with, the safer the vehicle becomes and the more additional services can be provided;

"How can one understand the intentions of the vehicle if the vehicle does not want to communicate?" ~ ***Interviewee 23***

"If a lot of vehicles are connected to each other as well as to for instance traffic lights it could be possible to let emergency vehicles speed through traffic flows as well as traffic lights. The vehicles would simply move aside and all traffic lights would switch to green as the emergency vehicle approaches." ***~ Interviewee 32***

As can be derived from the roadmaps of the Amsterdam Group (2013; p. 4), DITCM (2014, p. 8), DAVI (2013, p. 2), and Schultz van Haegen (2015, p. 1) the actors underlying the cooperative driving trajectory of the Netherlands expect that the introduction of cooperative systems will evolve gradually;

"The introduction of C-ITS will be an evolution involving transition phases over years instead of a big bang revolution like Google's self-driving car." ***~ Amsterdam Group (2013, p. 2)***

"The automotive industry and knowledge institutions all expect that it will take many years before self-driving vehicles will hit the public roads safely". ***Schultz van Haegen***

"The self-driving capabilities of vehicles will gradually evolve, taking more and more of the driving-task out of the hands of the driver." ***~ DITCM (2014, p. 8)***

Based on the roadmaps of the different network organizations and the interviews (Interviewee 20; 24; 25; 28; 29; 30; 31; 35) with the stakeholders a couple of reasons for this gradual deployment were identified. First of all, cooperative systems cannot be developed independently, implying that the car manufacturers rely on other entities (e.g. service providers, road authorities, regulators, other car manufacturers). As indicated in paragraph 4.4 this interdependency could lead to 'chicken-and-egg dilemmas' which could potentially slow down technological development. As indicated by some of the stakeholders (Interviewee 20; 24; 25; 28; 29; 30; 31; 35) this especially counts for V2I communications as here the car manufacturers have to deal with vested interests (in the case where the investments in road-side systems were already made) and/or have to wait for the road-authorities to invest in these road-side systems (in case the infrastructure is not ready).

Second, the stakeholders seem to prefer a more voluntary approach. As can be derived from the roadmap of the Amsterdam Group (2013, p. 6) as well as the policy paper of Minister Schultz van Haegen (2013, p. 2) both at a national as a European level there is a consensus that the deployment of cooperative driving solutions should be market driven;

"It does not favor a possible mandated deployment as expected in the USA as such an approach takes much longer to implement and will not be market driven." ***~ Amsterdam Group (2013, p. 7)***

"Cooperative driving solutions will be deployed gradually. User experiences will then determine the further deployment of cooperative driving solutions." ***~ Schultz van Haegen (2013, p. 5)***

This market driven approach implies that the decisions regarding implementation, standardization, legalization, best practices et cetera mainly depend on user-experiences. Despite that this market driven approach seems to ensure that the cooperative driving solutions align with the users, it also leads to a more time consuming process as all the involved entities have to come to a consensus (Interviewee 21; 22; 24; 28). Thus despite rapid advances in technological development it is generally expected that there will be mixed traffic for a long time (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38). A statement derived from the roadmap of Connekt(2013, p. 17) exemplifies this observation;

"Within 10 years 60% of the Dutch car fleet will be connected via short and/or long range communication technology." ***~ Connekt (2013, p. 17)***

Even though 10 years (2023) is already quite some time, the full penetration of cooperative driving systems will actually take much longer. First, not only is it unclear whether this expectation refers to vehicles with self-driving capabilities (e.g. DSRC systems) or just to the vehicles with some sort of connection in them (e.g. smartphone, navigation system). Second, whereas cooperative driving systems will easily penetrate in high-end markets (e.g. luxury vehicles) it will probably be much more difficult to penetrate into low-end markets (e.g. shopping cars) and the after-market (Interviewee 20; 24; 25; 28; 29; 30; 31; 35) as the collective benefits are difficult to calculate in the purchasing price of the vehicles. As indicated by a representative from the Amsterdam Group (Interviewee 22), even if cooperative driving systems would be mandated, it would still take a long period before these systems would be operational in every vehicle.

"Given that only a maximum of 7% of the entire car fleet is renewed annually, it will take more than 14 years before the 'day-one-services' are operational in every vehicle." ***Interviewee 22***

Whereas this claim does cover the second-hand market it does not take does not take in account the time it took to attain this mandate and the time the car manufactures are given to comply. All stakeholders therefore agree that there will be mixed traffic ranging from manually driven vehicles to full automated vehicles for a long period (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38).

According to TNO (2015, p. 9), DITCM (2014, p.4) and AutomotiveNL (2014, p.3) the first large scale implementation for cooperative driving will be via so-called 'truck platooning' on dedicated highways. The core premise underlying this expectation is that trucks are in usage more often than passenger vehicles. This implies that the associated fuel- and labor cost savings that can be achieved via truck platooning will lead to a faster return on investment. However, this also implies that a cooperative driving solution for the elderly and chronically ill is further away. As stated by representatives from DAF (Interviewee 28) and TNO (Interviewee 35);

"We expect the large-scale deployment of truck platooning will be legally permitted and commercially available in 2020" ~ ***Interviewee (28; 35)***

Another benefit of truck-platooning is that these trucks can relatively easy be shielded from the other vehicles on highways. Governments could for instance decide to dedicate a specific lane for truck-platooning (Interviewee 20; 21; 24; 27; 28; 34; 35; 36). The latter seems plausible as trucks already most often solely drive on the right lane at a maximum speed of 80 km/h. The expectation that the first large-scale deployment of cooperative driving systems will be via truck-platooning implies that most efforts are guided towards achieving this goal (e.g. best practices, standards, legislation). Truck platooning could therefore be seen as an accelerator for the cooperative driving trajectory of the Netherlands. However, it also implies that the majority of attention is dedicated to truck platooning rather than for instance a self-driving solution for the elderly and chronically ill.

Looking at the elderly and chronically ill, mixed traffic implies that it will probably take a long time before these people could actually benefit from cooperative vehicles. Especially as the degree in which these people can benefit from cooperative vehicles depends on the degree of penetration of cooperative systems as well as the level of automation. As indicated by a representative of the RDW (Interviewee 21) as long as there are vehicles on the road which do not communicate, the human driver has to remain attentive. This implies that only the elderly and chronically ill with a low level of impediments could make use of cooperative driving vehicles. However, as became clear during the focus group session (Participant 04; 05; 06; 07) it is questionable if the elderly and chronically ill would be willing to pay extra for vehicles with cooperative systems that still require them to stay attentive. Thus in order for people with serious constraints to make use of cooperative driving vehicles, there has to be a high degree of penetration to somehow guarantee that this can be done safely. However, this does not imply that there are no situations imaginable where this can be undertaken in a safe manner. During the interviews with the stakeholders (Interviewee 20, 24, 25, 27, 28, 29, 30, 31, and 35) two opportunities were repeatedly mentioned;

1) *Roadways that are specifically dedicated for vehicles equipped with cooperative driving capabilities (e.g. bus-lanes, highway lanes).*
2) *Low speed campus solution which drives on public roads (e.g. between a community of elderly and chronically ill towards a shopping center, community center, public transportation service et cetera).*

As can be derived from these two statements there remains a trade-off for the elderly and the chronically ill. Whereas dedicated roadways could provide a safe environment for cooperative driving vehicles to be operated it is still raises some questions about to what extend these can actually deliver a last mile solution (Interviewee 20, 24, 25, 27, 28, 29, 30, 31, and 35). Should infrastructural investments be made to extend the amount of dedicated highways? Do the benefits of these dedicated lanes (e.g. traffic jams) outweigh the loss of roadways for vehicles with no cooperative systems (which could for instance cause extra traffic jams)? Do people still need to transfer between different transportation services?

For the low-speed campus the trade-off is mainly between developing a cooperative system that is robust enough to be safe, while at the same time being tolerant enough to allow errors that might make the ride less enjoyable (e.g. continuous stops). However, as indicated in paragraph 2.3 for those who are seriously constrained in their ability to move (e.g. blind people) this might not matter as a less enjoyable ride is already better than no ride.

Given that there will be mixed traffic for a relatively long time, it is likely that the first large-scale implementation of cooperative systems will take place on (dedicated) highways. As the majority of efforts are dedicated towards truck-platooning the first implementation for the elderly and chronically ill will take some time. Despite that the cooperative driving trajectory is 'user-driven' it will therefore take a while before users, such as the elderly and chronically ill, can actually benefit from these solutions. The biggest opportunity to serve the elderly and chronically ill is therefore via providing a last mile solution. This is probably also why the majority of interviewees expect that the first visible business case will be in the form of a low speed campus solution (on dedicated roads). As indicated by a representative of TNO (Interviewee 28), a low speed vehicle which is only allowed in a limited-environment, will be socially- and technologically viable sooner than a vehicle that has to be capable to operate everywhere.

4.7 Dealing with different capabilities

Given the expectation that there will be mixed traffic for a long period (paragraph 4.6), and the ambition of Minister Schultz van Haegen to position the Netherlands as an international test-bed for self-driving vehicles (paragraph 4.2), there will be a lot of scenarios in which there will be vehicles with different levels of automation on public roads. Regulators are therefore being asked on how to deal with these different capabilities. To what extend certain vehicles are allowed on public roads therefore influences the elderly and chronically ill in multiple ways. Whereas vehicles with a low level of automation (SAE level 1-2-3) could potentially enhance the driving capabilities of the elderly and chronically ill with a low level of impediments, vehicles with a high level of automation (SAE level 4-5), could potentially enable people who due to certain circumstances cannot drive from A to B independently (e.g. blind people), to drive from A to B independently! Whereas full automation (SAE level 4-5) has the highest benefits for the elderly and chronically ill, the stakeholders agree (Interviewee 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30 31; 32; 33; 34; 35) that this is also the most challenging scenario for regulators. That this raises some difficulties for the regulators becomes clear from some of the statements made by a representative of the RDW (Interviewee 21);

- *How do you ticket a robot?*
- *In case an accident does occur, who pays?*
- *In case of an unavoidable accident, should the vehicle decide what and/or whom to hit?*
- *Who gets to develop the software to make these live and death decisions?*
- *Should vehicles be allowed to break the rules under certain conditions?*

As of July 1, 2015 legislation has been put into force which enables the large-scale testing of vehicles with self-driving capabilities on public roads in the Netherlands (RDW, 2015). This legislation covers both vehicles with autonomous capabilities as vehicles with cooperative driving capabilities. As can be derived from the policy paper of Schultz van Haegen (2014, p. 3) this was achieved via adjusting the existing 'exemption permits' for exceptional transportation by the RDW. Untill July 1, 2015 the 'exemption permits for exceptional transportation' only allowed small-scale demonstrations. To allow large-scale testing on public roads Minister Schultz van Haegen (2014) authorized the RDW to approve / disapprove vehicles with self-driving capabilities on public roads. However, this also implies that the RDW can be held liable for approving and/or disapproving vehicles with self-driving capabilities on public roads by producers and/or third parties (AON, 2015, p. 17).

As indicated by Minister Schultz (2015, p. 2) the approval / disapproval of vehicles with self-driving capabilities can therefore be a daunting process. First, due to the novelty of the technologies, there are hardly any assessment criteria and legislations for the actual implementation available (Interviewee 21). Second, permit requests for self-driving prototypes will range from vehicles with low self-driving capabilities to vehicles with full self-driving capabilities (Interviewee 21). Third, to understand where technological development is going, the RDW relies on input from the OEMs (Interviewee 21). Not only does the Netherlands have a low prominence in OEMs, especially in the field of high automation (SAE level 4-5) there is very little knowledge available (Interviewee 21). Finally, vehicles are often retrofitted with self-driving capabilities, implying that the already approved vehicle has to be approved again (Interviewee 23). As can be derived from a statement made by Schultz van Haegen (2015, p. 2) and the representative of the RDW, this complexity implies that the RDW has to approach every testing application separately.

"As it is very difficult to predict where technological development is going, the RDW has to determine per vehicle what, where, for how long and under which circumstances the self-driving capabilities will be tested." **~ Schultz van Haegen (2015, p. 3)**

"There is a difficult trade-off between manufacturer and regulator. On the one hand a test-site should provide sufficient traffic situations to challenge the technology. On the other hand the consequences of a collision have to stay within acceptable limits." ***~ Interviewee 21***

Given the uncertainty surrounding the implementation of self-driving vehicles, Minister Schultz van Haegen (2014; 2015) has expressed her ambition for a voluntary approach, in which legislations will be adjusted along the way. As can be derived from the statements of Schultz van Haegen (2014; 2015) this has to make sure that legislation does not hinder the future potential of self-driving vehicles.

"Flexibility in regulation is crucial in order to quickly adjust to changes that result from technological advances." ***~ Schultz van Haegen (2014, p. 3)***

"I want the Netherlands to become an international test-bed for self-driving vehicles and Intelligent Transportation Systems (ITS) and thus facilitate technological advances instead of hindering these developments via stringent regulations." ***~ Schultz van Haegen (2015, p. 2)***

The legislations that are currently in place in the Netherlands are therefore primarily aimed to harness the public (safety, reachability, livability) and economic (supply industry) benefits of self-driving vehicles. Given that the Netherlands will likely not produce self-driving vehicles (paragraph 4.5); legislation is therefore primarily directed towards enabling foreign manufacturers to test their self-driving solutions on Dutch public roads. However, despite that the Netherlands can develop national legislations independently of foreign OEMS (paragraph 2.2), when it comes to the actual market introduction of self-driving vehicles, the Dutch rules and regulations needs to comply with European legislations (Schultz van Haegen , 2015, p. 4). Thus to understand how current legislations might hinder and/or stimulate a self-driving solution for the elderly and chronically ill, one needs to look at the regulations as expressed in the Vienna Convention on Road Traffic of 1949. The most noticeable regulation expressed in the Geneva Convention on Road Traffic (1949) is that the human driver has to remain in control;

"Drivers shall at all times be able to control their vehicles or guide their animals. When approaching other road users; they shall take such precautions as may be required for the safety of the latter" ***~ Article 8.5***

Hence, this implies that the driver of a 'passenger vehicle' must be a human being, and thus not an automated system. According to the convention, this implies that vehicles with SAE level 4-5 self-driving capabilities should not be allowed on public roads. As indicated in paragraph 2.1 this is mainly because vehicles with SAE-level 4-5 capabilities take the driver out of the loop, implying that the system takes over the driving task entirely. As can be derived from two statement of a representative of the RDW the current requirement is in place to avoid some of the complex situations which could arise if the human driver is replaced with an automated system.

"The Geneva Convention of Road Traffic states that in case of a crash, drivers are legally obligated to stop and help the injured. However, how does this work if there is no one in the car? What if the person missed it because he or she was sleeping?" ***~ Interviewee 23***

"Allowing a car to park or to keep its lane automatically does not cause the complexity. It is the moment when the car is asked to drive it-self that raises a lot of moral and legal issues that at the moment only human beings can cope with." ***~ Interviewee 23***

However, despite that the premise that a vehicle should by a human being already holds since 1949, this does not mean that these legislations are not questioned. The latter became clear on March 2014, when the European Association of Automotive Suppliers pushed successfully for an adjustment to the Vienna Convention on Road Traffic (CLEPA, 2015);

"The amendment allows a car to drive it-self, as long as the system can be overridden or switched off by the driver." ***~ CLEPA (2015, p. 7)***

According to the representative of the CLEPA (2015) this amendment was required to increase the competitiveness of the European automotive industry. Notice that even though this amendment allows car manufacturers to install self-driving features, ranging from partial automation till full automation, the human driver still has to be present in the vehicle at all times and has to be capable to take over the wheel. Looking at the elderly and chronically ill this implies that even though the vehicles will have more self-driving capabilities and thus enhance their driving capabilities, they would still have to remain attentive. This implies that these vehicles will only be interesting to the elderly and chronically ill with a very low degree of impediments. For people with serious constraints in their ability to drive (e.g. blind people) the current legislation would therefore represent a hurdle.

4.8 Conclusion

As indicated in paragraph 3.2 the core principle underlying Strategic Niche Management is that novelties emerge in niches (e.g. cooperative driving) which need to be shielded, nurtured and empowered in order to compete with the dominant socio-technical regime (e.g. person-driven vehicles) and/or other niches (e.g. autonomous driving). To understand what cooperative driving in the Netherlands would look like for the elderly and chronically ill, one first needs to look at how the different expectations (table 9) are translated into the technological trajectory and how these expectations create stability (paragraph 4.1).

4.8.1 Stability via consensus

First of all, it becomes clear that the stability of the cooperative driving trajectory is mainly created via consensus. As indicated in paragraph 4.4 the belief that self-driving should be achieved via enabling vehicles to communicate to each other (V2V) and/or road-side systems (V2I) is shared among a multitude of entities on multiple levels. All the stakeholders therefore agree that the Netherlands should focus on cooperative driving as this maximizes the potential of self-driving vehicles in terms of safety, reachability, and livability (paragraph 4.2). All the stakeholders therefore argue that the autonomous driving trajectory shifts attention away from the cooperative driving approach (paragraph 4.2).

Whereas the Ministry I&E plays an important role in coordinating the efforts towards cooperative driving in the Netherlands, the Amsterdam Group ensures that these efforts align with the efforts on a European level (paragraph 4.3). The socio-technical configuration surrounding cooperative driving in the Netherlands is therefore strongly embedded in Europe (paragraph 4.4). However as indicated in paragraph 4.2 all actors agreed that the Netherlands is not a producing state, implying that cooperative driving vehicles have to come from somewhere else. The stability of the cooperative driving trajectory could therefore hinder the implementation of non-cooperative systems. Given that the cooperative driving approach of the Netherlands has already gained a lot of momentum, as more and more projects are starting to align on both national (e.g. DITCM) and European (e.g. ITS corridor) levels, the cooperative driving trajectory has built up a lot of resilience towards disruptions from outside (paragraph 4.5).

The observed stability of the cooperative driving trajectory has two indirect implications for the elderly and chronically ill. On the one hand, if cooperative driving would be preferred by the elderly and chronically ill, it would imply that the cooperative driving trajectory is probably resilient enough to make this possible. On the other hand, if it turns out that cooperative driving is not preferred by the elderly and chronically ill, it would be difficult for another solution (e.g. autonomous driving) to break through the cooperative driving trajectory.

The main tension that is visible within the cooperative driving trajectory is the uncertainty between the market parties and road authorities. As indicated in paragraph 4.3, despite that there is a consensus that the role of the road authorities will shift more and more toward market parties; it is uncertain what the magnitude and time-scale of these changes will be. The cooperative driving trajectory could therefore potentially be slowed down by vested interests (e.g. investments made by road authorities) and/or lagging investments (e.g. infrastructural projects are costly and time-consuming). As indicated in paragraph 4.3 this tension is visible on both national as European levels.

Thus whereas the chicken and egg dilemmas between road authorities and market parties slow down the cooperative driving trajectory, the gradual shift of traffic management from road authorities to market parties implies that the elderly and chronically ill will be more and more served via in-car systems instead of road-side systems. As indicated in paragraph 4.4 this could potentially make the driving task more complicated as more and more information will be available inside the vehicle. Given that the elderly and chronically ill are currently not taken in account (paragraph 4.2) and that the added value of cooperative driving depends on the amount of connected objects (paragraph 4.6) this could imply that it will likely take quite a while before the cooperative driving trajectory will lead towards a solution for the elderly and chronically ill. Especially as people who are seriously constraint in their ability to drive (e.g. blind people) would have to rely on a high penetration of cooperative driving vehicles as well as a high level of automation (SAE level 4-5).

4.8.2 Gradually gaining momentum

Second, the cooperative driving trajectory is a gradual trajectory in which momentum is generated via gradually connecting more and more objects. The cooperative driving is therefore primarily driven by the expectations that consumers increasingly want to stay connected wherever and whenever they want to. As indicated in paragraph 4.6 all stakeholders therefore agreed that the deployment of cooperative systems should be market-driven instead of mandated. As indicated in paragraph 4.6 and 4.7 this more gradual approach makes the process manageable, enabling the actors to gradually learn from the implications the technology can have on society. Given the uncertainty surrounding the self-driving discourse and the potential chicken-and-egg dilemmas between public and private parties it is imaginable that the stakeholders opt for a more gradual approach. The main benefit of this gradual approach is that it enables regulators to develop legislations along the way, while at the same it provides potential users the time required to get acquainted with the technology. Due to this market driven approach the stakeholders expect that the first large-scale implementation of cooperative systems will be in the logistics sector

(Paragraph 4.6). Instead of the passenger vehicle, the stakeholders therefore consider truck-platooning as the main accelerator behind the cooperative driving trajectory of the Netherlands.

This gradual approach has a couple of indirect effects on the elderly and chronically ill. As indicated in paragraph 4.6 all stakeholders expect that the first large-scale implementation of self-driving vehicles will be via autonomous systems (paragraph 4.6). However, as indicated above this implies that these vehicles have to compete with the stable socio-technical configuration surrounding cooperative driving vehicles. On the other hand this implies that in case the elderly and chronically ill would prefer a cooperative driving solution, it would take longer before the elderly and chronically ill could actually benefit from the solution. First, as indicated in paragraph 4.6, the extent in the elderly and chronically ill can benefit from cooperative systems is determined by the degree of penetration. In other words, the higher the degree of penetration the less attentive the human driver has to be. Second, the benefit of self-driving for the elderly and chronically ill is also determined by the level of automation. In other words, the higher the level of automation the less attentive the human driver has to be. The stakeholders agree that the degree of automation as well as the degree of penetration will evolve gradually as there are a lot of regulatory (paragraph 4.7), technical (paragraph 2.1) and societal (paragraph 4.4) challenges that need to be overcome before the driver can actually benefit from high levels of automation. This is also the reason why most of the interviewed stakeholders expected that the first cooperative driving solutions for the elderly and chronically ill would emerge as low-speed vehicles which are only allowed on dedicated roads. However, this also implies that it will remain difficult for this solution to break-out of the niche as the capabilities of the solution depends on the number of cooperative systems the vehicle can communicate with. The socio-technical regime of person-driven vehicles will therefore remain dominant for a long period (paragraph 4.6).

4.8.3 Substituting entire socio-technical configurations

Third, as indicated in paragraph 4.4 to enable cooperative driving collaborations are required between public and private parties. These collaborations are, as indicated in paragraph 4.4, required as cooperative can have a large impact on the way transportation is currently fulfilled. As more and more objects get connected the lines between manufacturers, users, and even objects start to blur. New entrants and different business models will continue to emerge. In order to deal with these challenges the socio-technical configuration surrounding person-driven vehicles needs to be adjusted on a lot of elements. This implies that the transition from person-driven vehicles towards cooperative driving vehicles would not just imply replacing one technology (person-driven vehicles) for the other technology (cooperative driven vehicles). Instead it would imply that the entire socio-technical configuration surrounding person-driven vehicles should be changed, depending on the degree of automation. The transition towards cooperative driving would for instance require changes in culture (e.g. freedom to drive), the structure of the industry (e.g. new entrants), the maintenance model (e.g. preventive maintenance), the road infrastructure (e.g. ITS), the financial rules (e.g. manufactures that become liable), et cetera. However, this also implies that there are a lot more hurdles to be overcome in order to replace the socio-technical configuration surrounding person driven vehicles, with the socio-technical configuration surrounding cooperative driving vehicles.

As can be derived from paragraph 4.6 the cooperative driving trajectory is based on the increasing need of people to stay connected wherever and whenever they want to. Despite that it is questionable to what extend the elderly and chronically ill can actually benefit from this connectedness; it does imply that the entire socio-technical configuration surrounding person-driven vehicles would change. As indicated in paragraph 4.5 this transition would bring the user in a more central position as the lines between technology and society will continue to blur. This connectedness could therefore open up a lot of new business models. Given that the elderly and chronically form an interesting niche market (paragraph 2.3) this would imply that it is likely that there will be more and more services specifically directed towards the elderly and chronically ill. Thus even though a cooperative driving solution for the elderly and chronically ill seems something for the long-term (paragraph 4.2), the cooperative driving trajectory of the Netherlands seems to have the potential to actually involve this user group in the process.

5.

AUTONOMOUS DRIVING

5. Autonomous driving

As indicated in paragraph 2.1 autonomous driving is the belief that self-driving can be achieved via the implementation of autonomous technologies that do not rely on communication between vehicles (V2V) and between vehicles and road-side systems (V2I). To understand how the stakeholders shape the autonomous driving trajectory, this paragraph elaborates on how the expectations of the stakeholders (local level) are translated into the autonomous driving trajectory (global level). As indicated by Geels & Raven (2006, p.379) when expectations align between the different entities on a local level, these shared expectations will be translated into a technological trajectory. These technological trajectories in turn provide stability among actors regarding where technological development should be going (Geels & Raven, 2006, p. 378). Via investigating how local variety is translated into the autonomous driving trajectory some indirect and direct effects of the trajectory on the elderly and chronically ill were identified.

5.1 The autonomous driving trajectory

As can be derived paragraph 2.2 the most active entities in the field of autonomous driving in California are the DMV (regulator), PATH (advisor), Google (25 permits), Audi (2 permits), Mercedes-Benz (2 permits), Nissan (2 permits), Tesla (1 permit), Delphi Automotive (2 permits) and Bosch (2 permits). These entities all influence the autonomous driving trajectory in similar and/or different ways. After comparing the different annual reports (Audi, 2014; Daimler01, 2014; Delphi, 2014; Nissan, 2014; TeslaMotors, 2014), roadmaps (Becker et al., 2014; Dolgov, 2014; Chea, 2012) company blogs (Nissan01, n.d.; Urmson, 2013; Urmson, 2014; Urmson, 2015; Teslablog, 2014; Mercedes-Benz, 2015), websites (AudiUSA, n.d.; Bosch, n.d.; Delphi, n.d.; Google, n.d; Mercedes-Benz, n.d.; Nissan02, n.d.; Tesla, n.d.), video conferences (Medford, 2013; Elon Musk, 2014; Stanford, 2013; Connected Car Expo, 2014) and interviews (Interviewee 01; 02; 03; 04; 05; 06; 07; 08; 09; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19) from the stakeholders, the main dynamics underlying the autonomous driving approach were identified. Table 10 therefore represents an overview of 1) how the autonomous driving trajectory is legitimized, 2) how search efforts are guided towards autonomous driving, and 3) how the autonomous driving trajectory is coordinated.

Table 10: How actor expectations shape the autonomous driving trajectory (global level)

Three forces of expectations:	
1) Legitimize investments	
- Autonomous driving improves safety and comfort	
- Autonomous driving reduces congestion and emissions	
- The implementation of cooperative systems takes longer than autonomous systems	
- Self-driving provides opportunities for those who are constrained in their ability from A to B independently	
- Very little progress has been made in terms of V2V and V2I over the years	
- Infrastructural (ITS) investments are lagging behind.	
- Autonomous systems deal better with mixed traffic conditions	
2) Provide direction:	**Entity:**
- Gradually enhance autonomous capabilities (autopilot).	OEMs, Suppliers
- Main areas of focus: Parking (low speed), highways (high + low speed)	OEMs, Suppliers
- Driver is essential for the development of vehicles.	OEMs, Suppliers
- Selling autonomous capabilities as features (increasing sales revenue).	OEMs, Suppliers

-	Directly aim for fully autonomous vehicle (SAE level 4-5).	Google, Suppliers
-	Door to door solution (high + low speed)	Google, Suppliers
-	Driver should be taken out of the loop.	Google, Suppliers
-	Selling mobility as a service (increasing data generation).	Google, Suppliers
-	Remain agnostic	Suppliers
-	Focus on the brains of the vehicle (highest value proposition)	Suppliers, Google
-	Gradual develop legislation that contemplates the different philosophies (Google and OEMs) equally.	DMV
-	Autonomous driving should be embedded in the cooperative driving trajectory.	DMV
-	Investigate the hurdles for safe implementation	DMV
3)	**Coordinate efforts:**	
-	DMV → Facilitate autonomous driving (not hinder)	
-	DMV→ Develop regulations for testing on public roads	
-	DMV → Ensure safety	
-	OEMs → Almost all coordination occurs in-house (race = on)	
-	Google → Almost all coordination occurs in-house (race = on)	
-	Suppliers→ Almost all coordination occurs in-house (race = on)	

From table 10 already some interesting patterns can be identified. First, despite that there is a consensus (shared expectations) about why self-driving should be achieved via autonomous systems; there are some different philosophies about how these autonomous capabilities should be achieved. Whereas Google directly focusses on full automation, the OEMs take a more gradual approach via gradually enhancing their existing features. Second, the coordination of the OEMs, Google and suppliers mainly occurs in-house. As indicated in paragraph 2.2 this is mainly because there is a lot at stake for the automotive companies implying that there is a lot of secrecy and competition within the autonomous driving trajectory. The coordinating efforts of Google, the OEMs and the suppliers are therefore not represented in table 10, as due to this secrecy these are not translated into the autonomous trajectory (global level).

Based on the three forces of expectations framework, six patterns were identified which might have a direct (how the elderly and chronically ill are served by autonomous driving) and/or indirect (e.g. speed of implementation, stability of the technological trajectory) effect on the elderly and chronically ill.

1) Before the elderly and chronically ill should be allowed inside vehicles with autonomous capabilities the autonomous systems have to be proven safe.
2) V2V and V2I investments are lagging behind, implying that these would slow down the autonomous driving trajectory.
3) The OEMs aim to sell autonomous driving capabilities as features which users can buy to improve their safety and comfort.
4) Google aims to provide an A to B solution in which mobility will be provided as a service and the drivers do not longer have to stay attentive.
5) The Tier 1 suppliers aim to increase market share via staying agnostic, implying that the actual implementation of their autonomous systems have to come from their customers.
6) Regulators have to deal with vehicles with different self-driving capabilities, which in turn have a different effect on the elderly and chronically ill.

The following six paragraphs are dedicated to explain the different patterns as well as the specific consequences these can have on the elderly and chronically ill.

5.2 Safety first

As indicated in paragraph 2.2 California has a higher prominence in OEMs and a less intelligent infrastructure than the Netherlands. This might therefore explain why the autonomous driving trajectory of California is mainly driven by the industry. Whereas the government in the Netherlands takes a central role in the self-driving vehicle developments (paragraph 2.2), the government in California takes more of a facilitating role (Soriano et al., 2014; Interviewee 01; 02; 03; 12; 13). This facilitating role can be derived from a statement made by Governor Brown during the signing of Senator Bill 1298 at the headquarters of Google (SB1298, 2012)**;**

"Instead of standing in the way of technological development, the government can help and build the frameworks that facilitate and hopefully accelerate developments." ***~ Governor Edmund G. Brown Jr.***

Given that the autonomous driving trajectory is mainly driven by the industry, the autonomous driving efforts are mainly legitimized via referring to the potential benefits in terms of safety and comfort (Interviewee 01; 02; 03; 04; 05; 06; 07; 08; 09; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19). Whereas safety and comfort can be calculated into the purchasing price of the autonomous vehicles, collective benefits such as reducing traffic jams and emissions are more difficult to calculate in the purchasing price of the vehicle. This does not mean that these collective benefits are not used to legitimize the autonomous driving trajectory it means that these benefits are less prominently mentioned than the benefits in terms of safety and comfort.

Besides referring to the benefits in terms of safety and comfort, the autonomous driving trajectory is quite often legitimized via referring to the potential autonomous vehicles can have for the elderly and chronically ill (AudiUSA, n.d.; Bosch, n.d.; Delphi, n.d.; Google, n.d; Mercedes-Benz, n.d.; Nissan02, n.d.; Tesla, n.d). Statements derived from the main pages of the autonomous vehicle websites of Nissans (n.d.) and Google (n.d.) exemplify this observation;

"The technology could also greatly benefit elderly people and those with disabilities who otherwise could not drive by themselves." ***~ Nissan02 (n.d.)***

"Imagine if everyone could get around easily and safely, regardless of their ability to drive. Aging or visually impaired loved ones wouldn't have to give up their independence." ***~ Google (n.d.)***

However, from the annual reports (Audi, 2014; Daimler01, 2014; Delphi, 2014; Nissan, 2014; TeslaMotors, 2014), roadmaps (Becker et al., 2014; Dolgov, 2014; Chea, 2012) company blogs (Nissan01, n.d.; Urmson, 2013; Urmson, 2014; Urmson, 2015; Teslablog, 2014; Mercedes-Benz, 2015), websites (AudiUSA, n.d.; Bosch, n.d.; Delphi, n.d.; Google, n.d; Mercedes-Benz, n.d.; Nissan02, n.d.; Tesla, n.d.) and interviews (Interviewee 01; 02; 03; 04; 05; 06; 07; 08; 09; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19) all agree that in order to reach this goal, first a lot of safety challenges need to be overcome. Before elaborating further on the elderly and chronically ill it is therefore important to understand how the stakeholders deal with these challenges.

As becomes clear from the interviews (Interviewee 04; 05; 06; 07; 08; 09; 10; 11; 13; 14; 15; 16; 18; 19), the proponents of autonomous driving all legitimize their decisions via referring to the inability of humans when it comes to driving;

"90% of all accidents are caused by human error". ~ ***Interviewee 05***

This statement is often mentioned on the company websites (AudiUSA, n.d.; Bosch, n.d.; Delphi, n.d.; Google, n.d; Mercedes-Benz, n.d.; Nissan02, n.d.; Tesla, n.d.) and video conferences (Medford, 2013; Elon Musk, 2014; Stanford, 2013; Connected Car Expo, 2014) of the main stakeholders. The expectation is therefore mainly used to convince others (in particular those less familiar with the concept), about why a transition from person-driven vehicles towards self-driving vehicles is desired.

Whereas the industrial parties argue that self-driving vehicles improve safety via reducing the number of traffic accidents, the regulators take a more sceptic view (Interviewee 01; 02; 03; 12; 17);

"Given that an injury crash occurs every 64.400 hours this implies that the autonomous systems have to be extremely robust and reliable." ~ ***Interviewee 02***

All regulators therefore agree (Interviewee 01; 02; 03; 12; 17) that even though there are a lot of regulatory and societal hurdles to be overcome, first the technological challenges need to be overcome. This is also one of the reasons why the DMV closely collaborates with the Partners for Advanced Transportation Technology (PATH) program at UC Berkeley. To explain how the regulators look at autonomous driving, this study elaborates on a paper from the Shladover (2014) directed to the DMV.

As can be derived from the paper of Shladover (2014, p. 3) autonomous systems have to perform under all environmental conditions in which the user expects the system to be available (Shladover, 2014, p. 3).

- *Dealing with bad weather conditions*
- *Dealing with vehicles violating traffic laws*
- *Anticipating on human intentions*
- *Spotting negative obstacles*
- *Unpredicted events (truckload loss)*
- *Dealing with law enforcement vehicles*

To make it even more complicated Shaldover (2014, p. 2) refers to the trade-off autonomous systems have to make under all these environmental conditions;

"An automated vehicle's threat detection systems face a classic signal detection dilemma –they must detect all genuine threats (to save the vehicle from crashing) and reject virtually all non-threatening targets (to avoid spurious braking or crash avoidance maneuvers)." ~ ***Interviewee 02***

The latter is the reason why the regulators (Interviewee 01; 02; 03; 12; 17) all agree that in an ideal world cooperative driving would be preferred, as due to the ability of vehicles to communicate to each other, the systems no longer has to make assumptions about what other objects are going to do.

Thus whereas the regulators take a more skeptical view, the representatives of the industry all agree that the technology will get there. As frequently mentioned by the representatives of the industry during interviews (Interviewee 04; 05; 06; 07; 08; 09; 10; 11; 13; 14; 15; 16; 18; 19), the race is on, and those who get there first will determine what self-driving in the future would look like.

During the interviews it became clear that all stakeholders envision a similar implementation. This implementation can be exemplified via looking at the so-called six-sigma dilemma;

"In order for a system to be viable and usable in a public environment it has to be able to make the right decisions 99.9999 percent of the time." ***~ Interviewee 10***

Based on this challenge all stakeholders (Interviewee 01; 02; 03; 04; 05; 06; 07; 08; 09; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19) agree that the implementation on public roads will occur in four steps. The first implementation of vehicles with autonomous driving capabilities will be at low speed in structured traffic (e.g. traffic jam). The second implementation will be at low speeds in chaotic traffic (e.g. parking). The third implementation will be at high speed in structured traffic (e.g. highway). The fourth implementation will be at high speed in chaotic traffic (e.g. last mile). Whereas the first two scenarios are already visible, the third and fourth scenarios are still in an experimental stage (Soriano et al. 2013).

Looking at the expected order of implementation it becomes clear that the degree of impediments determines the waiting time for the elderly and chronically ill. Whereas people with a low degree of constrained can already be served via making a few driving tasks redundant (paragraph 2.3), the people with a high degree of impediments (e.g. blind people) would have to wait for a driving solution from A to B. As will be explained later on the way in which the elderly and chronically ill will be served by the different entities is therefore determined by the different strategies of the industrial parties (paragraph 5.3, 5.4 and 5.5) as well as to what extend the regulations allow these strategies (paragraph 5.6).

5.3 Infrastructural ignorance

Given the aim to explore to what extend the cooperative driving trajectory of the Netherlands and the autonomous driving trajectory of California lead towards a solution for the elderly and chronically ill, it is important to understand why the stakeholders underlying the autonomous driving approach chose not to communicate with other vehicles (V2V) and/or road-side systems (V2I). The reason why the stakeholders underlying the autonomous driving trajectory chose not to communicate is nicely described by one of the representatives of PATH (Interviewee 02);

"*The cooperative driving and autonomous driving pathway are not so much the result of a geographical difference, it is a difference in perspectives; the public perspective versus the automotive perspective. Even though the auto industry agreed to cooperate in certain fields, they prefer not to depend on others."* ***~ Interviewee 02***

As can be derived from the interviews (Interviewee 04; 05; 06; 07; 08; 09; 10; 11; 13; 14; 15; 16; 18; 19), blogs (Nissan01, n.d.; Urmson, 2013; Urmson, 2014; Urmson, 2015; Teslablog, 2014; Mercedes-Benz, 2015), and the video conferences (Nissan Newsroom01, 2014; ITS America, 2015; Elon Musk, 2014; CES, 2015; Connected Car Expo, 2014) of representatives of the industry, the decision to focus on autonomous vehicles is primarily based on the expectation that the implementation of V2V and V2I communications takes longer than autonomous vehicles. The following statements made during the different interview sessions provide a valuable indicator of the main arguments that the representatives of the automotive industry use to legitimize their decision for autonomous driving;

"We do not focus on V2V and/or V2I communications as this would slow our progress down." **~ *Interviewee 05***

"For the successful deployment of V2V and V2I a high penetration is required." **~ *Interviewee 09***

"Even when the federal government mandates car manufacturers to equip communication technologies in every automobile which is produced, it would still take till at least 2020 before passenger vehicles equipped with this technology will roll out of the assembly line." ~ ***Interviewee 12***

"The first large scale experiment of cooperative driving was already done in San Diego 1997. However, nothing much happened ever since." **~ *Interviewee 14***

"There will be mixed traffic for a long period, making communication a daunting process involving a lot of chicken and egg dilemma's" **~ *Interviewee 19***

First of all, the representatives of the automotive industry argue that autonomous driving will deliver a self-driving solution faster than cooperative driving vehicles (Interviewee 04; 05; 06; 07; 08; 09; 10; 11; 13; 14; 15; 16; 18; 19; ITS America, 2015; CES, 2015; Connected Car Expo 2014). The following claims made by representatives of Google (Interviewee 05) and Mercedes-Benz (Interviewee 09) exemplify how the representatives of the automotive industry legitimize their decision not to focus on cooperative driving.

"Cooperative driving sounds great for the long term. However looking at the short term it does not make sense. How can a vehicle communicate if there is nothing to communicate with?" **~ *Interviewee 9***

"The technologies are advancing so fast that it simply does not make sense to wait for regulators to be ready." **~ *Interviewee 5***

As can be derived from the statement made by the representative of Mercedes-Benz (Interviewee 09), the representatives of the automotive industry all agree that the first implementation of self-driving passenger vehicles will be via autonomous systems rather than cooperative systems (Interviewee 04; 05; 06; 07; 08; 09; 10; 11; 13; 14; 15; 16; 18; 19; ITS America, 2015; CES, 2015; Connected Car Expo 2014). This claim is imaginable given that the added value of cooperative vehicles strongly depends on the number of objects with which the vehicle can communicate (paragraph 2.1). Given that in order to reach a sufficient degree of penetration the car manufacturers need to collaborate with a multitude of public and private parties on multiple levels, potentially causing multiple chicken-and-egg dilemmas (paragraph 2.2); it is imaginable that the automotive companies have decided to develop their autonomous driving solutions independently. According to the stakeholders (Interviewee 04; 05; 06; 07; 08; 09; 10; 11; 13; 14; 15; 16; 18; 19) especially V2I communications are problematic as the ITS investments are lagging behind in

California. The latter is also confirmed by the organizations responsible for these investments (Interviewee 01; 02; 03; 04);

"In an ideal world the investments in the infrastructure for V2I as well as the investments in V2V will take place first so that autonomous vehicles could take advantage of that when they enter the roads." **~ *Interviewee 01***

This statement can be interpreted in two ways. On the one hand the DMV prefers the cooperative driving trajectory above the autonomous driving trajectory. On the other hand the DMV recognizes that investments to enable V2V and V2I are lagging behind. According to representatives of the (auto) industry (Interviewee 05; 06; 07; 08; 09; 14; 19) this implies that in order to enable V2I communications, they would have to wait for the government to invest in these systems. Given that infrastructural adjustments are expensive (Interviewee 12), take relatively long to implement (Interviewee 01; 12), and there is a lot of uncertainty whether communication should be provided via in-car systems and/or road-side systems (Interviewee 01; 02; 12), the stakeholders all agree that the autonomous driving trajectory will evolve faster than the cooperative driving trajectory.

Second, most of the representatives of the industry (Interviewee 05; 06; 07; 08; 09; 14; 19) argue that even if the government would take a pro-active role in terms of enabling cooperative driving, it would still take too long before a significant penetration can be achieved. The representatives of the (auto) industry therefore all expect that the superior sensors of autonomous vehicles will deal better with mixed traffic. All actors therefore agree that the first large-scale implementation of self-driving will be achieved via vehicles with autonomous capabilities. As can be derived from the official reports (Nissan, 2014; Daimler02, 2014; CARS, 2014; Audi, Audi 2014 Annual Report, 2014; Delphi, 2014) and websites from the most active OEMs (Nissan02, n.d.; Tesla, n.d.; Mercedes-Benz, n.d.; Volkswagen, n.d.; AudiUSA, n.d.), and suppliers (Bosch, n.d.; Delphi, n.d.), in California, this does not imply that the cooperative driving approach is ignored. Mercedes-Benz, Nissan, Volkswagen, Audi, Bosch and Delhi Automotive all have divided their search efforts towards self-driving in 1) autonomous driving and 2) cooperative driving. However, their majority of efforts are dedicated to autonomous driving as all expect that autonomous vehicles will be implemented on a large scale first. As can be derived from one of the statements made by a representative of Nissan (Interviewee 06), the automotive companies want to keep momentum going via making a lot of 'time-consuming' collaborations redundant.

"Negotiation processes with governments and other authorities would only slow technological process down. We cannot afford to lose competition due to these time-consuming processes" ~ **Interviewee 06**

Even though cooperative driving might provide benefits for the elderly and chronically ill in terms of information provision and other additional services (paragraph 2.3), the stakeholders underlying the autonomous driving trajectory have all indicated to neglect the cooperative driving trajectory. To understand how the autonomous driving trajectory will serve the elderly and chronically ill one therefore needs to look at to what extend the different strategies of the OEMs, Google, the suppliers and the regulators seem to lead towards a solution for the elderly and chronically ill.

5.4 OEMs go autopilot

As indicated in paragraph 2.1 California has a high prominence in OEMs. Whereas some OEMs have allocated their R&D activities on autonomous driving in Silicon Valley (e.g. Tesla Motors, Nissan, Mercedes-Benz, Volkswagen, Ford), others are mainly there to keep track about what is happening (e.g. BMW, Honda, General Motors, Hyundai). As indicated in paragraph 2.2 the most active OEMs in Silicon Valley include Tesla Motors, Nissan, Daimler (Mercedes-Benz) and Volkswagen (Audi), which all have attained permits from the DMV to test their autonomous driving prototypes on public roads.

From the interviews (Interviewee 06; 07; 08; 09), company websites (Nissan02, n.d; Tesla n.d.; Mercedes-Benz n.d.; Volkswagen, n.d.; AudiUSA, n.d.), company blogs (Nissan01, n.d.; Teslablog, 2014; Mercedes-Benz, 2015), company reports (Nissan, 2014; Capgemini, 2014; Daimler01, 2014; CARS, 2014; Audi, 2014) and video conferences (Nissan Newsroom01, 2014; Nissan Newsroom02, 2013; Elon Musk, 2014; CES, 2015) it becomes clear that the OEMs all have a similar philosophy towards autonomous driving. This philosophy can be derived from a statement made by one of the representatives of the DMV;

"The philosophy of the OEMs is that the driver is essential for the development of the vehicle. In other words; autonomous driving features should stimulate sales." ***~ Interviewee 01***

The strategy of the OEMs is therefore to enhance the driving experience via selling autonomous capabilities which enhance the safety and comfort of the human driver. This gradual approach can be explained by looking at some of the statements made by the CEO's and Board-members of Nissan (Stanford, 2013), Tesla Motors (Elon Musk, 2014), Audi (n.d.) and Mercedes-Benz (CES, 2015);

"Nissan's autonomous driving is aimed to provide customers an autonomous drive package that can assist and/or enhance driving. Though we might end up with a full autonomous vehicle this is not the original intention." ***~ Carlos Ghosn (CEO Nissan)***

"Our system is called 'Tesla Autopilot' because it is similar to the systems that pilots use to increase comfort and safety when conditions are clear" ***~ Elon Musk (CEO Tesla Motors)***

"Piloted driving is not a 'must', but rather something you 'can' select. Audi will never build robot cars, but instead will always put the driver in the focus of its decisions." ***~ Luca de Meo (Board member sales and marketing Audi)***

"We at Mercedes-Benz believe that the user will always remain the decision maker. That is true independence. There will simply always be occasions in which the driver wants to drive." ***~ Dieter Zetsche (Chairman Mercedes-Benz)***

From these statements already a couple of important patterns can be identified. First of all, the OEMs are all expecting that even in the far future the user will remain the main decision maker. As indicated by the interviewees (Interviewee 06; 07; 08; 09) this implies that under certain conditions (e.g. traffic jams, highways, and parking) the human driver gets the option to allow the vehicle to take over. This is one of the reasons why the representatives (Interviewee 06; 07; 08; 09) indicate that their autonomous vehicles will always possess a steering wheel. Hence, the implications for this decision are twofold. On the one hand the driver will always experience the freedom to drive whenever and wherever they want to. On the other hand, the ability to switch the autonomous driving mode(s) on and off implies that during the trip the human driver has to remain attentive. The latter implies that the autonomous vehicles of the OEMs can only be operated by human drivers which are capable to take over. Only when the vehicle will be capable to drive 'autonomously' the entire trip, the vehicle can be operated by people who due to certain circumstances are not capable and/or allowed to drive independently. As the OEMs aim to gradually increase the number of traffic situations in which the 'autopilot' can take over (Interviewee 06; 07; 08; 09), this implies that the elderly and chronically ill would have to wait for the OEMs to deliver a vehicle that possesses sufficient autonomous features to drive 'autonomously' during the entire trip.

As the OEMs belief that the human driver should always have the ability to turn the self-driving mode(s) on or off, the driver remains the main decision maker implying that there will always be scenario's in which the driver has to remain attentive (Interviewee 06; 07; 08; 09). As can be derived from the interviews (Interviewee 06; 07; 08; 09) via keeping the driver attentive the OEMs can avoid two major challenges. On the one hand a full autonomous vehicle (SAE-level 4-5) is technologically more difficult to develop given the amount of redundancy that is required (paragraph 5.2). On the other hand developing a full autonomous vehicle (SAE-level 4-5) would imply that the OEMs would have to deal with a lot of complicated liability issues (paragraph 5.7).

However, whereas in certain scenario's the system might take over the driving task entirely (e.g. parking), there are a lot of scenario's (e.g. highways, inner cities) in which the OEMs have the daunting task to keep the driver attentive. How challenging this can be becomes clear from some of the measures Mercedes, Nissan, Audi and Tesla have implemented to keep the driver attentive;

"The Mercedes S550 Distronic Cruise Control and Active Steering Assist require the driver to torque the steering wheel every 8 seconds." ***~ Mercedes-Benz (n.d.)***

"Nissan's Driver Attention Alert system analyzes the steering behavior of the driver in order to detect signs of inattention and drowsiness" ~ ***Nissan02 (n.d.)***

"The driver decides under predetermined conditions when to activate and deactivate the 'Autopilot' features." ***~ Interviewee 06***

"Once the traffic jam disperses or the end of the highway has been reached, the driver is prompted to take back control. If the driver fails to respond, the system safely brings the car to a standstill." ***~ Audi (n.d.)***

Thus whereas the OEMs avoid some of the liability challenges associated with vehicles that have "full autonomous" capabilities, they are equipped with the daunting task to keep the driver attentive. How challenging this can be can be derived from a statement made by one of the representative of Ford;

"A lot of technological efforts are required in order for the vehicle to make sense of its environment. However, it might be just as difficult to make sense of what the human driver is doing" ***~ Interviewee 19***

Second, the OEMs all expect that consumers still want to possess their own vehicles (Interviewee 06; 07; 08; 09). This expectation is of course in line with the core business of OEMs; selling vehicles. A statement made by a representative of Volkswagen (Interviewee 08) exemplifies this belief;

"Though Volkswagen believes that car sharing has a lot of potential, to enjoy the full package of all the benefits, people would still like to possess self-driving vehicles as their private and individual retreat on the road." ***~ Interviewee 08***

The OEMs (Interviewee 06; 07; 08; 09), legitimize this expectations via referring to the capability of self-driving vehicles to offer time and space, which is according to the representatives something many modern consumer electronics cannot offer. As can be derived the company websites (Nissan02, n.d; Tesla n.d.; Mercedes-Benz n.d.; Volkswagen, n.d.; AudiUSA, n.d.) and company blogs (Nissan01, n.d.; Teslablog, 2014; Mercedes-Benz, 2015) the OEMs aim to fulfill this need via marketing the autonomous capabilities as features that increase safety and comfort. The business model of the OEMs is therefore aimed to sell 'autonomous driving packages' to consumers. As indicated by the representatives of Nissan (Interviewee 07), Tesla (Interviewee 06), Audi (Interviewee 08) and Mercedes-Benz (Interviewee 09) there are differences between the packages in terms of functionality as well as level of automation. Roughly these packages can be divided into three categories. First there is the 'traffic-jam assist' which deals with structured traffic at low speeds. Second there is 'parking assist' which deals with chaotic traffic at low speed. Third, there is 'highway assist' which deals with structured traffic at high speed. The customer therefore gets the opportunity to choose from different packages to increase their safety and comfort (Interviewee 06; 07; 08; 09). Despite that this does sound like a strong business case in a world where everyone expects the number of passenger vehicles to decrease (Interviewee 01), it does raise some interesting difficulties. As can be derived from a statement of a representative of Mercedes-Benz (Interviewee 09), it still requires a lot of effort to convince consumers of the added value of autonomous features;

"Our database shows that despite that ADAS significantly improves safety and comfort, customers still prefer leather seats." ***~ Interviewee 09***

The expectation that consumers still want to own their vehicles is also translated into the design of the autonomous prototypes that are currently being tested in California. As can be derived from figure 5.1 the autonomous systems are all neatly hidden into the design of the original model.

Figure 13: Autonomous prototypes of the OEMs which are allowed on Californian public roads

This decision is mainly based on the expectation that the trend towards 'individualization' will continue (Nissan, 2014; Capgemini, 2014; Daimler01, 2014; CARS, 2014; Audi, 2014; Nissan Newsroom01, 2014; Nissan Newsroom02, 2013; Elon Musk, 2014; CES, 2015). A statement made by one of the representatives of Volkswagen clearly describes this decision;

"We will not position overly expensive LIDAR systems on top of our vehicles as we believe that customers prefer to use this space for other purposes such as a sunroof, ski-box or bicycle rack." ***~ Interviewee 08***

Instead of developing entirely different vehicles, the OEMs aim to position 'autonomous driving' in their existing technological trajectory. Even future visions, such as the Mercedes-Benz F015 concept car introduced at the Consumer Electronics Show, still look relatively similar to the vehicles that are currently on the road (Mercedes-Benz, n.d.; CES, 2015).

The decision of the OEMs to position their 'autonomous driving' efforts within their existing technological trajectory implies that the autonomous capabilities will evolve gradually. As indicated by a representative of Nissan (Interviewee 07), customer demand will determine how the autonomous capabilities will evolve. At the moment the majority of efforts are therefore focused on highways. As can be derived from the interviews (Interviewee 06; 07; 08; 09) and company blogs (Nissan01, n.d.; Teslablog, 2014; Mercedes-Benz, 2015) these efforts range from bumper to bumper traffic (level 2) to for instance lane changing (level 3). All the interviewed OEM's (Interviewee 06; 07; 08; 09; 14; 19) expect that the main benefits of autonomous driving for consumers will be on highways. This decision is legitimized by referring to the amount of time people spend in highway traffic (Interviewee 06; 07; 08; 09; 14; 19). As indicated by a representative of PATH (Interviewee 02), via focusing on highway traffic the OEMs avoid the complexity of inner-city traffic and the regulatory challenges that come with it.

"Highways are an easy environment as there is limited interaction with other vehicles and objects on the road" ***~ Interviewee 02***

Translated into the business model of the OEMs this implies that the first usage of 'autonomous driving features' by consumers will be in the form of an autopilot on highways, which will gradually be improved to encompass more and more traffic situations. First these systems will be visible in the luxury brands, such as Tesla, Mercedes-Benz and Audi, as their customers are willing to pay extra for these kind of features (Interviewee 06; 07; 08; 09; 14; 19). Later on these features will become visible in mass-market vehicles, such as the Nissan Leaf.

For the elderly and chronically ill the strategy of the OEMs has a multitude of implications. First of all, the business model of the OEMs is based on selling autonomous capabilities. This implies that the elderly and the chronically ill would have to buy options that could enhance their driving capabilities. Despite that certain options (e.g. park assist) will take the driver entirely out of the loop; most of these options require the driver to stay attentive. This implies that the approach undertaken by the OEMs mainly provides benefits for the elderly and chronically ill who are willing to pay for these extra options in order to enhance their driving capabilities. However, this also implies that these options are not sufficient for people who are seriously constrained in their ability to drive. These people would have to wait for the OEMs to deliver a vehicle that possesses sufficient features to drive 'autonomously' the entire trip.

Third, the decision to keep the driver attentive implies that the elderly and chronically would have remain liable in case the autonomous system fails. This can be problematic as for people who are seriously constraint in their ability to drive from A to B, the constraints that currently hinder them from driving, might hinder them from taking over the autonomous systems.

Fourth, the OEMs build on their existing knowledge and expertise via gradually enhancing the autonomous driving capabilities. This implies that the elderly and chronically ill who are seriously constrained in their ability to drive will have to wait for the OEMs to offer a door to door solution. This gradual approach would imply that the socio-technical configuration surrounding person-driven vehicles would remain similar. Despite that there will be different business models, the person-driven vehicles would gradually be replaced with vehicles that contain more and more autonomous capabilities. Given that the elderly and chronically ill are currently unserved in terms of transportation (paragraph 2.3) one could argue if it would not be better to change the existing system. Despite that the OEMs do put the user in the center of development, it is questionable to what extend the envisioned driver is constrained in its ability to drive. As indicated in paragraph 2.3 the majority of efforts are focused on a so-called 'rich middleclass'.

5.5 Google shoots for the moon

As indicated in paragraph 2.2 the launch of the 'Google Self-driving Car' project in 2009 generated a lot of media attention for self-driving vehicles. Not only could Google be considered a new entrant to the automotive industry, as can be derived from interviews (Interviewee 02; 05; 15), company blogs (Chea, 2012; Dolgov, 2014; Urmson, 2015; Urmson, 2014; Urmson, 2013) and video conferences (ITS America, 2015; Swisher, 2014; Medford, 2013; UC Berkeley Events, 2013), Google opts for a strategy different than the OEMs. Whereas the OEMs argue that the user should always remain the main decision maker (paragraph 5.4), Google aims to take the driver out of the loop. Instead of gradually enhancing the self-driving capabilities of the vehicle, Google directly aims for a full autonomous vehicle (SAE level 4-5). A statement made by the Head of Google Self-Driving Cars project Chris Urmson (2015) in one of his blogs on the 'Google self-driving car project' exemplifies how Google legitimizes this decision;

"Keeping a driver attentive might be even more difficult than taking the driver out of the equation." ***~ Chris Urmson (Head Google Self-Driving Car)***

Despite that it is more difficult to develop full autonomous vehicles (paragraph 5.1); it is only at this stage that the maximum benefits of self-driving vehicles become visible. As indicated by Google (n.d.) vehicles with SAE-level 4-5 capabilities take over all driving tasks of the human driver under all traffic conditions. Hence, this is also the only stage at which people, who due to certain circumstances cannot and/or are not allowed to drive from A to B independently, can drive independently. Whereas the OEMs consider this to be a long term potential (Interviewee 06; 07; 08; 09; 14; 19), Google specifically legitimizes their self-driving car project via referring to the potential full autonomous vehicles can have for these people. The latter can for instance be derived from a statement made at the website of the Google (n.d.) Self-Driving Car project and a statement made by Sergey Brin (Co-Founder Google) during a conference at UC Berkeley (UC Berkeley Events, 2013);

"What if it could be easier and safer for everyone to get around? Aging or visually impaired loved ones wouldn't have to give up their independence. ***Google (n.d.)***

"There are huge amounts of people that are seriously hampered in their ability to get around to the world, waiting for a solution to give them their freedom back" ***~ Sergey Brin (Co-founder Google Inc.)***

This more radical approach of Google seems to be in line with the so-called "moonshots" of which the Google Self-Driving Car project is part of. Moonshots refer to ambitious projects, aimed to address huge problems with radial solutions, with no prospect of near-term profitability (Google, n.d.). Via dedicating a lot of technological efforts and investments into these projects Google aims to open-up large unexplored markets, such as potentially the community that is currently unserved by transportation.

As indicated in paragraph 2.1 the added value of vehicles is continuously shifting from hardware to software. This implies that vehicles are getting closer and closer to the core business of Google; data mining (Google, n.d.). Given that Google does not have the experience of the OEMs it does make sense for Google to follow a different strategy (Interviewee 05);

"Whereas the OEM's already have a lot of technologies inside their vehicles which they can gradually improve, Google needs to start from scratch to reach full autonomous driving." ***~ Interviewee 05***

Thus instead of building on existing knowledge, Google starts their self-driving project from scratch. However, compared to the OEM's this also implies that Google can take another look at mobility (Interviewee 02; 05; 15). This different approach can already be identified from the design of their prototype vehicles. Whereas the self-driving features of the OEMs are almost invisible (figure 13), the prototypes of Google (figure 14) can easily be recognized via the 360 degree LIDAR system on top of the vehicles.

Figure 14**:** Google's low speed (left) and high speed (right) self-driving vehicles

Figure 14 also provides some more detailed insight into the current strategy of Google. As indicated by a representative of Google (Interviewee 05) the two types of vehicles are used for different purposes. Whereas the Lexus RX450h is primarily used to gather data on-highways, the self-designed prototype is mainly used to gather data off-highways. That the self-designed prototype is designed to gather data under more complex traffic situations (e.g. inner cities) can already be identified via some of its specifications. The vehicle has a top-speed of 25mph, is equipped with two feet of foam on the front, a flexible plastic windshield, and in the future outside airbags. As indicated by the representative of the DMV and PATH (interviewee 01; 02) these specifications are required to ensure that the data logging is done safely.

Thus whereas the OEMs focus on providing its customers the opportunity to ‘autopilot’ under certain conditions (paragraph 5.4), Google seems to envision a vehicle which could drive itself under all conditions. However, as indicated in paragraph 2.1, to make this possible the autonomous vehicles first need to gather a lot of data in order to recognize as many situations as possible. These two prototypes therefore do not necessarily represent how Google envisions autonomous driving, it represents what is required for Google to gather the data they consider necessary to develop their envisioned self-driving vehicles (Interviewee 05).

As indicated in paragraph 1.1 there have been a lot of rumors about what Google aims to achieve with its Self-Driving Car project. From the interviewees (Interviewee 02; 05; 15), company blogs (Chea, 2012; Dolgov, 2014; Urmson, 2015; Urmson, 2014; Urmson, 2013) and video conferences (ITS America, 2015; Swisher, 2014; Medford, 2013; UC Berkeley Events, 2013) it is possible to gain a better understanding of what Google is envisioning with its self-driving vehicle concept. Whereas the OEMs build on their existing technological trajectories, Google does not rely on a quick selling strategy. Given its strong financial position Google has the ability to wait and let users decide (Interviewee 15). This strategy can also be derived from a statement made by one of the representatives of Google;

“First the vehicle has to be safe enough to allow people in the car. Second, user experience will determine what the business model is going to look like”. ***~ Interviewee 05***

This implies that user experiences will determine what the Google car will look like, who will produce the car, whether their business model will be based on car-sharing, ride-sharing and/or car-ownership et cetera. The self-designed prototype therefore symbolizes how Google envisions what full autonomous driving could potentially look like. This vision can be derived from the similar expectations expressed by the representatives of the Google Self-Driving Car project during public events (ITS America, 2015; Swisher, 2014; Medford, 2013; UC Berkeley Events, 2013);

“Future cars will be shared and thus parking spots can be transformed to car parks.” ***~ Sergey Brin (Co-founder Google Inc.)***

For the very least she could just call the car (application) and say where she wants to go.” ~ ***Anthony Levandowski (Project Lead Google Self-Driving Car)***

“We at Google believe that self-driving will become electric as this is a better.” ***~ Chris Urmson (Head Google Self-Driving Car)***

Thus even though these visions might change based on user experience it becomes clear that Google has some long term visions that guide their project efforts. Translated into the elderly and chronically ill this vision seems to guide search efforts towards a door to door solution in which the vehicle will be provided as a service. As indicated by a representative of Google, this is the main business model Google is currently exploring (Interviewee 05).

Given the in paragraph 5.1 mentioned technical, regulatory, and societal challenges that need to be overcome, many representatives (Interviewee 02; 07; 09; 12; 13; 14; 16; 17; 18; 19) consider the project too risky. As stated by one of the representatives of PATH (Interviewee 02);

"*The Google car is called 'Deaf, Dum and Blind' as it doesn't listen to anyone, doesn't talk to anyone and there will be cases in which it simply does not see everything."* ***~ Interviewee 02***

However, if one takes a look at the core business of Google as well as their vision of the Google Self-Driving Car, it becomes clear that the project might not be as risky as many consider the project to be. First of all, Google is a data company and as indicated in paragraph 2.1 vehicles generate lots of data. Thus even though the project might not work out, there is still a lot of data generated which Google could use (for other purposes). Second, suppose Google will not be capable and/or allowed to deliver an A to B solution, it would still have a transportation solution (low speed / car sharing) for private properties (e.g. campuses). Instead of the relatively inflexible people movers visible on for instance airports, the Google cars could be re-routed and adjusted according to demands. Given that Google (n.d.) is a data company and does already develop its own algorithms to coordinate its own vehicle fleets, this a solution Google could deliver. As indicated by a representative of Google (interviewee 05) this is one of the reasons why Google will first implement their vehicle at their own campus. Not only does this provide an environment where testing is allowed, in case something does occur, it will probably involve Google-minded employees.

The strategy of Google has a multitude of implications for the elderly and chronically ill. First of all, Google specifically targets the elderly and chronically ill as a (future) niche market. Instead of gradually building on their existing knowledge and expertise (as the OEMs), Google has decided to build their prototype from the ground up. Especially as Google states that the user experiences will determine their eventual business case, the elderly and chronically ill will be taken more in account than with the gradual approach undertaken by the OEMs.

Second, whereas the OEMs want to offer autonomous capabilities under certain condition (e.g. highways, parking) during the trip, Google focusses on a door to door solution. A door to door solution opens up opportunities for everyone who is somehow constrained in their ability to drive. This implies that the driver no longer has to stay attentive and/or has to switch between different modes of transportation (paragraph 2.3). Even if Google would not be able to deliver an autonomous system that performs under all conditions, their strategy still seems to evolve towards a last mile solution, which might benefit the elderly and chronically ill.

Third, as indicated above, Google aims to take the driver entirely out of the loop. Despite that this does lead to the highest benefits in terms of self-driving, it does also raise some liability issues. Whereas in the traditional model the driver is attentive, at high levels of automation (SAE level 4-5) the autonomous system becomes liable. Instead of selling vehicles and/or options, Google therefore seems to envision a business model in which mobility is provided as a service. For the elderly and chronically ill this would imply that they no longer have to worry about the activities that normally come with car ownership (e.g. maintenance). This kind of mobility would therefore significantly reduce the complexity of driving as well as of car ownership.

Fourth, given that the strategy of Google raises some questions regarding liability, car-ownership, insurance, et cetera that go beyond the rules of the socio-technical regime of person-driven vehicles, this implies that in order for the 'Google Car' to emerge, the Google Car has to compete with the socio-technical configuration of person-driven vehicles on multiple levels. This implies that compared to the gradual strategy of the OEMs in which a technology is substituted for another, Google will face more resistance from the socio-technical regime of person-driven vehicles. Thus even though the Google Car seems more beneficial for the elderly and chronically ill, for the vehicle to emerge a lot of socio-technical hurdles need to be overcome.

5.6 From Tier 1 to Tier 0 supplier

As indicated in paragraph 2.2 there are two tier 1 suppliers that are especially active in the field of autonomous driving in California; Delphi Automotive and Bosch. Whereas the OEMs and Google focus on developing self-driving vehicles (be it for other purposes), the suppliers show a different strategy. Instead of developing their own self-driving vehicles, the Tier 1 suppliers seem to move towards what they specify as Tier 0 suppliers (Interviewee 10; 11). Whereas a tier 1 supplier refers to suppliers that deliver directly to the OEMs, a Tier 0 supplier refers to a supplier that can add more value to the car than the car manufacturer itself. As can be derived from statements made by the representatives of Delphi Automotive (Interviewee 10) and Bosch (Interviewee 11), this decision was primarily legitimized on the expectation that the value proposition will continue to change;

"As the added value of vehicles will continue to shift from hardware to software, those who possess the brains of the vehicle will have the highest value proposition." ***~ Interviewee 10***

"The value of vehicles will reside in software, and the extent in which the software is capable to control as many components of the vehicle as possible." ***~ Interviewee 11***

Thus instead of developing their own self-driving vehicles Delphi Automotive and Bosch aim to stay agnostic and via that way increase their market share (Bosch, n.d.; Delphi, n.d.). This decision can also be derived from the company reports of Bosch (Becker et al., 2014) and Delphi Automotive (Delphi, 2014) in which both the 'full autonomous' as the 'driver assistance' pathway are mentioned as desirable directions for future development. Thus whereas the OEMs (paragraph 5.4) and Google (paragraph 5.5) legitimize their chosen strategies via referring to the drawbacks of their competitors strategies, Bosch and Delphi Automotive prefer not to choose sides. Instead as indicated by a representative of Delphi Automotive, the suppliers aim to develop the building blocks on which the OEMs can develop their vehicles (Connected Car, 2014);

"At Delphi we are dedicated to create the 'building blocks' for an automated future with zero accidents."
~ John Absmeier (Director Delphi Labs @ Silicon Valley

This strategy can also be derived from the different set-ups that are used for the, in this case, prototypes of Bosch. As can be derived from figure 15 the BMW 325D is equipped with a LIDAR system such as the in figure 14 visualized prototypes of Google. The Tesla model S on the other hand is in line with the vision of the OEM's (figure 13) equipped with almost invisible autonomous technologies.

Figure 15: BMW 325D (left) and Tesla Model S (right) autonomous prototypes of Bosch

The decision of the suppliers to remain agnostic implies that the actual implementation of their systems will have to come from the car manufacturers. To what extend the systems of Delphi Automotive and Bosch will serve the elderly and chronically ill, is therefore determined by the strategy of the car manufactures (Interviewee 10; 11). Both the representative of Delhi Automotive (Interviewee 10) and Bosch (Interviewee 11) indicated that they do work on systems that could benefit the elderly and chronically ill. However, to what extend these systems are developed for the OEMs and/or Google, and the degree to which these systems comply with the elderly and the chronically ill is kept secret.

5.7 Dealing with different capabilities

On September 25, 2012, Governor Edmund G. Brown Jr. signed Senate Bill (SB) 1298, which authorized the Department of Motor Vehicles (DMV) to develop standards and regulations that governs the licensing, bonding, testing and operation of autonomous vehicle technology before January 2015(Soriano et al. 2014, p. 15). As indicated in paragraph 2.1 SB 1298 was signed at the headquarters of Google after a short drive of Senator Padilla and Governor Brown in one of Google's self-driving cars. As can be derived from statements made by Governor Brown and Senator Padilla during the signing ceremony (SB1298, 2012), the signing of SB 1298 was legitimized via the expectation that self-driving vehicles can deliver a lot of public and economic benefits to California;

"The spirit of supercharging the economy and culture in California continue. This is the place where new ideas, risk and imagination come together to build the future." ~ ***Governor Brown***

"Self-driving is a legislative hat trick: We can save lives, create jobs and reduce congestion and emission in the process." ***~ Senator Padilla***

Despite that the autonomous trajectory seems to diverge from the, by the government, preferred cooperative driving trajectory (paragraph 5.2) the government does not want to hinder technological development. As indicated in paragraph 2.2 this might explain why the government in California takes a more facilitating role. Thus even though for the government it might be more beneficial to slow the autonomous driving trajectory down, enabling V2V and/or V2I investments to catch-up, the government wants to facilitate the autonomous driving trajectory. The latter becomes for instance clear from two statements made by Governor Brown Jr. and Senator Padilla during the signing of SB1298 (2012);

"When you are designing something new and you need to move forward, facing a lot of obstacles, you cannot make it if you are operating on instructions of the past. You need to envision something new." ***~ Governor Brown***

"Public Policy is not about staying ahead of technology, it is about keeping up with it. Think of the stop sign which was only introduced 12 years after the first automobile entered the road." ***~ Senator Padilla***

Thus, the DMV is equipped with the challenge to keep the autonomous approach aligned with the governmental ambitions in terms of cooperative driving, while at the same time ensuring that legislations not hinder the potential of the autonomous driving trajectory (Interviewee 01; 02; Soriano et al., 2014, p. 15).

To make this even more challenging the DMV has to deal with a lot of trade-offs. First, as indicated in paragraph 5.4 and paragraph 5.5 there seem to be two approaches towards autonomous driving. One is a more gradual approach in which the driver has to remain attentive (OEMs) the other is based on the premise that the driver should be taken out of the loop (Google). As can be derived from a statement made by a representative of the DMV (Interviewee 01), the DMV has to approach both philosophies equally;

"DMV recognizes these two philosophies and therefore is challenged to develop laws that contemplate these two philosophies on equal terms." ***~ Interviewee 01***

Second, these different approaches come with different business models which might have different implications on society. Whereas some parties focus on selling vehicles, and thus increase the impact of vehicles on roads, others seem to provide mobility as a service (e.g. ride-sharing, car-sharing) (Interviewee 01; 02; 13; 15).

Third, as indicated in paragraph 5.4 and 5.5 these different philosophies also have different implications for the area of implementation the different entities might envision. Whereas some dedicate their majority of efforts on highways, others mainly focus on inner cities (Interviewee 01).

Fourth, there might be differences between the user groups the different stakeholders might envision for their autonomous vehicles. Whereas some manufacturers focus on the mass market, the luxury market, and/or the after-market, others focus on specific niche markets, such as the elderly and chronically ill (Interviewee 01).

All these differences influence the way in which the technology will interact with society, and thus the regulatory adjustments that are required to deal with changes that are considered desired or undesirable. Given the ambition of the autonomous vehicle developers to deploy their first self-driving vehicles around 2018 – 2020, the DMV has to make these complex regulatory decisions under a lot of time pressure (interviewee 01). Based on this observation it is imaginable why the DMV opts for a more gradual approach in which legislations will be deployed in small steps;

"We want to take small steps in terms of testing and the role out of the technology. Not only does this make the process more manageable for us, it also enables society to gradually get adjusted to the technology." ~ ***Interviewee 01***

This gradual approach as well as the involved complexity of the decision making process might therefore explain why the DMV did not meet the January 2015 deadline of SB 1298. To understand to what extend regulations might lead towards a solution for the elderly and chronically ill, one needs to look at how the DMV currently deals with the autonomous driving trajectory.

As can be derived from the official website of the DMV CA (n.d.) and the paper of Soriano et al. (2014) the current legislation only allows autonomous vehicles on public roadways in which a human driver is seated capable of taking over in case the autonomous system might fail. As stated under Vehicle Code 38750, which became effective in May 19, 2014, motor vehicles with an autonomous mode may only be operated by an 'autonomous vehicle test driver' (DMV CA, n.d.);

An "Autonomous vehicle test driver" refers to a natural person seated in the driver's seat of an autonomous vehicle, whether the vehicle is in autonomous or conventional mode, who possesses the proper class of license for type of vehicle being driven or operated, and is capable of taking over active physical control of the vehicle at any time." ~ ***#227.02***

As can be derived from this statement, the driver acts as a sort of 'back-up' in case the autonomous technology might fail. In order for the human driver to take over, the vehicle must thus possess a steering wheel and pedals. The self-designed prototype of Google (figure 14) which was originally designed with no steering wheel and pedals is therefore not allowed on public-roads (Interviewee 01). This is also the reason why Google has now equipped some of its prototypes with a steering wheel and pedals in order to test on public roads (Interviewee 05). In line with the expectation that self-driving capabilities should be deployed gradually, the current legislation is therefore more in line with the approach of the OEM's than with Google. The latter is imaginable as the approach undertaken by the OEMs would require less regulatory adjustments than the approach undertaken by Google. Moreover, the more gradual approach of the OEMs could also provide the government more time to catch-up with their cooperative driving efforts.

As can be derived from Vehicle Code 38750 section 227.04 potential users are currently not allowed to operate an autonomous vehicle;

"The vehicle is operated by an autonomous vehicle test driver who is an employee, contractor, or designee of the manufacturer, who has been certified by the manufacturer to the department as competent to operate the vehicle and has been authorized by the manufacturer to operate the vehicle." ~ ***#227.04***

The representatives of the DMV expect that this scenario will hold for quite a while as there are still some regulatory and technological hurdles to be overcome (Interviewee 01; 02). The latter can also be derived from Vehicle Code 38750 section 227.24 which specifies that before manufacturers can attain a testing permit, the autonomous vehicle has to be tested under controlled conditions as close as possible to the real world conditions the manufacturer aims to achieve on public roads. This is also why the first tests with users are currently being undertaken on private property (e.g. Googleplex, privately owned test-tracks) and/or on dedicated test-tracks (e.g. Gomentum station). Given the complex liability issues and to avoid less knowledgeable parties to test on public roads it was chosen that the manufacturer has to be able to respond to a judgement for damages for personal injury, death, or property damage in the amount of 5.000.000 dollars in order to attain a testing permit.

Despite that the regulators (Interviewee 01; 02; 03; 12; 13) do recognize the potential of autonomous vehicles to serve the elderly and chronically ill, there is a lot of skepticism whether this should be achieved via full autonomous vehicles (paragraph 5.2). Thus despite that the DMV aims to contemplate between the approach undertaken by the OEMs and Google on equal terms, the DMV seems to favor a gradual approach which aligns with the in their eyes preferred cooperative driving trajectory. As indicated above this does make sense given the uncertainty about where technological development is going as well as the ambition to embed the autonomous approach into the cooperative driving approach. However, this also implies that the strategy undertaken by the DMV aligns better with the gradual approach of the OEMs. The more radical approach of Google therefore has to deal with more resistance from the regulators. As indicated in paragraph 2.2 this might also be the reason why Google is actively lobbying at the Californian government.

Given that the DMV envisions the autonomous technology to evolve via gradually connecting more and more autonomous features together, it seems that a door to door solution for the elderly and chronically ill seems relatively far away. Thus even though the approach undertaken by Google seems to meet the needs of the elderly and chronically ill better and faster than the strategy of the OEMs, this strategy would have to deal with more regulatory challenges.

5.8 Conclusion

As indicated in paragraph 3.2 the core principle underlying Strategic Niche Management is that novelties emerge in niches (e.g. autonomous driving) which need to be shielded, nurtured and empowered in order to compete with the dominant socio-technical regime (e.g. person-driven vehicles) and/or other niches (e.g. cooperative driving). To understand what autonomous driving in California would look like for the elderly and chronically ill one therefore needs to look at how the different actor expectations (table 10) are translated into the autonomous driving trajectory, and how these expectations create stability.

5.8.1 Stability via redundancy

First of all, it becomes clear that the stakeholders create stability via shielding the undertaken autonomous efforts from other entities. As indicated in paragraph 5.1 this can largely be attributed to the competition between the different entities. Instead of collaborating, most of the search and coordination efforts therefore occur in-house. This does not imply that there are no collaborations at all, or if there are no shared visions, it means that the majority of the coordination and R&D efforts are shielded from other entities. In order to keep momentum going, all the producing entities agree that their autonomous systems should be developed as independently as possible (paragraph 5.2). As indicated in paragraph 5.2 this is the reason why all the industrial entities agreed not to focus on V2V and/or V2I communications. According to them cooperative driving would require a lot of collaborations with a multitude of public and private parties on multiple levels, slowing the technological development down. The latter is imaginable giving the amount of competition that can be observed between the different industrial entities (paragraph 2.2). Thus even though the autonomous driving trajectory diverges from the vision of the regulators (paragraph

5.6) it does provide stability for the different industrial entities. However, given the ambition of the DMV to embed the autonomous driving trajectory into the cooperative driving trajectory, the autonomous driving trajectory does seem open for cooperative driving solutions. Thus even though there is a lot of momentum behind the autonomous driving approach, stability strongly depends on how the regulators facilitate the trajectory.

The observed way in which the actors create stability has two indirect implications for the elderly and chronically ill. First of all, the decision that there is less collaboration between the different entities implies that every entity could potentially follow a different strategy. As can be derived from paragraph 5.4 and 5.5 some differences can be observed in terms of the envisioned target market, the area of implementation and the way in which mobility is provided. This would imply that a multitude of options will emerge which might serve the elderly and chronically ill in different ways. Second, the created stability implies that there is a clear vision towards where technological development should be going. There are no tensions between different entities (e.g. road authorities, service providers) implying that the different entities can independently keep momentum going. For the elderly and chronically ill this implies that it can be assumed that vehicles with autonomous capabilities will emerge on public roads before vehicles with cooperative vehicles. However, as indicated in paragraph 5.6, the implementation of autonomous vehicles strongly depends on how the DMV aims to facilitate this trajectory.

5.8.2 Two approaches to gain momentum

Second, as indicated in paragraph 5.4 and 5.5 two philosophies can be observed within the autonomous driving trajectory. The first philosophy, which is shared among the OEMs and their associated suppliers, is that the human driver is the final decision maker. As indicated in paragraph 5.3 this strategy has a multitude of implications for the elderly and chronically ill. First of all, the OEMs will gradually connect more and more of the autonomous features of the vehicle. For the elderly and chronically ill which are seriously constraint in their ability to drive from A to B, this implies that they would have to wait until the vehicle is capable to drive itself the entire trip. For the elderly and chronically ill with a low level of impediments one could question if the autonomous features that these people can buy outweigh the hassles of staying attentive. Second, the decision of the OEMs to keep the driver attentive implies that the elderly and chronically would be liable in case the autonomous system might fails. This can be problematic as for people who are seriously constraint in their ability to drive from A to B, the constraints that currently hinder them from driving, might also hinder them from taking over the autonomous systems. Third, the first large-scale implementation of vehicles with autonomous capabilities is expected in the luxury segment. The decision of the OEMs to build on their existing expertise and knowledge implies that the trajectory is mainly driven with the ‘rich middle class’ in mind, rather than the elderly and chronically ill. Despite recognizing that there might be other autonomous driving strategies visible within California, the majority of strategies only seem to lead towards a solution for the elderly and chronically ill at a very late stage of the technological developments.

The second philosophy is based on the belief that autonomous driving should be achieved via taking the driver out of the loop (paragraph 5.5). This strategy, which is undertaken by Google, has a multitude of implications for the elderly and chronically ill. First of all, Google specifically targets the elderly and chronically ill with their self-driving car project. Given that the vehicle is built from the ground up and that the eventually business model will be based on user experiences, one can assume that the elderly and chronically ill will likely be more taken into account than with the approach undertaken by the OEMs. Second, Google takes full autonomous driving as a starting position, gradually increasing the number of miles that the vehicle can drive itself. This seems to meet the needs of the elderly and chronically ill better than the strategy of the OEMs as they no longer have to remain attentive. Only in this scenario people who due to certain circumstances are not allowed and/or capable to drive from A to B independently, can drive independently. Third, Google will likely provide mobility as a service implying that the elderly and chronically ill would no longer have to deal with the issues that normally come with car ownership (e.g. maintenance). Fourth, the approach undertaken by Google would imply that the autonomous system becomes liable instead of the human driver.

5.8.3 Substituting technologies

Third, the full autonomous approach undertaken by Google requires more changes in the current socio-technical configuration surrounding person-driven vehicles than the more gradual approach undertaken by the OEMs. This implies that even though the approach undertaken by Google might be more beneficial for the elderly and chronically ill, the approach will likely face more resistance from the actors of the current dominant socio-technical regime of person-driven vehicles than the strategy of the OEMs. Looking at legislation one can already observe that despite that the DMV aims to contemplate between both philosophies equally, their strategy seems to favor the more gradual approach of the OEMs. However, as indicated in paragraph 5.5, the Google self-driving car project is part of their 'moonshot program' implying that Google, also because of their strong financial position, can afford to wait. Thus instead of collaborating with multiple entities on multiple levels, Google seems to keep momentum going via making a lot of these collaborations redundant (technology push). Thus even though the approach undertaken by Google would require more changes in the socio-technical configuration surrounding person-driven vehicles than the approach undertaken by the OEMs, it does seem to lead towards a better and faster solution for the elderly and chronically ill.

6.

CONCLUSION & REFLECTION

6. Conclusion & reflection

The first chapter of this study posed the research question as well as the goals for this study. In this chapter the gained insights in how actor expectations shape the cooperative driving trajectory of the Netherlands and the autonomous driving trajectory of California, as well as two what extend these trajectories lead towards a self-driving solution for the elderly and chronically ill, is discussed. The first paragraph answers the research question via bringing the different findings together and providing a reflection on them. The second paragraph provides a theoretical reflection in which a critical view is taken on the implications and limitations of the theoretical framework in relation to the research question. The third paragraph provides a managerial reflection in which implications of the findings are discussed in relation to the Consulate General of the Netherlands, and in particular the Coast to Coast E-Mobility Connection.

6.1 Research question

Q1: How do actor expectations shape the cooperative driving trajectory undertaken in the Netherlands?
Q2: How do actor expectations shape the autonomous driving trajectory undertaken in California?

As became clear from chapter 4 (table 9) and chapter 5 (table 10) there are different expectations (local level) underlying both technological trajectories. The degree to which these expectations are shared among the different actors determines the stability of the trajectories (global level). Via comparing how the different actors 1) legitimize, 2) coordinate and 3) guide their respective technological trajectories differences in how these expectations were translated into the technological trajectory were observed.

First, whereas the cooperative driving approach of the Netherlands is mainly legitimized via referring to the expected higher public benefits in terms of safety, reachability and livability, the autonomous driving approach of California is mainly legitimized via referring to the expected benefits in terms of safety and comfort. This difference can be explained via looking at the context in which these expectations were expressed as well as the way in which the different actors are organized. Whereas the cooperative driving trajectory is mainly driven by the government (public benefits), the autonomous driving trajectory is mainly driven by the industry (profit). The latter is imaginable as whereas the Netherlands has a more intelligent infrastructure, California has a higher prominence in OEMs. Thus, whereas in California the focus is on selling self-driving vehicles (push strategy); the focus in the Netherlands is more on using these vehicles to harness the public and economic benefits (market pull).

Second, whereas the cooperative driving trajectory of the Netherlands is coordinated via the expectation that the public and economic benefits should be harnessed via collaborations, the autonomous driving trajectory is coordinated via the expectation that self-driving can be achieved without 'excessive' collaborations. This difference can be explained via looking at the context in which these expectations were expressed as well as the way in which the different actors are organized. Whereas cooperative driving requires collaborations between multiple public and private parties, autonomous driving can be achieved rather independently. Thus whereas the cooperative driving trajectory is coordinated via public-private collaborations on multiple levels, the autonomous driving trajectory is mainly coordinated by the different industrial entities in-house (secrecy). The latter is imaginable as there is a lot of competition between the different entities.

Third, whereas in the Netherlands cooperative driving efforts are directed towards a gradual (market driven) implementation in which more and more cooperative systems will be connected, the autonomous driving efforts are mainly directed towards a gradual implementation in which the number of occasions where the vehicle can drive itself increases. In the Netherlands the benefits of self-driving vehicles therefore depend on the penetration of cooperative systems in society. In California the benefits of self-driving vehicles depends on the occasions in which the vehicle can drive autonomously. Whereas in the Netherlands the search and development efforts are mainly directed towards positioning the Netherlands as an international test-bed for self-driving vehicles (using-country), in California the search and development efforts are mainly directed towards increasing the autonomous capabilities that need to be achieved under certain conditions (producing state).

These shared expectations create stability via guiding technological development in a direction the actors consider worthwhile. However, as indicated in chapter 4 and chapter 5 this does not mean that there is no variety at the local level. Looking within the technological trajectory it becomes clear that there are different beliefs towards how cooperative driving or autonomous driving should be achieved.

First, whereas in the Netherlands a tension can be observed between the road authorities and market parties regarding to what extend cooperative driving should be achieved via V2V communications and/or V2I communications, in California a tension between Google and the OEMs can be observed regarding whether the driver should remain attentive (OEMs) or should be taken out of the loop (Google). The tension in the Netherlands is mainly driven by the expectation that more and more information will be provided via in-car systems rather than road-side systems. Given the vested interests in road-side systems (e.g. investments in ITS) and the uncertainty to what extend these systems will become redundant there is a tension between market parties and road authorities on multiple levels (national and European). The tension between Google and the OEMs is mainly driven by two expectations. On the one hand the OEMs expect that the driver will always remain the main decision maker, implying that the driver has to remain attentive. On the other hand Google expects that the driver should be taken out of the loop. As indicated in paragraph 5.8 these different philosophies imply that the different entities follow different strategies to meet the needs of their potential customers.

Second, whereas in the Netherlands a consensus between public-private parties can be observed regarding the implementation of cooperative driving solutions, in California there seems to be a tension between the DMV and the industry regarding the implementation of autonomous driving. As indicated in paragraph 5.7 this tension is mainly driven by the expectation of the DMV that in an ideal world autonomous driving vehicles would make use of already installed V2V and/or V2I communications. The DMV therefore aims to embed the autonomous driving trajectory into the cooperative driving trajectory. The industry on the other hand expects that the required V2V and/or V2I installations will not be ready. Given that there is a lot of competition it is imaginable that the industrial parties choose not to wait and focus specifically on autonomous driving. Thus whereas the DMV aims to collaborate with the industry, the industry aims to keep momentum going via keeping the knowledge and innovations in-house.

All in all, it becomes clear that expectations play an important role in shaping the cooperative and autonomous driving trajectories. Not only are there different expectations underlying the two technological trajectories, there is also a difference in the degree in which the expectations are shared among the different entities. The different ways in which the expectations are 1) legitimized, 2) coordinated and 3) directed therefore have different implications for the stability, direction and speed of the different technological trajectory, as well as to what extend these trajectories might lead towards a solution for the elderly and chronically ill.

Q3: How do the cooperative driving approach of the Netherlands and the autonomous driving approach of California lead towards a self-driving solution for the elderly and chronically ill?

As can be derived from paragraph 2.3 the higher the level of automation, the higher the benefits for the elderly and chronically ill. This also implies that the higher the level of automation, the larger the potential target group of elderly and chronically ill. The speed, direction and stability of the technological trajectory therefore all influence the implementation of a self-driving solution for the elderly and chronically ill.

First of all, despite that all stakeholders agree that self-driving vehicles have the potential to serve the elderly and chronically ill, this user group is currently not taken in account. All actors indicated that first a lot of technological, regulatory and societal challenges need to be overcome. Both in California and the Netherlands the actors therefore expect that self-driving vehicles for the elderly and chronically ill is something for the long term. However, it is important to mention that Google seems to target this user group with their full autonomous vehicles (moonshot).

Second, whereas the benefits of the cooperative driving depend on the level of automation as well as the number of vehicles (V2V) and/or road-side systems (V2I) to communicate with, the benefits of autonomous driving solely depend on the level of automation. Whereas the stakeholders underlying the cooperative driving trajectory expect the first benefits to be in truck-platooning, California takes the passenger vehicle as the accelerator. This in combination with the chicken-and-egg dilemmas between public and private parties within the cooperative driving trajectory, implies that the autonomous driving trajectory will lead towards a solution for the elderly and chronically ill earlier than the cooperative driving trajectory.

Third, whereas cooperative driving offers a better match between the generated data and the needs of the user (e.g. rush safely through traffic flow in case of an emergency); autonomous driving offers higher self-driving capabilities as the vehicle is equipped with more advanced sensors. Thus whereas the cooperative driving trajectory evolves faster towards providing more and more additional services, the autonomous trajectory evolves faster towards reducing the complexity of the driving task. The amount of information and the way in which the information is provided (in-car and/or road-side systems) therefore influences the elderly and chronically ill. Taken in account that both the elderly and chronically ill might experience difficulties in dividing attention between different tasks under time pressure, the autonomous driving seems to benefit the elderly and chronically ill before the cooperative driving trajectory.

Fourth, whereas Google aims to deliver a door-to-door solution via taking the driver out of the loop, the OEMs opt for a more gradual approach in which the driver has to remain attentive. The decision of Google to build the vehicle from the ground up, and let user experiences decide what their eventual business model would look like, matches better with the elderly and chronically ill than the gradual approach of the OEMs, in which the elderly and chronically ill would have to pay for autonomous features. The latter leads to a complex trade-off in which the elderly and chronically ill would have to decide whether the features offered by the OEMs would sufficiently enhance their driving capabilities to let the system take-over.

Fifth, the implementation of self-driving vehicles for the elderly and chronically ill depends on the resistance from the dominant socio-technical regime of person-driven vehicles and/or competing technological trajectories. As can be derived from paragraph 4.8 and 5.8 the cooperative driving trajectory is more stable than the autonomous driving approach. Whereas the actors underlying the cooperative driving trajectory create stability via consensus, the actors underlying the autonomous driving approach create stability via shielding their autonomous efforts from other entities. Given that there is a lot of competition between the different entities in California, and a preference of the DMV for cooperative driving, the autonomous driving trajectory is more open to cooperative driving solutions than the cooperative driving trajectory is to autonomous driving solutions. Especially the more radical approach undertaken by Google will likely face more resistance from the dominant socio-technical regime of person-driven vehicles as well as from the socio-technical configuration surrounding cooperative driving in the Netherlands.

Sixth, how the autonomous driving trajectory and the cooperative driving trajectory will transform society depends on the extent to which the socio-technical configuration surrounding the autonomous driving trajectory and/or cooperative driving trajectory align with the current socio-technical regime of person-driven vehicles. Whereas the autonomous driving approach seems to move towards a substitution of technologies, the cooperative driving approach seems to require changes in the entire socio-technical configuration of person-driven vehicles. As more and more objects will become connected the lines between consumers, producers and objects will continue to blur, opening up more and more business cases. Even though the autonomous driving trajectory seems to move towards a solution that better meets the needs of the elderly and chronically ill in terms of enhancing their ability to drive, the cooperative driving trajectory seems to give the elderly and chronically ill more of a voice inside the entire socio-technical configuration surrounding self-driving vehicles.

Thus, even though both approaches could potentially lead towards a solution for the elderly and chronically ill, the autonomous approach with in particular the strategy undertaken by Google seems to be more beneficial for the elderly and chronically ill in terms of speed and implementation. However, as indicated, this is also the strategy which will likely experience the most resistance from the socio-technical regime of person-driven vehicles and/or the vested interests of the actors surrounding the cooperative driving trajectory.

Q4: How and under what circumstances can both pathways benefit from each other in order to enable a self-driving vehicles for the elderly and chronically ill?

As can be derived from paragraph 2.1, in an ideal world both the autonomous driving trajectory and the cooperative driving trajectory would converge. In this scenario the elderly and chronically ill could benefit from the solution that best deals in reducing the complexity of the driving task (autonomous driving) as well as the solution that provides the best information and communication services (cooperative driving).

This is also the reason why both the Californian and Dutch government aim to embed the autonomous driving approach in the cooperative driving approach as much as possible.

Before elaborating on how both technological trajectories can benefit from each other it is important to place both actors in the right perspective. Whereas the Netherlands is a ‘using’ country, California is a ‘producing’ state. As can be derived from chapter 4 and chapter 5 this implies that the actors underlying both trajectories are not only organized differently, these actors also hold different perceptions towards where technological development should be going. This implies that the extent to which both technological trajectories could benefit from each other depends on the ability of the ‘benefit’ to break through the socio-technical configuration surrounding the technological trajectory.

As indicated in chapter 4 the Netherlands aims to harness the benefits of self-driving vehicles via positioning themselves as an international test-bed. However, given the preference of Dutch actors for cooperative driving, the autonomous driving trajectory, within particular the radical approach undertaken by Google, is considered disruptive. However, despite that this approach diverges from the cooperative driving approach, it does seem to lead towards a faster and better solution for the elderly and chronically ill. Thus whereas self-driving for the elderly and chronically ill (with high constraints) via cooperative driving is considered a long-term goal, autonomous vehicles do prevail some opportunities on a shorter term. Thus instead of focusing on ‘truck platooning’ and/or the ‘rich middle class’, the elderly and chronically ill could also be positioned as a community of early adopters. As indicated in paragraph 2.3 a ‘low-speed last-mile solution’ could already open-up a lot of opportunities for testing with the elderly and chronically ill. Not only would this involve the elderly and chronically ill in the process at an early stage, it also creates awareness of the potential that self-driving vehicles can provide for the increasing group of elderly and chronically ill. The Netherlands can therefore strengthen its position as an international test-bed for self-driving vehicles while at the same time gaining more insights in how the autonomous driving trajectory interacts with society. The latter is currently lagging behind due to a preference for cooperative driving.

The added value of the cooperative driving approach of the Netherlands for California in terms of serving the elderly and chronically ill is more difficult to define. First of all, the study takes a broader perspective implying that the most detailed information that is derived from the Netherlands comes from network organizations rather than manufactures, as in California. Therefore it can be that certain detailed benefits of the cooperative driving approach of the Netherlands are not taken in account. Second, there is a lot of secrecy and competition visible within the autonomous driving approach. Third, given that California is a producing ‘state’ and the Netherlands a ‘using’ country, there is a miss-match between both regions in terms of harnessing the potential of self-driving vehicles. As indicated in paragraph 2.2 whereas the Netherlands is just one of the countries where manufactures could test their vehicles, for the Netherlands there are only a few OEMs that can actually deliver the required self-driving capabilities to harness the expected benefits. Despite that the knowledge of cooperative driving seems desired by the DMV, the stakeholders underlying the autonomous driving approach decided to neglect the cooperative driving approach as this would slow their current efforts down. The added value of the Netherlands is therefore mainly in providing what the actors define as a ‘total solution’ (chapter 4). Instead of just supplying a technology (which comes from OEMs) the ‘supply industry’ of the Netherlands aims to deliver a broad scale of products and services that connect the technology with society. These products and services could therefore potentially create a better match between the technology and the elderly and chronically ill.

RQ: How do the actor expectations underlying the autonomous driving (California) and cooperative driving (The Netherlands) innovation pathways lead towards a self-driving solution for the elderly and chronically ill?

This thesis has resulted in showing how the different expectations underlying the cooperative driving trajectory of the Netherlands and the autonomous driving trajectory of California are translated into their respective trajectories. As can be derived from chapter 4 and chapter 5 the actors underlying both trajectories 1) legitimize 2) coordinate and 3) guide the trajectories in different ways. First, whereas the cooperative driving trajectory is mainly legitimized via referring to the expected public and economic benefits, the autonomous driving trajectory is primarily legitimized via referring to the expected benefits in terms of safety and comfort, which can be calculated in the price of the vehicles. Second, whereas the cooperative driving trajectory is coordinated via public-private collaborations on multiple levels, the autonomous driving trajectory is mainly coordinated in-house, implying that there is a lot of secrecy. Third, whereas the cooperative driving trajectory is directed towards a gradual implementation in which more and more cooperative systems will be connected, the autonomous driving trajectory is directed towards a gradual implementation in which the number of occasions in which the vehicle can drive autonomously is increased. These differences can partly be explained via looking at how the different actors are organized as well as the contextual differences in terms of the presence of OEMs, the available pool of knowledge and innovations, and the intelligence of the infrastructure.

Via looking at how local actor expectations are translated into the technological trajectory two main tensions were observed. Within the cooperative driving trajectory a tension between road-authorities and market parties on multiple levels was observed. This tension is mainly the result of uncertainties about the extent in which cooperative driving should be enabled via V2I communications and/or V2V communications. Within the autonomous driving trajectory a tension between the OEMs, Google and the DMV was observed. Whereas the OEMs expect that the user wants to remain the final decision maker, Google aims to take the driver out of the loop. The tension between the DMV and the industry is mainly driven by different views regarding the potential of cooperative driving.

These patterns all influence the speed, stability and direction of the technological trajectory, which in turn influences to what extend both trajectories will lead towards a solution for the elderly and chronically ill. Thus even though answering the research question is difficult due to the dynamic character of both technological trajectories and the complex interactions between the different entities in their respective contexts, via looking at how the expectations are translated into the respective technological trajectories it was possible to observe how the different trajectories seem to stimulate and/or hinder a self-driving solution for the elderly and chronically ill.

Given that among most of the stakeholders self-driving for the elderly and chronically ill is seen as a long-term goal, the needs of this user group are not yet taken in account. How and at which speed the different strategies aim to reduce the complexity of the driving task therefore determines to what extend the technological trajectories will lead towards a solution for the elderly and chronically ill. As can be derived from chapter 4 and 5 there are three main strategies that can be identified. First, the OEMs aim to reduce the complexity of the driving task via increasing the number of occasions at which the driver can let the system take over. The business model of the OEMs therefore seems to align with their traditional business model of selling features as a means to improve safety and comfort. Second, Google aims to reduce the complexity of the driving task via extending more and more of the miles where the vehicle can drive itself. The business model of Google therefore seems to be based on providing mobility as a service, in which users pay for miles that the autonomous vehicle will drive them. Third, the strategy underlying the cooperative driving approach is to increase the number of occasions in which the system can take over via gradually connecting more and more cooperative systems together. This strategy is therefore similar with the strategy of the OEMs. From these three strategies a couple of patterns can be identified.

First of all, the autonomous approach evolves faster towards a self-driving solution for the elderly and chronically ill than the cooperative driving trajectory. Compared to autonomous vehicles, the performance of cooperative driving vehicles depends on the degree of penetration. Whereas the actors underlying the cooperative driving trajectory need to collaborate in order to reach a higher degree of penetration, the actors underlying the autonomous driving trajectory can develop their systems independently. Despite that the OEMs can already deliver the elderly and chronically ill options in which the vehicle takes over (e.g. parking assist), an actual door-to-door solution seems to come from Google. Whereas the elderly and chronically ill would have to wait for the OEMs to provide enough options to let the vehicle drive itself from A to B, with Google the elderly and chronically ill would have to wait till the vehicle can cover sufficient miles to fulfill their needs (e.g. last mile). The approach undertaken by Google will therefore lead towards a solution for the elderly and chronically ill faster than the approach undertaken by the OEMs.

Second, looking at the different business models underlying the different strategies, the strategy undertaken by Google seems to meet the needs for the elderly and chronically ill the best. First of all, Google starts with taking the driver out of the loop implying that the vehicle could drive people who due to circumstances are not capable and/or allowed to drive. Second, Google seems to focus at least on a low-speed last-mile solution, which is, as indicated in paragraph 2.3, where most of the dilemmas for the elderly and chronically ill occur. Third, Google is the entity that most explicitly focusses on the elderly and chronically ill as a future niche market (moonshot). Not only is this argument often mentioned on their website and during interviews, there are also videos of Google testing their prototypes on this user group at their headquarters. Fourth, the business model underlying the Google car will be based on user experiences implying that the car will be built from the ground up. This will likely create a better match between the technology and the elderly and chronically ill. Fifth, Google seems to envision a business model in which mobility is provided as a service, implying that the elderly and chronically ill would not have to deal with issues that normally come with car ownership.

Third, despite that the approach undertaken by Google seems to meet the needs of the elderly and chronically ill better than the approaches undertaken by the OEMs and/or the approaches undertaken towards cooperative driving, it is also the approach that faces most of the resistance from the actors surrounding the socio-technical regime of person-driven vehicles, the cooperative driving trajectory and even the autonomous driving trajectory. The reason for this is twofold. On the one hand the approach undertaken by Google would require more changes (e.g. legislation, liability) in the socio-technical configuration surrounding person-driven vehicles than the approach undertaken by the OEMs. On the other hand the cooperative driving trajectory of the Netherlands is the result of a consensus on multiple levels making it resilient to approaches the actors consider disruptive. This does not mean that the approaches undertaken by the OEMs and/or the Dutch actors will not meet the needs for the elderly and chronically ill, it means that the approach undertaken by Google seems to meet the needs of this user group in a faster and better manner. Thus even though the efforts undertaken by Google are often criticized, it seems to be the approach which is best directed towards the real innovation behind self-driving vehicles; enabling people who due to certain circumstances cannot and/or are not allowed to drive from A to B independently, to drive independently!

6.2 Theoretical reflection

As indicated in the introduction this study aimed to compare the role of agency in two different technological trajectories, visible in two geographically separated areas, characterized by a multitude of relevant similarities and differences. As indicated in paragraph 1.5, despite that the comparative method provides a valuable means to conduct explorative research, establishing general causing explanations turns out to be rather difficult. The strength of the comparison is therefore mainly established by the capability of the researcher to penetrate into a different context and get acquainted with the context-specific meanings attached to the phenomena under observation. Before elaborating deeper on the theoretical framework which was used to observe the different phenomena, it is important to reflect on the implications and limitations of the undertaken comparison.

First, given the decision to conduct a comparison between two different trajectories that originated in two different contexts, the study provided a lot of insights in the role of agency in shaping technological trajectories. Given the contextual differences in which both different philosophies towards self-driving originated, the comparison was able to gain knowledge beyond a single unit. Even though both philosophies emerged in two geographically separated regions, this geographical separation made it possible to gain valuable in why and how these technological trajectories evolve. As became clear in chapter 2, 4 and 5, the way in which the agents interact, the context in which the agents are active and the expectations these agents hold, all influence the respective socio-technical structure (technological trajectory) the agents are part of. Via comparing how the geographically separated agents shape stability and deal with tensions made it possible to not only compare to what extend the different actor expectations lead towards a solution for the elderly and chronically ill, it also made it possible to compare how the socio-technical structure (technological trajectory) these actors are part of, might hinder and/or stimulate a solution for the elderly and chronically ill. Nevertheless, whereas the broad exploratory nature of the study made it possible to find these dynamics, this broad exploratory approach also meant that the study sacrificed some of its in-depth explanatory power. Gaining more in-depth knowledge on the patterns found in the comparative study would therefore seriously strengthen the validity of the findings.

Despite that the comparative method resulted in knowledge beyond the two separated technological trajectories, it is important to recognize that comparing both trajectories on equal terms was difficult. Despite that multiple strategies have been used to ensure that the collected data equally contributes in answering the research question (paragraph 3.4), it could still be that there is some sort of skewness in the data. Not only did the study require different data collection methods to gain an equal amount of valuable data (paragraph 3.4), given the amount of secrecy surrounding the autonomous driving trajectory in

California, a lot of effort from the researcher was required to attain this information. To make this even more complicated, the technological trajectories are continuously evolving, implying that certain observations might no longer hold and/or new phenomena might have emerged. Despite that all these factors provide valuable insights in the complex interactions between technology and society, these complex interactions could also lead towards asymmetries in the comparison. Thus even though a lot of methods were used to deal with these potential asymmetries, it is important to mention that this is no guarantee that all these asymmetries were taken out.

Second, despite that the comparison enabled the researcher to gain a deeper understanding of how the different actors underlying both trajectories shape technological development, it is important to mention that these observations strongly rely on the interpretations of the researcher. The applied theoretical framework provided a valuable means in understanding the messages behind the different actor expectations as well as the context in which these expectations were expressed. However, given that there is a lot of competition and secrecy surrounding the self-driving vehicle developments (especially in California), it should be recognized that there is still a possibility that expectations were interpreted differently. Though multiple strategies have been used to deal with this challenge (paragraph 3.5) it is difficult to deny that there might be some form of interpretation bias. Whereas the amount of time spend in both fields made it possible for the researcher to get acquainted with how the different actors shape technological development, one could also argue that this made it more difficult for the researcher to keep enough critical distance.

Third, as indicated in paragraph 3.5 the researcher is the primary instrument in the data collection procedures implying that the responses of the participants could be biased by the presence of the researcher. In addition to the presence of the researcher, the fact that the study was undertaken on behalf of the Consulate General of the Netherlands in San Francisco could have influenced the outcomes of this research. Given that all the participants recognize the political challenges that come with the implementation of self-driving vehicles, it could be that they were less conservative. The fact that the researcher is the primary instrument in the data collection procedure could also imply that important information might be lost in the research process. Besides that certain patterns might be overlooked it is also important to indicate that the decisions made during the research process strongly influence the outcome of the study. Including other entities, including different data sources, including different units of analysis et cetera would therefore all influence the outcome of the study. As indicated in paragraph 3.4 the research study entailed multitudes of interconnected variables, making mediating between the real world and the research study a challenging process.

The above mentioned limitations of the comparative method could potentially lead towards asymmetries in the data, which in turn strongly influence the outcomes of the study. Thus despite that the comparative method provided a valuable source for exploring the role of agency (e.g. actor expectations) in technological development (e.g. self-driving vehicles), it turns out to be difficult to establish general causing explanations. However, as indicated in paragraph 1.5 this study does not necessarily use the comparative method to establish general causing explanations. Rather, this study aims to use the comparison as a starting position which others can use as a starting position to gain more in-depth knowledge about the identified patterns.

As explained in chapter 3, in order to attain the required information to conduct the comparison between the cooperative driving trajectory of the Netherlands and the autonomous driving trajectory of California, this study primarily elaborated on the theoretical lens of Strategic Niche Management (SNM) and insights from the sociology of expectations. As indicated in paragraph 3.5, the causality of the findings therefore strongly depends on the applied theoretical framework as well as how the researcher deals with the observed differences and similarities. From the theoretical approach therefore multiple theoretical implications, limitations and recommendations can be derived.

First of all, insights from the sociology of expectations provided a valuable addition to SNM literature. Whereas the 'three forces of expectations framework' provided valuable insight in how local actors 1) legitimize, 2) coordinate, and 3) guide technological development (independent variables), the 'SNM perspective' made it possible to understand how these expectations were translated into the different technological trajectories (dependent variables). Insights from the sociology of expectations therefore significantly strengthened the explanatory power of the SNM perspective via lowering some of the fundamental criticisms on the SNM perspective.

Via adding insights from the sociology of expectations it is possible to gain a deeper understanding in how the different agents shape technological development beyond the socio-technical structures that define them. The 'three forces of expectations framework' made it possible to gain deeper insight in how the different entities shape their own realities. Thus rather than focusing on how actors part of a defined population (e.g. niche) interact with other populations (e.g. socio-technical regime) this framework made it possible to gain more insight in how the different entities interact (tensions, stability) and how this influences the pre-determined socio-technical structures of which these entities belong to (e.g. technological trajectory).

Given that there is a lot of noise surrounding the self-driving vehicle developments (especially in California), the 'three forces of expectations framework' provided a valuable tool for differentiating between the different actor expectations. Via comparing all the expectations on similar aspects (legitimization, coordination, heuristic guidance) it was possible to understand to what extend the different meanings behind the actors expectations aligned and/or diverged and how the actors deal with these alignments and/or tensions. These insights generate knowledge which goes beyond the explanatory power of the SNM perspective. Via adding insights from the sociology of expectations it is not only possible to understand how differences in socio-technical structures enable technological transitions (SNM perspective), it is also possible to gain a deeper understanding of the role of agency in these processes (sociology of expectations).

Third, the 'three forces of expectations framework' can be used to gain a deeper understanding of where technological development is going. This can especially be interesting with emerging technologies, such as self-driving vehicles. Rather than using expectations as a hindsight mechanism, which is common among SNM practitioners, expectations can be used as a foresight mechanism. Insights from the sociology of expectations could therefore strengthen the explanatory power of the SNM perspective. Thus even though it will remain uncertain where technological development is actually going, understanding how the different actors shape technological development does provide valuable insights in the role of agency in technological development beyond the explanatory power of the SNM perspective. However, it must be emphasized that the use of this combined perspective has been rather explorative, implying that the gained insights as well as the theoretical framework need further validation.

Second, despite that the SNM perspective makes it possible to identify patterns via positioning the different concepts (e.g. autonomous driving, cooperative driving, the elderly and chronically ill) into the multi-level perspective, it is important to mention that the way in which these concepts are positioned within the SNM perspective influences the outcome of the study. Moreover, as explained in paragraph 3.3 it can be difficult to distinguish between the niche, regime and landscape levels as there are a lot of complex interactions underlying these socio-technical structures. The insights from chapter 2 especially contributed in the process of carefully position the different concepts into the SNM framework. However, depending on the aim of the study, future research could position the concepts different within the SNM framework. Instead of looking at autonomous driving as a technological trajectory within the niche of self-driving vehicles, one could for instance look at autonomous driving as a socio-technical regime. Dividing the different concepts could therefore lead towards different insights. These insights would then contribute to SNM literature in two ways. On the one hand it would provide a deeper understanding in how and why it is important for SNM practitioners to distinguishing between the different socio-technical structures. On the other hand it would strengthen the empirical work on self-driving vehicles via looking at the role of agency in technological development from multiple angles, further validating the observed findings.

Third, as indicated in paragraph 3.1 a the dynamics underlying the cooperative driving trajectory of the Netherlands and the autonomous driving trajectory of California has been relatively unexplored within SNM literature, implying that this study could provide a valuable tipping point for future research. Especially, the interaction between self-driving vehicles and society will open-up more opportunities for future research, as the first large-scale tests with actual users still have to occur. Due to ambition to explore where technological development is going, the undertaken study has a rather technocratic character. Thus whereas the study provides valuable insights in how experts shape technological development and how this could potentially hinder and/or stimulate a solution for the elderly and chronically ill, there is less emphasize on the specific needs of the elderly and chronically ill. Some of the findings which can add to the understanding of how self-driving vehicles interact with society can therefore not be fully explained by the chosen theoretical framework. Given the ambition to find a mobility solution for the elderly and chronically ill some suggestions for future research constitute the following ideas;

- First, future research could take a more specific emphasize on the elderly and chronically ill. What do they want? How do they envision future transportation? Rather than understanding how socio-technical structures hinder and/or stimulate a solution for the elderly and chronically ill, the opinions and visions of the elderly and chronically ill could be taken as a starting position. The latter can particularly be interesting as this user group is currently not taken in account and except from a few marketing studies there is not much information on how the elderly and chronically ill look at the different self-driving vehicle developments.
- Second, for the purpose of this research it was chosen to explore how the different agents underlying the two different technological trajectories which originated in two geographically separated regions, with some important contextual differences, shaped technological development. However, future SNM research could place a more in-depth emphasize on specific regions (e.g. California), specific technological trajectories (e.g. autonomous driving) and/or strategies (e.g.

Google) and reflect these on the elderly and chronically ill. These different angles could therefore contribute to the validity of the findings of this study.

- Third, for the purpose of this study it was chosen to focus specifically on the potential of self-driving vehicles for the elderly and chronically ill. This implies that other options, such as public transportation, ride-sharing, car-sharing, were mainly left out of the analysis (see paragraph 2.3). How do these modes of transportation compete and/or align with self-driving vehicles? How do these mode of transportation interact with the elderly and chronically ill?
- Finally, whereas this research explores the potential of self-driving vehicles to provide a driving solution for a user group that currently relies on others to drive them from A to B, this study does not encompass the implications this can have on the transportation system. For instance, if the dominant business model would be based on selling vehicles, opening up this target group would imply an increase in 'Vehicle Miles Traveled' which could lead to drawbacks in terms of congestion and environmental damage.

All in all, it becomes clear that the combination of the SNM perspective with insights from the sociology of expectations provided valuable insights in relation to the research questions. Despite that the outcomes are strongly influenced by how the researcher deals with contextual differences (chapter 2), how the different concepts are positioned within the SNM perspective (chapter 3) and how the different findings are interpreted (chapter 4 and 5), it does provide a valuable overview of how the different actors underlying both technological trajectories shape technological development, and to what extend their decisions might lead towards a solution for the elderly and chronically ill.

6.3 Managerial reflection and recommendations

As indicated in the introduction (paragraph 1.4.3) the role of the Consulate General of the Netherlands in San Francisco and the Coast to Coast E-Mobility Connection (C2C) is to use economic diplomacy as a means to remove international trade and investment impediments, and via that way strengthen the competitive position of the Netherlands. However, even though there is a lot of ambition when it comes to self-driving vehicles, there is hardly any knowledge available at the Consulate General about what is going on in the field of self-driving vehicles in as well the Netherlands as California. The study therefore mainly contributes in providing the Consulate General an overview of where technological development in the Netherlands and California are going;

- How do the efforts undertaken in the Netherlands differ from the efforts undertaken in California?
- Who are the main stakeholders underlying both technological trajectories?
- How are the different stakeholders organized?
- How do the different actors shape technological development?

This knowledge helps the Consulate General to connect Dutch entities with Californian entities and via that way stimulate international knowledge and innovation exchange between governments, knowledge institutions and market parties. After all, this is the primary role of the Consulate General in technological development.

Given the ambition of the Consulate General to explore the potential of self-driving vehicles for vulnerable groups, such as the elderly and chronically ill, several recommendations can be provided. First of all, it becomes clear that self-driving for the elderly and chronically ill is considered a long-term goal implying that, as often in technological development, this group is not taken in account. Given the ambition of the Netherlands to position themselves as an international test-bed for self-driving vehicles the elderly and chronically ill could provide an interesting community of early adopters. Not only would this involve the elderly and chronically ill more in the process, it also strengthens the position of the Netherlands as an international test-bed for self-driving vehicles.

Second, the autonomous driving trajectory seems to meet the needs of the elderly and chronically ill in a faster and better manner than the cooperative driving trajectory. However, due to the stability of the cooperative driving trajectory, the autonomous driving solutions will likely face more resistance from the actors underlying the, in the Netherlands, dominant cooperative driving trajectory. Given their (broker) position, the Consulate General can play two important roles. On the one hand the Consulate General could convince Dutch parties of the potential of autonomous driving for the elderly and chronically ill via connecting them with Californian parties active in this field. On the other hand the Consulate General could promote the Netherlands as an international test-bed for autonomous driving. The latter is in particular important, as the Netherlands relies on foreign car manufacturers to deliver the actual passenger vehicles. Given the mismatch between California and the Netherlands, in terms of technological dependency, economic diplomacy could provide a valuable means via which the Consulate General could leverage the Dutch economy in the field of self-driving vehicles.

Third, even though the actors underlying the cooperative driving trajectory consider the autonomous driving efforts undertaken in California as disruptive, this does not mean that it is not important to learn from these efforts. Especially given that this trajectory evolves faster, it is most likely that autonomous vehicles will hit the roads first. Given the ambition of the Netherlands to position themselves as an international test-bed for self-driving vehicles it is therefore important to create awareness about what is going on in California and learn from these efforts. The Consulate General can do this via a so-called 'Trade Mission' in which governmental officials and business people explore the business opportunities between the Netherlands and California. This could provide a first step to enable the Consulate General to build an international consortium to develop an autonomous driving solution for the elderly and chronically ill on public roads in the Netherlands.

6.4 Epilogue

This study was started with the ambition to find a solution for the elderly and chronically ill while at the same time gaining a deeper understanding of the self-driving efforts currently being undertaken in California and the Netherlands. Via conducting a comparison a lot of insights were gathered on how agents shape their own realities and how their decisions are affected by the different socio-technical structures these agents belong to. As explained in paragraph 6.1 these decision determined to what extend the technological trajectories seemed to lead towards a self-driving solution for the elderly and chronically ill and the importance of agency in these processes. This study therefore provides an overview on which those who are in the position to decide what self-driving for the elderly and chronically ill would look like can make the decisions. Thus even though this study ends here, this research should be a starting point for those who really want to make an impact in the way transportation is currently fulfilled. Who will unlock the real innovation behind self-driving vehicles? Who will provide people, who due to certain circumstances cannot and/or are not allowed to drive from A to B independently, the ability to drive independently?

7.

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8.

APPENDICES

Appendix A: List of Interviewees

Table A: Interviewees California

Organization:	Position:	Reference:	Date of interview:
DMV	Chief Information Officer	Interviewee 01	03/17/2015
DMV	Chief Strategic Planning & Organization	Interviewee 01	03/17/2015
PATH (UC Berkeley)	Program Manager Mobility	Interviewee 02	03/19/2015
ITS (UC Berkeley)	Director Innovative Mobility Research	Interviewee 03	04/14/2015
CARS (Stanford)	PhD student CARS	Interviewee 04	04/08/2015
CARS (Stanford)	Former Executive Director CARS	Interviewee 04	04/08/2015
Google X	Head of Policy Google X	Interviewee 05	03/30/2015
Google X	Technical Lead Google Self-driving Car	Interviewee 05	03/30/2015
Tesla	Business Developer Autopilot R&D	Interviewee 06	03/20/2015
Tesla	Intern Autopilot R&D	Interviewee 06	03/19/2015
Tesla	Division Manager Autopilot R&D	Interviewee 06	03/19/2015
Nissan	Researcher Simulation Lead	Interviewee 07	04/17/2015
Nissan	Director Nissan Research Center Silicon Valley	Interviewee 07	04/17/2015
Volkswagen	Director Volkswagen Electronics Lab	Interviewee 08	04/02/2015
Volkswagen	Program Manager Autonomous	Interviewee 08	04/02/2015
Mercedes-Benz	Head of Autonomous Driving	Interviewee 09	04/17/2015
Mercedes-Benz	Director Autonomous Driving U.S.	Interviewee 09	04/17/2015
Delphi Automotive	Director Delphi Labs @ Silicon Valley	Interviewee 10	03/20/2015
Delphi Automotive	Technical Director Automated Driving	Interviewee 10	03/20/2015
Bosch	Director Bosch Automated Driving	Interviewee 11	04/13/2015
Caltrans	Division Chief	Interviewee 12	03/18/2015
Caltrans	Office Chief (ITS)	Interviewee 12	03/18/2015
Gomentum Station	Executive Director Contra Costa Transportation	Interviewee 13	04/16/2015
BMW	Advanced Technology Engineer	Interviewee 14	03/25/2015
BMW	Vice President Governmental Affairs	Interviewee 14	03/25/2015
Singularity University	Chairman Network and Computers	Interviewee 15	03/31/2015
Cruise	CEO and Founder	Interviewee 16	04/16/2015
NVidia	Commercial Director Automotive	Interviewee 17	04/06/2015
Renault	Innovation Project Manager	Interviewee 18	04/07/2015
Ford	Director Silicon Valley R&D facility	Interviewee 19	04/07/2015

Table B: Interviewees the Netherlands

Organization:	Position:	Reference:	Date of interview:
Automotive NL	Senior Advisor Smart & Green Mobility	Interviewee 20	05/28/2015
Automotive NL	Manager Business Development	Interviewee 20	05/28/2015
RDW	Vehicle Certification RDW (automated driving)	Interviewee 21	06/22/2015
Amsterdam Group	Senior Advisor Arcadis (Cooperative ITS)	Interviewee 22	06/05/2015
Amsterdam Group	Chairman Amsterdam Group	Interviewee 22	06/05/2015
Ministry I&M	Senior Advisor Public Policy	Interviewee 23	07/07/2015
Ministry I&M	Senior Advisor ITS	Interviewee 23	07/07/2015
DITCM	Director DITCM Innovations	Interviewee 24	06/10/2015
TU Eindhoven	Professor Automotive Technology	Interviewee 25	05/27/2015
TU Eindhoven	Program Manager Smart Mobility	Interviewee 25	05/29/2015
TU Eindhoven	Professor Systems & Control	Interviewee 25	05/29/2015
SWOV	Advisor Behavior & ITS	Interviewee 26	06/30/2015
TU Delft	Professor Transport Modelling	Interviewee 27	07/13/2015
TNO	Program Manager Automated Driving	Interviewee 28	03/23/2015
TNO	Market Manager Automotive	Interviewee 28	03/23/2015
TomTom	Director New Product Development	Interviewee 29	04/16/2016
TomTom	Vice President Traffic Solutions	Interviewee 29	05/29/2015

NXP	Senior Director Business Development Automotive	Interviewee 30	06/26/2015
Connekt	Board member Connekt	Interviewee 31	06/10/2015
Connekt	Member Board of Advisors	Interviewee 31	05/29/2015
Provincie Noord Holland	Project Leader Traffic Management	Interviewee 32	06/17/2015
Arcadis	Advisor Cooperative ITS	Interviewee 33	06/12/2015
BOVAG	President Director	Interviewee 34	06/09/2015
BOVAG	Program Manager Innovation	Interviewee 34	06/09/2015
DAF	President Director	Interviewee 35	06/16/2015
BOM	Program Manager Smart Mobility	Interviewee 36	02/06/2015
AON	Client Director AON Risk Solutions	Interviewee 37	03/06/2015
Rijkswaterstaat	Advisor Knowledge & Innovation	Interviewee 38	03/06/2015

Table C: Focus group participants

Organization:	Position:	Reference:	Date of interview:
Innovation Attaché	Science & Technology Advisor	Participant 01	02/24/2015
Innovation Attaché	Science & Technology Advisor	Participant 02	02/24/2015
C2C connection	Program Director / Diplomatic Liaison	Participant 03	02/24/2015
CARS Stanford	Director CARS Stanford	Participant 04	02/24/2015
UC Berkeley	Director Innovative Mobility Research	Participant 05	02/24/2015
HIT	Program Director	Participant 06	02/24/2015
TRIP	Advisor Aging Population	Participant 07	02/24/2015

Table D: Expert interviews

Organization:	Position:	Reference:	Date of interview:
Rathenau Instituut	Junior Technology Analyst	Expert 01	06/12/2015
University Utrecht	Professor 'Institutions and Societal Transitions'	Expert 02	06/16/2015

Appendix B: Structure focus group

02/10/2015

Self-driving for the elderly and chronically ill?!

Dear sir/madam,

On behalf of the Coast to Coast E-Mobility Connection you are cordially invited to attend a discussion session on the potential of self-driving vehicles for the elderly and chronically ill. The discussion session will take place between 1pm and 3pm at the on February 02, 2015 at the at the Consulate General of the Netherlands located at 120 Kearny Street, Suite 31, CA94104 San Francisco.

On behalf of the Eindhoven University of Technology, the Coast to Coast E-Mobility Connection and the Consulate General of the Netherlands in San Francisco I have been investigating the potential of self-driving vehicles for the elderly and chronically ill. In order to conduct this research the following research question was formulated:

- How do the actor expectations underlying the cooperative driving approach of the Netherlands and the autonomous driving approach of California affect the elderly and chronically ill.

The discussion session is mainly aimed to discuss some of the earlier findings as well as to identify paths that require some additional information. In order to make the discussion session as fruitful as possible the following statements, which were derived from the literature findings, are formulated:

1) Autonomous driving vehicles will be implemented on public roads earlier than vehicles based on vehicle to vehicle (V2V) and/or vehicle to infrastructure (V2I) communications.

2) The elderly and chronically ill provide an interesting niche market for self-driving vehicles.

3) Gradually taking over more and more off the driving tasks of the elderly and chronically ill is better than providing the elderly with more driving information.

4) The radical approach undertaken by Google (driver out of the loop) will lead to a better suitable solution for the elderly and chronically ill than the gradual improvements made by the OEMs (keeping driver attentive).

5) Road-side systems (for V2I communication) will become more and more redundant.

6) Legislation should be adjusted to allow self-driving vehicle manufacturers to test their ‘full autonomous’ prototypes on public roads, accelerating a solution for the elderly and chronically ill.

7) Self-driving vehicle developments should be guided by the industry (competition) instead of the government (concensus).

For additional information and/or a confirmation for participation please respond to jeroenaerts88@gmail.com.

Look forward to meet and learn from you.

Kind regards,
Jeroen Aerts

Appendix C: Semi-structured interview

Shared structure

Introduction:

- Introducing myself
- Explain that this interview is undertaken on behalf of Eindhoven University of Technology and the Consulate General of the Netherlands in San Francisco.
- Introduce the research question and how this interview contributes to answering this question.
- Ask if the interview is fine if the interview is recorded.
- Explain that you are aware of the amount of noise surrounding the implementation and development of self-driving vehicles.
- Ask to what extend the interviewee wants the information to stay confidential.

Background information:

- Name organization:
- Name interviewee:
- Function
- Size of the department's active in the field of self-driving vehicles.

Part A: Autonomous driving approach of California

Core questions:

- What is the role of the organization when it comes to the implementation and/or development of self-driving vehicles?
  - Focus solely on autonomous or also other self-driving possibilities and why?
- What is their vision of autonomous driving?
  - Short term?
  - Long term?
  - When deliver what capabilities?
- What is their revenue model?
  - Selling vehicles and/or options?
  - Mainly focus on software?
  - Pay for mobility?
  - Data logging?
- Why focus on autonomous driving?
  - Infrastructure?
  - Why less attention for V2V and V2I communications?
- Why located in California?
  - Where do they get their knowledge and innovation from?
  - What is the role of Silicon Valley?
- What is the role of the government?
  - Legislation?
  - Facilitation?
  - Guiding efforts?
- How will the self-driving capabilities be tested on future user groups?
  - First implementation?
  - Mass market, specific user groups, after-market?
  - Testing is data driven and/or hardware driven?
- Given the amount of nearby competitors is there are there a lot of knowledge and innovation transfers going on?
  - Meetings? Communities? Brain drain?

Specific questions:

- Why do you (and your organization) belief self-driving vehicles are the future?

    - ‘90% of all traffic accidents are due to human error’
    - ‘Traffic accidents occur 1/64.400 hours implying that systems must be extremely robust.
    - Try to figure out if they are taking a proponents or opponents viewpoint (see quotes).
- Why focus on keeping the driver in control and/or getting the driver out of the loop?
    - When and why?
    - The role of ADAS in vehicles?
- Do you consider the elderly and chronically ill as an interesting niche market?
    - Are these groups already taken in account? Why or why not?
    - What are the main bottlenecks?
    - What are the main opportunities?
- How to reduce the complexity of the driving task?
    - The role of information in this process?
    - Different levels of automation for different levels of impedements?
- Which approach will deliver the first solution for the elderly and chronically ill?
    - Autonomous driving? Why?
    - Cooperative driving? Why?
- Are there other modes of transportation that might serve the elderly and chronically ill better?
    - Public transportation?
    - Ride-sharing? Car-sharing?
    - Last mile dilemmas?
    - How about costs?

Part B: Cooperative driving approach of the Netherlands

Core questions:

- What is the role of the organization when it comes to the implementation and/or development of self-driving vehicles?
    - How does the organization contribute in cooperative driving?
- What is their vision of cooperative driving?
    - Short term?
    - Long term?
    - When deliver what capabilities?
- What is their revenue model (given no OEMs)?
    - Reducing costs associated with congestion, traffic accidents and environmental damage?
    - Pay for mobility?
    - Data driven business models?
    - Living labs?
- Why focus on cooperative driving?
    - Infrastructure?
    - What do you think of the autonomous efforts undertaken in California?
- Why all these network organizations?
    - Where do they get their knowledge and innovation from?
    - What is the role of these network organizations?
- What is the role of the government?
    - Legislation?
    - Facilitation?
    - Guiding efforts?
    - Test-bed?
    - Funding?
- How will the self-driving capabilities be tested on future user groups?
    - First implementation in the Netherlands?
    - Mass market, specific user groups, after-market?
    - Testing is data driven and/or hardware driven?

<u>Specific questions:</u>

- Why do you (and your organization) belief self-driving vehicles are the future?
  - ‘Reducing emissions, traffic accidents and congestions’
  - ‘More comfortable and safer driving’
  - Try to figure out if they are taking a governmental perspective and/or industry perspective
- Why focus on keeping the driver in control and/or getting the driver out of the loop?
  - When and why?
  - The role of ADAS in vehicles?
- Do you consider the elderly and chronically ill as an interesting niche market?
  - Are these groups already taken in account? Why or why not?
  - What are the main bottlenecks?
  - What are the main opportunities?
  - What are interesting test-cases?
- How to reduce the complexity of the driving task?
  - The role of information in this process?
  - Different levels of automation for different levels of impediments?
- Which approach will deliver the first solution for the elderly and chronically ill?
  - Autonomous driving? Why?
  - Cooperative driving? Why?
- Are there other modes of transportation that might serve the elderly and chronically ill better?
  - Public transportation?
  - Ride-sharing? Car-sharing?
  - Last mile dilemmas?
  - How about costs?

Shared structure

<u>End-notes:</u>

- Is there some interesting information I have missed out on?
  - What do you think of my approach?
  - What do you think of the research question and ambition?
- Given my research question who are interesting persons and organizations I should approach?
  - Mention the ones that are already included.
- Thank for participation
  - Would you like to receive the transcription of the interview?
  - Would you like to receive a digital version of the master thesis?